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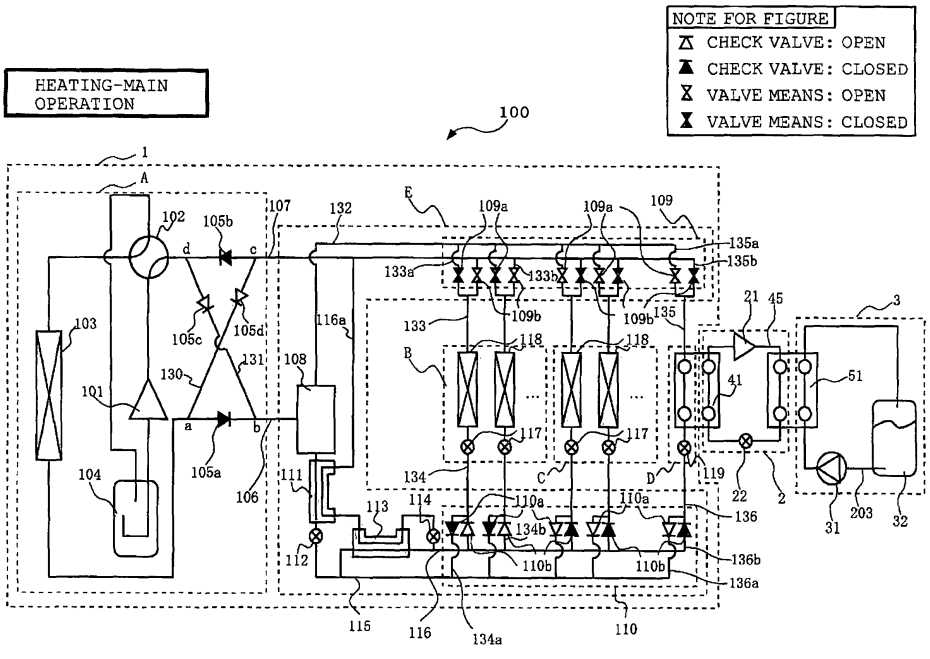
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(54) COMPLEX SYSTEM FOR AIR CONDITIONING AND HOT WATER SUPPLYING

(57) To provide an air-conditioning hot-water supply complex system that can simultaneously cover a cooling load, a heating load and a high-temperature hot-water supply load, thus can provide a stable heat source throughout the year, and allows rapid rise from startup.

The air-conditioning hot-water supply complex system 100 includes a bypass pipe 303 connecting a portion between a heat medium-refrigerant heat exchanger 51 and a hot water storage tank 32 and a portion between the hot water storage tank 32 and a water circulation pump 31, in a water circuit of a hot-water supply load 3b.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to an air-conditioning hot-water supply complex system including a heat pump cycle and being capable of simultaneously providing a cooling load, a heating load and a hot-water supply load.

Background Art

[0002] There have been air-conditioning hot-water supply complex systems in which a single-stage refrigeration cycle can simultaneously provide a cooling load, a heating load and a hot-water supply load. For example, there had been proposed a "multifunctional heat pump system which includes a single compressor, and a refrigeration cycle including a refrigerant circuit to which the compressor, an outdoor heat exchanger, an indoor heat exchanger, a cooling energy storage tank and a hot-water supply heat exchanger are connected, and allowing independent operations and complex operations for air conditioning, hot-water supply, heat storage and cool storage by switching the flow of a refrigerant between the heat exchangers" (see, for example, Patent Document 1).

[0003] Also, there are air-conditioning hot-water supply complex systems in which a two-stage refrigeration cycle simultaneously allows high-temperature hot-water supply and indoor air conditioning. For example, there has been proposed a "heat pump-type hot-water supply apparatus that includes: a lower-stage refrigerant circuit through which a first refrigerant flows, connecting a first compressor, a refrigerant distribution device, a first heat exchanger, a second heat exchanger, a first throttle device, an outdoor heat exchanger, a four-way valve and the first compressor in that order and establishing a connection from the refrigerant distribution device to the line between the second heat exchanger and the first throttle device through the four-way valve, an indoor heat exchanger and a second throttle device in that order; a higher-stage refrigerant circuit through which a second refrigerant flows, connecting a second compressor, a condenser, a third throttle device, the first heat exchanger and the second compressor in that order; and a hot-water supply channel through which hot water to be supplied flows, connecting the second heat exchanger and the condenser in that order (see, for example, Patent Document 2).

[0004]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 11-270920 (Pages 3-4, Fig. 1)

[Patent Document 2] Japanese Unexamined Patent Application Publication No. 4-263758 (Pages 2-3, Fig. 1)

Disclosure of Invention

Problems to be Solved by the Invention

[0005] The multifunctional heat pump system disclosed in Patent Document 1 is configured such that a single stage refrigeration cycle, that is, a single refrigeration cycle, simultaneously provides a cooling load, a heating load and a hot-water supply load. In such a system, however, since the temperature of a heat radiation process for heating water and the temperature of a heat radiation process for heating air become substantially the same, the system cannot cover a load for supplying high-temperature hot water during cooling operation, and accordingly cannot stably supply heating energy throughout the year disadvantageously. In addition, the compressor must continue working until the heat source is heated, and thus, the system is inefficient in operation disadvantageously as well.

[0006] The heat pump-type hot-water supply apparatus disclosed in Patent Document 2 is configured such that a two-stage refrigeration cycle, that is, two refrigeration cycles, simultaneously provides a cooling load, a heating load and a hot-water supply load. In such a system, however, since the refrigerant circuit through which an indoor unit performs air conditioning and the refrigerant circuit supplying hot water are treated in different manners, a hot-water supply function cannot be simply added as an alternative to the indoor unit, and thus, it is not easy to apply the system to installed air conditioners.

[0007] The present invention is intended to solve the above disadvantages, and an object of the invention is to provide an air-conditioning hot-water supply complex system that can simultaneously cover a cooling load, a heating load and a high-temperature hot-water supply load, thus can provide a stable heat source throughout the year, and allows rapid rise from startup.

Means for Solving the Problems

[0008] A air-conditioning hot-water supply complex system of the present invention includes an air-conditioning refrigeration cycle that has a first refrigerant circuit, in which an air-conditioning compressor, a flow channel switching means, an outdoor heat exchanger, an indoor heat exchanger, and air-conditioning throttle means are connected in series, and a refrigerant-refrigerant heat exchanger and hot-water supply heat source throttle means that are connected each other in series are connected to the indoor heat exchanger and the air-conditioning throttle means in parallel, and that makes an air-conditioning refrigerant be circulated in the first refrigerant circuit, a hot-water supply refrigeration cycle that has a second refrigerant circuit, in which a hot-water supply compressor, a heat medium-refrigerant heat exchanger, hot-water supply throttle means and the refrigerant-refrigerant heat exchanger that are connected in series, and that makes a hot-water supply refrigerant be circu-

lated in the second refrigerant circuit, and a hot-water supply load that has a water circuit, in which a water circulation pump, the heat medium-refrigerant heat exchanger, and a hot water storage tank are connected in series, and that makes water for hot-water supply be circulated in the water circuit, wherein the air-conditioning refrigeration cycle and the hot-water supply refrigeration cycle are cascade-connected so as to perform heat exchange between the air-conditioning refrigerant and the hot-water supply refrigerant in the refrigerant-refrigerant heat exchanger, wherein the hot-water supply refrigeration cycle and the hot-water supply load are cascade-connected so as to perform heat exchange between the hot-water supply refrigerant and the water in the heat medium-refrigerant heat exchanger, and wherein in the water circuit, a bypass pipe is provided which connects between the heat medium-refrigerant heat exchanger and the hot water storage tank, and between the hot water storage tank and the water circulation pump.

Advantages

[0009] According to the air-conditioning hot-water supply complex system of the present invention, air-cooling operation, air-heating operation, and hot-water supply operation can be simultaneously or selectively performed according to an air-conditioning load and a hot-water supply load without forming a complicated circuit, and, in addition, highly efficient operation can be performed by improving the rise of startup (particularly the hot-water supply compressor).

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram showing a refrigerant circuit configuration of an air-conditioning hot-water supply complex system according to an embodiment.

[Fig. 2] Fig. 2 is a schematic circuit diagram illustrating another embodiment of the hot-water supply load.

[Fig. 3] Fig. 3 is a representation of an example of the configuration of an outdoor heat exchanger.

[Fig. 4] Fig. 4 is a schematic circuit diagram illustrating still another embodiment of a hot-water supply load.

[Fig. 5] Fig. 5 is a schematic circuit diagram of an example of the circulation of the heat medium in the hot-water supply load.

[Fig. 6] Fig. 6 is a flow chart showing the switching operation of flow channels of the heat medium in the hot-water supply load.

[Fig. 7] Fig. 7 is a graph showing an example of the operational range of a hot-water supply compressor.

[Fig. 8] Fig. 8 is a graph showing another example of the operational range of the hot-water supply compressor.

[Fig. 9] Fig. 9 is a graph showing an open/closed area ratio of a first flow channel switching device.

[Fig. 10] Fig. 10 is a graph showing a shifted open/closed area ratio of the first flow channel switching device.

[Fig. 11] Fig. 11 is a graph showing a relationship between the capacity of the auxiliary tank and the capacity of the heat medium-refrigerant heat exchanger.

Reference Numerals

[0011] 1: air-conditioning refrigeration cycle, 2: hot-water supply refrigeration cycle, 3: hot-water supply load, 3a: hot-water supply load, 3b: hot-water supply load, 4: hot-water supply water circulation cycle, 21: hot water supply compressor, 22: hot-water supply throttle means, 31: water circulation pump, 31 a: heat medium circulation pump; 32: hot water storage tank, 41: refrigerant - refrigerant heat exchanger, 45: refrigerant pipe, 5l: heat medium-refrigerant heat exchanger, 100: air-conditioning hot-water supply complex system, 101: air-conditioning compressor, 102: four-way valve, 103: outdoor heat exchanger, 103a: divided heat exchanger, 104: accumulator, 105a: check valve, 105b: check valve, 105c: check valve, 105d: check valve, 106: high-pressure side connecting pipe, 107: low-pressure side connecting pipe, 108: gas-liquid separator, 109: distribution portion, 109a: valve means, 109b: valve means, 110: distribution portion, 110a: check valve, 110b: check valve, 111: internal heat exchanger, 112: first relay throttle means, 113: internal heat exchanger, 114: second relay throttle means, 115: association portion, 116: association portion, 116a: association portion, 117: air-conditioning throttle means, 118: indoor heat exchanger, 119: hot-water supply heat source throttle means, 130: connecting pipe, 131: connecting pipe, 132: connecting pipe, 133: connecting pipe, 133a: connecting pipe, 133b: connecting pipe, 134: connecting pipe, 134a: connecting pipe, 134b: connecting pipe, 135: connecting pipe, 135a: connecting pipe, 135b: connecting pipe, 136: connecting pipe, 136a: connecting pipe, 136b: connecting pipe, 201: water-water heat exchanger, 202: circulating water pipe, 203: storage hot water circulation pipe, 203a: storage hot water circulation pipe, 209: solenoid valve (on-off valve), 209a: solenoid valve (bypass on-off valve), 300: bypass circuit, 301: first flow channel switching device, 302: second flow channel switching device, 303: bypass pipe, 305: auxiliary tank, 310: first temperature sensor, 311: second temperature sensor, A: heat source apparatus, B: cooling indoor unit, C: heating indoor unit, D: hot-water supply heat source circuit, E: relay, a: junction, b: junction, C: junction, d: junction.

Best Modes for Carrying Out the Invention

[0012] An Embodiment of the present invention will be

described with reference to the drawings.

Fig. 1 is a refrigerant circuit diagram showing a refrigerant circuit configuration (particularly refrigerant circuit configuration in a heating-main operation) of an air-conditioning hot-water supply complex system 100 according to the embodiment of the present invention. A refrigerant circuit configuration, particularly the refrigerant circuit configuration in a heating-main operation of the air-conditioning hot-water supply complex system 100 will be described with reference to Fig. 1. The air-conditioning hot-water supply complex system 100 is installed in a building, a condominium or the like, and can simultaneously provide a cooling load, a heating load and a hot-water supply load using a refrigeration cycle (heat pump cycle) in which a refrigerant (air-conditioning refrigerant) is made to circulate. In the following drawings including Fig. 1, the relationship of each dimension of components may be different from actual one.

