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(71) Applicant: **Mitsubishi Electric Corporation**
Tokyo 100-8310 (JP)

(72) Inventor: **SHINOZAKI, Kazuyoshi**
Tokyo 100-8310 (JP)

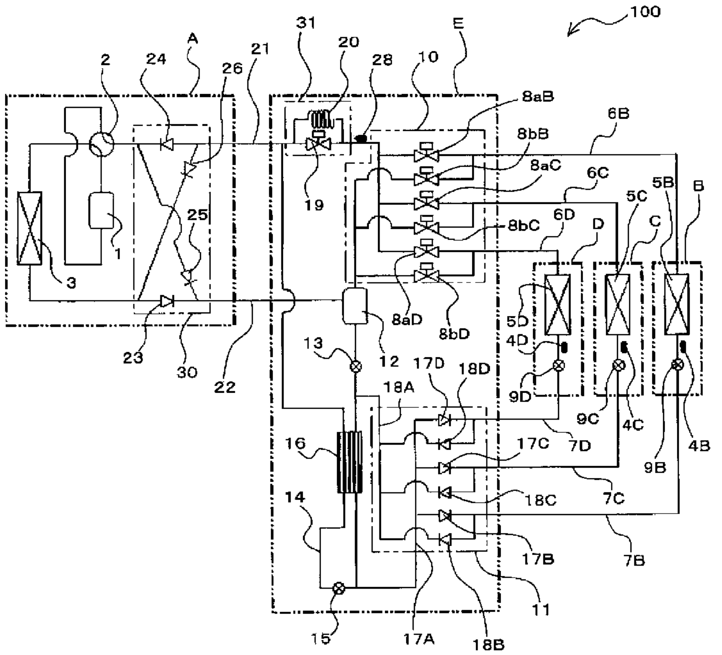
(74) Representative: **Pfenning, Meinig & Partner GbR**
Theresienhöhe 13
80339 München (DE)

(54) **AIR CONDITIONER**

(57) To provide an air-conditioning apparatus that can prevent the formation of frost on indoor-side heat exchangers functioning as an evaporator even when the outside air temperature is low, and can use unmodified normal indoor units even when a portion of the indoor units is used in a place that has a large sensible heat load.

An air-conditioning apparatus 100 capable of simultaneous heating and cooling operation includes a heat source unit A, a plurality of indoor units B, C, and D, and a relay unit E that connects the heat source unit A to the indoor units B, C, and D. A flow control unit 31 that controls a flow amount of a refrigerant that flows through the indoor units that are in cooling operation is provided to a piping (a first connecting piping 21) on the downstream side of a merging section (a first branching unit 10) of a piping through which flows the refrigerant that flows out from the indoor units that are in cooling operation.

FIG. 1



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Description

Technical Field

[0001] The present invention is related to an air-conditioning apparatus, and, in particular, a multi-room heat pump air-conditioning apparatus that is capable of selectively heating and cooling each indoor unit and simultaneously operating indoor units performing cooling and indoor units performing heating, the multi-room heat pump air-conditioning apparatus connecting to a plurality of indoor units.

Background Art

[0002] As a conventional air-conditioning apparatus capable of selectively heating and cooling each indoor unit and simultaneously operating indoor units performing cooling and indoor units performing heating (hereinafter referred to as an air-conditioning apparatus capable of simultaneous cooling and heating operation), for example, the following has been proposed (for example, refer to Patent Literature 1): "an air-conditioning apparatus capable of simultaneous heating and cooling operation, wherein one heat source unit consisting of a compressor, a four-way switching valve, a heat source unit-side heat exchanger, an accumulator, and the like is connected via first and second connecting pipings to a plurality of indoor units each consisting of an indoor-side heat exchanger, a first flow control device, and the like; a first branching unit that switchably connects one end of the indoor-side heat exchangers of the plurality of indoor units to the first connecting piping or the second connecting piping is connected via a second flow control device to a second branching unit which is connected to the other end of the indoor-side heat exchangers of the plurality of indoor units via the first flow control device and is connected to the second connecting piping via the second flow control device; the second branching unit and the first connecting piping are connected via a third flow control device; a relay unit containing the first branching unit, the second flow control device, the third flow control device, and the second branching unit is interposed between the heat source unit and the plurality of indoor units; the first connecting piping is constituted to have a larger diameter than the second connecting piping; a switching valve is provided between the first and second connecting pipings of the heat source unit; and the first connecting piping is switchable to a low pressure side of the heat source unit and the second connecting piping is switchable to a high pressure side of the heat source unit during both cases of operation in which the heat source unit-side heat exchanger is a condenser and operation in which the heat source unit-side heat exchanger is an evaporator".

Citation List

Patent Literature

[0003]

Patent Literature 1 : Japanese Unexamined Patent Application, First Publication No. 4-335967 (Paragraph [0006] and Fig. 1)

Summary of Invention

Technical Problem

[0004] However, the conventional air-conditioning apparatus capable of simultaneous cooling and heating operation has the following problems.

[0005] For example, during simultaneous cooling and heating operation, when the heating load is larger than the cooling load, the heat source unit (outdoor) side heat exchanger functions as an evaporator. In this case, the heat exchangers of the indoor units (indoor-side heat exchangers) which are cooling also function as an evaporator. Accordingly, the heat source unit-side heat exchanger and the indoor-side heat exchangers functioning as an evaporator are serially connected. At this time, if the temperature of air sucked in by the heat source unit-side heat exchanger (that is, the outside air temperature) is low, the evaporation temperature of the indoor-side heat exchangers functioning as an evaporator will drop as the evaporation temperature of the heat source unit-side heat exchanger drops. Therefore, there has been a problem in that frost forms on the indoor-side heat exchangers functioning as an evaporator leading to a drop in cooling capacity. Further, there has been another problem in that in order to remove the frost, the indoor units performing cooling operation repeatedly starts and stop cooling, and thus making it difficult to maintain a continuous and stable operation state.

Furthermore, in some conventional air-conditioning apparatuses, in order to prevent drop of the evaporation temperature of the indoor-side heat exchangers functioning as an evaporator, an expansion device has been provided on an outlet-side piping of the indoor-side heat exchangers (more specifically, in each piping that is on the refrigerant outlet side when functioning as an evaporator). In such a conventional air-conditioning apparatus, the pressure loss on the evaporator outlet side is increased by adjusting the expansion device in order to prevent drop of the evaporation temperature of the indoor-side heat exchangers functioning as an evaporator. However, in this kind of conventional air-conditioning apparatus, an expansion device is provided for each indoor-side heat exchanger, and thus the throttling of each expansion device varies. Therefore, the throttle control of the flow control device provided on the inlet-side piping (more specifically, in the piping that is on the refrigerant inlet side when functioning as an evaporator) of each indoor-side heat exchanger changes. Accordingly, there has been a problem in that the operation of the air-conditioning apparatus becomes unstable.

[0006] In a case in which a portion of the indoor units are used for the cooling operation of a place that has a large sensible heat load such as a computer room provided in a building or the like, or in other words, in a place in which the sensible heat ratio among the cooling load (the ratio of the sensible heat load relative to the cooling load) is large, there has been a problem in that the other indoor units used in a place that has a normal cooling operation load cannot obtain the necessary sensible heat capacity. Since the sensible heat load is large and the latent heat load (load when the sensible heat load is removed from the cooling load) is small, there has been a problem in terms of the balance of the refrigeration cycle in that the evaporation temperature of the indoor-side heat exchangers drops leading to the indoor-side heat exchangers to freeze in which water leaks are caused. In order to obtain the necessary sensible heat capacity, it is necessary to use a specialized indoor unit that has large sensible heat ratios. However, when the sensible heat load on the indoor side changes such as when computers are increased, it is necessary to exchange the indoor units with ones tailored to the sensible heat load in each case, and, thus, leading to excessive cost.

[0007] In consideration of the above problems, an objective of the present invention is to provide an air-conditioning apparatus that can, even when the outside air temperature is low, prevent the formation of frost on the indoor-side heat exchangers functioning as an evaporator and operate continuously and stably, and can inexpensively obtain the necessary sensible heat capacity using unmodified normal indoor units even when a portion of the indoor units is used in a place that has a large sensible heat load such as a computer room.

Solution to Problem

[0008] The air-conditioning apparatus of the present invention is an air-conditioning apparatus that includes a heat source unit having a compressor, a four-way switching valve, and a heat source unit-side heat exchanger that is connected to the four-way switching valve; a plurality of indoor units each having an indoor-side heat exchanger and a first flow control device connected to one end of the indoor-side heat exchanger; and a relay unit that connects the heat source unit to the indoor units, and that is capable of simultaneous heating and cooling operation in which each of the indoor units selectively performing a cooling operation or a heating operation. The relay unit is connected to the heat source unit by a first connecting piping through which a refrigerant that flows out to the heat source unit flows and a second connecting piping through which the refrigerant that flows in from the heat source unit flows. The relay unit comprises a first branching unit that switchably connects the other end of each of the indoor-side heat exchangers to the first connecting piping or the second connecting piping, a second branching unit that switchably connects each first flow control device to the first connecting piping or the second connecting piping, and a flow control unit provided to the first connecting piping that controls a flow amount of the refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator.

