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

(72) Inventors:
- **MATUI, Kenji**
  Tokyo 100-8310 (JP)
- **TAKATA, Shigeo**
  Tokyo 100-8310 (JP)
- **YABUUCHI, Hironori**
  Tokyo 100-8310 (JP)

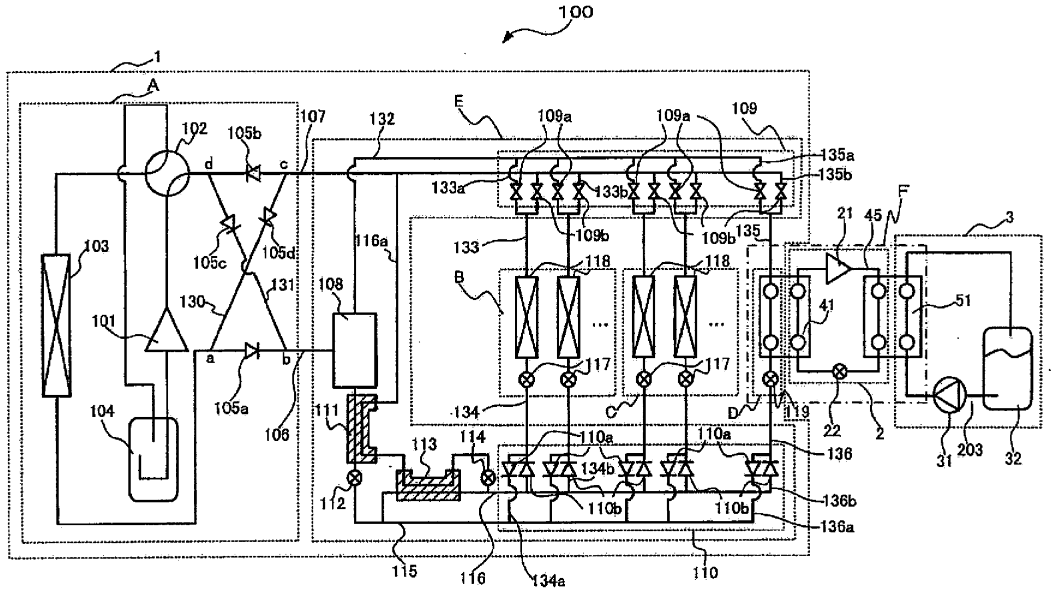
(74) Representative: **Pfenning, Meinig & Partner GbR**
Patent- und Rechtsanwälte
Theresienhöhe 13
80339 München (DE)

(54) REFRIGERATION CYCLE DEVICE AND INFORMATION PROPAGATION METHOD ADAPTED THERETO

(57) To provide a refrigeration cycle apparatus that achieves load balancing (for example, the balance between the cooling load and the heating load, and the balance between the cooling load and the heating and hot water loads) to increase system COP and an information transfer method used in the refrigeration cycle apparatus.

A refrigeration cycle apparatus 100 operates a plurality of indoor units so that the thermal cooling load and the thermal heating load to be executed by the plurality of indoor unit are balanced.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a refrigeration cycle apparatus used in an air-conditioning apparatus or an air-conditioning hot-water supply combined system and an information transfer method used in the refrigeration cycle apparatus, and to a refrigeration cycle apparatus that increases system COP and an information transfer method used in the refrigeration cycle apparatus.

Background Art

[0002] Conventionally, there are air-conditioning hot-water supply combined systems capable of simultaneously supplying a cooling load, a heating load, and a hot water load. As such, there has been proposed a "multi-functional heat pump system including one compressor and constituted by refrigerant circuits in which the compressor, an outdoor heat exchanger, an indoor heat exchanger, a cooling energy storage tank, and a hot water heat exchanger are connected to one another, wherein flows of refrigerant to the respective heat exchangers are switched to construct refrigeration cycles that enable single operations of cooling, heating, hot-water supply, heat storage, and cool storage and also enable combinations of these operations" (see, for example, Patent Literature 1).

Citation List

Patent Literature

[0003]

> Patent Literature 1: Japanese Unexamined Patent Application Publication No. 11-270920 (Fig. 1 etc.)

Summary of Invention

Technical Problem

[0004] In the air-conditioning hot-water supply combined systems capable of simultaneously supplying a cooling load, a heating load, and a hot water load, including the air-conditioning hot-water supply combined system as described in Patent Literature 1, it has been hitherto known that balancing between a cooling load and heating and hot water loads increases system COP. In actuality, however, since the air conditioning load and the hot water load required by users varies in time zones and in the amount required, efficient operations with increased system COP have not necessarily been achieved. For example, in the summer, the cooling load becomes high primarily in the daytime, and the hot water load becomes high in the nighttime when baths, showers, or the like are frequently taken. The operations for the air conditioning load and the hot water load generally span many different time zones.

[0005] In conventional air-conditioning hot-water combined systems, there is also a problem in that, while in a low-capacity operation, because the motor efficiency of the compressor is low while operated by an inverter at low speed, the efficiency of energy consumption is impaired. In conventional air-conditioning hot-water supply combined systems, furthermore, there is another problem in that when the system is operating under conditions indicating small-capacity overloaded heating operation, a situation occurs in that the operation cannot be continued because high-pressure-side pressure becomes too high.

[0006] The present invention has been made in order to overcome the above problems, and an object thereof is to provide a refrigeration cycle apparatus that achieves load balancing (for example, the balance between a cooling load and the heating load and the balance between the cooling load and the heating and hot water loads) to increase system COP and an information transfer method used in the refrigeration cycle apparatus. Solution to Problem

[0007] A refrigeration cycle apparatus according to the present invention is a refrigeration cycle apparatus including at least one heat source unit having mounted therein at least an air conditioning compressor and a heat-source-side heat exchanger; a plurality of use-side units each having mounted therein at least a use-side heat exchanger; and at least one relay unit that is disposed between the heat source unit and the use-side units and that transfers heating energy or cooling energy generated by the heat source side unit to the use-side units, wherein the plurality of use-side units are operated so that a thermal cooling load and a thermal heating load to be executed by the plurality of use-side units are balanced.

[0008] An information transfer method according to the present invention is an information transfer method used in the above refrigeration cycle apparatus, wherein the heat source unit is provided with a heat source unit controller, the relay unit is provided with a relay unit controller, and each of the use-side units is provided with a use-side unit controller; and transfer of information from each of the controllers enables any of the controllers to determine the load balance between the plurality of use-side units.

Advantageous Effects of Invention

[0009] A refrigeration cycle apparatus according to the present invention allows a plurality of use-side units to be operated so that the thermal cooling load and the thermal heating load to be executed by the plurality of use-side units are balanced, and can therefore increase system COP and achieve a reduction in running cost while realizing energy saving.

[0010] An information transfer method according to the present invention is used in the above refrigeration cycle apparatus. Therefore, a stable operation can be efficiently continued.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram illustrating an example of the refrigerant circuit configuration of a refrigeration cycle apparatus according to an embodiment of the present invention.
[Fig. 2] Fig. 2 is a schematic configuration diagram for explaining information transfer in a refrigeration cycle apparatus according to an embodiment of the present invention.
[Fig. 3] Fig. 3 is a schematic diagram schematically illustrating the connection state in a hot-water supply unit of a refrigeration cycle apparatus according to an embodiment of the present invention.
[Fig. 4] Fig. 4 is a flowchart illustrating a flow of a communication/operation process executed by a heat source unit controller.
[Fig. 5] Fig. 5 is a refrigerant circuit diagram illustrating another example of the refrigerant circuit configuration of a refrigeration cycle apparatus according to an embodiment of the present invention.

Description of Embodiments

[0012] Embodiments of the present invention will be described below with reference to the drawings.
Fig. 1 is a refrigerant circuit diagram illustrating an example of the refrigerant circuit configuration of a refrigeration cycle apparatus 100 according to an embodiment of the present invention. The refrigerant circuit configuration and operation of the refrigeration cycle apparatus 100 will be described with reference to Fig. 1. In Fig. 1, a case where the refrigeration cycle apparatus 100 is an air-conditioning hot-water supply combined system capable of simultaneously supplying a cooling load (thermal cooling load) and heating and hot water loads (thermal heating load) by utilizing a refrigeration cycle in which a refrigerant (air conditioning refrigerant) is circulated is illustrated by way of example. It should be noted that the dimensional relationships of components in Fig. 1 and other subsequent figures may be different from the actual ones.

[0013] The refrigeration cycle apparatus 100 is constituted by a refrigeration cycle for air conditioning 1, a refrigeration cycle for hot-water supply 2, and a hot-water supply device 3, and is configured such that the refrigeration cycle for air conditioning 1 and the refrigeration cycle for hot-water supply 2 exchange heat in a refrigerant-to-refrigerant heat exchanger 41 and the refrigeration cycle for hot-water supply 2 and the hot-water supply device 3 exchange heat in a heat medium-to-refrigerant heat exchanger 51 without each of the refrigerants and water being mixed. The refrigeration cycle apparatus 100 further has mounted therein a hot-water supply unit F.

[Refrigeration cycle for air conditioning 1]

[0014] The refrigeration cycle for air conditioning 1 is constituted by a heat source unit A, an indoor unit B and an indoor unit C each of which takes charge of the cooling load or the heating load, a heat source circuit for hot-water supply D serving as a heat source of the refrigeration cycle for hot-water supply 2, and a relay unit E. Among them, the indoor unit B, the indoor unit C, and the heat source circuit for hot-water supply D are connected in parallel to the heat source unit A and mounted. The relay unit E, which is disposed between the heat source unit A and the other components, that is, the indoor unit B, the indoor unit C, and the heat source circuit for hot-water supply D, switches a flow of a refrigerant to cause the indoor unit B, the indoor unit C, and the heat source circuit for hot-water supply D to perform their respective functions.

{Heat Source Unit A}

[0015] The heat source unit A has a function for supplying heating energy or cooling energy to the indoor unit B, the indoor unit C, and the heat source circuit for hot-water supply D. The heat source unit A has mounted therein an air conditioning compressor 101, a four-way valve 102, an outdoor heat exchanger (heat source side heat exchanger) 103, and an accumulator 104, which are connected in series.

[0016] The air conditioning compressor 101 is configured to suck in the air conditioning refrigerant and compress the air conditioning refrigerant into a high-temperature high-pressure state. The four-way valve 102 is configured to switch the flow of the air conditioning refrigerant. The outdoor heat exchanger 103 functions as an evaporator or a radiator (condenser), and is configured to exchange heat between air supplied from a fan or the like (not illustrated) and the air conditioning refrigerant to evaporate and gasify the air conditioning refrigerant or condense and liquefy the air conditioning refrigerant. The accumulator 104 is disposed on the suction side of the air conditioning compressor 101, and is configured to store excessive air conditioning refrigerant. The accumulator 104 may be any container capable of storing excessive air conditioning refrigerant.