[0013] The air-conditioning hot-water supply complex system 100 according to the present embodiment includes an air-conditioning refrigeration cycle 1, a hot-water supply refrigeration cycle 2, and a hot-water supply load 3. The air-conditioning refrigeration cycle 1 and the hot-water supply refrigeration cycle 2 are configured so that heat exchange can be performed without mixing their refrigerant and water together in a refrigerant-refrigerant heat exchanger 41, and also the hot-water supply refrigeration cycle 2 and the hot-water supply load 3 are configured so that heat exchange can be performed without mixing their refrigerant and water together in a heat medium-refrigerant heat exchanger 51. Fig. 1 shows a cycle state where the load for a cooling indoor unit B is lower than the total load for a heating indoor unit C and a hot-water supply heat source circuit D in the air-conditioning refrigeration cycle 1, and the outdoor heat exchanger 103 acts as an evaporator (referred to as heating-main operation, for the sake of convenience).

[Air-conditioning refrigeration cycle 1]

[0014] The air-conditioning refrigeration cycle 1 has a heat source apparatus A, a cooling indoor unit B covering the cooling load, a heating indoor unit C covering the heating load, a hot-water supply heat source circuit D for the heat source of the hot-water supply refrigeration cycle 2, and a relay unit E. In this structure, the cooling indoor unit B, the heating indoor unit C and the hot-water supply heat source circuit D are installed so as to be connected in parallel with the heat source apparatus A. The relay unit E, which is disposed between the heat source apparatus A and each of the cooling-indoor unit B, the heating-indoor unit C and the hot-water supply heat source circuit D, switches the flow of the refrigerant, so that the cooling indoor unit B, the heating indoor unit C and the hot-water supply heat source circuit D function as are intended

[Heat source apparatus A]

[0015] The heat source apparatus A has an air-conditioning compressor 101, a four-way valve 102 being flow channel switching means, an outdoor heat exchanger 103 and an accumulator 104 that are connected in series, and the heat source apparatus A has a function to supply cooling energy to the cooling indoor unit B, the heating indoor unit C, and the hot-water supply heat source circuit D. It is preferable that a fan or the like for supplying air to the outdoor heat exchanger 103 be disposed near the outdoor heat exchanger 103. In the heat source apparatus A, while a check valve 105a allowing the air-conditioning refrigerant to flow only in a predetermined direction (in a direction from the heat source apparatus A to the relay unit E) is disposed in a high-pressure side connecting pipe 106 between the outdoor heat exchanger 103 and the relay unit E, and a check valve 105b allowing the air-conditioning refrigerant to flow only in a predetermined direction (in a direction from the relay unit E to the heat source apparatus A) is disposed in a low-pressure side connecting pipe 107 between the four-way valve 102 and the relay unit E respectively.

[0016] The high-pressure side connecting pipe 106 and the low-pressure side connecting pipe 107 are connected to each other with a first connecting pipe 130 connecting the upstream side of the check valve 105a and the upstream side of the check valve 105b, and with a second connecting pipe 131 connecting the downstream side of the check valve 105a and the downstream side of the check valve 105b. More specifically, the junction a of the high-pressure side connecting pipe 106 with the first connecting pipe 130 lies upstream from the junction b of the high-pressure side connecting pipe 106 with the second connecting pipe 131 with the check valve 105a therebetween, and also, the junction c of the low-pressure side connecting pipe 107 with the first connecting pipe 130 lies upstream from the junction d of the low-pressure side connecting pipe 107 with the second connecting pipe 131 with the check valve 105b therebetween.

[0017] The first connecting pipe 130 is provided with a check valve 105c allowing the air-conditioning refrigerant to flow only in the direction from the low-pressure side connecting pipe 107 toward the high-pressure side connecting pipe 106. The second connecting pipe 131 is also provided with a check valve 105d allowing the air-conditioning refrigerant to flow only in the direction from the low-pressure side connecting pipe 107 toward the high-pressure side connecting pipe 106. In Fig. 1, which shows the refrigerant circuit configuration in the heating-main operation, the check valve 105a and the check valve 105b are in a closed state (represented by black symbols), and the check valve 105b and the check valve 105c are in an open-state (represented by white symbols).

[0018] The air-conditioning compressor 101 takes in the air-conditioning refrigerant and compresses the air-conditioning refrigerant to a high-temperature high-pres-

sure state. The four-way valve 102 switches the flow of the air-conditioning refrigerant. The outdoor heat exchanger 103 functions as an evaporator or a radiator (condenser), and exchanges heat between the air supplied from a fan (not shown) and the air-conditioning refrigerant to evaporate or condense the air-conditioning refrigerant into gas or liquid. The accumulator 104 is disposed between the four-way valve 102 and the air-conditioning compressor 101, and accumulates an excess of the air-conditioning refrigerant in the heating-main operation. Any vessel can be used as the accumulator 104 as long as it can accumulate the excess of the air-conditioning refrigerant.

[Cooling Indoor unit B and Heating Indoor unit C]

[0019] The cooling indoor unit B and the heating indoor unit C each has an air-conditioning throttle means 117 and an indoor heat exchanger 118 that are connected to each other in series. It is shown as an example that two air-conditioning throttle means 117 and two indoor heat exchangers 118 are installed in parallel in each of the cooling indoor unit B and the heating indoor unit C. The cooling indoor unit B receives cold or heat supply from the heat source apparatus A to cover the cooling load, and the heating indoor unit C receives cold or heat supply from the heat source apparatus A to cover the heating load.

[0020] In other words, in the embodiment, a state is shown in which the relay unit E has determined that the cooling indoor unit B covers the cooling load, and that the heating indoor unit C covers the heating load. It is preferable that a fan or the like for supplying air to the indoor heat exchanger 118 be disposed near the indoor heat exchanger 118. For the sake of convenience, a connecting pipe connecting the relay unit E to the indoor heat exchanger 118 is referred to as a connecting pipe 133, and a connecting pipe connecting the relay unit E to the air-conditioning throttle means 117 is referred to as a connecting pipe 134.

[0021] The air-conditioning throttle means 117 functions as a reducing valve and an expansion valve to decompress the air-conditioning refrigerant to expand it. The air-conditioning throttle means 117 can be advantageously constituted by those whose opening-degree can be variably controlled, such as precise flow rate control means by an electronic expansion valve or inexpensive refrigerant flow rate control means such as capillary. The indoor heat exchanger 118 functions as a radiator (condenser) or an evaporator, and exchanges heat between the air supplied from blowing means (not shown) and the air-conditioning refrigerant to condense and liquefy or evaporate and gasify the air-conditioning refrigerant. The air-conditioning throttle means 117 and the indoor heat exchanger 118 are connected in series.

[Hot-water supply Heat Source Circuit D]

[0022] The hot-water supply heat source circuit D has a hot-water supply heat source throttle means 119 and a refrigerant-refrigerant heat exchanger 41 that are connected in series, and functions to supply cold or heat from the heat source apparatus A to the hot-water supply refrigeration cycle 2 through the refrigerant-refrigerant heat exchanger 41. Hence, the air-conditioning refrigeration cycle 1 and the hot-water supply refrigeration cycle 2 are cascade connected to each other with the refrigerant-refrigerant heat exchanger 41. For the sake of convenience, the connecting pipe connecting the relay unit E to the refrigerant-refrigerant heat exchanger 41 is referred to as a connecting pipe 135, and the connecting pipe connecting the relay unit E to the hot-water supply heat source throttle means 119 is referred to as a connecting pipe 136.

[0023] The hot-water supply heat source throttle means 119 functions as a pressure reducing valve and an expansion valve to decompress the air-conditioning refrigerant to expand it as with the air-conditioning throttle means 117. The hot-water supply heat source throttle means 119 can be advantageously constituted of a means whose degree of opening can be variably controlled, such as a precise flow rate control means with an electronic expansion valve or an inexpensive refrigerant flow rate control means using a capillary or the like. The refrigerant-refrigerant heat exchanger 41 functions as a radiator (condenser) or an evaporator, and exchanges heat between the hot-water supply refrigerant circulating in the refrigeration cycle of the hot-water supply refrigeration cycle 2 and the air-conditioning refrigerant circulating in the refrigeration cycle of the air-conditioning refrigeration cycle 1.

[Relay unit E]

[0024] The relay unit E has a function to connect each of the cooling indoor unit B, the heating indoor unit C and the hot-water supply heat source circuit D to the heat source apparatus A, and a function to open or close either the valve means 109a or the valve means 109b of a first distribution portion 109 so as to determine whether the indoor heat exchanger 118 is used as a radiator or an evaporator, or whether the refrigerant-refrigerant heat exchanger 41 is used as a water cooler or a water heater. The relay unit E includes a gas-liquid separator 108, the first distribution portion 109, a second distribution portion 110, a first internal heat exchanger 111, a first relay throttle means 112, a second internal heat exchanger 113, and a second relay throttle means 114.

[0025] In the first distribution portion 109, each of the connecting pipes 133 and 135 branches into two: one (connecting pipe 133b and connecting pipe 135b) is connected to the low-pressure side connecting pipe 107; the other (connecting pipe 133a and connecting pipe 135a) is connected to a connecting pipe (referred to as con-

necting pipe 132) connected to the gas-liquid separator 108. In the first distribution portion 109, also, the connecting pipe 133a and the connecting pipe 135a are each provided with a valve means 109a that is on/off-controlled to transmit or not to transmit the refrigerant, and the connecting pipe 133b and the connecting pipe 135b are each provided with a valve means 109b that is on/off-controlled to transmit or not to transmit the refrigerant. The open/losed states of the valve means 109a and 109b are represented by white symbols (open state) and black symbols (closed state).

[0026] In the second distribution portion 110, connecting pipes 134 and 136 are branches into two: one (connecting pipe 134a and connecting pipe 136a) is connected to a first association portion 115; the other (connecting pipe 134b and connecting pipe 136b) is connected to a second association portion 116. In the second distribution portion 110, the connecting pipes 134a and the connecting pipe 136a are provided with a check valve 110a allowing the refrigerant to flow only in a single direction, and the connecting pipe 134b and the connecting pipe 136b are each provided with a check valve 110b allowing the refrigerant to flow only in a single direction. The open/closed states of check valves 110a and 110b are represented by outline character (open state) and black-coated (closed state) respectively.

[0027] The first association portion 115 is connected to the gas-liquid separator 108 from the second distribution portion 110 through the first relay throttle means 112 and the first internal heat exchanger 111. The second association portion 116 branches between the second distribution portion 110 and the second internal heat exchanger 113: one passes through the second internal heat exchanger 113 and is connected to the first association portion 115 between the second distribution portion 110 and the first relay throttle means 112; the other (second association portion 116a) is connected to the low-pressure side connecting pipe 107 through the second relay throttle means 114, the second internal heat exchanger 113 and the first internal heat exchanger 111.

[0028] The gas-liquid separator 108, which separates the air-conditioning refrigerant into a gas refrigerant and a liquid refrigerant, is disposed in the high-pressure side connecting pipe 106: one end is connected to the valve means 109a of the first distribution portion 109, and the other end is connected to the second distribution portion 110 through the first association portion 115. The first distribution portion 109 functions to open or close either the valve means 109a or the valve means 109b so that the air-conditioning refrigerant can flow into the indoor heat exchanger 118 and the refrigerant-refrigerant heat exchanger 41. The second distribution portion 110 has a function allowing the air-conditioning refrigerant to flow in either direction with the check valve 110a and the check valve 110b.

[0029] The first internal heat exchanger 111 is disposed in the first association portion 115 between the gas-liquid separator 108 and the first relay throttle means 112, and exchanges heat between the air-conditioning refrigerant flowing through the first association portion 115 and the air-conditioning refrigerant flowing through the second association portion 116a diverging from the second association portion 116. The first relay throttle means 112 is disposed in the first association portion 115 between the first internal heat exchanger 111 and the second distribution portion 110, and decompresses the air-conditioning refrigerant to expand it. The first relay throttle means 112 can be advantageously constituted of a means whose degree of opening can be variably controlled, such as a precise flow rate control means with an electronic expansion valve or an inexpensive refrigerant flow rate control means using a capillary or the like.