Advantageous Effects of Invention

[0009] According to the present invention, the flow amount of a refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator (heat exchangers of the indoor units that are performing a cooling operation) is controlled by the flow control unit. Therefore, the evaporation temperature of the indoor-side heat exchangers functioning as an evaporator can be raised, and thus the sensible heat capacity of the indoor-side heat exchangers functioning as an evaporator can be improved.

Therefore, the air-conditioning apparatus of the present invention can, even when the outside air temperature is low, prevent the formation of frost on the indoor-side heat exchangers functioning as an evaporator and operate continuously and stably, and can inexpensively obtain the necessary sensible heat capacity using unmodified normal indoor units even when a portion of the indoor units is used in a place that has a large sensible heat load such as a computer room.

Brief Description of Drawings

[0010]

[Fig. 1] Fig. 1 is a diagram of a refrigerant circuit showing the air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a diagram of the operation state during a cooling only operation and a heating only operation in the air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is a diagram of the operation state during a heating main operation in the air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 4] Fig. 4 is a diagram of the operation state during a cooling main operation in the air-conditioning apparatus according to Embodiment 1 of the present invention.

[Fig. 5] Fig. 5 is a diagram of a refrigerant circuit showing an air-conditioning apparatus according to Embodiment 2 of the present invention. Description of Embodiments

Embodiment 1

[0011] Fig. 1 is a diagram of a refrigerant circuit showing an air-conditioning apparatus according to Embodiment 1 of the present invention. Fig. 1 explains a case in which three indoor units and one relay unit are connected to one heat source unit. However, the same effects can also be obtained when two or more heat source units, two or more indoor units, and two or more relay units are connected.

[0012] The air-conditioning apparatus 100 according to Embodiment 1 is an air-conditioning apparatus capable of a simultaneous heating and cooling operation in which a cooling operation can be selected in one or some indoor units while a heating operation can be selected in the remaining one or some indoor units. The air-conditioning apparatus 100 includes a heat source unit A, a relay unit E, and indoor units B, C, and D that are connected in parallel to each other.

(Heat Source Unit A)

[0013] The heat source unit A includes a compressor 1, a four-way switching valve 2, a heat source unit-side heat exchanger 3, a flow switching device 30, and the like.

[0014] The discharge side of the compressor 1 is connected to a connection port of the four-way switching valve 2. The suction side of the compressor 1, one end of the heat source unit-side heat exchanger 3, and the flow switching device 30 are connected to the remaining connection ports of the four-way switching valve 2. In other words, the four-way switching valve 2 switches the passage of a refrigerant discharged from the compressor 1 to a passage flowing to the heat source unit-side heat exchanger 3 or a passage flowing to the flow switching device 30. The other end of the heat source unit-side heat exchanger 3 is connected to the flow switching device 30.

[0015] The flow switching device 30 includes four check valves (check valve 23 to check valve 26), and the four-way switching valve 2, the heat source unit-side heat exchanger 3, one end of a first connecting piping 21, and one end of a second connecting piping 22 are connected thereto.

The check valve 23 is provided between the heat source unit-side heat exchanger 3 and the second connecting piping 22, and permits the flow of the refrigerant only from the heat source unit-side heat exchanger 3 to the second connecting piping 22. The check valve 24 is provided between the four-way switching valve 2 and the first connecting piping 21, and permits the flow of the refrigerant only from the first connecting piping 21 to the four-way switching valve 2. The check valve 25 is provided between the four-way switching valve 2 and the second connecting piping 22, and permits the flow of the refrigerant only from the four-way switching valve 2 to the second connecting piping 22. The check valve 26 is provided between the heat source unit-side heat exchanger 3 and the first connecting piping 21, and permits the flow of the refrigerant only from the first connecting piping 21 to the heat source unit-side heat exchanger 3.

The other end of the second connecting piping 22 branches and is connected to a first branching unit 10 and a second branching unit 11 of the relay unit E explained below. The other end of the first connecting piping 21 is connected to the first branching unit 10 of the relay unit E explained below.

[0016] By providing the flow switching device 30, the refrigerant discharged from the compressor 1 always flows into the relay unit E through the second connecting piping 22, and the refrigerant that flows out from the relay unit E always passes through the first connecting piping 21. Therefore, it is possible to make the pipe diameter of the second connecting piping 22 narrower than the pipe diameter of the first connecting piping 21.

(Indoor Units B, C, and D)

[0017] Each of the indoor units B, C, and D has the same constitution.

[0018] In more detail, the indoor unit B includes an indoor-side heat exchanger 5B. One end of the indoor-side heat exchanger 5B is connected to a second branching unit 11 of the relay unit E explained below via a second indoor unit-side connecting piping 7B. A flow control device 9B is provided to the second indoor unit-side connecting piping 7B. A temperature sensor 4B for detecting the temperature of the refrigerant flowing through the piping (or the piping temperature) is provided between the flow control device 9B and the indoor-side heat exchanger 5B. The other end of the indoor-side heat exchanger 5B is connected to the first branching unit 10 of the relay unit E explained below via a first indoor unit-side connecting piping 6B.

[0019] The indoor unit C includes an indoor-side heat exchanger 5C. One end of the indoor-side heat exchanger 5C is connected to the second branching unit 11 of the relay unit E explained below via a second indoor unit-side connecting piping 7C. A flow control device 9C is provided to the second indoor unit-side connecting piping 7C. A temperature sensor 4C for detecting the temperature of the refrigerant flowing through the piping (or the piping temperature) is provided between the flow control device 9C and the indoor-side heat exchanger 5C. The other end of the indoor-side heat exchanger 5C is connected to the first branching unit 10 of the relay unit E explained below via a first indoor unit-side connecting piping 6C.

[0020] The indoor unit D includes an indoor-side heat exchanger 5D. One end of the indoor-side heat exchanger 5D is connected to the second branching unit 11 of the relay unit E explained below via a second indoor unit-side connecting piping 7D. A flow control device 9D is provided to the second indoor unit-side connecting piping 7D. A temperature sensor 4D for detecting the temperature of the refrigerant flowing through the piping (or the piping temperature) is provided between the flow control device 9D and the indoor-side heat exchanger 5D. The other end of the indoor-side heat exchanger 5D is connected to the first branching unit 10 of the relay unit E explained below via a first indoor unit-side connecting piping 6D.

[0021] The flow control devices 9 (9B to 9D) correspond to the first flow control devices in the present invention.

The opening degree of the flow control devices 9 (9B to 9D) is controlled as follows. If the corresponding indoor units (B to D) are in cooling operation, the opening degree of the flow control devices 9 (9B to 9D) is controlled based on the degree of superheat at the outlet side of the indoor-side heat exchangers 5 (5B to 5D). If the corresponding indoor units (B to D) are in heating operation, the opening degree of the flow control devices 9 (9B to 9D) is controlled based on the degree of supercooling at the outlet side of the indoor-side heat exchangers 5 (5B to 5D).

Below, if it is unnecessary to differentiate each indoor unit during the explanation, the reference symbols B to D may be omitted in the explanation.

(Relay Unit E)

[0022] The relay unit E includes the first branching unit 10, the second branching unit 11, a gas-liquid separating device 12, a flow control device 13, a flow control device 15, a heat exchange portion 16, a flow control unit 31, and the like.

[0023] The first branching unit 10 includes a number of valve devices 8a and 8b in accordance with the number of indoor units. Embodiment 1 includes 3 sets of valve devices 8a and 8b (valve devices 8aB and 8bB, valve devices 8aC and 8bC, and valve devices 8aD and 8bD).

[0024] In more detail, the ends at one side of the valve devices 8aB and 8bB are connected to the indoor-side heat exchanger 5B via the first indoor unit-side connecting piping 6B. The other end of the valve device 8aB is connected to the first connecting piping 21, and the other end of the valve device 8bB is connected to the second connecting piping 22.

The ends at one side of the valve devices 8aC and 8bC are connected to the indoor-side heat exchanger 5C via the first indoor unit-side connecting piping 6C. The other end of the valve device 8aC is connected to the first connecting piping 21, and the other end of the valve device 8bC is connected to the second connecting piping 22.

The ends at one side of the valve devices 8aD and 8bD are connected to the indoor-side heat exchanger 5D via the first indoor unit-side connecting piping 6D. The other end of the valve device 8aD is connected to the first connecting piping 21, and the other end of the valve device 8bD is connected to the second connecting piping 22.

[0025] Basically, the first branching unit 10 switches the passage to which the indoor-side heat exchangers 5 (5B to 5D) are connected to between the first connecting piping 21 and the second connecting piping 22 by controlling the opening/closing of the valve devices 8a and the valve devices 8b.

[0026] The second branching unit 11 includes check valves 17 and 18, which are in an anti-parallel relationship with each other, according to the number of indoor units. Each check valve 17 permits the refrigerant to flow only in the direction into the indoor units. Each check valve 18 permits the refrigerant to flow only in the direction out from the indoor units. In Embodiment 1, the second branching unit 11 includes three sets of check valves 17 and 18 (check valves 17B and 18B, check valves 17C and 18C, and check valves 17D and 18D).

[0027] In more detail, the ends at one side of the check valves 17B and 18B are connected to the indoor-side heat exchanger 5B via the second indoor unit-side connecting piping 7B. The other end of the check valve 17B is connected to a first junction 17A, and the other end of the check valve 18B is connected to a second junction 18A.