[0017] In the heat source unit A, furthermore, a check valve 105a is provided in a high-pressure-side connection pipe 106 between the outdoor heat exchanger 103 and the relay unit E for permitting the air conditioning refrigerant to flow only in a predetermined direction (the direction from the heat source unit A to the relay unit E), and a check valve 105b is provided in a low-pressure-side connection pipe 107 between the four-way valve 102 and the relay unit E for permitting the air conditioning refrigerant to flow only in a predetermined direction (the direction from the relay unit E to the heat source unit A).

[0018] The high-pressure-side connection pipe 106 and the low-pressure-side connection pipe 107 are connected to each other through a first connection pipe 130 that connects the upstream side (connection portion a) of the check valve 1 05a and the upstream side (connection portion c) of the check valve 105b and through a second connection pipe 131 that connects the downstream side (connection portion b) of the check valve 105a and the downstream side (connection portion d) of the check valve 105b. A check valve 105c is provided in the first connection pipe 130 for permitting the air conditioning refrigerant to be distributed only in the direction from the low-pressure-side connection pipe 107 to the high-pressure-side connection pipe 106. Also, a check valve 105d is provided in the second connection pipe 131 for permitting the air conditioning refrigerant to be distributed only in the direction from the low-pressure-side connection pipe 107 to the high-pressure-side connection pipe 108.

{Indoor Unit B and Indoor Unit C}

[0019] Each of the indoor unit B and the indoor unit C has a function of taking charge of the heating load or the cooling load upon receipt of heating energy or cooling energy supplied from the heat source unit A. Each of the indoor unit B and the indoor unit C has mounted therein air conditioning expansion devices 117 and indoor heat exchangers (use side heat exchangers) 118, which are connected in series. The indoor unit B and the indoor unit C, each of which has mounted therein two air conditioning expansion devices 117 and two indoor heat exchangers 118 in such a manner the two air conditioning expansion devices 117 are parallel to each other and the two indoor heat exchangers 118 are parallel to each other, are illustrated by way of example.

[0020] The relay unit E determines that, for example, the indoor unit B takes charge of the cooling load and the indoor unit C takes charge of the heating load. For convenience of description, connection pipes that connect the relay unit E to the indoor heat exchangers 118 are referred to as connection pipes 133, and connection pipes that connect the relay unit E to the air conditioning expansion devices 117 are referred to as connection pipes 134.

[0021] The air conditioning expansion devices 117 function as pressure reducing valves and expansion valves, and are configured to reduce the pressure of the air conditioning refrigerant to cause the air conditioning refrigerant to expand. Each of the air conditioning expansion devices 117 may be constituted by a mechanism whose opening degree is variably controllable, such as a precise flow rate control device based on an electronic expansion valve or an inexpensive refrigerant flow rate regulating device such as a capillary tube. The indoor heat exchangers 118 function as radiators (condensers) or evaporators, and are configured to exchange heat between air supplied from the fan or the like (not illustrated) and the air conditioning refrigerant to evaporate and gasify the air conditioning refrigerant or condense and liquefy the air conditioning refrigerant. The air conditioning expansion devices 117 and the indoor heat exchangers 118 are connected in series.

{Heat Source Circuit for Hot-Water Supply D}

[0022] The heat source circuit for hot-water supply D has a function for supplying the heating energy or cooling energy from the heat source unit A to the refrigeration cycle for hot-water supply 2 via the refrigerant-to-refrigerant heat exchanger 41. The heat source circuit for hot-water supply D is configured such that a heat source expansion device for hot-water supply 119 and the refrigerant-to-refrigerant heat exchanger 41 are connected in series. That is, the refrigeration cycle for air conditioning 1 and the refrigeration cycle for hot-water supply 2 are cascade-connected via the refrigerant-to-refrigerant heat exchanger 41. For convenience of description, a connection pipe that connects the relay unit E to the refrigerant-to-refrigerant heat exchanger 41 is referred to as a connection pipe 135, and a connection pipe that connects the relay unit E to the heat source expansion device for hot-water supply 119 is referred to as a connection pipe 136.

[0023] Similarly to the air conditioning expansion devices 117, the heat source expansion device for hot-water supply 119 functions as a pressure reducing valve and an expansion valve, and is configured to reduce the pressure of the air conditioning refrigerant to cause the air conditioning refrigerant to expand. The heat source expansion device for hot-water supply 119 may be constituted by a mechanism whose opening degree is variably controllable, such as a precise flow rate control device based on an electronic expansion valve or an inexpensive refrigerant flow rate regulating device such as a capillary tube. The refrigerant-to-refrigerant heat exchanger 41 functions as a radiator (condenser) or an evaporator, and is configured to exchange heat between the hot-water supply refrigerant circulating in the refrigeration cycle of the refrigeration cycle for hot-water supply 2 and the air conditioning refrigerant circulating in the refrigeration cycle of the refrigeration cycle for air conditioning 1.

{Relay Unit E}

[0024] The relay unit E connects the use-side units (the indoor unit B, the indoor unit C, and the heat source circuit for hot-water supply D) and the heat source unit A, and has a function of determining whether the indoor heat exchangers 118 are to be radiators or evaporators and the refrigerant-to-refrigerant heat exchanger 41 is to be a water cooler or a water heater by opening and closing either valve means 109a or valve means 1 09b of a first distribution unit 109. The relay unit E is constituted by a gas-liquid separator 108, the first distribution unit 109, a second distribution unit 110, a first internal heat exchanger 111, a first relay expansion device 112, a second internal heat exchanger 113, and a second relay expansion device 114.

[0025] In the first distribution unit 109, the connection pipes 133 and the connection pipe 135 each branch into two pipes, first pipes (connection pipes 133b and a connection pipe 135b) of which are connected to the low-pressure-side connection pipe 107 and second pipes (connection pipes 133a and a connection pipe 135a) of which are connected to a connection pipe (referred to as a connection pipe 132) connected to the gas-liquid separator 108. In the first distribution unit 109, furthermore, the valve means 109a that are controlled to be opened or closed to allow the refrigerant to pass or not pass therethrough are provided in the connection pipes 133a and the connection pipe 135a, and the valve means 109b that are controlled to be opened or closed to allow the refrigerant to pass or not pass therethrough are provided in the connection pipes 133b and the connection pipe 135b.

[0026] In the second distribution unit 110, the connection pipes 134 and the connection pipe 136 each branch into two pipes, first pipes (connection pipes 134a and a connection pipe 136a) of which are connected to a first junction unit 115 and second pipes (connection pipes 134b and a connection pipe 136b) of which are connected to a second junction unit 116. In the second distribution unit 110, furthermore, check valves 110a that permit the refrigerant to be distributed only in one direction are provided in the connection pipes 134a and the connection pipe 136a, and check valves 110b that permit the refrigerant to be distributed only in one direction are provided in the connection pipes 134b and the connection pipe 136b.

[0027] The first junction unit 115 is connected to the gas-liquid separator 108 from the second distribution unit 110 via the first relay expansion device 112 and the first internal heat exchanger 111. The second junction unit 116 branches into pipes between the second distribution unit 110 and the second internal heat exchanger 113, one pipe being connected via the second internal heat exchanger 113 to the first junction unit 115 between the second distribution unit 110 and the first relay expansion device 112 and the other pipe (a second junction unit 116a) being connected to the low-pressure-side connection pipe 107 via the second relay expansion device 114, the second internal heat exchanger 113, and the first internal heat exchanger 111.

[0028] The gas-liquid separator 108 is configured to separate the air conditioning refrigerant into gas refrigerant and liquid refrigerant, and is provided in the high-pressure-side connection pipe 108. The gas-liquid separator 108 has one end connected to the valve means 109a of the first distribution unit 109 and another end connected to the second distribution unit 110 through the first junction unit 115. The first distribution unit 109 has a function of allowing the air conditioning refrigerant to flow into the indoor heat exchangers 118 and the refrigerant-to-refrigerant heat exchanger 41 by either the valve means 109a or the valve means 109b being opened or closed. The second distribution unit 110 has a function of permitting the air conditioning refrigerant to flow in either one direction through each of the check valves 110a and check valves 110b.

[0029] The first internal heat exchanger 111 is provided in the first junction unit 115 between the gas-liquid separator 108 and the first relay expansion device 112, and is configured to exchange heat between the air conditioning refrigerant passing through the first junction unit 115 and the air conditioning refrigerant passing through the second junction unit 116a branching from the second junction unit 116. The first relay expansion device 112 is provided in the first junction unit 115 between the first internal heat exchanger 111 and the second distribution unit 110, and is configured to reduce the pressure of the air conditioning refrigerant to cause the air conditioning refrigerant to expand. The first relay expansion device 112 may be constituted by a mechanism whose opening degree is variably controllable, such as a precise flow rate control device based on an electronic expansion valve or an inexpensive refrigerant flow rate regulating device such as a capillary tube.

[0030] The second internal heat exchanger 113 is provided in the second junction unit 116, and is configured to exchange heat between the air conditioning refrigerant passing through the second junction unit 116 and the air conditioning refrigerant passing through the second junction unit 116a branching from the second junction unit 116. The second relay expansion device 114 is provided in the second junction unit 116 between the second internal heat exchanger 113 and the second distribution unit 110. The second relay expansion device 114 functions as a pressure reducing valve and an expansion valve, and is configured to reduce the pressure of the air conditioning refrigerant to cause the air conditioning refrigerant to expand. Similarly to the first relay expansion device 112, the second relay expansion device 114 may be constituted by a mechanism whose opening degree is variably controllable, such as a precise flow rate control device based on an electronic expansion valve or an inexpensive refrigerant flow rate regulating device such as a capillary tube.

[0031] As described above, the refrigeration cycle for air conditioning 1 constitutes a first refrigerant circuit in which the air conditioning compressor 101, the four-way valve 102, the indoor heat exchangers 118, the air conditioning expansion devices 117, and the outdoor heat exchanger 103 are connected in series, in which the air conditioning compressor 101, the four-way valve 102, the refrigerant-to-refrigerant heat exchanger 41, the heat source expansion device for hot-water supply 119, and the outdoor heat exchanger 103 are connected in series, and in which the indoor heat exchangers 118 and the refrigerant-to-refrigerant heat exchanger 41 are connected in parallel via the relay unit E, and is established by circulating an air conditioning refrigerant in the first refrigerant circuit.

[0032] The air conditioning compressor 101 may be of any type capable of compressing a sucked refrigerant into a high-pressure state, and the type thereof is not particularly limited. The air conditioning compressor 101 may be of any of various types such as reciprocating, rotary, scroll, and screw types. The air conditioning compressor 101 may also be of a type whose rotation speed is variably controllable by an inverter, or of a type whose rotation speed is fixed. Furthermore, the kind of refrigerant circulating in the refrigeration cycle for air conditioning 1 is not particularly limited, and natural refrigerants such as carbon dioxide (CO_2), hydrocarbon, and helium, alternative chlorine-free refrigerants such as HFC410A, HFC407C, and HFC404A, and fluorocarbon refrigerants used in existing products, such as R22 and R134a, may be used.