[0030] The second internal heat exchanger 113 is disposed in the second association portion 116, and exchanges heat between the air-conditioning refrigerant flowing through the second association portion 116 and the air-conditioning refrigerant flowing through the second association portion 116a diverging from the second association portion 116. The second relay throttle means 114 is disposed in the second association portion 116 between the second internal heat exchanger 113 and the second distribution portion 110, and functions as a check valve and an expansion valve to decompress the air-conditioning refrigerant to expand it. As with the first relay throttle means 112, the second relay throttle means 114 can be advantageously constituted of a means whose degree of opening can be variably controlled, such as a precise flow rate control means with an electronic expansion valve or an inexpensive refrigerant flow rate control means using a capillary or the like.

[0031] As described above, the air-conditioning refrigeration cycle 1 is realized with a first refrigeration circuit wherein the air-conditioning compressor 101, the four-way valve 102, the indoor heat exchanger 118, the air-conditioning throttle means 117 and the outdoor heat exchanger 103 are connected in series, wherein the air-conditioning compressor 101, the four-way valve 102, the refrigerant-refrigerant heat exchanger 41, the hot-water supply heat source throttle means 119 and the outdoor heat exchanger 103 are connected in series, and wherein the indoor heat exchanger 118 and the refrigerant-refrigerant heat exchanger 41 are connected in parallel via the relay unit E, by making the air-conditioning refrigerant circulate in the first refrigerant circuit.

[0032] Any type can be used as the air-conditioning compressor 101 without particular limitation, as long as the refrigerant taken in can be compressed to a high pressure state. For example, the air-conditioning compressor 101 may include any type such as a reciprocal, rotary, scroll or screw type. The air-conditioning compressor 101 may be a type capable of variably controlling the rotational speed with an inverter or a type having a fixed rotational speed. The type of the refrigerant circulating in the air-conditioning refrigeration cycle 1 is not particularly limited, and, for example, any type can be used, including natural refrigerants such as carbon dioxide

(CO_2), hydrocarbons and helium, chlorine-free alternate refrigerants such as HFC410A, HFC407C and HFC404A, and fluorocarbon refrigerants used in existing products such as R22 and R134a.

[0033] The heating-main operation behavior of the air-conditioning refrigeration cycle 1 will be described.

First, the air-conditioning refrigerant whose temperature and pressure have been increased by the air-conditioning compressor 101 is discharged from the air-conditioning compressor 101, transmitted through the four-way valve 102 and the check valve 105c, and conducted to the high-pressure side connecting pipe 106, and, thus, the refrigerant in an overheated gas state flows into the gas-liquid separator 108 of the relay unit E. The air-conditioning refrigerant in an overheated gas state that has flowed into the gas-liquid separator 108 is distributed to circuits in which the valve means 109a of the first distribution portion 109 is open. The air-conditioning refrigerant in an overheated gas state flows into the heating indoor unit C and the hot-water supply heat source circuit D.

[0034] The air-conditioning refrigerant that has flowed into the heating indoor unit C dissipates heat in the indoor heat exchanger 118 (that is, warms the indoor air) and is decompressed by the air-conditioning throttle means 117, thus being merged in the first association portion 115. Also, the air-conditioning refrigerant that has flowed into the hot-water supply heat source circuit D dissipates heat in the refrigerant-refrigerant heat exchanger 41 (that is, gives the heat to the hot-water supply refrigeration cycle 2), and is decompressed by the hot-water supply heat source throttle means 119, thus being merged with the air-conditioning refrigerant discharged from the heating indoor unit C in the first association portion 115. On the other hand, part of the air-conditioning refrigerant in an overheated gas state that has flowed into the gas-liquid separator 108 is subjected to heat exchange by the second relay throttle means 114 in the first internal heat exchanger 111 with the air-conditioning refrigerant that has been expanded to a low temperature and a low pressure, thereby being supercooled to a temperature.

[0035] Then, it merges with the air-conditioning refrigerant that has passed through the first relay throttle means 112 and has been used for air conditioning (air-conditioning refrigerant that has flowed into the heating indoor unit C and the hot-water supply heat source circuit D and has released heat in the indoor heat exchanger 118 and the refrigerant-refrigerant heat exchanger 41) in the first association portion 115. Part of the air-conditioning refrigerant in an overheated gas state passing through the first relay throttle means 112 may be completely lost by fully closing the first relay throttle means 112. Then, in the second internal heat exchanger 113 and second relay throttle means 114 it is subjected to heat exchange with the air-conditioning refrigerant that has been expanded to a low temperature and a low pressure, thereby being supercooled. The air-conditioning refrigerant is distributed into the second association portion 116 side and the second relay throttle means 114 side.

[0036] The air-conditioning refrigerant passing through the second association portion 116 is distributed to circuits in which the valve means 109b is open. The air-conditioning refrigerant passing through the second association portion 116 flows into the cooling indoor unit B, in which it is expanded to a low temperature and a low pressure in the air-conditioning throttle means 117 and evaporated in the indoor heat exchanger 118, and merges in the low-pressure side connecting pipe 107 through the valve means 109b. Also, the air-conditioning refrigerant that has passed through the second relay throttle means 114 is subjected to heat exchange to evaporate in the second internal heat exchanger 113 and the first internal heat exchanger 111, and is merged with the air-conditioning refrigerant discharged from the cooling indoor unit B in the low-pressure side connecting pipe 107. The air-conditioning refrigerant merged in the low-pressure side connecting pipe 107 is conducted to the outdoor heat exchanger 103 through the check valve 105d, and evaporates the remaining liquid refrigerant depending on the operational conditions, thus returning to the air-conditioning compressor 101 through the four-way valve 102 and the accumulator 104.

[Hot-Water Supply Refrigeration Cycle 2]

[0037] The hot-water supply refrigeration cycle 2 has a hot water compressor 21, a heat medium-refrigerant heat exchanger 51, a hot-water supply throttle means 22, and the refrigerant-refrigerant heat exchanger 41. More specifically, the hot-water supply refrigeration cycle 2 is realized with a second refrigerant circuit, wherein the hot-water supply compressor 21, the heat medium-refrigerant heat exchanger 51, the hot-water supply throttle means 22 and the refrigerant-refrigerant heat exchanger 41 are connected in series with a refrigerant pipe 45, by making the hot-water supply refrigerant circulate in the second refrigerant circuit. The behavior of the hot-water supply refrigeration cycle 2 is independent from the operational state of the air-conditioning refrigeration cycle 1, that is, from whether it is in cooling-main operation or in heating-main operation.

[0038] The hot-water supply compressor 21 takes in the air-conditioning refrigerant and compresses the air-conditioning refrigerant to a high-temperature high-pressure state. The hot-water supply compressor 21 may be a type capable of variably controlling the rotational speed with an inverter or a type having a fixed rotational speed. Any type can be used as the hot-water supply compressor 21 without particular limitation, as long as the refrigerant taken in can be compressed to a high pressure state. For example, the hot-water supply compressor 21 may include any type such as a reciprocal, rotary, scroll, or screw type.

[0039] The heat medium-refrigerant heat exchanger 51 exchanges heat between the heat medium (liquid, such as water) circulating in the hot-water supply load 3 and the hot-water supply refrigerant circulating in the hot-

water supply refrigeration cycle 2. That is, the hot-water supply refrigeration cycle 2 and the hot-water supply load 3 are cascade connected with the heat medium-refrigerant heat exchanger 51. The hot-water supply throttle means 22 functions as a pressure reducing valve and an expansion valve to decompress the hot-water supply refrigerant to expand it. The hot-water supply throttle means 22 can be advantageously constituted of a means whose degree of opening can be variably controlled, such as a precise flow rate control means with an electronic expansion valve or an inexpensive refrigerant flow rate control means using a capillary or the like.

[0040] The refrigerant-refrigerant heat exchanger 41 exchanges heat between the hot-water supply refrigerant circulating in the hot-water supply refrigeration cycle 2 and the air-conditioning refrigerant circulating in the air-conditioning refrigeration cycle 1. The type of the refrigerant circulating in the hot-water supply refrigeration cycle 2 is not particularly limited, and, for example, any type can be used, including a natural refrigerant such as carbon dioxide, hydrocarbons, and helium, a chlorine-free alternate refrigerant such as HFC410A, HFC407C and HFC404A, and a fluorocarbon refrigerant used in existing products such as R22 and R134a.

[0041] The operation behavior of the hot-water supply refrigeration cycle 2 will be described.

First, the hot-water supply refrigerant whose temperature and pressure have been increased by the hot-water supply compressor 21 is discharged from the hot-water supply compressor 21 and flows into the heat medium-refrigerant heat exchanger 51. The hot-water supply refrigerant that has flowed into the heat medium-refrigerant heat exchanger 51 heats the water circulating in the hot-water supply load 3, thereby dissipating heat. The hot-water supply refrigerant is expanded by the hot-water supply throttle means 22 to a temperature lower than or equal to the outlet temperature of the refrigerant-refrigerant heat exchanger 41 in the hot-water supply heat source circuit D of the air-conditioning refrigeration cycle 1. The expanded hot-water supply refrigerant is evaporated in the refrigerant-refrigerant heat exchanger 41 by receiving heat from the air-conditioning refrigerant flowing through the hot-water supply heat source circuit D of the air-conditioning refrigeration cycle 1, thus returning to the hot-water supply compressor 21.

[Hot-water Supply Load 3]

[0042] The hot-water supply load 3 has a water circulation pump 31, the heat medium-refrigerant heat exchanger 51 and a hot water storage tank 32. More specifically, the hot-water supply load 3 is realized with a water circuit (heat medium circuit) wherein the water circulation pump 31, the heat medium-refrigerant heat exchanger 51 and the hot water storage tank 32 are connected in series with a storage hot water circulation pipe 203, by making hot-water supply water circulate in the water circuit. The behavior of the hot-water supply load 3 is independent from the operational state of the air-conditioning refrigeration cycle 1, that is, from whether it is in cooling-main operation or in heating-main operation. The storage hot water circulation pipe 203 of the water circuit is a steel pipe, a stainless steel pipe, a vinyl chloride pipe, or the like.

[0043] The water circulation pump 31 takes in water stored in the hot water storage tank 32, compresses the water, and circulates the water in the hot-water supply load 3, and, for example, it can be a type whose rotational speed is controlled by an inverter. The heat medium-refrigerant heat exchanger 51 exchanges heat between the heat medium (liquid, such as water) circulating in the hot-water supply load 3 and the hot-water supply refrigerant circulating in the hot-water supply refrigeration cycle 2, as described above. The hot water storage tank 32 stores water heated in the heat medium-refrigerant heat exchanger51.

[0044] First, relatively low-temperature water stored in the hot water storage tank 32 is drawn from the bottom of the hot water storage tank 32 and compressed by the water circulation pump 31. The water compressed by the water circulation pump 31 flows into the heat medium-refrigerant heat exchanger 51, and receives heat from the hot-water supply refrigerant circulating in the hot-water supply refrigeration cycle 2 in the heat medium-refrigerant heat exchanger 51. The water that has flowed into the heat medium-refrigerant heat exchanger 51 is boiled with the hot-water supply refrigerant circulating in the hot-water supply refrigeration cycle 2 to increase the temperature. The boiled water is returned to the upper portion of the hot water storage tank 32, where the temperature is relatively high, and stored in the hot water storage tank 32.

[0045] Since the air-conditioning refrigeration cycle 1 and the hot-water supply refrigeration cycle 2 have respective refrigerant circuit configurations (first refrigerant circuit configuring the air-conditioning refrigeration cycle 1 and second refrigerant circuit configuring the hot-water supply refrigeration cycle 2), as described above, the refrigerants circulated through the respective refrigerant circuits may be the same kind or different kind. The refrigerants in the respective refrigerant circuits flow so as to be subjected to heat exchange in the refrigerant-refrigerant heat exchanger 41 and the heat medium-refrigerant heat exchanger 51 without being mixed together.