The ends at one side of the check valves 17C and 18C are connected to the indoor-side heat exchanger 5C via the second indoor unit-side connecting piping 7C. The other end of the check valve 17C is connected to the first junction 17A, and the other end of the check valve 18C is connected to the second junction 18A.

The ends at one side of the check valves 17D and 18D are connected to the indoor-side heat exchanger 5D via the second indoor unit-side connecting piping 7D. The other end of the check valve 17D is connected to the first junction 17A, and the other end of the check valve 18D is connected to the second junction 18A.

[0028] The first junction 17A is also connected to an end of the second connecting piping 22. The second junction 18A is also connected to the middle of the second connecting piping 22 (the second connecting piping 22 between the flow control device 13 and the heat exchange portion 16 to be explained later).

[0029] As explained above, the second connecting piping 22 branches and is connected to the first branching unit 10 and the second branching unit 11. The gas-liquid separating device 12 is provided to this branching portion. In the second connecting piping 22 between the gas-liquid separating device 12 and the second branching unit 11, the flow control device 13 and the heat exchange portion 16 are provided from the upstream side of the refrigerant flow.

[0030] One end of a bypass piping 14 is connected to the second connecting piping 22 between the heat exchange portion 16 and the second branching unit 11. The other end of the bypass piping 14 is connected to the first connecting piping 21. The heat exchange portion 16 described above is provided in the bypass piping 14. In other words, in the heat exchange portion 16, heat is exchanged between the refrigerant that flows through the second connecting piping 22 and the refrigerant that flows through the bypass piping 14. The flow control device 15 is also provided in the bypass piping 14 on the refrigerant flow upstream side of the heat exchange portion 16.

When the refrigerant that has flowed out from the second branching unit 11 flows into the first connecting piping

21, it flows through the bypass piping 14. In this case, the bypass piping 14 constitutes a portion of the first connecting piping 21.

[0031] I n the relay unit E of Embodiment 1, a flow control unit 31 is provided to the first connecting piping 21 between the first branching unit 10 and the heat source unitA.

The flow control unit 31 includes a valve device 19 capable of opening/closing and a capillary tube 20 that is connected in parallel to the valve device 19.

The flow control unit 31 controls the flow amount of the refrigerant flowing through the first connecting piping 21 by opening/closing the valve device 19. Thereby, the flow amount of the refrigerant flowing through the indoor-side heat exchangers 5 functioning as an evaporator (the indoor-side heat exchangers 5 discharging the refrigerant to the first branching unit 10) is controlled.

A temperature sensor 28 for detecting the temperature of the refrigerant flowing through the piping (or the piping temperature) is provided in the first connecting piping between the flow control unit 31 and the first branching unit 10.

[0032] It is also conceivable to provide a flow control unit 31 to each of the first indoor unit-side connecting pipings 6B to 6D, which are pipings before the refrigerant merges into the first connecting piping 21. However, with this kind of refrigerant circuit, control of each of the flow control units 31 becomes necessary, and thus the control becomes complex. In addition, the piping constitution becomes complex. Thus, in Embodiment 1, the flow control unit 31 is provided to the first connecting piping 21, which is the piping after the refrigerant flowing through each of the first indoor unit-side connecting pipings 6B to 6D has merged (more specifically, to the first connecting piping 21, which is on the refrigerant flow upstream side from the merging section of the first connecting piping 21 and the bypass piping 14). The temperature sensor 28 is provided on the refrigerant flow upstream side of the flow control unit 31.

[0033] Basically, if a flow control unit 31 and a temperature sensor 28 were provided to each of the first indoor unit-side connecting pipings 6B to 6D, which are pipings before the refrigerant merges, then it would be necessary to provide a number of flow control units 31 and temperature sensors 28 matching the number of indoor-side heat exchangers. In other words, the number of actuators to be controlled (valve devices 19) would be the same as the number of indoor-side heat exchangers, and the number of detected temperatures to be used for control (temperatures detected by the temperature sensors 28) would be the same as the number of indoor-side heat exchangers. Therefore, the control would become complicated. Further, if each of the flow control units 31 (more specifically, the valve devices 19) is made to perform a throttle operation, the throttle control of each flow control devices 9B to 9D would change in accordance with the change in the flow amount of the refrigerant in each of the indoor-side heat exchangers owing to each throttle operation. Therefore, the operation of the air-conditioning apparatus would become unstable.

However, in Embodiment 1, the flow control unit 31 is provided to the first connecting piping 21 (more specifically, to the first connecting piping 21, which is on the refrigerant flow upstream side of the merging section of the first connecting piping 21 and the bypass piping 14), and a temperature sensor 28 is provided on the refrigerant flow upstream side of the flow control unit 31. Therefore, the flow amount of the refrigerant flowing through the indoor-side heat exchangers 5 functioning as an evaporator can be controlled by controlling one actuator (the valve device 19) in accordance with a specific detected temperature (temperature detected by one temperature sensor 28). Thus, the air-conditioning apparatus 100 can operate stably.

Thereby, the air-conditioning apparatus 100 can operate stably, the control can be simplified, and the piping constitution can also be simplified.

<Description of Operation>

[0034] Next, the operation of the air-conditioning apparatus 100 according to Embodiment 1 will be explained. The air-conditioning apparatus 100 performs mainly three types of operations. Basically, the air-conditioning apparatus 100 performs a cooling only operation, a heating only operation, and a simultaneous cooling and heating operation. The cooling only operation is an operation in which all of the plurality of indoor units are either in cooling operation or stopped. The heating only operation is an operation in which all of the plurality of indoor units are either in heating operation or stopped. The simultaneous cooling and heating operation is an operation mode in which one or some of the plurality of indoor units are in cooling operation, and the remaining one or some are in heating operation (of course, one or some of the indoor units may be in a stopped state). Regarding the simultaneous cooling and heating operation, two types of operations are performed, that is, a heating main operation in which a majority of the plurality of indoor units are in heating operation, and cooling main operation in which a majority of the plurality of indoor units are in cooling operation. Below, the operation state in each of the operations will be explained.

(Cooling Only Operation)

[0035] First, the cooling only operation will be explained.

Fig. 2 is a diagram of the operation state during the cooling only operation and the heating only operation in the air-conditioning apparatus according to Embodiment 1 of the present invention. The solid arrows in Fig. 2 show the flow of the refrigerant in the cooling only operation. In addition, Fig. 2 shows a case in which all of the indoor units B, C, and D are in cooling operation.

[0036] High-temperature, high-pressure gas refrigerant that is discharged from the compressor 1 passes through the four-way switching valve 2 and flows into the heat source unit-side heat exchanger 3. The refrigerant which has flowed into the heat source unit-side heat exchanger 3 exchanges heat with the outdoor air and is condensed, passes through the check valve 23 and the second connecting piping 22, and flows into the relay unit E. The refrigerant which has flowed into the relay unit E passes through the gas-liquid separating device 12 and the flow control device 13 in that order, and flows into the heat exchange portion 16. The refrigerant that has flowed into the heat exchange portion 16 is cooled by the refrigerant flowing through the bypass piping 14, obtains a sufficient degree of supercooling, and flows into the second branching unit 11. The refrigerant which has flowed into the second branching unit 11 is diverged at the first junction 17A, flows into the second indoor unit-side connecting pipings 7B, 7C, and 7D, and flows into each of the flow control devices 9 (9B to 9D).

[0037] The refrigerant which has flowed into the flow control devices 9 (9B to 9D) is decompressed to a predetermined low pressure based on the degree of superheat of the outlets of each of the indoor-side heat exchangers 5, and flows into each indoor unit B, C, and D (each indoor-side heat exchanger 5). The refrigerant which has flowed into each indoor unit B, C, and D (each indoor-side heat exchanger 5) exchanges heat with the indoor air in the indoor-side heat exchangers 5, is evaporated and gasified, and cools the indoors. The refrigerant which has entered a gaseous state passes through the first indoor unit-side connecting pipings 6B, 6C, and 6D, the first branching unit 10 (more specifically, the valve devices 8aB, 8aC, and 8aD), the flow control unit 31, and the first connecting piping 21, and flows into the heat source unit A. The refrigerant that has flowed into the heat source unit A passes through the check valve 24 and the four-way switching valve 2 and is sucked into the compressor 1. At this time, the valve devices 8aB, 8aC, and 8aD are in an opened state, and the valve devices 8bB, 8bC, and 8bD are in a closed state.

[0038] At this time, since the first connecting piping 21 is under low pressure, and the second connecting piping 22 is under high pressure, the refrigerant necessarily flows to the check valve 23 and the check valve 24. In the cooling only operation shown in Fig. 2, a portion of the refrigerant that has passed through the flow control device 13 flows into the bypass piping 14. This portion of the refrigerant is decompressed to low pressure in the flow control device 15 and flows into the heat exchange portion 16. The refrigerant that has been decompressed in the flow control device 15 cools the refrigerant flowing through the second connecting piping 22, evaporates, and flows into the first connecting piping 21. This refrigerant merges with the refrigerant that has flowed out from the flow control unit 31, passes through the check valve 24 and the four-way switching valve 2, and is sucked into the compressor 1.

[0039] In the cooling only operation explained above, the flow control unit 31 is controlled as follows.