[0033] The operation of the refrigeration cycle for air conditioning 1 will now be described. Here, a description will be given of the operation when the indoor unit B takes charge of the cooling load, the indoor unit C takes charge of the heating load, and the heat source circuit for hot-water supply D takes charge of the hot water load.

[0034] First, the air conditioning refrigerant compressed into a high-temperature high-pressure refrigerant by the air conditioning compressor 101 is discharged from the air conditioning compressor 101, traveling through the four-way valve 102, passing through the check valve 105c, introduced into the high-pressure-side connection pipe 106, and flows into the gas-liquid separator 108 of the relay unit E in a superheated gaseous state. The air conditioning refrigerant in the superheated gaseous state flowing into the gas-liquid separator 108 is distributed to circuits of the first distribution unit 109 in which the valve means 109a are open. Here, the air conditioning refrigerant in the superheated gaseous state flows into the indoor unit C and the heat source circuit for hot-water supply D.

[0035] The air conditioning refrigerants flowing into the indoor unit C transfer heat in the indoor heat exchangers 118 (to thereby warm indoor air), undergo pressure reduction in the air conditioning expansion devices 117, and merge in the first junction unit 115. Also, the air conditioning refrigerant flowing into the heat source circuit for hot-water supply D transfers heat in the refrigerant-to-refrigerant heat exchanger 41 (to thereby supply heat to the refrigeration cycle for hot-water supply 2), undergoes pressure reduction in the heat source expansion device for hot-water supply 119, and merges with the air conditioning refrigerants flowing from the indoor unit C in the first junction unit 115.

[0036] On the other hand, a portion of the air conditioning refrigerant in the superheated gaseous state flowing into the gas-liquid separator 108 exchanges heat, in the first internal heat exchanger 111, with the air conditioning refrigerant that has been expanded and has become a low-temperature low-pressure refrigerant in the second relay expansion device 114 to obtain a degree of supercooling. The portion of the air conditioning refrigerant in the superheated gaseous state output from the first internal heat exchanger 111 travels through the first relay expansion device 112, and merges with the air conditioning refrigerant that has been used for air conditioning (air conditioning refrigerants that have flowed into the indoor unit C and the heat source circuit for hot-water supply D and that have transferred heat in the indoor heat exchangers 118 and the refrigerant-to-refrigerant heat exchanger 41) in the first junction unit 115.

[0037] The portion of the air conditioning refrigerant in the superheated gaseous state to travel through the first relay expansion device 112 may be prevented from traveling through the first relay expansion device 112 by fully closing the first relay expansion device 112. After that, the portion of the air conditioning refrigerant in the superheated gaseous state exchanges heat, in the second internal heat exchanger 113, with the air conditioning refrigerant that has been expanded and has become a low-temperature low-pressure refrigerant in the second relay expansion device 114 to obtain a degree of supercooling. This air conditioning refrigerant is distributed to the second junction unit 116 side and to the second relay expansion device 114 side.

[0038] The air conditioning refrigerant passing through the second junction unit 116 is distributed to circuits in which the valve means 109b are open. Here, the air conditioning refrigerant passing through the second junction unit 116 flows into the indoor unit B, and is caused to expand into low-temperature low-pressure refrigerants by the air conditioning expansion devices 117. The low-temperature low-pressure refrigerants evaporate in the indoor heat exchangers 118, traveling through the valve means 109b, and merge in the low-pressure-side connection pipe 107. The air conditioning refrigerant passing through the second relay expansion device 114 evaporates by heat exchange in the second internal heat exchanger 113 and the first internal heat exchanger 111, and merges with the air conditioning refrigerants flowing from the indoor unit B in the low-pressure-side connection pipe 107. The merged air conditioning refrigerant in the low-pressure-side connection pipe 107 is introduced into the outdoor heat exchanger 103 through the check valve 1 05d, where liquid refrigerant that may remain depending on operating conditions is evaporated, and returns to the air conditioning compressor 101 through the four-way valve 102 and the accumulator 104.

[Refrigeration Cycle for Hot-Water Supply 2]

[0039] The refrigeration cycle for hot-water supply 2 is constituted by a hot-water supply compressor 21, the heat medium-to-refrigerant heat exchanger 51, a hot-water supply expansion device 22, and the refrigerant-to-refrigerant heat exchanger 41. That is, the refrigeration cycle for hot-water supply 2 constitutes a second refrigerant circuit in which the hot-water supply compressor

21, the heat medium-to-refrigerant heat exchanger 51, the hot-water supply expansion device 22, and the refrigerant-to-refrigerant heat exchanger 41 are connected in series by a refrigerant pipe 45, and is established by circulating the hot-water supply refrigerant in the second refrigerant circuit.

[0040] The hot-water supply compressor 21 is configured to suck in the hot-water supply refrigerant and compress the hot-water supply refrigerant into a high-temperature high-pressure state. The hot-water supply compressor 21 may be of a type whose rotation speed is variably controllable by an inverter, or of a type whose rotation speed is fixed. Furthermore, the hot-water supply compressor 21 may be of any type capable of compressing a sucked refrigerant into a high-pressure state, and the type thereof is not particularly limited. The hot-water supply compressor 21 may be constituted by any of various types such as reciprocating, rotary, scroll, and screw types.

[0041] The heat medium-to-refrigerant heat exchanger 51 is configured to exchange heat between the heat medium (fluid such as water) circulating in the hot-water supply device 3 and the hot-water supply refrigerant circulating in the refrigeration cycle for hot-water supply 2. That is, the refrigeration cycle for hot-water supply 2 and the hot-water supply device 3 are cascade-connected via the heat medium-to-refrigerant heat exchanger 51. The hot-water supply expansion device 22 functions as a pressure reducing valve and an expansion valve, and is configured to reduce the pressure of the hot-water supply refrigerant to cause the hot-water supply refrigerant to expand. The hot-water supply expansion device 22 may be constituted by a mechanism whose opening degree is variably controllable, such as a precise flow rate control device based on an electronic expansion valve or an inexpensive refrigerant flow rate regulating device such as a capillary tube.

[0042] The refrigerant-to-refrigerant heat exchanger 41 is configured to exchange heat between the hot-water supply refrigerant circulating in the refrigeration cycle for hot-water supply 2 and the air conditioning refrigerant circulating in the refrigeration cycle for air conditioning 1. The kind of refrigerant circulating in the refrigeration cycle for hot-water supply 2 is not particularly limited, and natural refrigerants such as carbon dioxide, hydrocarbon, and helium, alternative chlorine-free refrigerants such as HFC410A, HFC407C, and HFC404A, and fluorocarbon refrigerants used in existing products, such as R22 and R134a, may be used.

[0043] The operation of the refrigeration cycle for hot-water supply 2 will now be described.

First, the hot-water supply refrigerant compressed into a high-temperature high-pressure refrigerant by the hot-water supply compressor 21 is discharged from the hot-water supply compressor 21, and flows into the heat medium-to-refrigerant heat exchanger 51. In the heat medium-to-refrigerant heat exchanger 51, the flowing hot-water supply refrigerant transfers heat by heating the water circulating in the hot-water supply device 3. The hot-water supply refrigerant is expanded by the hot-water supply expansion device 22 until its temperature has dropped to less than or equal to the outlet temperature of the refrigerant-to-refrigerant heat exchanger 41 in the heat source circuit for hot-water supply D of the refrigeration cycle for air conditioning 1. The expanded hot-water supply refrigerant receives heat from the air conditioning refrigerant flowing in the heat source circuit for hot-water supply D included in the refrigeration cycle for air conditioning 1, evaporates in the refrigerant-to-refrigerant heat exchanger 41, and returns to the hot-water supply compressor 21.

[Hot-Water Supply Device 3]

[0044] The hot-water supply device 3 is constituted by a water circulation pump 31, the heat medium-to-refrigerant heat exchanger 51, and a hot-water storage tank 32. That is, the hot-water supply device 3 constitutes a water circuit (heat medium circuit) in which the water circulation pump 31, the heat medium-to-refrigerant heat exchanger 51, and the hot-water storage tank 32 are connected in series by a stored hot-water/water circulating pipe 203, and is established by circulating water for hot-water supply in the water circuit. The stored hot-water/water circulating pipe 203 included in the water circuit is composed of a copper tube, a stainless tube, a steel tube, a vinyl chloride pipe, or the like.

[0045] The water circulation pump 31 is configured to suck in the water stored in the hot-water storage tank 32, pressurize the water, and circulate the water in the hot-water supply device 3. The water circulation pump 31 may be of a type whose rotation speed is controlled by an inverter, by way of example. As described above, the heat medium-to-refrigerant heat exchanger 51 is configured to exchange heat between the heat medium (fluid such as water) circulating in the hot-water supply device 3 and the hot-water supply refrigerant circulating in the refrigeration cycle for hot-water supply 2. The hot-water storage tank 32 is configured to store the water heated by the heat medium-to-refrigerant heat exchanger 51.

[0046] The operation of the hot-water supply device 3 will now be described. First, comparatively low temperature water stored in the hot-water storage tank 32 is drawn out of the bottom of the hot-water storage tank 32 and is pressurized by the water circulation pump 31. The water pressurized by the water circulation pump 31 flows into the heat medium-to-refrigerant heat exchanger 51, and receives heat in the heat medium-to-refrigerant heat exchanger 51 from the hot-water supply refrigerant circulating in the refrigeration cycle for hot-water supply 2. That is, the water flowing into the heat medium-to-refrigerant heat exchanger 51 is boiled by the hot-water supply refrigerant circulating in the refrigeration cycle for hot-water supply 2, and its temperature rises. The boiled water returns to a comparatively high temperature upper portion of the hot-water storage tank 32, and is stored in the hot-water storage tank 32.

[0047] As described above, the refrigeration cycle for air conditioning 1 and the refrigeration cycle for hot-water supply 2 have independent refrigerant circuit configurations (the first refrigerant circuit constituting the refrigeration cycle for air conditioning 1 and the second refrigerant circuit constituting the refrigeration cycle for hot-water supply 2). The refrigerants to be circulated in the respective refrigerant circuits may be of the same type or of different types. That is, the refrigerants in the respective refrigerant circuits flow so as to exchange heat in the refrigerant-to-refrigerant heat exchanger 41 and the heat medium-to-refrigerant heat exchanger 51 without being mixed.