[0046] If a refrigerant having a low critical temperature is used as the hot-water supply refrigerant, it is supposed that the hot-water supply refrigerant in a radiation process of the heat medium-refrigerant heat exchanger 51 comes into a supercritical state for supplying high-temperature hot water. In general, however, if the refrigerant in a radiation process is in a supercritical state, the pressure and outlet temperature of the radiator fluctuate to vary the COP considerably. In order to perform an operation achieving a high COP, more sophisticated control is required. On the other hand, a refrigerant having a low critical temperature generally exhibits a higher saturation

pressure at the same temperature, and accordingly requires that the pipe and compressor used for the refrigerant have large thicknesses. This can be a reason to increase the cost.

[0047] In addition, considering that the recommended temperature of water stored in the hot water storage tank 32 is 60 degree C or more from the viewpoint of preventing the propagation of legionella and other bacteria, it is expected that the target temperature of hot water to be supplied is often set to at least 60 degree C or more. Accordingly, a refrigerant having a critical temperature of at least 60 degree C or more is used as the hot-water supply refrigerant. This is because the use of such a refrigerant as the hot-water supply refrigerant of the hot-water supply refrigeration cycle 2 allows a high COP operation to be stably performed at a lower cost. If the refrigerant is regularly used at temperatures around the critical temperature, the temperature and pressure in the refrigerant circuit is expected to be high. Accordingly, the use of a type of compressor using a high-pressure shell allows the hot-water supply compressor 21 to operate stably.

[0048] Although a case is shown where a surplus refrigerant is stored in a liquid receiver (accumulator 104) in the air-conditioning refrigeration cycle 1, it is not limited thereto, and the accumulator 104 may be omitted if the surplus refrigerant is stored in a heat exchanger acting as a radiator in the refrigeration cycle. In addition, although Fig. 1 shows a case where at least two cooling indoor units B and at least two heating indoor units C are connected, the number of connected units is not particularly limited, and, for example, at least one cooling indoor unit B and no or at least one heating indoor unit C may be connected. The capacity of the indoor units configuring the air-conditioning refrigeration cycle 1 may be the same or may differ from large to small.

[0049] As described above, in the air-conditioning hot-water supply complex system 100 according to the present embodiment, since the hot-water supply load system is defined by a two-stage cycle, it is suggested that the temperature of the radiator of the hot-water supply refrigeration cycle 2 is increased to high level (for example, a condensing temperature of 85 degree C) for providing high-temperature (for example, 80 degree C) hot-water supply. Thus, even if another heating load is used, it is not required that the condensing temperature (for example, 50 degree C) of the heating indoor unit C be increased, and energy can be saved. While, for example, hot-water supply has had to be provided by a boiler or the like when hot-water supply is demanded during an operation for air-conditioning in summer, the system of the embodiment recovers high-temperature heat, which has been discharged to the atmosphere in general, and recycles the heat to supply hot water, thus greatly increasing the system COP and saving energy.

[0050] Fig. 2 is a schematic circuit diagram for describing another embodiment of the hot-water supply load (hereinafter referred to as the hot-water supply load 3a). An exemplary mechanism for heating circulating water in the hot-water supply load 3a will be described with reference to Fig. 2. As shown in Fig. 2, a hot-water supply water circulation cycle (hot-water supply heat medium circulation cycle) 4 is cascade connected between a hot-water supply refrigeration cycle 2 and a hot-water supply load 3a with a heat medium-refrigerant heat exchanger 51 and a water-water heat exchanger (heat medium-heat medium heat exchanger) 201. While Fig. 1 shows a case where water is directly heated to increase the temperature by the heat medium-refrigerant heat exchanger 51 of the hot-water supply load 3 in an open circuit, Fig. 2 shows an example in which a hot-water supply water circulation cycle 4 is provided so that water is indirectly heated by the water-water heat exchanger 201 of the hot-water supply load 3a in an open circuit.

[Hot-water Supply Water Circulation Cycle 4]

[0051] The hot-water supply water circulation cycle 4 is constituted by a heat medium circulation pump 31 a, a heat medium-refrigerant heat exchanger 51, and a water-water heat exchanger 201. That is, the hot-water supply water circulation cycle 4 is realized by a water circuit (heat medium circuit), wherein the heat medium circulation pump 31 a, the heat medium-refrigerant heat exchanger 51 and the water-water heat exchanger 201 are connected in series with a circulating water pipe 202, by making a heat medium for heating (heating water) circulate the water circuit. The circulating water pipe 202 constituting the water circuit is constituted by a copper pipe, a stainless pipe, a steel pipe, a vinyl chloride pipe, or the like.

[0052] The heat medium circulation pump 31 takes in water (haring medium) transmitted through the circulating water pipe 202 and compresses the water to circulate in the hot-water supply circulation cycle 4, and, for example, can be a type whose rotational speed is controlled by an inverter. The heat medium-refrigerant heat exchanger 51 exchanges heat between the water circulating in the hot-water supply circulation cycle 4 and the hot-water supply refrigerant circulating in the hot-water supply refrigeration cycle 2. The water-water heat exchanger 201 exchanges heat between the water circulating in the hot-water supply water circulation cycle 4 and water circulating in the hot-water supply load 3a. While a case where water is circulated in the hot-water supply water circulation cycle 4 will be described as an example, other fluid, such as brine (antifreeze), may be circulated as a heat medium.

[0053] First, relatively low-temperature water stored in the hot water storage tank 32 is drawn from the bottom of the hot water storage tank 32 and compressed by the water circulation pump 31. The water compressed by the water circulation pump 31 flows into the water-water heat exchanger 201, and receives heat from the water circuiting in the hot-water supply water circulation cycle 4 in the water-water heat exchanger 201. The water that

has flowed into the water-water heat exchanger 201 is boiled with the water circulating in the hot-water supply water circulation cycle 4 to increase the temperature. The boiled water is returned to the upper portion of the hot water storage tank 32, where the temperature is relatively high, and stored in the hot water storage tank 32. That is, heat from the hot-water supply refrigeration cycle 2 is transmitted to each of the hot-water supply water circulation cycle 4 in the heat medium-refrigerant heat exchanger 51, and the hot-water supply load 3a in the water-water heat exchanger 201.

[0054] Fig. 3 is a representation of an example of the structure of an outdoor heat exchanger 103. An outdoor heat exchanger 103 capable of air-heating operation throughout the year will be described with reference to Fig. 3. When the air-conditioning hot-water supply complex system 100 is used only for conventional air conditioning, the air-heating operation is generally performed at an outside air wet-bulb temperature of 15 degree C or less, but for hot-water supply operation, it is performed independent of the outside air temperature. Accordingly, Fig. 3 shows a case where the outdoor heat exchanger 103 has a divided structure including a plurality of heat exchangers (hereinafter referred to as divided heat exchangers 103a). The outdoor heat exchanger 103 may be a divided structure in which four heat exchangers are combined, or a divided structure in which a single heat exchanger is divided into four parts.

[0055] As shown in Fig. 3, the high-pressure side connecting pipe 106 is branched into plural to be connected to the respective divided heat exchangers 103a constituting the outdoor heat exchanger 103. The branched high-pressure side connecting pipes 106 are each provided with a solenoid valve 209 that is an on/off valve controlled so as to allow or not allow the refrigerant to be conducted. One of the branched high-pressure side connecting pipes 106 is made to be a bypass circuit 300 detouring around the divided heat exchangers 103a. The bypass circuit 300 is also provided with a solenoid valve 209a being a bypass on/off valve. That is, in the outdoor heat exchanger 103 constituting the air-conditioning refrigeration cycle 1, the amount of the in-flow refrigerant can be adjusted by controlling the open/closed state of the solenoid valves 209 and the solenoid valve 209a, so that the capacity of the heat exchanger can be divided.

[0056] If the outside air wet-bulb temperature is increased, that is, if the intake temperature of the air-conditioning compressor 101 is increasing toward the outside of the operational range (generally, at most 15 degree C), it is preferable that the performance of the outdoor heat exchanger 103 be reduced. In the air-conditioning hot-water supply complex system 100, accordingly, all or some of the solenoid valves 209 are closed so as to interrupt the refrigerant flowing into the outdoor heat exchanger 103, and thus the deviation from the range of the operation temperature of the air-conditioning compressor 101 is prevented. More specifically, the number of divided heat exchangers 103a into which the refrigerant flows is determined according to the operational range of the air-conditioning compressor 101, and thus, the deviation from the operational range of the air-conditioning compressor 101 is prevented by controlling the switching of the solenoid valves 209 corresponding to the number to adjust the amount of the refrigerant flowing into the heat exchangers.

[0057] However, even if the performance of the heat exchanger 103 is reduced by closing the solenoid valve 209, the operational range of the air-conditioning compressor 101 can be deviated in some cases. In this instance, it is preferable that the refrigerant be returned to the air-conditioning compressor 101 without flowing into the outdoor heat exchanger 103. Accordingly, the solenoid valve 209a provided in the bypass circuit 300 is opened so that the refrigerant returns to the intake side of the air-conditioning compressor 101 without flowing into the outdoor heat exchanger 103. Consequently, the evaporating temperature can be prevented from increasing, and the operation can be performed without deviation from the operational temperature of the air-conditioning compressor 101.

[0058] When the flow coefficient of the refrigerant passing through the outdoor heat exchanger 103 is Cva and the flow coefficient of the refrigerant flowing through the bypass circuit 300 is CVb, the solenoid valve 209a provided in the bypass circuit 300 is selected so as to satisfy the relationship Cva < CVb. Furthermore, if the operational range of the air-conditioning compressor 101 cannot be maintained by only dividing the capacity of the heat exchanger, the solenoid valve 209a in the bypass circuit 300 is opened to allow the bypass of the refrigerant for maintaining the operational range. The divided structure may include electronic expansion valves instead of the solenoid valves.

[0059] Fig. 4 is a schematic circuit diagram for describing still another embodiment of a hot-water supply load (hereinafter referred to as the hot-water supply load 3b). Fig. 5 is a schematic circuit diagram showing an example of circulation of the heat medium (liquid used as heat source, such as water) in the hot-water supply load 3b. Fig. 6 is a flow chart showing the switching operation of flow channels for the heat medium in the hot-water supply load 3b. An example of the mechanism for heating the heat medium circulating in the hot-water supply load 3b (that is, heat medium circulating in the water circuit of the hot-water supply load 3b) will be described with reference to Figs. 4 to 6. Fig. 6 shows two flow channels (flow channel A and flow channel B) with it. Flow channel A is a flow channel in which the heat medium is circulated through a bypass pipe 303, and flow channel B is a flow channel in which the heat medium is circulated without passing through a bypass pipe 303.

[Hot-water supply Load 3b]

[0060] As shown in Fig. 4, the hot-water supply load 3b is configured such that a first flow channel switching

device 301 is disposed in the storage hot water circulation pipe 203 between the hot water storage tank 32 and the water circulation pump 31, a second flow channel switching device 302 is disposed in the storage hot water circulation pipe 203 between the heat medium-refrigerant heat exchanger 51 and the hot water storage tank 32, and the first flow channel switching device 301 and the second flow channel switching device 302 are connected by a bypass pipe 303 via an auxiliary tank 305. In other words, a bypass pipe 303 is provided in the water circuit (heat medium circuit) that is connected in series with the storage hot water circulation pipe 203, so that hot-water supply water can be circulated in the bypass pipe 303. In addition, the hot-water supply load 3b is provided with a first temperature sensor 310 and a second temperature sensor 311.

[0061] As with the hot water storage tank 32, the auxiliary tank 305 stores water heated in the heat medium-refrigerant heat exchanger 51. The first flow channel switching device 301 and the second flow channel switching device 302 switch the flow channel of water to either the storage hot water circulation pipe 203 or the bypass pipe 303, and may include, for example, a mixing valve or a three-way valve. The open/closed state of the mixing valve is controlled so that the rate at which a low-temperature heat medium circulating in the water circuit flows and the rate at which a high-temperature heat medium flows can be adjusted. By controlling the open/closed area of the mixing valve (cross section of the flow channel), a predetermined temperature of hot water to be discharged can be maintained. The three-way valve switches the flow of the heat medium to either of the flow channels (flow channel passing through the bypass pipe 303 or flow channel without passing through the bypass pipe 303).