For example, if the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D of the indoor units B, C, and D that are about to perform cooling is to be raised, control is performed to close the valve device 19. If the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D of the indoor units B, C, and D that are about to perform cooling is to be set to normal temperature or lowered, control is performed to open the valve device 19. In other words, if the valve device 19 is opened, the flow through area of the indoor-side heat exchangers 5B, 5C, and 5D increases, and thus the pressure loss of the indoor-side heat exchangers 5B, 5C, and 5D can be reduced. Therefore, the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D can be set to normal temperature or lowered. On the other hand, if the valve device 19 is closed, the refrigerant flows through the capillary tube 20, and thus the pressure loss of the indoor-side heat exchangers 5B, 5C, and 5D increases. Therefore, the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D can be increased. In this way, the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D can be selectively changed.

[0040] The relationship between the evaporation temperature and the sensible heat capacity of the indoor-side heat exchangers during cooling operation will be now explained. In the case of using a general indoor-side heat exchanger to perform cooling operation under certain air conditions (a certain dry-bulb temperature and a certain wet-bulb temperature), if the evaporation temperature of the indoor-side heat exchanger rises, the cooling capacity (sum of the latent heat capacity and the sensible heat capacity) of the indoor-side heat exchanger decreases. At this time, the sensible heat capacity is maintained at a nearly fixed capacity. In other words, the sensible heat ratio increases as the evaporation temperature rises.

[0041] In a conventional air-conditioning apparatus in which the flow control unit 31 according to Embodiment 1 is not provided, it has been necessary to select an indoor unit based on when the evaporation temperature was normal or low. Therefore, for an indoor unit installed in a place in which the sensible heat load is large such as a computer room, it has been necessary to select an indoor unit having a large cooling capacity, that is, an indoor unit having a large product form, so that it would conform to such a sensible heat load. However, the air-conditioning apparatus 100 according to Embodiment 1 can increase the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D by controlling the flow control unit 31. In other words, it can increase the sensible heat ratio by increasing the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D. Therefore, as an indoor unit installed in a place in which the sensible heat load is large such as a computer room, it is possible to select an indoor unit having a small cooling capacity, that is, an indoor unit having a small product form. Therefore, it is possible to reduce cost.

[0042] Conventionally, since attempts have been made to obtain the necessary sensible heat capacity using an indoor unit with a large cooling capacity, the cooling capacity of the indoor unit became large. Thus, depending on the balance in the refrigeration cycle, there were cases in which the evaporation temperature of the indoor-side heat exchangers dropped. Therefore, there was a possibility of defects in which the indoor-side heat exchangers freeze, causing water leaks. However, the air-conditioning apparatus 100 of Embodiment 1 can prevent such defects by increasing the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D.

(Heating Only Operation)

[0043] Next, the heating only operation will be explained using Fig. 2. The broken-line arrows in Fig. 2 show the flow of the refrigerant during the heating only operation. Fig. 2 shows a case in which all of the indoor units B, C, and D are in heating operation.

[0044] A high-temperature, high-pressure gas refrigerant that is discharged from the compressor 1 passes through the four-way switching valve 2, the check valve 25, and the second connecting piping 22, and flows into the relay unit E. The refrigerant that has flowed into the relay unit E passes through the gas-liquid separating device 12 and flows into the first branching unit 10. The refrigerant which has flowed into the first branching unit 10 passes through the valve devices 8bB, 8bC, and 8bD; the first indoor unit-side connecting pipings 6B, 6C, and 6D, and flows into each indoor unit B, C, and D (each indoor-side heat exchanger 5). The refrigerant which has flowed into each indoor unit B, C, and D (each indoor-side heat exchanger 5) exchanges heat with the indoor air in the indoor-side heat exchangers 5, and is condensed and liquefied to heat the indoors. The refrigerant which has entered a liquid state passes through the flow control devices 9 controlled by the degree of supercooling of the outlets of each indoor-side heat exchanger 5, the second indoor unit-side connecting pipings 7B, 7C, and 7D, and flows into the second branching unit 11. The refrigerant which has flowed into the second branching unit 11 passes through the check valves 18B, 18C and 18D, and merges at the second junction 18A. The refrigerant which has merged passes through the second connecting piping 22 and the bypass piping 14, flows into the flow control device 15, and is decompressed to a low pressure two-phase gas-liquid. The refrigerant that has been decompressed to a low pressure passes through the bypass piping 14, the heat exchange portion 16, and the first connecting piping 21, and flows into the heat source unit A. The refrigerant that has flowed into the heat source unit A passes through the check valve 26, and flows into the heat source unit-side heat exchanger 3. The refrigerant that has flowed into the heat source unit-side heat exchanger 3 exchanges heat with the outdoor air and evaporates into a gaseous state, and passes through the four-way switching valve 2 and is sucked into the compressor 1. At this time, the valve devices 8aB, 8aC, and 8aD are in a closed state, and the valve devices 8bB, 8bC, and 8bD are in an opened state. In addition, since the first connecting piping 21 is under low pressure, and the second connecting piping 22 is under high pressure, the refrigerant necessarily flows to the check valve 25 and the check valve 26.

(Heating Main Operation)

[0045] Next, the heating main operation, which is one type of the simultaneous cooling and heating operation, will be explained.

Fig. 3 is a diagram of the operation state during a heating main operation in the air-conditioning apparatus according to Embodiment 1 of the present invention. The solid arrows in Fig. 3 show the flow of the refrigerant during the heating main operation. Fig. 3 shows a case in which the indoor units B and C are in heating operation, and the indoor unit D is in cooling operation.

[0046] A high-temperature, high-pressure gas refrigerant that is discharged from the compressor 1 passes through the four-way switching valve 2, the check valve 25, and the second connecting piping 22, and flows into the relay unit E. The refrigerant that has flowed into the relay unit E passes through the gas-liquid separating device 12 and flows into the first branching unit 10. The refrigerant which has flowed into the first branching unit 10 passes through the valve devices 8bB and 8bC and the first indoor unit-side connecting pipings 6B and 6C, and flows into the indoor units B and C which are about to perform heating (the indoor-side heat exchangers 5B and 5C). The refrigerant which has flowed into the indoor units B and C (the indoor-side heat exchangers 5B and 5C) exchanges heat with the indoor air, is condensed and liquefied, and heat the indoors. The refrigerant which has entered a liquid state passes through the flow control devices 9B and 9C in a nearly completely opened state, in which the low control devices 9B and 9C are controlled by the degree of supercooling of the outlets of the indoor-side heat exchangers 5B and 5C, and it is slightly decompressed to a pressure that is between high pressure and low pressure (an intermediate pressure). The refrigerant that has been turned into an intermediate pressure passes through the second indoor unit-side connecting pipings 7B and 7C and the check valves 18B and 18C, and merges at the second junction 18A.

[0047] The refrigerant that has merged at the second junction 18A of the second branching unit 11 flows into the heat exchange portion 16. The refrigerant that has flowed into the heat exchange portion 16 is cooled by the refrigerant flowing through the bypass piping 14, obtains a sufficient degree of supercooling, and flows out of the heat exchange portion 16. A portion of the refrigerant that has flowed out of the heat exchange portion 16 flows into the second branching unit 11. The refrigerant which has flowed into the second branching unit 11 passes through the first junction 17A and the second indoor unit-side connecting piping 7D, and flows into the flow control device 9D. The refrigerant which has flowed into the flow control device 9D is decompressed to a predetermined low pressure based on the degree of superheat of the outlet of the indoor-side heat exchanger 5D, and flows into the indoor unit D (the indoor-side heat exchanger 5D). The refrigerant which has flowed into the indoor unit D (the indoor-side heat exchanger 5D) exchanges heat with the indoor air, is evaporated and gasified, and cools the indoors. The refrigerant which has entered a gaseous state passes through the first indoor unit-side connecting piping 6D, the first branching unit 10 (more specifically, the valve device 8aD), the flow control unit 31, and the first connecting piping 21, and flows into the heat source unit A. The refrigerant that has flowed into the heat source unit A passes through the check valve 26 and flows into the heat source unit-side heat exchanger 3. The refrigerant that has flowed into the heat source unit-side heat exchanger 3 exchanges heat with the outdoor air and evaporates into a gaseous state, and passes through the four-way switching valve 2 and is sucked into the compressor 1.

[0048] Meanwhile, the remaining portion of the refrigerant that has flowed out from the heat exchange portion 16 flows into the bypass piping 14. This refrigerant is decompressed to a predetermined pressure in the flow control device 15 and flows into the heat exchange portion 16. The refrigerant which is decompressed in the flow control device 15 cools the refrigerant flowing through the second connecting piping 22 and evaporates, and merges with the refrigerant flowing through the first connecting piping 21. The opening degree of the flow control device 15 is controlled so that the difference between the high pressure of the second connecting piping 22 and the intermediate pressure of the second branching unit 11 becomes constant.

[0049] At this time, regarding the valve devices 8a and the valve devices 8b connected to the indoor units B and C, which are about to perform heating, the valve devices 8aB and 8aC are in a closed state, and the valve devices 8bB and 8bC are in an opened state. Further, regarding the valve device 8a and the valve device 8b connected to the indoor unit D, which is about to perform cooling, the valve device 8aD is in an opened state and the valve device 8bD is in a closed state. Since the first connecting piping 21 is under low pressure and the second connecting piping 22 is under high pressure, the refrigerant necessarily flows to the check valve 25 and the check valve 26.