[0048] When a refrigerant with a low critical temperature is used as a hot-water supply refrigerant, the hot-water supply refrigerant in the heat transferring process performed by the heat medium-to-refrigerant heat exchanger 51 is assumed to enter a supercritical state during high-temperature hot-water supply. However, in general, when the refrigerant in the heat transferring process is in a supercritical state, the COP largely fluctuates due to changes in the radiator pressure and the radiator outlet temperature. In order to operate with high COP, more sophisticated control is demanded. In general, a refrigerant with a low critical temperature has a higher saturation pressure than other refrigerants for the same temperature, and the thickness of the pipes and compressors needs to be increased accordingly, resulting in an increase in cost.

[0049] In addition, taking into consideration that the recommended temperature of the water to be stored in the hot-water storage tank 32 is 60 degrees C or higher in order to prevent growth of legionella bacteria and the like, the target temperature of hot-water supply is assumed to be typically 60 degrees C or higher at minimum. On the basis of the above consideration, a refrigerant having a critical temperature of 60 degrees C or higher at minimum is used as the hot-water supply refrigerant. With the use of the above refrigerant as the hot-water supply refrigerant for the refrigeration cycle for hot-water supply 2, high COP can be achieved more stably with lower cost. It is anticipated that temperature and pressure will become high in the refrigerant circuit when the refrigerant is commonly used around the critical temperature. Using a high pressure shell type compressor as the hot-water supply compressor 21 enables stable operation.

[0050] While the refrigeration cycle for air conditioning 1 in which excessive refrigerant is stored in a liquid receiver (the accumulator 104) has been illustrated, the invention is not limited to this, and the accumulator 104 may be omitted if excessive refrigerant is stored in a heat exchanger serving as a radiator in a refrigeration cycle. Additionally, while in the illustration of Fig. 1, more than one indoor unit B and more than one indoor unit C are connected by way of example, the number of indoor units to be connected is not particularly limited, and, for example, one or more indoor units B and no indoor unit C or one or more indoor units C may be connected. The capacities of indoor units included in the refrigeration cycle for air conditioning 1 may be the same or different from high to low.

[0051] As described above, in the refrigeration cycle apparatus 100 according to this embodiment, the hot water load system uses a binary cycle. Thus, to provide a demand for high-temperature hot-water supply (for example, 80 degrees C), it is only required to set the temperature of the radiator of the refrigeration cycle for hot-water supply 2 to a high temperature (for example, a condensing temperature of 85 degrees C). Even if there are other heating loads, there is no need to also increase the condensing temperature (for example, 50 degrees C) of the indoor unit C, thus , energy saving is achieved. Furthermore, for example, a demand for high-temperature hot-water supply during the air conditioning cooling operation in the summer would conventionally need to be provided through a boiler or the like. Because hot-water supply is performed through collection and reuse of heating energy, which has been conventionally released in the air, the system COP is significantly increased, leading to energy saving.

[Hot-Water Supply Unit F]

[0052] The hot-water supply unit F has mounted therein the refrigerant-to-refrigerant heat exchanger 41, the heat source expansion device for hot-water supply 119, the heat medium-to-refrigerant heat exchanger 51, the hot-water supply compressor 21, and the hot-water supply expansion device 22. That is, the hot-water supply unit F accommodates therein a portion of the refrigeration cycle for air conditioning 1 via the refrigerant-to-refrigerant heat exchanger 41, the entirety of the refrigeration cycle for hot-water supply 2, and a portion of the hot-water supply device 3 via the heat medium-to-refrigerant heat exchanger 51.

[0053] Fig. 2 is a schematic configuration diagram for explaining information transfer in the refrigeration cycle apparatus 100 according to an embodiment of the present invention. The information transfer performed by the refrigeration cycle apparatus 100 will be described with reference to Figs. 1 and 2. In Fig. 2, the refrigeration cycle apparatus 100 in which two indoor units (an indoor unit B and an indoor unit C) and two hot-water supply units F (a hot-water supply unit F1 and a hot-water supply unit F2) are connected to one heat source unit A is illustrated by way of example.

[0054] As described with reference to Fig. 1, in the refrigeration cycle apparatus 100, the heat source unit A and the relay unit E are connected via refrigerant pipes 5 (the high-pressure-side connection pipe 106, the low-pressure-side connection pipe 107), and the relay unit E and the use-side units are connected via refrigerant pipes 6 (the connection pipes 133, the connection pipes 134, the connection pipe 135, the connection pipe 136), thereby constituting a single refrigerant circuit system (the refrigeration cycle for air conditioning 1). The heat source unit A is provided with a heat source unit controllers 61, and the relay unit E is provided with a relay unit controller 62. Each of the indoor unit B and the indoor unit C is provided with an indoor unit controller (use-side unit controller) 63, and each of the hot-water supply units F is provided with a hot-water supply unit controller (use-side unit controller) 64.

[0055] In the refrigeration cycle apparatus 100, the heat source unit A is controlled by the heat source unit controller 61, and the relay unit E is controlled by the relay unit controller 62. Further, the indoor unit B and the indoor unit C are controlled by the indoor unit controllers 63, and the hot-water supply units F are controlled by the hot-water supply unit controllers 64.

[0056] The heat source unit controller 61 and the relay unit controller 62 are connected to each other via a transmission line 7 so that information can be transferred between them. The relay unit controller 62 and the indoor unit controllers 63 are connected to each other via a transmission line 8 so that information can be transferred between them. Similarly, the relay unit controller 62 and the hot-water supply unit controllers 64 are connected to each other via the transmission line 8 so that information can be transferred between them. The indoor unit controllers 63 and the hot-water supply unit controllers 64 are connected to remote controllers 65 via transmission lines 9 so that information can be transferred between the indoor unit controllers 63 and the associated remote controllers 65 and between the hot-water supply unit controllers 64 and the associated remote controllers 65.

[0057] The heat source unit controller 61 is further connected to a heat source unit controller in another refrigerant system (not illustrated) via a transmission line 10. A centralized controller 66 for centralized management of the refrigeration cycle apparatus 100 is also connected to the transmission line 10.

[0058] Each of the heat source unit controller 61, the relay unit controller 62, the indoor unit controllers 63, the hot-water supply unit controllers 64, the remote controllers 65, and the centralized controller 66 is assigned a unique address, and is configured to obtain the address of a communication partner through manual setting or automatic determination at the time of system start. In addition, the heat source unit controller 61 is configured to obtain the operating capacities of all the units connected to the relay unit E, including the indoor unit B, the indoor unit C, and the hot-water supply units F, through communication at the time of system start.

[0059] Fig. 3 is a schematic diagram schematically illustrating the connection state in a hot-water supply unit F of the refrigeration cycle apparatus 100 according to an embodiment of the present invention. The connection state in a hot-water supply unit F will be described with reference to Fig. 3. As illustrated with reference to Fig. 1, the hot-water supply unit F is provided with the hot-water storage tank 32. The hot-water storage tank 32 is provided with a water supply valve 33 disposed at a water inlet (illustration omitted), a water discharge valve 34 disposed at a water outlet (illustration omitted), a water temperature sensor 35 that detects the temperature of water, hot water, or the like stored in the hot-water storage tank 32, and a water level sensor 36 that detects the amount (water level) of water, hot water, or the like stored in the hot-water storage tank 32.

[0060] The hot-water supply unit controller 64 is connected to the water temperature sensor 35 and the water level sensor 36, and is configured to be capable of obtaining the temperature of water and the amount of water in the hot-water storage tank 32 on the basis of information transferred from the water temperature sensor 35 and the water level sensor 36. The hot-water supply unit controller 64 is also connected to the water supply valve 33, and is configured to control the opening and closing of the water supply valve 33. That is, the hot-water supply unit controller 64 is configured to open the water supply valve 33 to supply the hot-water storage tank 32 with cold water. The hot-water supply unit controller 64 is further connected to the water discharge valve 34, and is configured to control the opening and closing of the water discharge valve 34. That is, the hot-water supply unit controller 64 is configured to open the water discharge valve 34 so that hot water can be discharged to the outside of the hot-water storage tank 32.

[0061] Fig. 4 is a flowchart illustrating a flow of a communication/operation process executed by the heat source unit controller 61. The flow of the communication/operation process executed by the heat source unit controller 61 will be described with reference to Fig. 4. Steps S100 to S106 illustrated in Fig. 4 represent processes executed by the heat source unit controller 61. A description will be given by taking the hot-water supply unit F1 as an example.

[0062] First, the details of communication when a set temperature of the hot-water supply unit F1 is set will be described.

A user operates the associated remote controller 65 and sets a set temperature of the hot-water supply unit F1. At this time, the user can set a binary set temperature. The term binary set temperature refers to a hot-water supply temperature (first set temperature) required for the hot-water supply unit F1 and a temperature (second set temperature) when the hot-water supply unit F1 automatically operates for the purpose of energy saving or continuation of stable operation of the overall system. The second set temperature is set to a value higher than the first set temperature. For example, the user sets 55 degrees C as the first set temperature and 60 degrees C as the second set temperature.

[0063] When a set temperature is input, the remote controller 65 saves the set binary set temperature in a memory, and transmits the set binary set temperature to the associated hot-water supply unit controller 64 via the transmission line 9. Upon receipt of the set binary set temperature, the hot-water supply unit controller 64 saves the received binary set temperature in a memory, and transmits the binary set temperature to the relay unit controller 62 via the transmission line 8. The binary set temperature is further transmitted to the centralized controller 66 through the transmission line 8, the transmission line 7, and the transmission line 10. The relay unit controller 62 that has received the binary set temperature also transmits the binary set temperature of each hot-water supply unit F to the heat source unit controller 61 via the transmission line 7.

[0064] When the user do not wish to cause the hot-water supply unit F to automatically operate, they may not set the second set temperature. Alternatively, it is possible to allow the setting of whether or not the automatic operation be carried out in the hot-water supply F by way of using, for example, a DIP switch or the like provided in the heat source unit A. It will also be possible for the user to set the binary set temperature by manipulating the centralized controller 66. In this case, the centralized controller 66 saves a set binary set temperature in a memory, and transmits the set binary set temperature to the associated hot-water supply unit controller 64 through the transmission line 10, the transmission line 7, and the transmission line 8.

[0065] Upon receipt of the set binary set temperature, the hot-water supply unit controller 64 transmits the received binary set temperature to the relay unit controller 62 via the transmission line 8, and also transmits the binary set temperature to the associated remote controller 65 through the transmission line 9. The above communication allows the heat source unit controller 61 to keep information about all the hot-water supply units F connected to the refrigerant circuit as to whether or not automatic operation is possible.

[0066] Next, the details of control during the operation of the heat source unit controller 61 will be described. First, the heat source unit controller 61 performs an analysis process for newly received communication (step S101). The communication received here includes the operating/stopping state of all the units connected to the refrigerant circuit, including the indoor units B, the indoor units C, and the hot-water supply units F, and information as to whether or not automatic operation is possible. After the analysis process has been performed, the heat source unit controller 61 determines whether or not automatic operation is possible (step S102). For example, if one or more of automatically operable hot-water supply units F are stopped or are under automatic operation, it is determined that automatic operation is possible. This is because the apparatus may be used such that even when there is a hot-water supply unit F that is set as a unit possible to perform automatic operation, it may not be permitted to automatically stop when normal operation is started by a user operation.