[0062] The first temperature sensor 310 is disposed upstream from the first flow channel switching device 301, that is, at the inlet side of the heat medium-refrigerant heat exchanger 51 so as to detect the inlet temperature of the heat medium circulating in the hot-water supply load 3b, and may be a thermistor or the like. The second temperature sensor 311 is disposed upstream from the second flow channel switching device 302, that is, at the outlet side of the heat medium-refrigerant heat exchanger 51 so as to detect the outlet temperature of the heat medium circulating in the hot-water supply load 3b, and may be a thermistor or the like.

[0063] The water circuit of the hot-water supply load 3b will be described.

In the water circuit of the hot-water supply load 3b, for delivering the heat medium toward the hot-water supply load 3b, the hot-water supply compressor 21 is started to deliver the heat medium, and hot-water supply refrigeration cycle 2 starts the operation. When the hot-water supply refrigeration cycle 2 is started, the heat medium flows through the first flow channel switching device 301 and the second flow channel switching device 302 while the first temperature sensor 310 and the second temperature sensor 311 measure the temperature of the heat medium circulating at the hot-water supply load 3b side, and is subjected to heat exchange in the heat medium-refrigerant heat exchanger 51, followed by being transmitted to the hot-water supply load side (hot water storage tank 32 side).

[0064] In the air-conditioning hot-water supply complex system 100, as shown in Fig. 5, when the hot-water supply compressor 21 is started, the first temperature sensor 310 measures the heat medium temperature, and the first flow channel switching device 301 and the second flow channel switching device 302 switch flow channels of the water; hence, the heat medium can be circulated through the bypass pipe 303. Consequently, first, the temperature of a small volume of heat medium can be increased, and thus the time of low-efficiency operation performed at startup can be reduced. Accordingly, the operational efficiency is increased by making faster the rise from startup of the hot-water supply refrigeration cycle 2. In the air-conditioning hot-water supply complex system 100, even if the load is seriously varied due to an acute change in load, a high-temperature heat medium can be constantly supplied by heating a small volume of heat medium.

[0065] The switching operation of the water circuit of the hot-water supply load 3b will be described.

In the air-conditioning hot-water supply complex system 100, first, on starting the hot-water supply compressor 21, the first temperature sensor 310 and the second temperature sensor 311 measure the temperature of the heat medium (Step S101). Then, the inlet temperature measured by the first temperature sensor 310 is compared with a predetermined reference temperature A degree C (Step S102). If the inlet temperature is higher than A degree C (inlet temperature > A degree C) (Step S102: YES), the water circuit of the hot-water supply load 3b is switched to flow channel B (Step S103). That is, flow channel B not passing through the bypass pipe 303 transmits a high-temperature heat medium for boiling.

[0066] On the other hand, if the inlet temperature is lower than or equal to A degree C (inlet temperature ≤A degree C) (Step S102: NO), the water circuit of the hot-water supply load 3b is switched to flow channel A (Step S104). That is, the heat medium is circulated until the relationship inlet temperature > A degree C is satisfied by boiling a small volume of heat medium in the flow channel A passing through the bypass pipe 303. Although it has been described that the flow channels are switched using the temperature of the heat medium as the determination threshold, the flow channels may be switched according to the pressure of the hot-water supply refrigeration cycle 2 at the refrigerant side as the determination threshold.

[0067] The reference temperature depends on the operational range of the hot-water supply compressor 21 used in the hot-water supply refrigeration cycle 2, and is a temperature equal to or more than the temperature calculated using the minimum pressure in the operational

range, converted in terms of saturation temperature. Although Figs. 4 to 6 show a case where the first flow channel switching device 301 and the second flow channel switching device 302 are each constituted of a single valve, they may be constituted of a plurality of valves. The first flow channel switching device 301 and the second flow channel switching device 302 each may be an electronic expansion valve or a structure using a plurality of solenoid valves.

[0068] Although a structure is shown in which an auxiliary tank 305 is provided in the hot-water supply load 3b, the structure is not limited to this, and only the bypass pipe 303 may be used without providing the auxiliary tank 305. In this instance, it is recommended that the length, the inner diameter and so forth of the bypass pipe 303 be determined, paying attention to the inner capacity of the bypass pipe 303. The capacity of the auxiliary tank 305 is not particularly limited. For example, an auxiliary tank 305 can be used which has such a capacity as can store small volume of heat medium. The volume of the heat medium will be described in detail with reference to Fig. 11.

[0069] Each control of the apparatuses and devices in the air-conditioning hot-water supply complex system 100 according to the embodiment is performed by a controller (not shown) including a microcomputer. This controller can be disposed in any of the heat source apparatus A, the relay unit E, the cooling indoor unit B, the heating indoor unit C and the hot-water supply heat source circuit D. Temperature information measured by the first temperature sensor 310 and the second temperature sensor 311 is transmitted to the controller. It is preferable that a low-pressure detection means measuring the pressure of the refrigerant taken in the air-conditioning compressor 101, such as a pressure sensor, be provided in the intake side pipe connected to the air-conditioning compressor 101 so that pressure information measured by the pressure sensor can also be transmitted to the controller. Also, the number of divided heat exchangers 103a of the outdoor heat exchanger 103, that is, the number of divided portions of the outdoor heat exchanger 103, is not particularly limited.

[0070] Fig. 7 is a graph showing an example of the operational range of the hot-water supply compressor 21. The example of the operational range of the hot-water supply compressor 21 installed in the air-conditioning refrigeration cycle 1 will be described with reference to Fig. 7. In Fig. 7, the horizontal axis represents Ps (suction pressure) of the hot-water supply compressor 21, and the vertical axis represents Pd (discharge pressure) of the hot-water supply compressor 21. The operational range of the hot-water supply compressor 21 shown in Fig. 7 is that of the case where R134a is used as the refrigerant circulating in the hot-water supply refrigeration cycle 2. Also, (1) to (3) shown in the figure represent temperature zones for heating a heat source load.

[0071] (1) represents an operation area of the hot-water supply compressor 21 in the early stage from startup. The operation area of the hot-water supply compressor 21 in this stage is typically 5 degree C to 25 degree C in heat medium temperature when the temperature of the heat medium is in the range of minimum temperature in operation. (2) represents an operation area of the hot-water supply compressor 21 when it completes the early stage from startup and is operated while the highest frequency is controlled so as not to deviate from the operational range of the compressor. The operational area of the hot-water supply compressor 21 in this stage is typically 25 degree C to 45 degree C in heat medium temperature. (3) represents an operation area of the hot-water supply compressor 21 when overheating is performed to a desired temperature area for hot-water supply. The operational area of the hot-water supply compressor 21 in this stage is typically 45 degree C to 90 degree C in heat medium temperature. Fig. 7 shows that R134a can be used for hot-water supply and for heating.

[0072] Fig. 8 is a graph showing another example of the operational range of the hot-water supply compressor 21. Another example of the operational range of the hot-water supply compressor 21 installed in the air-conditioning refrigeration cycle 1 will be described with reference to Fig. 8. In Fig. 8, the horizontal axis represents Ps (suction pressure) of the hot-water supply compressor 21, and the vertical axis represents Pd (discharge pressure) of the hot-water supply compressor 21. The operational range of the hot-water supply compressor 21 shown in Fig. 8 is that of the case where R410A is used as the refrigerant circulating in the hot-water supply refrigeration cycle 2. Also, (1) to (3) shown in the figure represent temperature zones for heating a heat source load.

[0073] (1) represents an operation area of the hot-water supply compressor 21 in the early stage from startup. The operation area of the hot-water supply compressor 21 in this stage is typically 5 degree C to 15 degree C in heat medium temperature when the temperature of the heat medium is in the range of minimum temperature in operation. (2) represents an operation area of the hot-water supply compressor 21 when it completes the early stage from startup and is operated while the highest frequency is controlled so as not to deviate from the operational range of the compressor. The operation area of the hot-water supply compressor 21 in this stage is typically 15 degree C to 45 degree C in heat medium temperature. (3) represents an operation area of the hot-water supply compressor 21 when overheating is performed to a desired temperature area for hot-water supply. The operation area of the hot-water supply compressor 21 in this stage is typically 45 degree C to 68 degree C in heat medium temperature.

[0074] Fig. 8 shows that R410A can be used for hot-water supply and for heating. In addition, if R410A is used for heating (typically 45 degree C), the hot-water supply compressor 21 does not require high-frequency operation in view of the critical temperature 68.3 degree C of the refrigerant, and accordingly, high-efficiency operation can be achieved.

[0075] Figs. 7 and 8 show that R134a and R410A are suitable as the refrigerant circulating in the hot-water supply refrigeration cycle 2. Although Figs. 7 and 8 show operational ranges of the hot-water supply compressor 21 using R134a or R410A, high-efficiency operation can be achieved by using a refrigerant having a critical temperature of 70 degrees or more for hot-water supply, and by using a refrigerant having a critical temperature of 70 degree C or less for heating.

[0076] Fig. 9 is a graph showing the open/closed area ratio of the first flow channel switching device 301. The open/closed area ratio of a first flow channel switching device 301 including a mixing valve will be described with reference to Fig. 9. Although Figs. 4 to 6 show cases where the heat medium (liquid such as water) is boiled by switching flow channels, assuming that the first flow channel switching device 301 is a three-way valve, Fig. 9 will show that the heat medium is boiled by mixing a high-temperature heat medium and a low-temperature heat medium, assuming that the first flow channel switching device 301 is a mixing valve. In Fig. 9, the horizontal axis represents the pulse, and the vertical axis represents the open/closed area ratio. Also, line (A) indicates flow channel A, and line (B) indicates flow channel B.

[0077] A mixing valve is arranged such that generally when a high-temperature heat medium and a low temperature heat medium are mixed, the output at a target temperature can be achieved by varying the area of the opening of the flow channel with. If the mixing valve is used in the first flow channel switching device 301, the first flow channel switching device 301 starts the operation at [START] shown in Fig. 9. As for the behavior of the first flow channel switching device 301, flow channel A is 70 degree C (line (A)) and flow channel B is 10 degree C (line (B)). If the target temperature is set at 40 degree C, a degree of opening (open area) of 0.5 is obtained from the open area ratio, and the target temperature is output.

[0078] By using a mixing valve having characteristics as shown in Fig. 9 as the first flow channel switching device 301, hot water having a predetermined temperature can be constantly output. That is, even if an excessive acute change occurs, the open area ratio can be varied according the excessive change by using a mixing valve as the first flow channel switching device 301. Accordingly, an operation whose efficiency is further increased can be achieved in comparison with the case where a three-way valve switching the flow channels is used in the first flow channel switching device 301. The first flow channel switching device 301 is described here as an example, but it goes without saying that the same applied to the second flow channel switching device 302.

[0079] Fig. 10 is a graph showing a case where the open/closed area ratio of the first flow channel switching device 301 is shifted. A case where the open/closed area ratio of the first flow channel switching device 301 including a mixing valve is shifted will be described with reference to Fig. 10. While Fig. 9 illustrates the open/closed area ratio, which is not shifted, of the first flow channel switching device 301, Fig. 10 illustrates a case where the open/closed area ratio of the first flow channel switching device 301 is shifted. In Fig. 10, the horizontal axis represents the pulse, and the vertical axis represents the open/closed area ratio. Also, line (A) indicates flow channel A, and line (B) indicates flow channel B.

[0080] Supposing that a low-temperature heat medium and a high-temperature heat medium are always delivered to flow channel A and flow channel B, respectively, operation up to a set temperature is few in an application in which the high-temperature heat medium is often used. Accordingly, by shifting the open/closed area ratio of the first flow channel switching device, it becomes possible that the temperature can reach a target value more quickly than the case of the open/closed area ratio shown in Fig. 9. Although the figure shows lines of flow channel A and flow channel B do not have inflection points, a mixing valve having characteristics having an inflection point may be used in the first flow channel switching device 301. The first flow channel switching device 301 is described here as an example, but it goes without saying that the same applied to the second flow channel switching device 302.