[0050] In the heating main operation explained above, the flow control unit 31 is controlled as follows.

For example, if the evaporation temperature of the indoor-side heat exchanger 5D of the indoor unit D that is about to perform cooling is to be raised, control is performed to close the valve device 19. If the evaporation temperature of the indoor-side heat exchanger 5D of the indoor unit D that is about to perform cooling is to be set to normal temperature or lowered, control is performed to open the valve device 19. In other words, if the valve device 19 is opened, the flow through area of the indoor-side heat exchanger 5D increases, and thus the pressure loss of the indoor-side heat exchanger 5D can be reduced. Therefore, the evaporation temperature of the indoor-side heat exchanger 5D can be set to normal temperature or lowered. On the other hand, if the valve device 19 is closed, the refrigerant flows through the capillary tube 20, and thus the pressure loss of the indoor-side heat exchanger 5D increases. Therefore, the evaporation temperature of the indoor-side heat exchanger 5D of the indoor unit D can be increased. In this way, the evaporation temperature of the indoor unit D which is about to perform cooling can be selectively changed.

[0051] During heating main operation, the evaporation temperature of the heat source unit-side heat exchanger 3 changes depending on the outside air temperature. In particular, if the outside air temperature is low and the evaporation temperature of the heat source unit-side heat exchanger 3 falls well below 0 degree C, the evaporation temperature of the indoor-side heat exchanger 5D that is serially connected to the heat source unit-side heat exchanger 3 drops in accordance with the drop in the evaporation temperature of the heat source unit-side heat exchanger 3 and becomes 0 degree C or less. If the evaporation temperature of the indoor-side heat exchanger 5D drops in this way, frost forms on the indoor-side heat exchanger 5D. Due to this frost formation, the air path of the indoor-side heat exchanger 5D becomes blocked, and the amount of air flowing into the indoor-side heat exchanger 5D decreases, leading to a decrease in cooling capacity. Further, in order to remove the frost on the indoor-side heat exchanger 5D, the cooling operation has to be temporarily suspended, and thus it becomes difficult to continue the cooling operation.

[0052] Thus, in the air-conditioning apparatus 100 according to Embodiment 1, the evaporation temperature of the indoor-side heat exchanger 5D of the indoor unit D which is about to perform the cooling operation is detected with the temperature sensor 4D provided on the second indoor unit-side connecting piping 7D (the piping on the side at which the refrigerant flows in of the indoor-side heat exchanger 5D). If the evaporation temperature of the indoor-side heat exchanger 5D becomes a predetermined temperature (for example, 0 degree C) or less, the valve device 19 explained above is closed, and the evaporation temperature of the indoor-side heat exchanger 5D is maintained to be higher than the predetermined temperature (for example, 0 degree C). Thereby, frost formation on the indoor-side heat exchanger 5D can be prevented, and a continuous and stable cooling operation can be maintained.

[0053] The evaporation temperature of the indoor-side heat exchanger 5D may also be detected by the temperature sensor 28. By maintaining this detected temperature to be higher than the predetermined temperature (for example, 0 degree C), the evaporation temperature of the indoor-side heat exchanger 5D which is upstream thereof becomes higher by the amount of pressure loss. Therefore, frost formation on the indoor-side heat exchanger 5D can be prevented.

[0054] By selectively changing the evaporation temperature of the indoor-side heat exchanger 5D with the flow control unit, the sensible heat ratio of the indoor unit D (the indoor-side heat exchanger 5D) can be increased, similar to during the cooling only operation. Therefore, when the indoor unit D is installed in a place in which the sensible heat load is large such as a computer room, it is possible to select an indoor unit D having a small cooling capacity, that is, an indoor unit D having a small product form. Therefore, it is possible to reduce cost.

[0055] The predetermined temperature described above, which is a threshold value for determining the opening/closing of the valve device 19, may of course be a value other than 0 degree C. For example, considering the detection error of the temperature sensor 4 and the temperature sensor 28 or the like, the predetermined temperature can be set a number of degrees C higher (for example, 3 degrees C).

(Cooling Main Operation)

[0056] Next, the cooling main operation, which is one type of the simultaneous cooling and heating operation, will be explained.

Fig. 4 is a diagram of the operation state during cooling main operation in the air-conditioning apparatus according to Embodiment 1 of the present invention. The solid arrows in Fig. 4 show the flow of the refrigerant during the cooling main operation. Fig. 3 shows a case in which the indoor units B and C are in cooling operation, and the indoor unit D is in heating operation.

[0057] A high-temperature, high-pressure gas refrigerant that is discharged from the compressor 1 passes through the four-way switching valve 2, exchanges an arbitrary amount of heat in the heat source unit-side heat exchanger 3 to become a high-temperature high-pressure two-phase gas-liquid refrigerant. This refrigerant passes through the check valve 23 and the second connecting piping 22, and flows into the relay unit E. The refrigerant that has flowed into the relay unit E flows into the gas-liquid separating device 12, and is separated into a gas refrigerant and a liquid refrigerant.

[0058] The gas refrigerant that has been separated in the gas-liquid separating device 12 passes through the valve device 8bD of the first branching unit 10 and the first indoor unit-side connecting piping 6D in that order, and flows into the indoor unit D which is about to perform heating. The refrigerant which has flowed into the indoor unit D (the indoor-side heat exchanger 5D) exchanges heat with the indoor air, is condensed and liquefied, and heats the indoors. The refrigerant which has entered a liquid state passes through the flow control device 9D which is controlled to be in a nearly completely opened state by the degree of supercooling of the outlet of the indoor-side heat exchanger 5D, and it is slightly decompressed to an intermediate pressure. The refrigerant which has been turned into an intermediate pressure passes through the second indoor unit-side connecting piping 7D, the check valve 18D, and the second junction 18A, and merges with the liquid refrigerant flowing through the second connecting piping 22 (the liquid refrigerant that was separated in the gas-liquid separating device 12).

[0059] The liquid refrigerant that has been separated in the gas-liquid separating device 12 of the relay unit E flows into the heat exchange portion 16. The refrigerant that has flowed into the heat exchange portion 16 is cooled by the refrigerant flowing through the bypass piping 14, obtains a sufficient degree of supercooling, and flows into the flow control device 13 to be decompressed to a predetermined pressure. At this time, the opening degree of the flow control device 13 is controlled so that the difference between the high pressure of the second connecting piping 22 that is on the upstream side of the flow control device 13 and the intermediate pressure of the second branching unit 11 becomes constant.

[0060] A portion of the refrigerant that has flowed out of the flow control device 13 passes through the first junction 17A of the second branching unit 11 and the second indoor unit-side connecting pipings 7B and 7C, and flows into the flow control devices 9B and 9C. The refrigerant which has flowed into the flow control devices 9B and 9C is decompressed to a predetermined low pressure based on the degree of superheat of the outlets of the indoor-side heat exchangers 5B and 5C, and flows into the indoor units B and C (the indoor-side heat exchangers 5B and 5C). The refrigerant which has flowed into the indoor units B and C (the indoor-side heat exchangers 5B and 5C) exchanges heat with the indoor air, is evaporated and is gasified, and cools the indoors. The refrigerant which has entered a gaseous state passes through the first indoor unit-side connecting pipings 6B and 6C, the first branching unit 10 (more specifically, the valve devices 8aB and 8aC), the flow control unit 31, and the first connecting piping 21, and flows into the heat source unit A. The refrigerant that has flowed into the heat source unit A passes through the check valve 24 and the four-way switching valve 2 and is sucked into the compressor 1.

[0061] Meanwhile, the remaining portion of the refrigerant that has flowed out of the flow control device 13 flows into the bypass piping 14. This refrigerant is decompressed to a low pressure in the flow control device 15 and flows into the heat exchange portion 16. The refrigerant that is decompressed in the flow control device 15 cools the refrigerant flowing through the second connecting piping 22, and evaporates and merges with the refrigerant flowing through the first connecting piping 21.

[0062] At this time, regarding the valve devices 8a and the valve devices 8b connected to the indoor units B and C which are about to perform cooling, the valve devices 8aB and 8aC are in an opened state, and the valve devices 8bB and 8bC are in a closed state. Further, regarding the valve device 8a and the valve device 8b connected to the indoor unit D which is about to perform heating, the valve device 8aD is in a closed state and the valve device 8bD is in an opened state. Since the first connecting piping 21 is under low pressure and the second connecting piping 22 is under high pressure, the refrigerant necessarily flows to the check valve 23 and the check valve 24.

[0063] In the cooling main operation explained above, the flow control unit 31 is controlled as follows.
For example, if the evaporation temperature of the indoor-side heat exchangers 5B and 5C of the indoor units B and C that are about to perform cooling is to be raised, control is performed to close the valve device 19. If the evaporation temperature of the indoor-side heat exchangers 5B and 5C of the indoor units B and C that are about to perform cooling is to be set to normal temperature or lowered, control is performed to open the valve device 19. In other words, if the valve device 19 is opened, the flow through area of the indoor-side heat exchangers 5B and 5C increases, and thus the pressure loss of the indoor-side heat exchangers 5B and 5C can be reduced. Therefore, the evaporation temperature of the indoor-side heat exchangers 5B and 5C can be set to normal temperature or lowered. On the other hand, if the valve device 19 is closed, the refrigerant flows through the capillary tube 20, and thus the pressure loss of the indoor-side heat exchangers 5B and 5C increases. Therefore, the evaporation temperature of the indoor-side heat exchangers 5B and 5C can be increased. In this way, the evaporation temperature of the indoor-side heat exchangers 5B and 5C of the indoor units B and C that are about to perform cooling can be selectively changed.