[0067] If automatic operation is possible (step S102; Y), the heat source unit controller 61 analyses the operating capacity, the load state, the system COP, and the like from various kinds of data, such as the operating/stopping state, pressure, temperature, compressor operating frequency, current, and the like of all the units connected to the refrigerant circuit, such as the indoor units B, the indoor units C, and the hot-water supply units F (step S103). For example, the balance of the cooling load, heating load, and the hot water load are determined from the total capacity of an indoor unit B and an indoor unit C with the cooling thermo-on, the total capacity of an indoor unit B and an indoor unit C with the heating thermo-on, and the total capacity of hot-water supply units F with the thermo-on. Further, when in a state where heating load is small with no cooling load, and the operating frequency of the compressor is low, then it can be determined that a small-capacity heating operation is being performed. Additionally, when the outdoor temperature is high along with the indoor temperature, and the high-pressure side pressure is high, then it can be determined that a small-capacity overloaded heating operation is performed.

[0068] After the analysis process has been performed, the heat source unit controller 61 determines whether or not the operating condition can be improved by operating or stopping an automatically operable hot-water supply unit F (step S104). For example, when the cooling load is larger than the heating and hot water loads, if the difference between the cooling load and the heating and hot water loads can be reduced by operating an automatically operable hot-water supply unit F, then it can be determined that the system COP will be increased by allowing the hot-water supply unit F to operate. Further, from this state, when the number of indoor units C that perform heating operation is increased by manipulation of a user operation and, accordingly, when the heating and hot water loads become larger than the cooling load, then, while preventing switching from the cooling main operation to the heating main operation, it can be determined that the system COP will be increased by stopping the hot-water supply unit F that has been allowed to automatically operate.

[0069] Furthermore, when in the state of the small-capacity heating operation, it can be determined that the motor efficiency of the air conditioning compressor 101 will be improved by allowing an automatically operable hot-water supply unit F to operate, which results in energy saving operation. Additionally, from this state, when the number of indoor units C that perform heating operation is increased by manipulation of an user operation and when the heating load becomes large, then, it can be determined that power consumption can be reduced by stopping the hot-water supply unit F that has been allowed to automatically operate. When in the state of the small-capacity overloaded heating operation, it can be determined that the high-pressure-side pressure can be reduced by operating an automatically operable hot-water supply unit F and that stable operation can be continued. After that, if the high-pressure-side pressure is sufficiently reduced by, for example, change of the number of units operated, it can be determined that power consumption can be reduced by stopping the hot-water supply unit F that has been allowed to automatically operate.

[0070] Here, when a plurality of automatically operable hot-water supply units F exist and the operating condition can be most improved by changing only some of the hot-water supply units F, the hot-water supply units F to be changed are determined in accordance with a preset priority. Here, for example, the priority may be manually set in advance. The priority may be set in accordance with the intended use such as for a guest room in a hotel, a room for employees, and the like. Another method is also possible in which the priority is set in accordance with the addresses of the hot-water supply unit controllers 64. In this case, the method is made feasible by setting the values of the addresses in ascending order or descending order in accordance with the priority.

[0071] There is another method in which the priority is determined in accordance with the integrated operating time of each hot-water supply unit F. In this method, a hot-water supply unit F with a short integrated operating time is operated with priority to make the integrated operating times uniform, thereby making it possible to avoid the problem of shortening the product life of only a specific hot-water supply unit F. There is also a method in which the priority is set in accordance with the value of the difference between the water temperature in the hot-water storage tank 32 of each hot-water supply unit F and a set temperature. In this method, a hot-water supply unit F having a large temperature difference is preferentially operated, thereby enabling continuous operation for a long time.

[0072] If it is determined that the operating condition can be improved by operating and stopping an automatically operable hot-water supply unit F (step S104; Y), the heat source unit controller 61 transmits information of the hot-water supply unit or units F to be operated and stopped to the relay unit controller 62 (step S105). After the completion of the transmission process, the heat source unit controller 61 performs normal processes such as receiving a sensor input and controlling the actuators (step S106). Meanwhile, also when it is determined that automatic operation is not possible (step S102; N) or when it is determined that the operating condition cannot be improved by operating and stopping an automatically operable hot-water supply unit F (step S104; N), the heat source unit controller 61 performs the normal processes (step S106).

[0073] Next, the operation of the relay unit controller 62 will be described. Upon receipt of an automatic operation/stopping command for a hot-water supply unit F from the heat source unit controller 61, the relay unit controller 62 transmits the automatic operation/stopping command to the associated hot-water supply unit controller 64. Upon receipt of notification of a change of the operating condition from an indoor unit controller 63 or a hot-water supply unit controller 64, the relay unit controller 62 transmits the notification of the change in the operating condition to the heat source unit controller 61.

[0074] Next, the operation of the hot-water supply unit controller 64 will be described.
Upon receipt of an automatic operation/stopping command from the relay unit controller 62, the hot-water supply unit controller 64 changes the operating condition in accordance with the command, and transmits notification of the change of the operating condition to the associated remote controller 65 and the centralized controller 66. Upon receipt of a normal operation or stopping command from the remote controller 65 or the centralized controller 66, the hot-water supply unit controller 64 changes the operating condition in accordance with the command, and transmits the change of the operating condition to the relay unit controller 62. The hot-water supply unit controller 64 further identifies the operating condition of the associated hot-water supply unit F as that in normal operation or automatic operation, and holds the operating condition. Further, the hot-water supply unit controller 64 also transmits information of the identified operating conditions of the remote controllers 65 and the centralized controller 66 to the remote controllers 65 and the centralized controller 66.

[0075] In normal operation, the hot-water supply unit controller 64 operates in order to allow the water temperature to reach the first set temperature, and the hot-water supply unit controller 64 turns off the thermostat when the water temperature has reached the first set temperature. In automatic operation, however, the hot-water supply unit controller 64 maintains the on-state of the thermostat until the water temperature has reached the second set temperature. This is because the hot-water supply unit F is made to be able to continue its operation for a long time for the purpose of energy saving or continuation of stable operation of the overall system. Here, when the water temperature is near the second set temperature, if the hot-water storage tank 32 has some room in its storage capacity, the water supply valve 33 is opened to supply the hot-water storage tank 32 with cold water to reduce the water temperature, and the operation is continued. If the hot-water storage tank 32 is full, the water discharge valve 34 is opened to discharge a certain amount of hot water. Then, the hot-water storage tank 32 is supplied with cold water, and the operation is continued. It is assumed here that the discharge control of cold water can be selected by separately providing a means for determining a priority over continuation of automatic operation.

[0076] Next, the operation of a remote controller 65 and the centralized controller 66 will be described.
Upon receipt of notification of a change of the automatic operation/stopping condition from the associated hot-water supply unit controller 64, the remote controller 65 and the centralized controller 66 recognize the information, and reflect the information on display. In this case, also regarding display, the normal operation and the automatic operation may be displayed in a distinguishable manner. The purpose is to allow the user to recognize that the automatic operation is in progress and to prevent the user from mistakenly thinking that some other event is in

progress such as forgetting to turn off the associated hot-water supply unit F using a remote control (remote controller 65). Additionally, when the associated hot-water supply unit F is operated or stopped by a user, the remote controller 65 and the centralized controller 66 recognize information, reflect the information on display, and transmit the information to the associated hot-water supply unit controller 64.

[0077] In Fig. 4, a case where the heat source unit controller 61 includes a means for allowing the hot-water supply unit F to operate is illustrated by way of example. Any other controller may include a means for allowing the hot-water supply unit F to operate. The advantage of the system having a means for allowing the hot-water supply unit F to operate in the heat source unit controller 61 is that the amount of communication can be reduced because the heat source unit A is capable of performing control determination using data of the pressure and temperature thereof, compressor operating frequency, current, and the like. In addition, the centralized controller 66 can include a means for operating a hot-water supply unit F. The advantage of this method is that an optimum operating schedule of the hot-water supply unit F can be predicted and created by performing determination using schedule setting information of the overall system which is held in the centralized controller 66.

[0078] Also, each of the indoor unit controllers 63 can include a means for operating a hot-water supply unit F. The advantage of this system is that control can be performed using a simple algorithm such as operating and stopping a hot-water supply unit F in association with operating and stopping of the indoor unit B and the indoor unit C. Additionally, a means for operating a hot-water supply unit F can also be provided in the hot-water supply unit controller 64 itself. The advantage of this system is that, due to the autonomous control, the hot-water supply unit F can contribute to energy saving while reducing changes in water temperature.

[0079] As described above, when the cooling load is larger than the heating load and the hot water load, the refrigeration cycle apparatus 100 operates the hot-water supply device, thereby increasing the system COP and enabling a reduction in running cost while achieving energy saving. Also, the refrigeration cycle apparatus 100 operates the hot-water supply device during the small-capacity heating operation, thereby improving the motor efficiency of the air conditioning compressor 101 and enabling a reduction in running cost while further achieving energy saving. Additionally, the refrigeration cycle apparatus 100 causes the hot-water supply device to operate in the case of the small-capacity overloaded heating operation, thereby reducing the high-pressure-side pressure and allowing for continuation of stable operation.

[0080] In this embodiment, the refrigeration cycle apparatus 100 in which the secondary refrigerant (hot water) of a hot-water supply unit F is used as a heat storing heat medium has been described by way of example. However, the configuration of the refrigeration cycle apparatus 100 is not limited to this. It goes without saying that, for example, an air-conditioning apparatus illustrated in Fig. 5 (of the type in which heat is transferred from a direct expansion air conditioner to another secondary refrigerant) can also be used in a similar manner. In this embodiment, furthermore, a case where a hot-water supply unit F is present has been described by way of example. However, it goes without saying that even in the case of the absence of a hot-water supply unit F, the overall air conditioning loads of the indoor unit B and the indoor unit C may be desirably balanced.

[0081] Fig. 5 is a refrigerant circuit diagram illustrating another example of the refrigerant circuit configuration of a refrigeration cycle apparatus according to an embodiment of the present invention (hereinafter referred to as a refrigeration cycle apparatus 100A). The refrigerant circuit configuration and operation of the refrigeration cycle apparatus 100A will be described with reference to Fig. 5. In Fig. 5, a case where the refrigeration cycle apparatus 100A is an air-conditioning apparatus capable of simultaneously supplying a cooling load and a heating load (or a hot water load) by utilizing a refrigeration cycle in which a refrigerant (heat-source refrigerant) is circulated is illustrated by way of example. The difference between Fig. 5 and Fig. 1 will be primarily described, and, in Fig. 5, the same portions as those in Fig. 1 are assigned the same numerals and a description thereof is omitted.