[0081] Fig. 11 is a graph showing the relationship between the capacity of the auxiliary tank 305 and the capacity of the heat medium-refrigerant heat exchanger 51. The volume of the heat medium flowing through the bypass pipe 303 will be described with reference to the relationship between the capacity of the auxiliary tank 305 and the capacity of the heat medium-refrigerant heat exchanger 51 shown in Fig. 11. In Fig. 11, the horizontal axis represents the capacity of the auxiliary tank 305, and the vertical axis represents the capacity of the heat medium-refrigerant heat exchanger 51. Also, line (A) indicates a case where the capacity of the auxiliary tank 305 and the capacity of the heat medium-refrigerant heat exchanger 51 are the same, line (B) indicates a case where the capacity of the auxiliary tank 305 is smaller than the capacity of the heat medium-refrigerant heat exchanger 51, and line (C) indicates a case where the capacity of the auxiliary tank 305 is larger than the capacity of the heat medium-refrigerant heat exchanger 51.

[0082] When the capacity of the auxiliary tank 305 and the capacity of the heat medium-refrigerant heat exchanger 51 are the same (line (A)), the operation for boiling is performed with a minimum volume. Since the minimum volume is boiled, it can be boiled in a shortest time with no useless operation. When the capacity of the auxiliary tank 305 is smaller than the capacity of the heat medium-refrigerant heat exchanger 51 (line (B)), the temperature of hot water to be discharged is not sufficient because the volume required for boiling in the early stage is insufficient due to an insufficient volume for minimum requirement. When the capacity of the auxiliary tank 305 is larger than the capacity of the heat medium-refrigerant heat exchanger 51 (line (C)), boiling at the early stage is performed more than required, and consequently it takes

a long time to rise from startup of the unit, and the operation does not save energy.

[0083] As shown in Fig. 11, for selecting the auxiliary tank 305, a tank capacity that can provide the most efficient operation is equal to the amount (volume) of water held in the heat medium-refrigerant heat exchanger 51. Accordingly, it is recommended that the capacity of the auxiliary tank 305 be determined from the capacity of the heat medium-refrigerant heat exchanger 51. Although a case where an auxiliary tank 305 is provided has been described, highly efficient operation can be achieved as well, as long as the heat medium having the same volume as the water held in the heat medium-refrigerant heat exchanger 51 can be transmitted through the bypass pipe 303, even if the auxiliary tank 305 is not provided.

Claims

1. An air-conditioning hot-water supply complex system comprising:

an air-conditioning refrigeration cycle that has a first refrigerant circuit, in which an air-conditioning compressor, a flow channel switching means, an outdoor heat exchanger, an indoor heat exchanger, and air-conditioning throttle means are connected in series, and a refrigerant-refrigerant heat exchanger and hot-water supply heat source throttle means that are connected each other in series are connected to said indoor heat exchanger and said air-conditioning throttle means in parallel, and that makes an air-conditioning refrigerant be circulated in said first refrigerant circuit;
a hot-water supply refrigeration cycle that has a second refrigerant circuit, in which a hot-water supply compressor, a heat medium-refrigerant heat exchanger, hot-water supply throttle means and said refrigerant-refrigerant heat exchanger that are connected in series, and that makes a hot-water supply refrigerant be circulated in said second refrigerant circuit; and
a hot-water supply load that has a water circuit, in which a water circulation pump, said heat medium-refrigerant heat exchanger, and a hot water storage tank are connected in series, and that makes water for hot-water supply be circulated in said water circuit,
wherein said air-conditioning refrigeration cycle and said hot-water supply refrigeration cycle are cascade-connected so as to perform heat exchange between said air-conditioning refrigerant and said hot-water supply refrigerant in said refrigerant-refrigerant heat exchanger,
wherein said hot-water supply refrigeration cycle and said hot-water supply load are cascade-connected so as to perform heat exchange between said hot-water supply refrigerant and said water in said heat medium-refrigerant heat exchanger, and
wherein in said water circuit,
a bypass pipe is provided which connects between said heat medium-refrigerant heat exchanger and said hot water storage tank, and between said hot water storage tank and said water circulation pump.

2. The air-conditioning hot-water supply complex system of claim 1,
wherein the volume of the heat medium circulating in said water circuit in the portion other than said heat medium-refrigerant heat exchanger is substantially equal to the volume of the heat medium circulating in said water circuit in said heat medium-refrigerant heat exchanger.

3. The air-conditioning hot-water supply complex system of claim 1, wherein said bypass pipe is provided with an auxiliary tank, and
the volume of the heat medium stored in said auxiliary tank is substantially equal to the volume of the heat medium circulating in said water circuit in said heat medium-refrigerant heat exchanger.

4. The air-conditioning hot-water supply complex system of any one of claims 1 to 3,
wherein a temperature sensor is provided for measuring a temperature of the heat medium at an inlet of said heat medium-refrigerant heat exchanger, and flow channels of the heat medium in said water circuit are switched according to temperature information measured by said temperature sensor.

5. The air-conditioning hot-water supply complex system of claim 4,
wherein when the inlet temperature of said heat medium-refrigerant heat exchanger is lower than or equal to a predetermined temperature,
the flow channels are switched so as to circulate the heat medium through said bypass pipe.

6. The air-conditioning hot-water supply complex system of claim 4 or 5,
wherein a flow channel switching device is provided at both ends of said bypass pipe, and
the flow channels of the heat medium in said water circuit are switched by controlling said flow channel switching device.

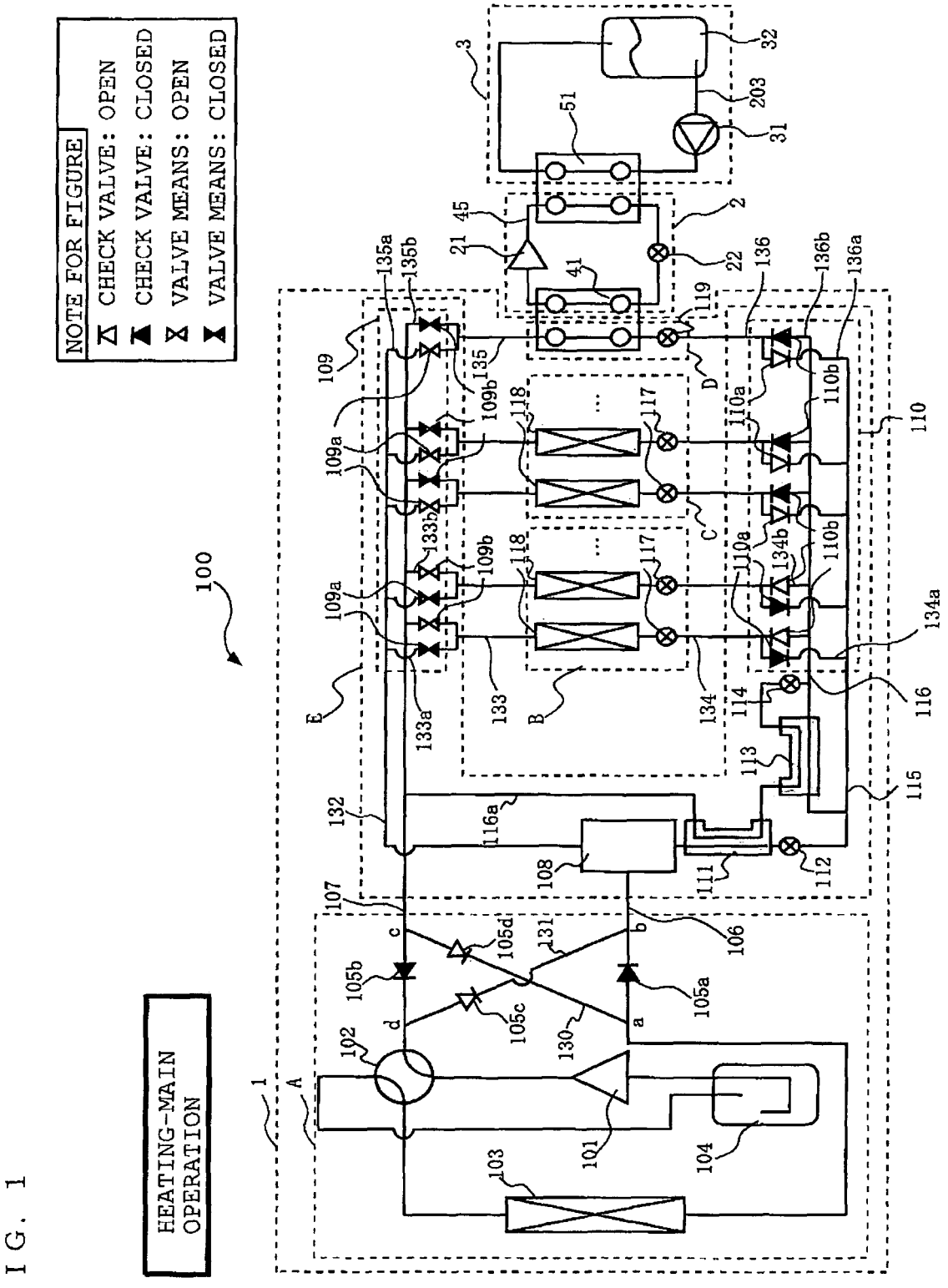
7. The air-conditioning hot-water supply complex system of claim 6,
wherein said flow channel switching device is constituted by a three-way valve switching flow path of the heat medium in said water circuit to any one of flow channels or a mixing valve capable of adjusting

the mixing ratio of a low-temperature heat medium and a high-temperature heat medium in said water circuit.

8. The air-conditioning hot-water supply complex system of claim 7,
wherein when said flow channel switching device is constituted by said mixing valve,
mixing ratio of the low-temperature heat medium and the high-temperature heat medium is determined so as to maintain a discharge temperature of hot water at a predetermined temperature by adjusting open/closed area ratio of said flow channel switching device.

9. The air-conditioning hot-water supply complex system of any one of claims 1 to 8,
wherein a refrigerant having a critical temperature of 60 degree C or more is employed as said hot-water supply refrigerant.

FIG. 1


NOTE FOR FIGURE
CHECK VALVE: OPEN
CHECK VALVE: CLOSED
VALVE MEANS: OPEN
VALVE MEANS: CLOSED
HEATING-MAIN OPERATION
100
1
A
101
102
103
104
105a
105b
105c
105d
106
107
108
109
109a
109b
110
110a
110b
111
112
113
114
115
116
116a
117
118
119
130
131
132
133
133a
134
134a
134b
135
135a
135b
136
136a
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22
3
31
32
41
45
51
203
B
C
D
E
a
b
c
d