[0064] By selectively changing the evaporation temperature of the indoor-side heat exchangers 5B and 5C with the flow control unit, the sensible heat ratio of the indoor units B and C (the indoor-side heat exchangers 5B and 5C) can be increased, similar to during the cooling only operation. Therefore, when the indoor units B and C are installed in a place in which the sensible heat load is large such as a computer room, it is possible to select indoor units B and C having a small cooling capacity, that is, indoor units B and C having a small product form. Therefore, it is possible to reduce cost.
Further, by selectively changing the evaporation temperature of the indoor-side heat exchangers 5B and 5C with the flow control unit, frost formation on the indoor-side heat exchangers 5B and 5C can be prevented, and a continuous and stable cooling operation can be maintained.

Embodiment 2

[0065] The flow control unit 31 is not limited to the constitution shown in Embodiment 1. For example, the flow control unit 31 can also be constituted as described below. In Embodiment 2, items that are not particularly described are the same as in Embodiment 1.

[0066] Fig. 5 is a diagram of a refrigerant circuit showing the air-conditioning apparatus according to Embodiment 2 of the present invention.
The flow control unit 31 of an air-conditioning apparatus 101 according to Embodiment 2 includes a flow control device 27 whose opening degree can be changed. The other constitutions are the same as those shown in the air-conditioning apparatus 100 according to Embodiment 1. Except for the flow control unit 31, the operation and the like (the flow of a refrigerant and the like) during each operation of the air-conditioning apparatus 101 (a cooling only operation, a heating only operation, a heating main operation, and a cooling main operation) are also the same as shown in the air-conditioning apparatus 100 according to Embodiment 1.

[0067] Basically, in the air-conditioning apparatus 101 according to Embodiment 2, the flow control unit 31 is controlled as follows.
For example, if the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D of the indoor units B, C, and D that are about to perform cooling is to be raised, control is performed to decrease the opening degree of the flow control device 27. If the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D of the indoor units B, C, and D that are about to perform cool is to be set to normal temperature or lowered, control is performed to increase the opening degree of the flow control device 27. In other words, as the opening degree of the flow control device 27 is increased, the flow through area of the indoor-side heat exchangers 5B, 5C, and 5D increases, and thus the pressure loss of the indoor-side heat exchangers 5B, 5C, and 5D can be reduced. Therefore, the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D can be set to normal temperature or lowered. On the other hand, as the opening degree of the flow control device 27 is decreased, the pressure loss of the indoor-side heat exchangers 5B, 5C, and 5D increases. Therefore, the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D can be increased. In this way, the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D can be selectively changed. Further, by using the flow control device 27 whose opening degree can be changed, the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D can be arbitrarily (linearly) controlled.

[0068] Therefore, in the air-conditioning apparatus 101 according to Embodiment 2, similar to the air-conditioning apparatus 100 according to Embodiment 1, the sensible heat ratio of the indoor units B, C, and D (the indoor-side heat exchangers 5B, 5C, and 5D) can be increased. Therefore, when the indoor units B, C, and D are installed in a place in which the sensible heat load is large such as a computer room, it is possible to select indoor units B, C, and D having a small cooling capacity, that is, indoor units B, C, and D having a small product form. Therefore, it is possible to reduce cost. Further, by selectively chang-

ing the evaporation temperature of the indoor-side heat exchangers 5B, 5C, and 5D with the flow control unit, frost formation on the indoor-side heat exchangers 5B, 5C, and 5D can be prevented, and a continuous and stable cooling operation can be maintained.
In addition, since the flow control unit 31 includes a flow control device 27 whose opening degree can be changed, the evaporation temperature and the sensible heat ratio of the indoor-side heat exchangers 5B, 5C, and 5D can be arbitrarily (for example, linearly) controlled.

Reference Signs List

[0069] 1...compressor; 2...four-way switching valve; 3...heat source unit-side heat exchanger; 4 (4B-4D)...temperature sensor; 5 (5B-5D)... indoor-side heat exchanger; 6 (6B-6D)...first indoor unit-side connecting piping; 7 (7B-7D)...second indoor unit-side connecting piping; 8a (8aB-8aD)...valve device; 8b (8bB-8bD)...valve device; 9 (9B-9D)...flow control device; 10...first branching unit; 11... second branching unit; 12...gas-liquid separating device; 13...flow control device; 14...bypass piping; 95...flow control device; 16... heat exchange portion; 17 (17B-17D)...check valve; 17A...first junction; 18 (18B-18D)...check valve; 18A...second junction; 19...valve device; 20 ... capillary tube; 21...first connecting piping; 22...second connecting piping; 23...check valve; 24...check valve;25...check valve;26... check valve;27...flow control device; 28...temperature sensor; 30...flow switching device; 31...flow control unit; 100... air-conditioning apparatus; 101... air-conditioning apparatus; A... heat source unit; B, C, AND D...indoor unit; E... relay unit.

Claims

1. An air-conditioning apparatus, comprising:

a heat source unit having a compressor, a four-way switching valve, and a heat source unit-side heat exchanger that is connected to the four-way switching valve;
a plurality of indoor units each having an indoor-side heat exchanger and a first flow control device connected to one end of the indoor-side heat exchanger; and
a relay unit that connects the heat source unit to the indoor units,
the air-conditioning apparatus being capable of simultaneous heating and cooling operation in which each of the indoor units selectively performs a cooling operation or a heating operation, wherein
the relay unit is connected to the heat source unit by a first connecting piping through which a refrigerant that flows out to the heat source unit flows and a second connecting piping through which the refrigerant that flows in from the heat source unit flows, and
the relay unit comprises
a first branching unit that switchably connects the other end of each indoor-side heat exchanger to the first connecting piping or the second connecting piping,
a second branching unit that switchably connects each first flow control device to the first connecting piping or the second connecting piping, and
a flow control unit provided to the first connecting piping that controls a flow amount of the refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator.

2. The air-conditioning apparatus of claim 1, wherein the flow control unit comprises an openable and closable valve device and a capillary tube connected in parallel to the valve device, and
a flow amount of the refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator is controlled by the opening and closing of the valve device.

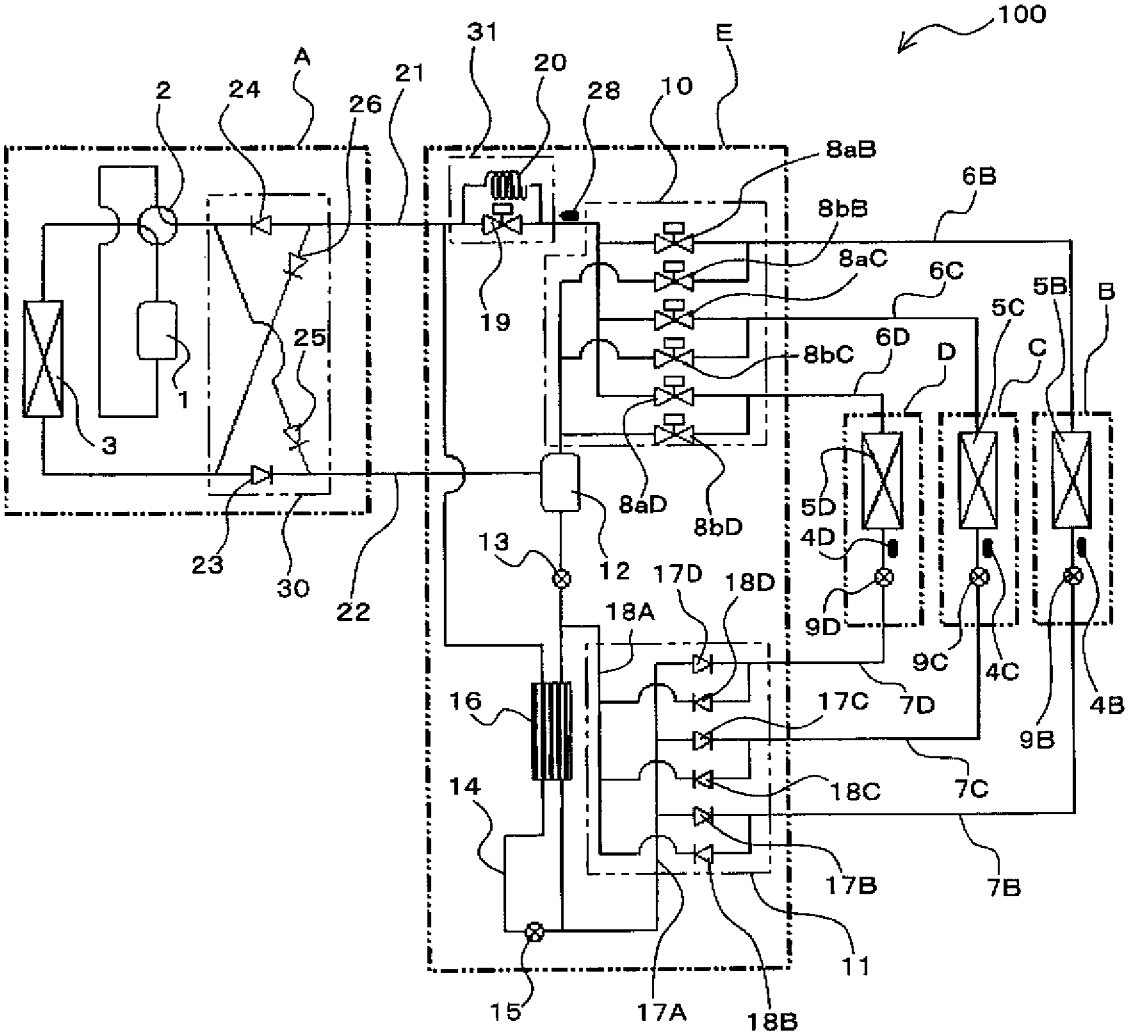
3. The air-conditioning apparatus of claim 1, wherein the flow control unit includes a second flow control device whose opening degree can be changed, and
a flow amount of the refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator is controlled by controlling the opening degree of the second flow control device.