[0082] As illustrated in Fig. 5, the heat source unit A and a relay unit (hereinafter referred to as the relay unit E1) are connected to each other by a refrigerant pipe 5 (the high-pressure-side connection pipe 106, the low-pressure-side connection pipe 107) via a heat exchanger related to heat medium 71 a and a heat exchanger related to heat medium 71 b which are included in the relay unit E1. The relay unit E1 and an indoor unit (hereinafter referred to as the indoor unit B1) are also connected to each other by a refrigerant pipe 6 via the heat exchanger related to heat medium 71 a and the heat exchanger related to heat medium 71 b. In Fig. 5, all the illustrated indoor units are referred to as indoor units B1 for convenience of illustration.

[Indoor Units B1]

[0083] Each of the indoor units B1 has mounted therein an indoor heat exchanger 118. That is, each of the indoor units B1 is different from the indoor unit B in that the air conditioning expansion device 117 is not mounted. The indoor heat exchangers 118 are designed to be connected to heat medium flow control devices 75 and second heat medium flow switching devices 76 in the relay unit E1 by refrigerant pipes 6. In Fig. 5, a case where four indoor units B1 are connected to the relay unit E1 is illustrated by way of example. However, the number of indoor units B1 connected is not limited to four.

[Relay Unit E1]

[0084] The relay unit E1 has mounted therein the two heat exchangers related to heat medium 71, two expansion devices 72, two on-off devices 73, two second refrigerant flow switching devices 74, two pumps 80, four first heat medium flow switching devices 77, the four second heat medium flow switching devices 76, and the four heat medium flow control devices 75.

[0085] Each of the two heat exchangers related to heat medium 71 (the heat exchanger related to heat medium 71 a and the heat exchanger related to heat medium 71 b) functions as a condenser (radiator) or an evaporator, and is configured to exchange heat between the heat-source-side refrigerant and the heat medium to transfer cooling energy or heating energy generated by the heat source unit A and stored in the heat-source-side refrigerant to the heat medium. The heat exchanger related to heat medium 71 a is provided between the expansion device 72a and a second refrigerant flow switching device 74a, and serve to cool the heat medium in a cooling/heating combined operation mode. The heat exchanger related to heat medium 71 b is provided between the expansion device 72b and a second refrigerant flow switching device 74b, and serves to heat the heat medium in the cooling/heating combined operation mode.

[0086] Each of the two expansion devices 72 (the expansion device 72a and the expansion device 72b) has the function of a pressure reducing valve or an expansion valve, and is configured to reduce the pressure of the heat-source-side refrigerant to cause the heat-source-side refrigerant to expand. The expansion device 72a is provided upstream from the heat exchanger related to heat medium 71 a in the direction of the flow of the heat-source-side refrigerant during the cooling operation. The expansion device 72b is provided upstream from the heat exchanger related to heat medium 71 b in the direction of the flow of the heat-source-side refrigerant during the cooling operation. Each of the two expansion devices 72 may be constituted by a mechanism whose opening degree is variably controllable, such as an electronic expansion valve.

[0087] The two on-off devices 73 (an on-off device 73a and an on-off device 73b) are constituted by two-way valves or the like, and are configured to open and close the refrigerant pipe 5. The on-off device 73a is provided on the heat-source-side refrigerant inlet side of the refrigerant pipe 5. The on-off device 73b is provided in a pipe that connects the heat-source-side refrigerant inlet and outlet sides of the refrigerant pipe 5. Each of the two second refrigerant flow switching devices 74 (the second refrigerant flow switching device 74a and the second refrigerant flow switching device 74b) is constituted by a four-way valve or the like, and is configured to switch the flow of the heat-source-side refrigerant in accordance with the operation mode. The second refrigerant flow switching device 74a is provided downstream from the heat exchanger related to heat medium 71a in the direction of the flow of the heat-source-side refrigerant during the cooling operation. The second refrigerant flow switching device 74b is provided downstream from the heat exchanger related to heat medium 71 b in the direction of the flow of the heat-source-side refrigerant during the cooling only operation.

[0088] The two pumps 80 (a pump 80a and a pump 80b) are configured to circulate the heat medium passing through the refrigerant pipes 6. The pump 80a is provided in the refrigerant pipe 6 between the heat exchanger related to heat medium 71 a and the second heat medium flow switching devices 76. The pump 80b is provided in the refrigerant pipe 6 between the heat exchanger related to heat medium 71 b and the second heat medium flow switching devices 76. The two pumps 80 may be constituted by, for example, pumps whose capacity can be controlled or the like.

[0089] Each of the four first heat medium flow switching devices 77 is constituted by a three-way valve or the like, and is configured to switch the flow path of the heat medium. The first heat medium flow switching devices 77, the number of which corresponds to the number of indoor units B1 installed (here, four), are provided. In each of the first heat medium flow switching devices 77, one of the three ways is connected to the associated heat exchanger related to heat medium 71 a, another of the three ways is connected to the associated heat exchanger related to heat medium 71b, and the other of the three ways is connected to the associated heat medium flow control device 75. The first heat medium flow switching devices 77 are provided on the outlet side of the heat medium flow paths extending from the indoor heat exchangers 118.

[0090] Each of the four second heat medium flow switching devices 76 is constituted by a three-way valve or the like, and is configured to switch the flow path of the heat medium. The second heat medium flow switching devices 76, the number of which corresponds to the number of indoor units B installed (here, four), are provided. In each of the second heat medium flow switching devices 76, one of the three ways is connected to the associated heat exchanger related to heat medium 71 a, another of the three ways is connected to the associated heat exchanger related to heat medium 71b, and the other of the three ways is connected to the associated indoor heat exchanger 118, and the second heat medium flow switching devices 76 are provided on the inlet side of the heat medium flow paths extending from the indoor heat exchangers 118.

[0091] Each of the four heat medium flow control devices 75 is constituted by a two-way valve or the like using, for example, a stepping motor, and is configured to make changeable the opening degree of the associated refrigerant pipe 6 serving as a heat medium flow path to control the flow rate of the heat medium. The heat medium flow control devices 75, the number of which corresponds to the number of indoor units B1 installed (here, four), are provided. In each of the heat medium flow control devices 75, one way is connected to the associated indoor heat exchanger 118 and the other way is connected to the associated first heat medium flow switching device 77, and the heat medium flow control devices 75 are provided on the outlet side of the heat medium flow paths extending from the indoor heat exchangers 118. The heat medium flow control devices 75 may be provided on the inlet side of the heat medium flow paths extending from the indoor heat exchangers 118.

[0092] In the refrigeration cycle apparatus 100A, therefore, the heat source unit A and the relay unit E1 are connected to each other via the heat exchanger related to heat medium 71 a and the heat exchanger related to heat medium 71 b which are provided in the relay unit E1, and the relay unit E1 and the indoor units B1 are also connected to each other via the heat exchanger related to heat medium 71 a and the heat exchanger related to heat medium 71 b. That is, the refrigeration cycle apparatus 100a is configured such that the heat-source-side refrigerant circulating in the refrigeration cycle for air conditioning 1 and the heat medium circulating in the a heat medium cycle (for example, the refrigeration cycle for hot-water supply 2 described with reference to Fig. 1) exchange heat in the heat exchanger related to heat medium 71 a and the heat exchanger related to heat medium 71b.

[0093] The refrigeration cycle apparatus 100A having the above configuration increases the system COP by causing the hot-water supply device to operate when the cooling load is larger than the heating load (or the hot water load), and enables a reduction in running cost while achieving energy saving. The refrigeration cycle apparatus 100A further improves the motor efficiency of the air conditioning compressor 101 by causing the heating device (or the hot-water supply device) to operate during the small-capacity heating operation, and enables a reduction in running cost while further achieving energy saving. Additionally, in the case of the small-capacity overloaded heating operation, the refrigeration cycle apparatus 100A causes the heating device (or the hot-water supply device) to operate, thereby reducing the high-pressure-side pressure and allowing for continuation of stable operation.

Reference Signs List

[0094] 1 refrigeration cycle for air conditioning, 2 refrigeration cycle for hot-water supply, 3 hot-water supply device, 5 refrigerant pipe, 6 refrigerant pipe, 7 transmission line, 8 transmission line, 9 transmission line, 10 transmission line, 21 hot-water supply compressor, 22 hot-water supply expansion device, 31 water circulation pump, 32 hot-water storage tank, 33 water supply valve, 34 water discharge valve, 35 water temperature sensor, 36 water level sensor, 41 refrigerant heat exchanger, 45 refrigerant pipe, 51 refrigerant heat exchanger, 61 heat source unit controller, 62 relay unit controller, 63 indoor unit controller, 64 hot-water supply unit controller, 65 remote controller, 66 centralized controller, 71 heat exchanger related to heat medium, 71 a heat exchanger related to heat medium, 71 b heat exchanger related to heat medium, 72 expansion device, 72a expansion device, 72b expansion device, 73 on-off device, 73a on-off device, 73b on-off device, 74 refrigerant flow switching device, 74a refrigerant flow switching device, 74b refrigerant flow switching device, 75 heat medium flow control device, 76 second heat medium flow switching device, 77 first heat medium flow switching device, 80 pump, 80a pump, 80b pump, 100 refrigeration cycle apparatus, 100A refrigeration cycle apparatus, 101 air conditioning compressor, 102 four-way valve, 103 outdoor heat exchanger, 104 accumulator, 105a check valve, 105b check valve, 105c check valve, 105d check valve, 106 high-pressure-side connection pipe, 107 low-pressure-side connection pipe, 108 gas-liquid separator, 109 first distribution unit, 109a valve means, 109b valve means, 110 second distribution unit, 110a check valve, 110b check valve, 111 internal heat exchanger, 112 first relay expansion device, 113 internal heat exchanger, 114 second relay expansion device, 115 first junction unit, 116 second junction unit, 116a second junction unit, 117 air conditioning expansion device, 118 indoor heat exchanger, 119 heat source expansion device for hot-water supply, 130 first connection pipe, 131 second connection pipe, 132 connection pipe, 133 connection pipe, 133a connection pipe, 133b connection pipe, 134 connection pipe, 134a connection pipe, 134b connection pipe, 135 connection pipe, 135a connection pipe, 135b connection pipe, 136 connection pipe, 136a connection pipe, 136b connection pipe, 203 stored hot-water/water circulating pipe, A heat source unit, B indoor unit, B1 indoor unit, C indoor unit, D heat source circuit for hot-water supply, E relay unit, E1 relay unit, F hot-water supply unit, F1 hot-water supply unit, F2 hot-water supply unit, a connection portion, b connection portion, c connection portion, d connection portion.