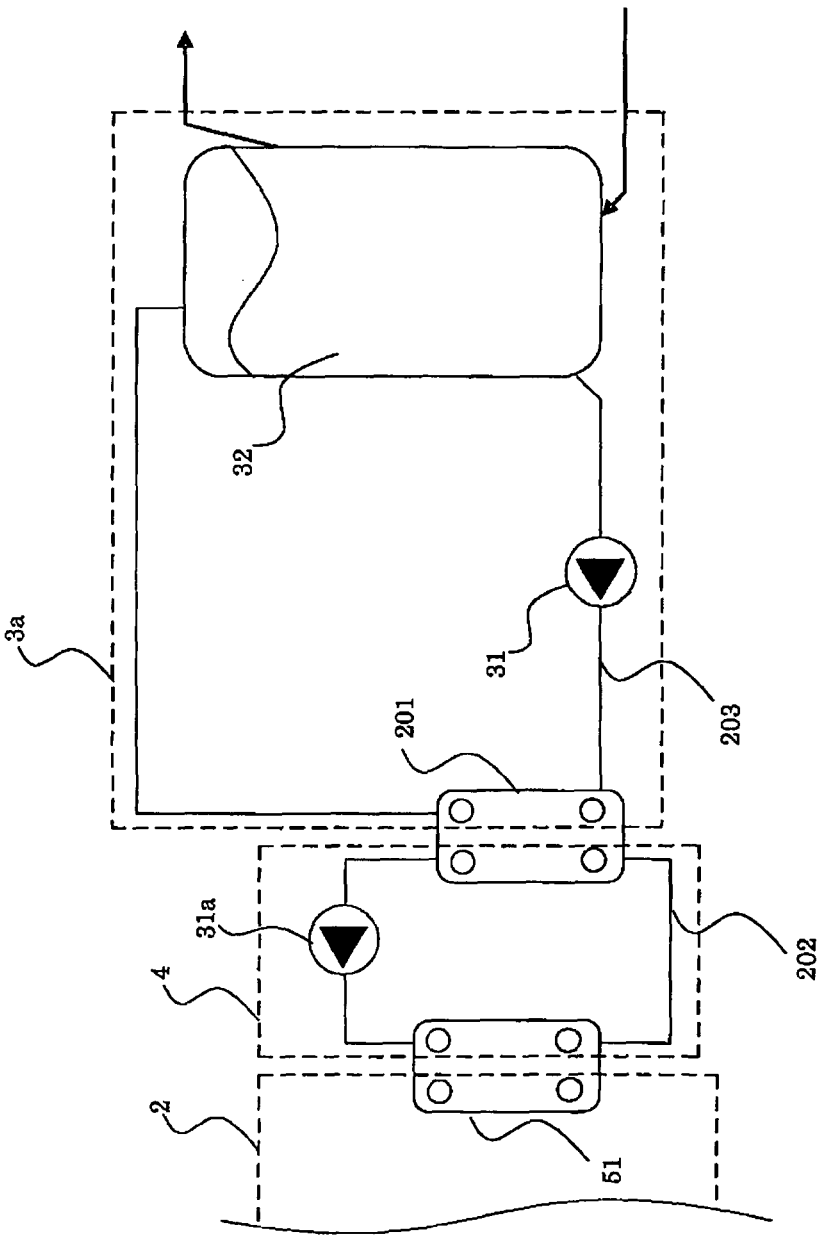


FIG. 2

FIG. 3

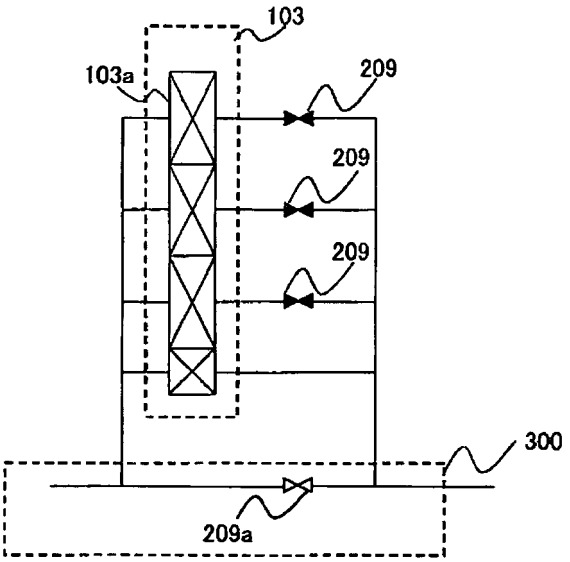


FIG. 4

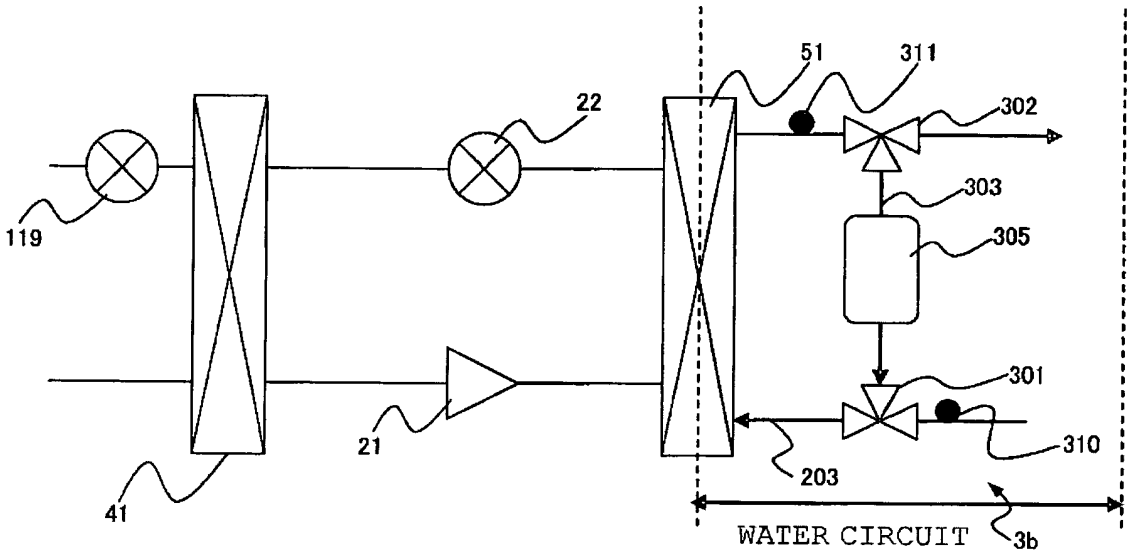

51
311
22
302
303
305
119
301
310
21
203
41
WATER CIRCUIT
3b

FIG. 5

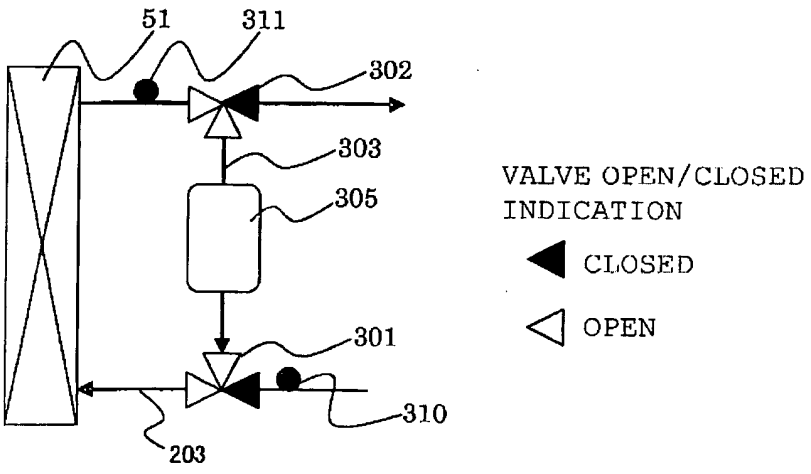
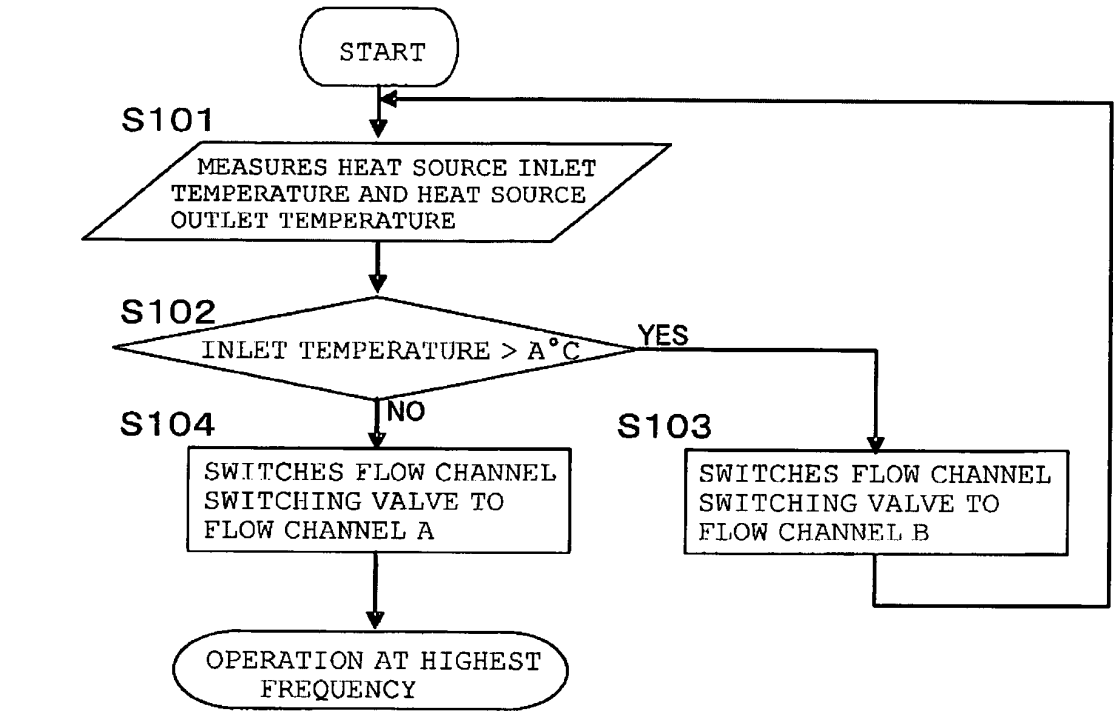
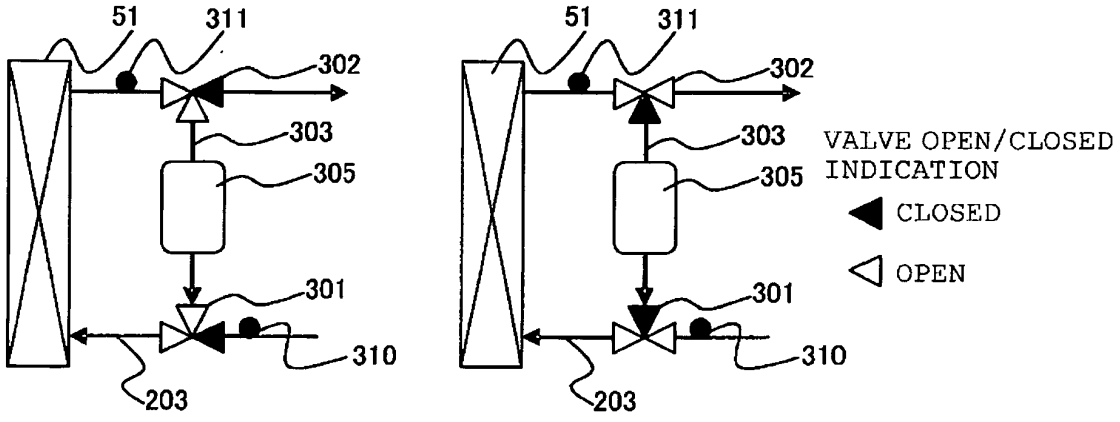

51
311
302
303
305
301
310
203
VALVE OPEN/CLOSED INDICATION
CLOSED
OPEN

FIG. 6





FLOW CHANNEL A FLOW CHANNEL B

FIG. 7

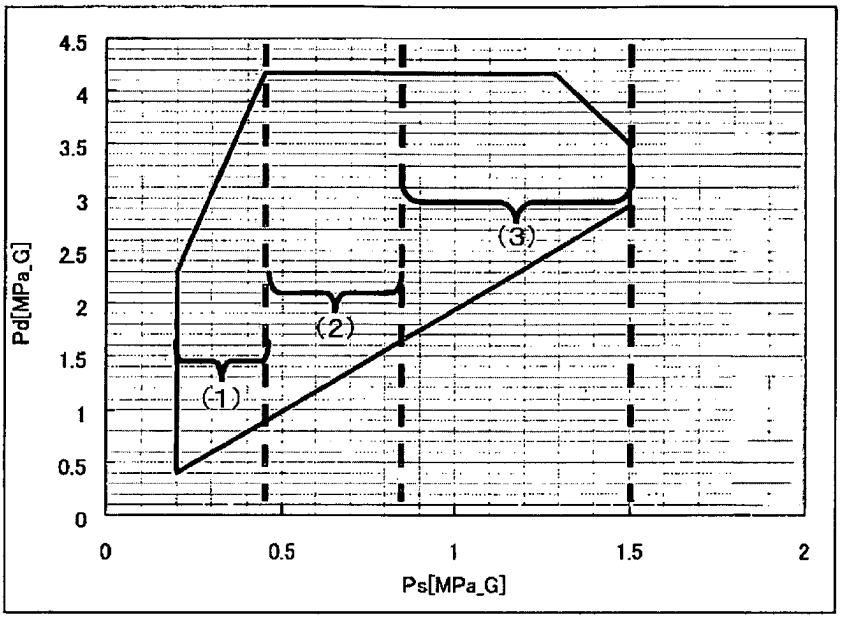

4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Pd[MPa_G]
0
0.5
1
1.5
2
Ps[MPa_G]
(1)
(2)
(3)