4. The air-conditioning apparatus of any one of claims 1 to 3, wherein when the heat source unit-side heat exchanger functions as an evaporator, the indoor-side heat exchangers functioning as an evaporator, the flow control unit, and the heat source unit are serially connected.

5. The air-conditioning apparatus of any one of claims 1 to 4, wherein the flow control unit adjusts a flow amount of the refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator based on an evaporation temperature of the refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator.

6. The air-conditioning apparatus of any one of claims 1 to 4, wherein a temperature detection device that detects the temperature of the refrigerant is provided to the first connecting piping between the first branching unit and the flow control unit, and
a flow amount of the refrigerant that flows through the indoor-side heat exchangers functioning as an evaporator is controlled based on a temperature detected by the temperature detection device.

F I G. 1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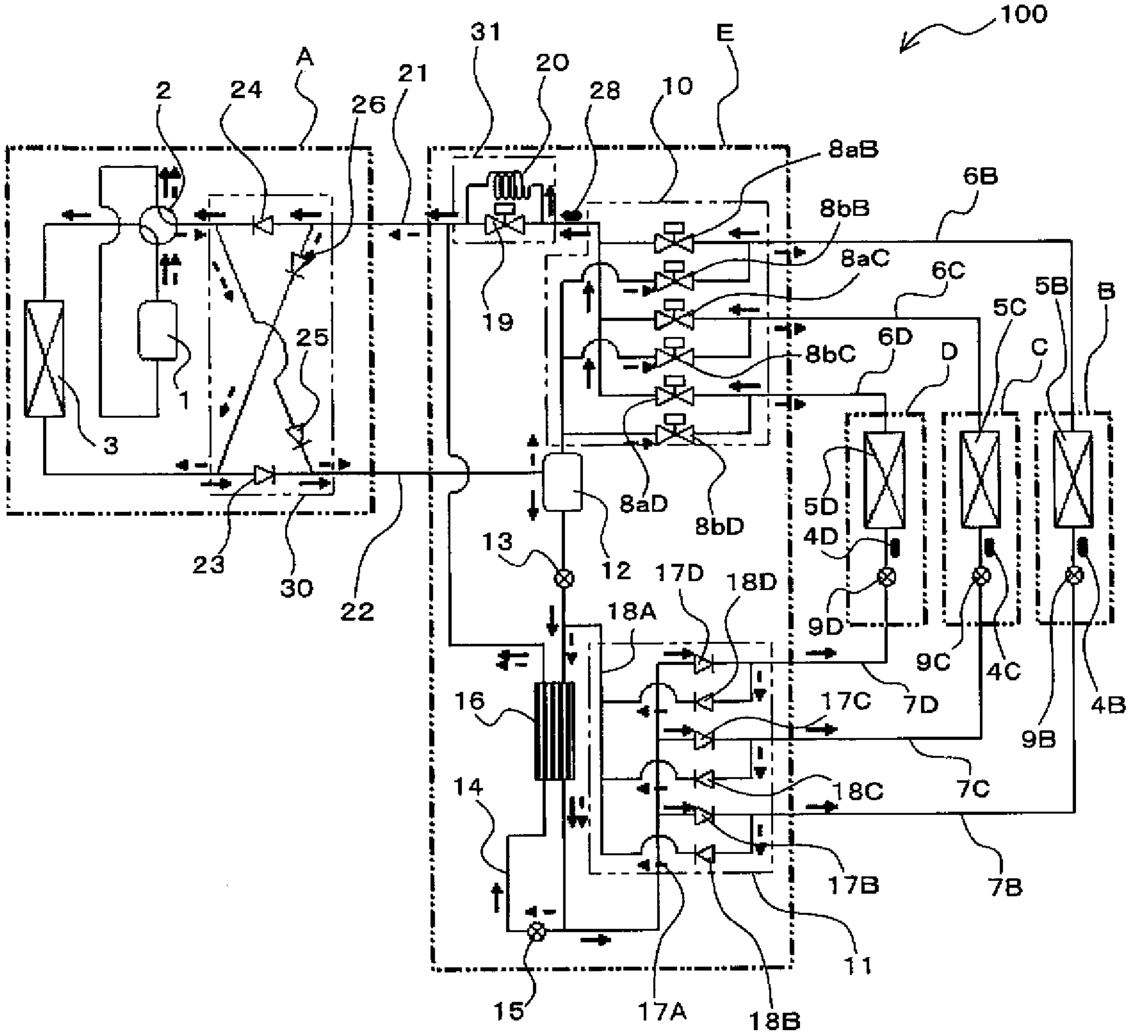
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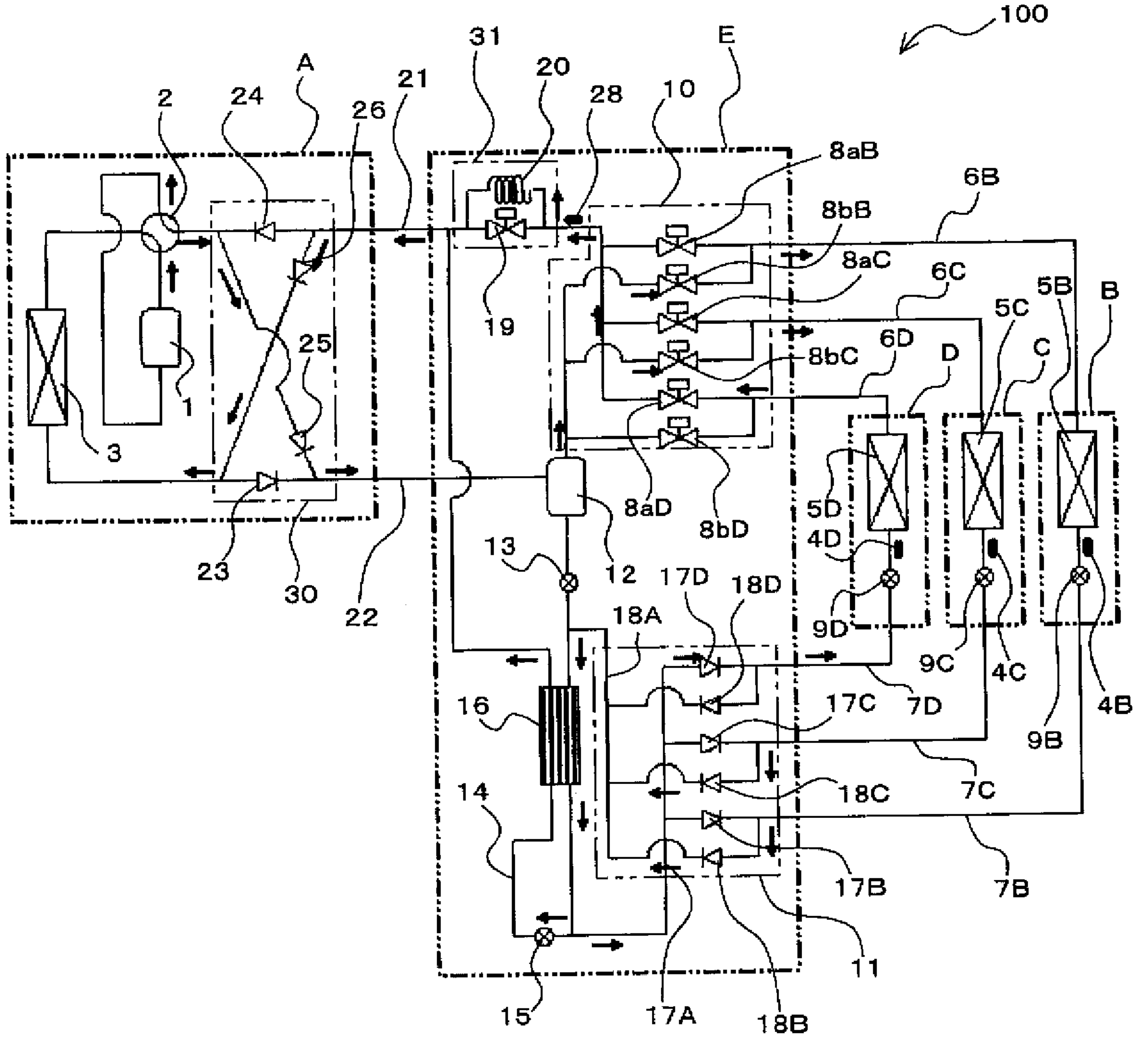
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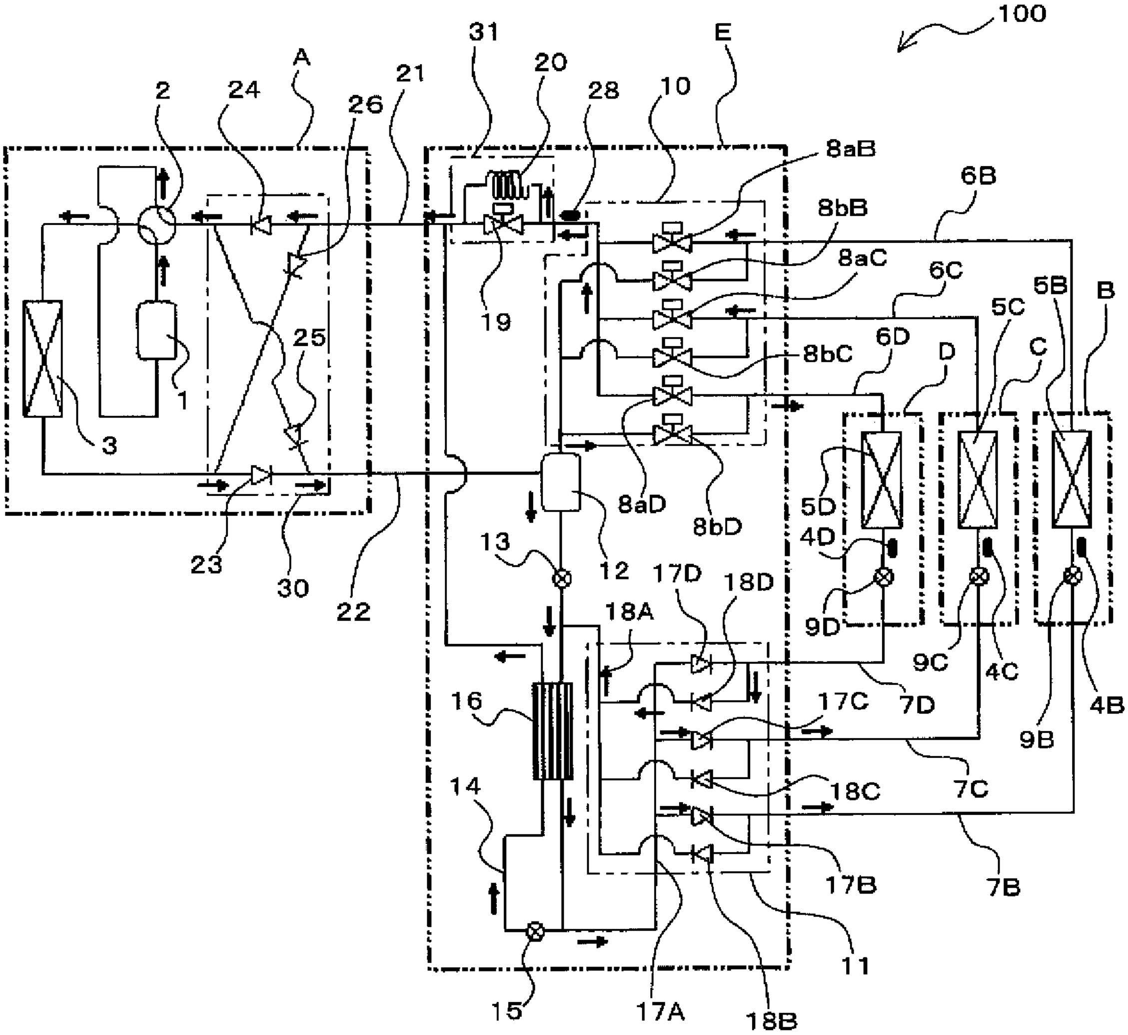
F I G. 4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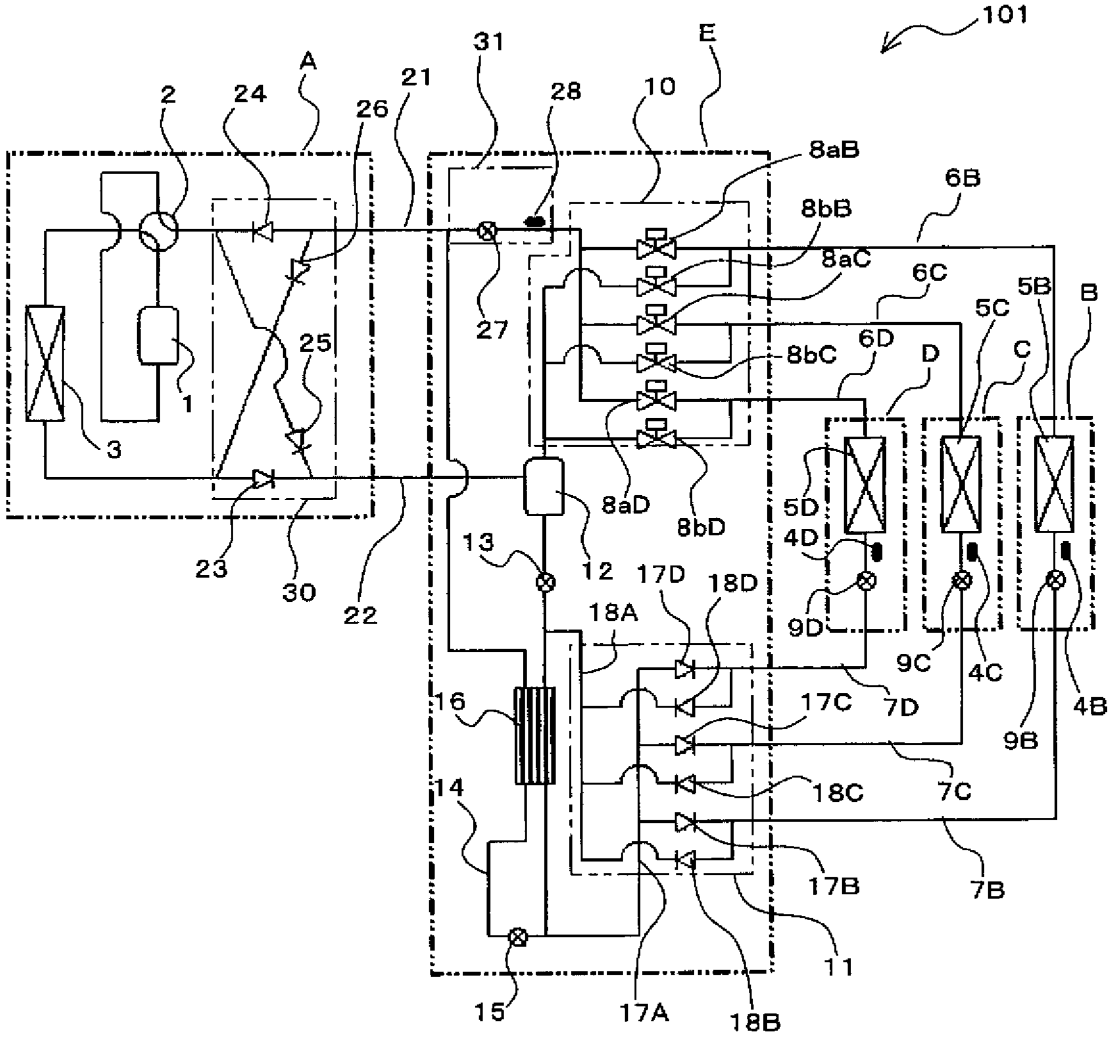
F I G. 5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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/006878