Claims

1. A refrigeration cycle apparatus comprising:

   at least one heat source unit having mounted therein at least an air conditioning compressor and a heat-source-side heat exchanger;
   a plurality of use-side units each having mounted therein at least a use-side heat exchanger; and
   at least one relay unit that is disposed between the heat source unit and the use-side units and that transfers heating energy or cooling energy generated by the heat source side unit to the use-side units,
   wherein the plurality of use-side units are operated so that a thermal cooling load and a thermal

heating load to be executed by the plurality of use-side units are balanced.

2. The refrigeration cycle apparatus of claim 1, wherein when a total load on a use-side unit that is executing a thermal cooling load operation is larger than a total load on a use-side unit that is executing a thermal heating load operation,
a use-side unit that is not executing either the thermal heating load operation or the thermal cooling load operation is made to execute the thermal heating load operation.

3. The refrigeration cycle apparatus of claim 2, wherein when the thermal heating load is small under no thermal cooling load and a compressor operating frequency is low, or when both an outside temperature and an indoor temperature are high and a high-pressure-side pressure is high,
it is determined that a total load on a use-side unit that is executing the thermal cooling load operation is larger than a total load on a use-side unit that is executing the thermal heating load operation.

4. The refrigeration cycle apparatus of any one of claims 1 to 3, wherein
the thermal heating load operation to be executed by a use-side unit is a heating operation or a hot-water supply operation, and
the thermal cooling load operation to be executed by a use-side unit is a cooling operation.

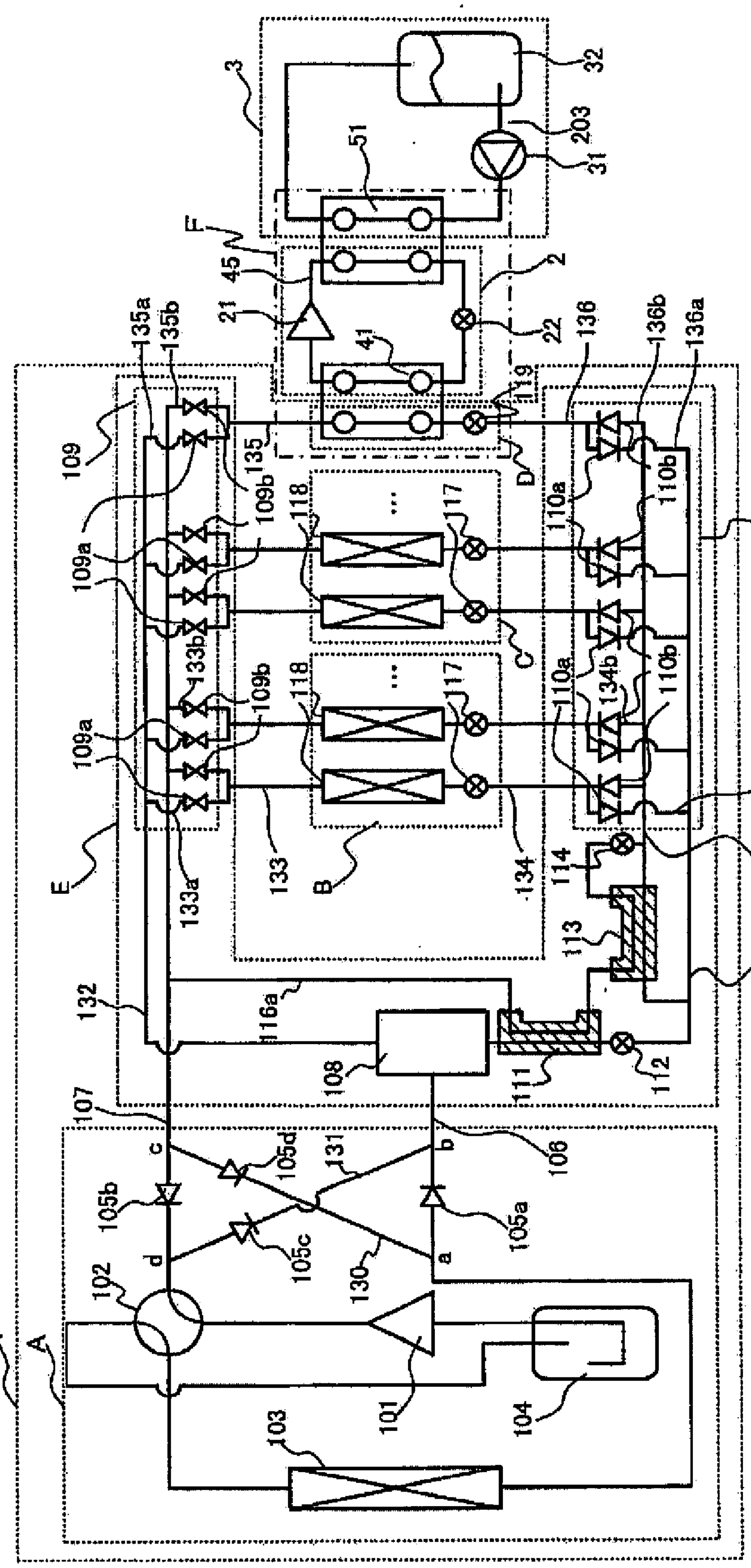
5. The refrigeration cycle apparatus of any one of claims 2 to 4, wherein
two temperatures can be set for each of the use-side units, the two temperatures including a temperature required by the use-side unit and a temperature when the use-side unit is automatically operated.

6. The refrigeration cycle apparatus of any one of claims 2 to 5, wherein
when there are a plurality of use-side units that are not executing either the thermal heating load operation or the thermal cooling load operation,
a use-side unit among the not-executing use-side units is made to execute the thermal heating load operation in accordance with a preset priority.

7. The refrigeration cycle apparatus of any one of claims 4 to 6, wherein
when there is no use-side unit that is not executing either the thermal heating load operation or the thermal cooling load operation,
the thermal heating load operation is continued by supplying- cold water.

8. An information transfer method applied to the refrigeration cycle apparatus of any one of claims 1 to 7, wherein
the heat source unit is provided with a heat source unit controller, the relay unit is provided with a relay unit controller, each of the use-side units is provided with a use-side unit controller, and
transfer of information from each of the controllers enables any of the controllers to determine the load balance between the plurality of use-side units.

F I G. 1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105b
105c
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110b
111
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113
114
115
116
116a
117
118
119
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132
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133a
133b
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134a
134b
135
135a
135b
136
136a
136b
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b
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C
D
E
F
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22
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51
3
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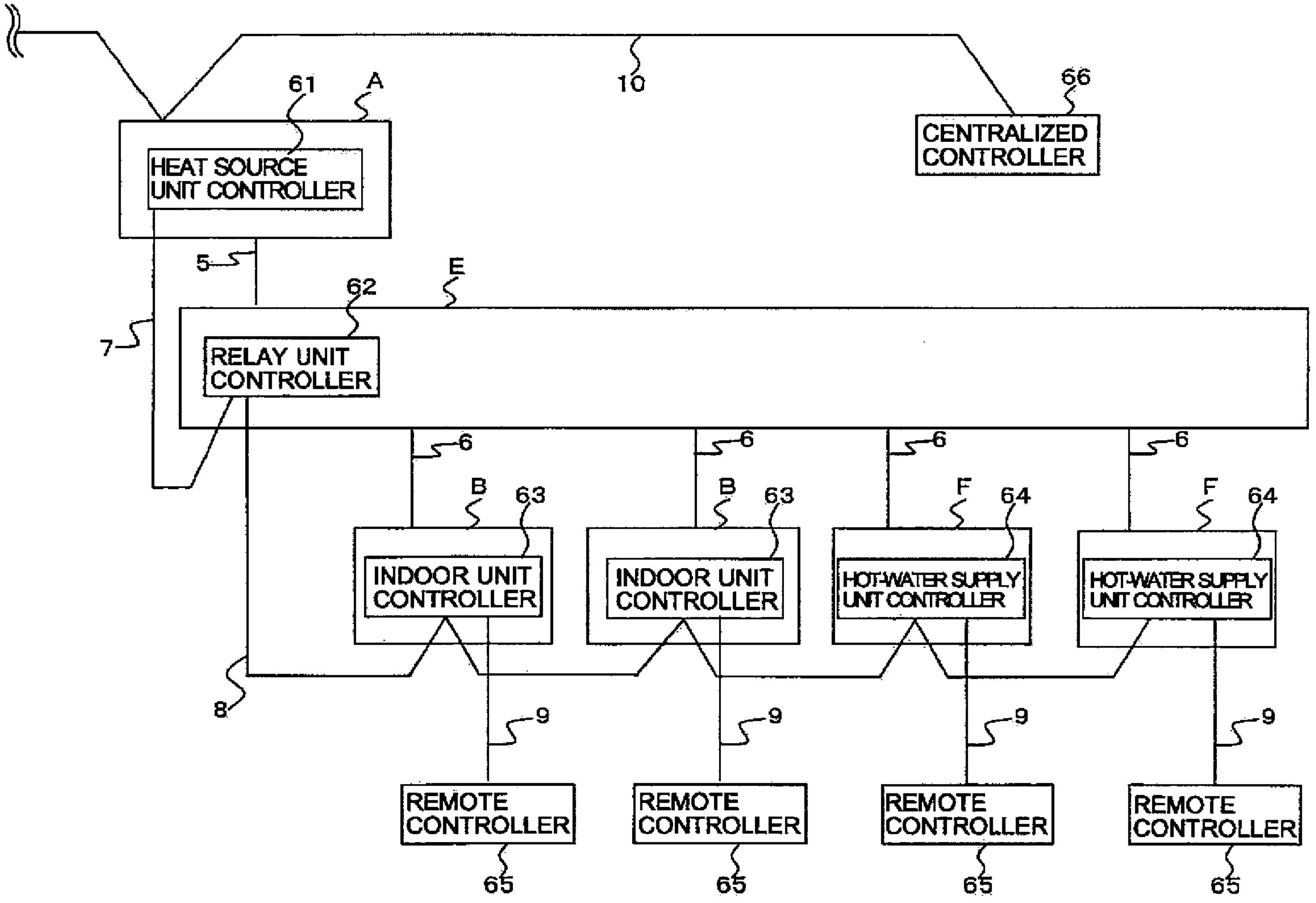
32
203

FIG. 2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A
10
66
HEAT SOURCE UNIT CONTROLLER
CENTRALIZED CONTROLLER
5
62
E
7
RELAY UNIT CONTROLLER
6
6
6
6
B
63
B
63
F
64
F
64
INDOOR UNIT CONTROLLER
INDOOR UNIT CONTROLLER
HOT-WATER SUPPLY UNIT CONTROLLER
HOT-WATER SUPPLY UNIT CONTROLLER
8
9
9
9
9
REMOTE CONTROLLER
REMOTE CONTROLLER
REMOTE CONTROLLER
REMOTE CONTROLLER
65
65
65
65