FIG. 8

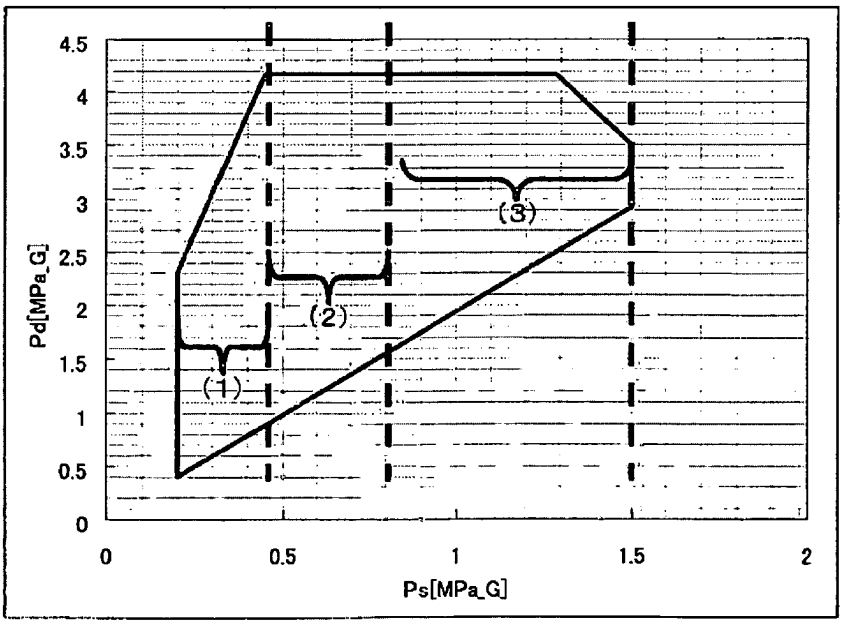

4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Pd[MPa_G]
0
0.5
1
1.5
2
Ps[MPa_G]
(1)
(2)
(3)

FIG. 9

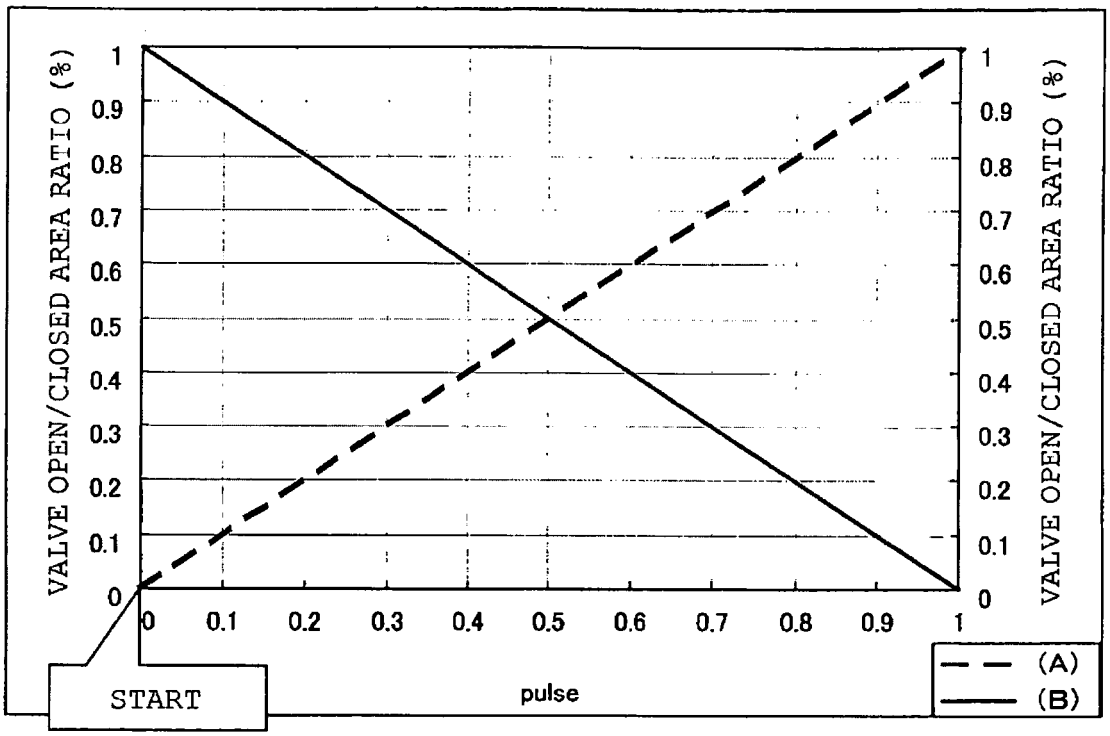

VALVE OPEN/CLOSED AREA RATIO (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
START
pulse
(A)
(B)

FIG. 10

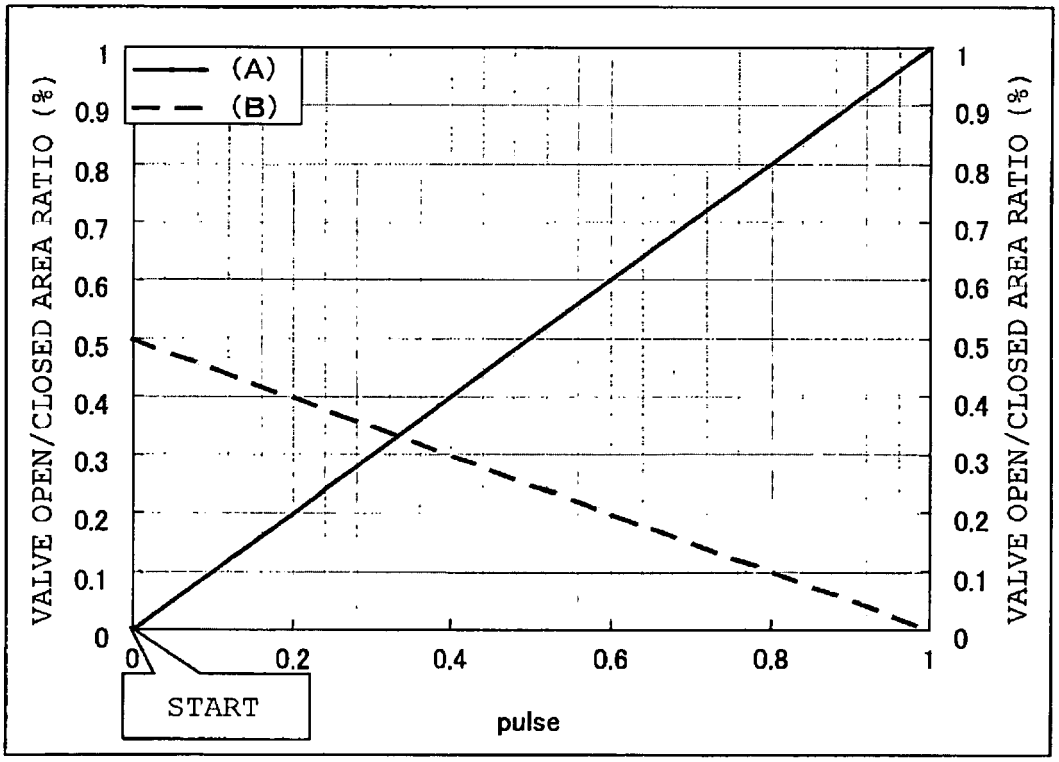
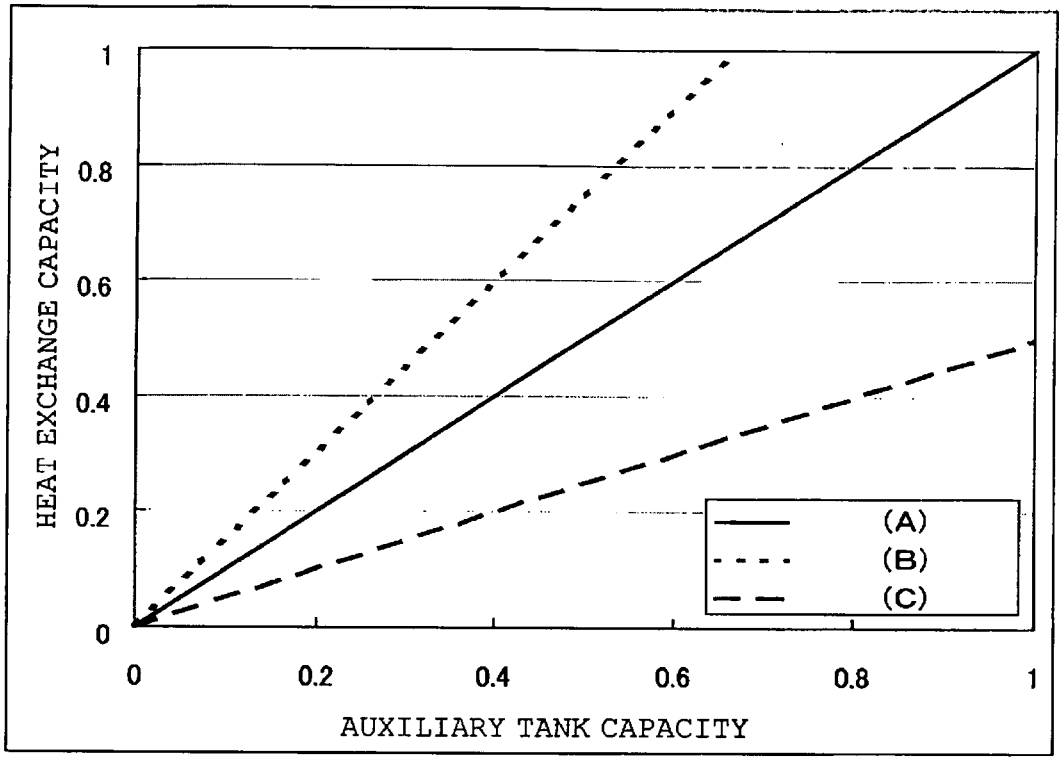

VALVE OPEN/CLOSED AREA RATIO (%)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1
START
pulse
(A)
(B)

FIG. 11


HEAT EXCHANGE CAPACITY
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
AUXILIARY TANK CAPACITY
(A)
(B)
(C)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/050407

A. CLASSIFICATION OF SUBJECT MATTER
F25B29/00(2006.01)i, *F24H1/00*(2006.01)i, *F25B7/00*(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, F24H1/00, F25B7/00

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 1996-2009
Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2008/117408 A1 (Mitsubishi Electric Corp.), 02 October, 2008 (02.10.08), Par. Nos. [0001] to [0095]; Claims; Figs. 1 to 5 (Family: none)	1-9
Y	JP 60-248945 A (Osaka Gas Co., Ltd.), 09 December, 1985 (09.12.85), Claims; page 2, upper left column, line 1 to page 4, upper left column, line 14 (Family: none)	1-9
Y	JP 2003-139392 A (Denso Corp.), 14 May, 2003 (14.05.03), Claims; Par. Nos. [0001] to [0053]; Figs. 1 to 6 (Family: none)	1-9

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

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Date of the actual completion of the international search	Date of mailing of the international search report
05 February, 2009 (05.02.09)	17 February, 2009 (17.02.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/050407

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-270920 A (Mitsubishi Electric Corp.), 05 October, 1999 (05.10.99), Full text; all drawings (Family: none)	1-9
A	JP 4-263758 A (The Kansai Electric Power Co., Inc.), 18 September, 1992 (18.09.92), Full text; all drawings (Family: none)	1-9

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Patent documents cited in the description

- JP 11270920 A **[0004]**
- JP 4263758 A **[0004]**