A. CLASSIFICATION OF SUBJECT MATTER
F25B29/00(2006.01)i, *F24F11/02*(2006.01)i, *F25B1/00*(2006.01)i, *F25B13/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F25B29/00, F24F11/02, F25B1/00, F25B13/00

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	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2003-130482 A (Mitsubishi Electric Corp.), 08 May 2003 (08.05.2003), claims; paragraphs [0001] to [0056]; fig. 1 to 12 (Family: none)	1-6
Y	JP 2007-263444 A (Mitsubishi Electric Corp.), 11 October 2007 (11.10.2007), claims; paragraphs [0001] to [0056]; fig. 1 to 7 (Family: none)	1-6
Y	JP 6-323637 A (Mitsubishi Heavy Industries, Ltd.), 25 November 1994 (25.11.1994), claims; fig. 1 (Family: none)	2-6

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 February, 2010 (03.02.10)	23 February, 2010 (23.02.10)

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

Form PCT/ISA/210 (second sheet) (April 2007)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/006878

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-76933 A (Mitsubishi Electric Corp.), 24 March 2005 (24.03.2005), claim 8; fig. 6 (Family: none)	2-6
Y	JP 2009-198087 A (Mitsubishi Electric Corp.), 03 September 2009 (03.09.2009), claims; paragraphs [0001] to [0142]; fig. 1 to 24 (Family: none)	2-6
A	JP 4-335967 A (Mitsubishi Electric Corp.), 24 November 1992 (24.11.1992), entire text; all drawings & US 5297392 A & EP 514086 A2 & DE 69226381 T2 & AU 16034/92 B & ES 2092035 T3	1-6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 4335967 A **[0003]**