FIG. 3

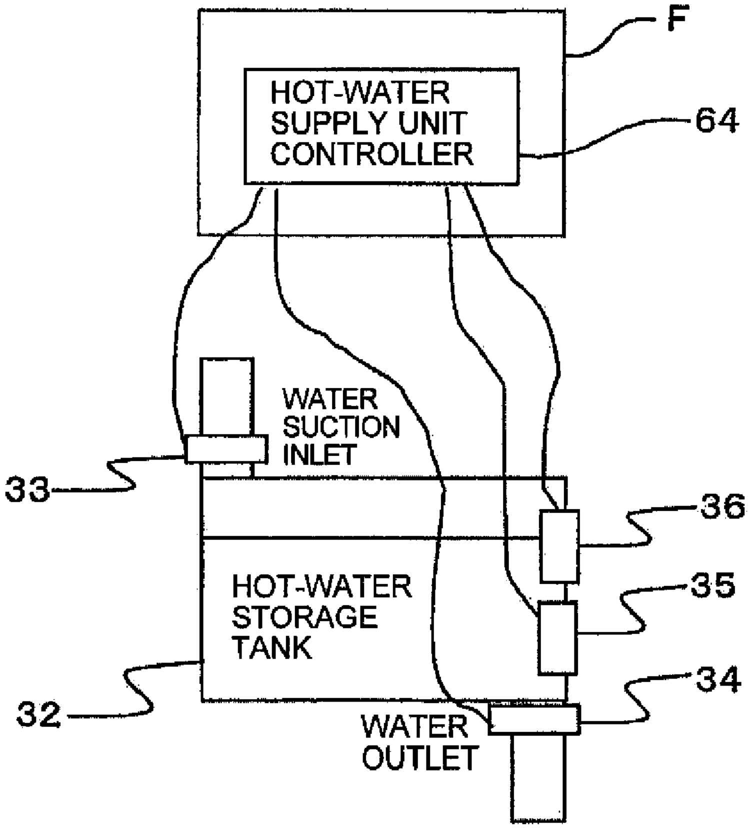

F
HOT-WATER SUPPLY UNIT CONTROLLER
64
WATER SUCTION INLET
33
36
35
HOT-WATER STORAGE TANK
34
32
WATER OUTLET

FIG. 4

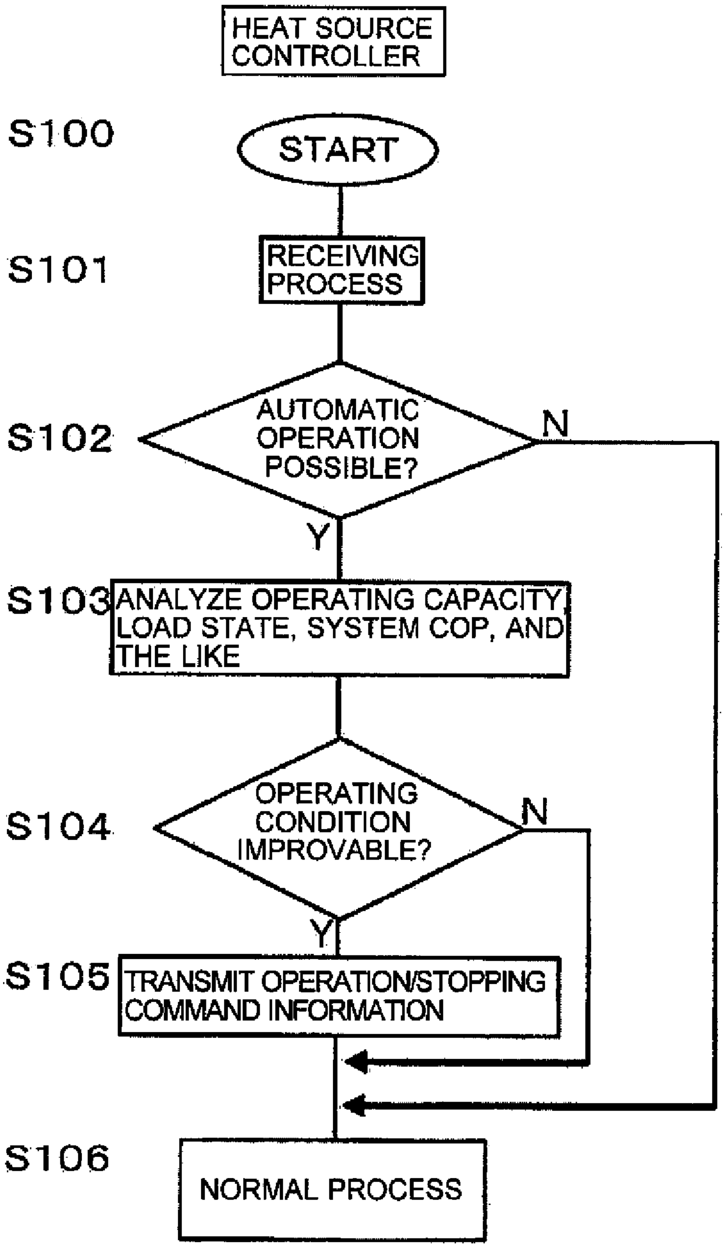
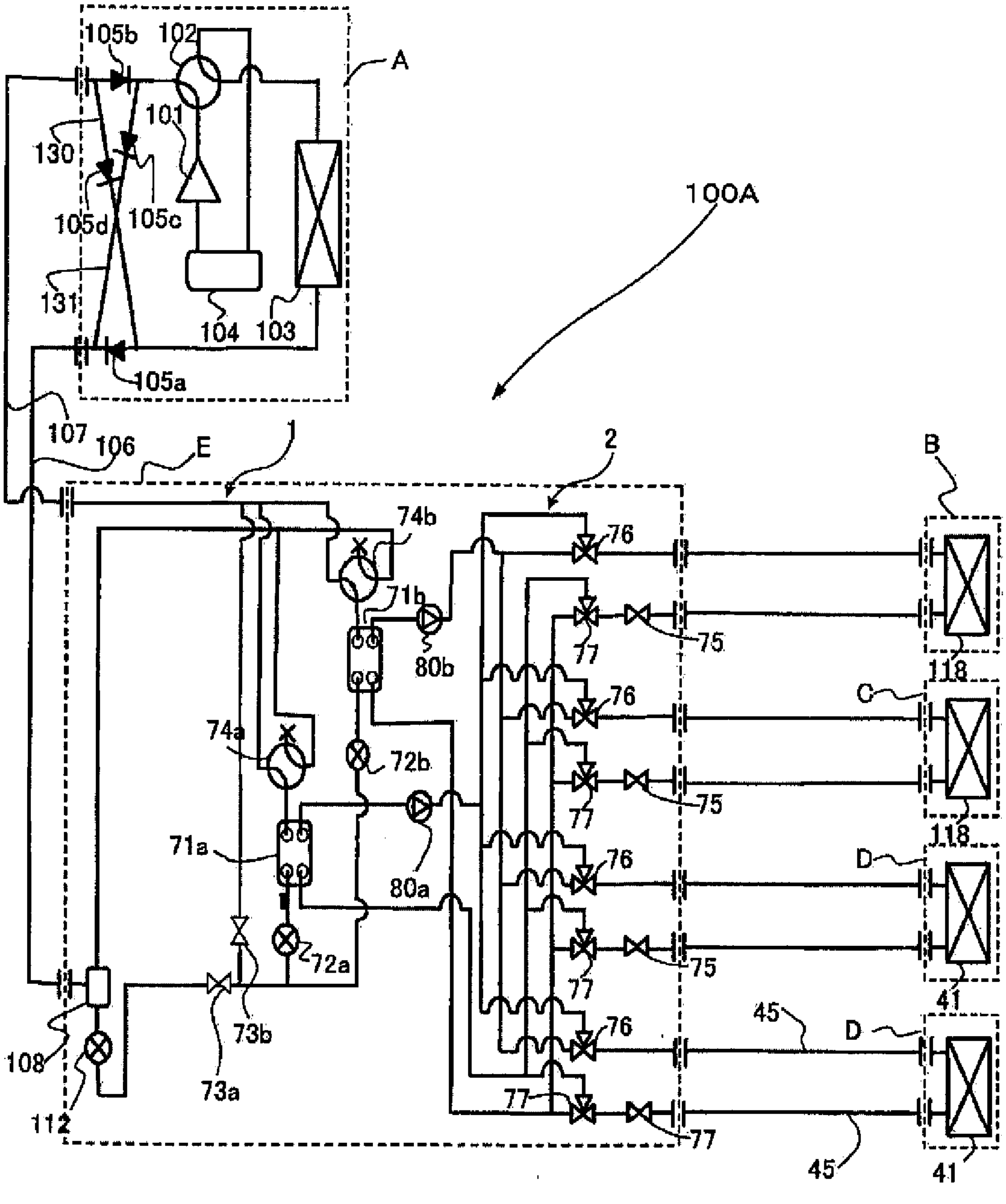

HEAT SOURCE CONTROLLER
S100
START
S101
RECEIVING PROCESS
S102
AUTOMATIC OPERATION POSSIBLE?
N
Y
S103
ANALYZE OPERATING CAPACITY, LOAD STATE, SYSTEM COP, AND THE LIKE
S104
OPERATING CONDITION IMPROVABLE?
N
Y
S105
TRANSMIT OPERATION/STOPPING COMMAND INFORMATION
S106
NORMAL PROCESS

FIG. 5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118
76
C
74a
72b
75
77
118
71a
80a
76
D
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77
108
73b
76
45
D
112
73a
77
77
45
41
41

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/006177

A. CLASSIFICATION OF SUBJECT MATTER
F25B29/00(2006.01)i, *F24F11/02*(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, 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.
X Y	JP 2-50056 A (Daikin Industries, Ltd.), 20 February 1990 (20.02.1990), entire text; fig. 1 to 12 (Family: none)	1-4 5-8
Y	JP 2007-232232 A (Sanyo Electric Co., Ltd.), 19 September 2007 (19.09.2007), entire text; fig. 1 to 8 & US 2007/0234752 A1 & EP 1826509 A2 & CN 101029785 A	5,7,8
Y	JP 9-119736 A (Sanyo Electric Co., Ltd.), 06 May 1997 (06.05.1997), paragraphs [0021] to [0026]; fig. 1, 2 (Family: none)	6

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

*	Special categories of cited documents:	"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
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier application or patent but published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 12 February, 2010 (12.02.10)	Date of mailing of the international search report 23 February, 2010 (23.02.10)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/006177

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	WO 2009/122477 A1 (Mitsubishi Electric Corp.), 08 October 2009 (08.10.2009), paragraphs [0059] to [0064]; fig. 4 (Family: none)	8 1-7

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 11270920 A **[0003]**