(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 278 237 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
26.01.2011 Bulletin 2011/04

(21) Application number: **08874120.2**

(22) Date of filing: **11.11.2008**

(51) Int Cl.:
F25B 1/00 *(2006.01)*

(86) International application number:
PCT/JP2008/070452

(87) International publication number:
WO 2009/133643 (05.11.2009 Gazette 2009/45)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MT NL NO PL PT RO SE SI SK TR
Designated Extension States:
AL BA MK RS

(30) Priority: **30.04.2008 JP 2008118227**

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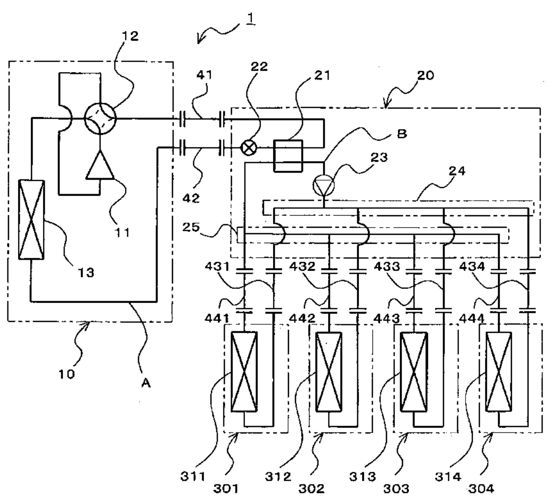
(54) AIR-CONDITIONING APPARATUS

(57) A heat source side refrigerant circuit A to which a compressor 11, an outdoor heat exchanger 13, a refrigerant flow amount control device 22 and an intermediate heat exchanger 21 are connected in sequence, a use side refrigerant circuit B having a pump 23 that is connected with one end of the use side refrigerant circuit B that performs heat exchange with the heat source side refrigerant circuit A of the intermediate heat exchanger 21 and a plurality of indoor heat exchangers 31n whose one end is connected with the pump 23 and other end with the other end of the use side refrigerant circuit B of the intermediate heat exchanger 21 are provided.
The compressor 11 and the outdoor heat exchanger 13 are provided in an outdoor unit 10. The refrigerant flow amount control device 22, the intermediate heat exchanger 21, and the pump 23 are provided at a relay portion 20. An indoor heat exchanger 31n is provided in an indoor unit 30n. In the use side refrigerant circuit B, at least one of water or an antifreezing fluid circulates as a use side refrigerant.

FIG.1



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Description

Technical Field

[0001] The present invention relates to an air-conditioning apparatus, more specifically to a multi-chambered air-conditioning apparatus equipped with a plurality of indoor units.

Background Art

[0002] A conventional multi-chambered air-conditioning apparatus equipped with a plurality of indoor units is proposed such that "an air-conditioning apparatus (1) is provided with a primary refrigerant circuit (2) and a plurality of secondary refrigerant circuits (3). The primary refrigerant circuit (2) is configured over an outdoor unit (4) and a plurality of heat exchanger units (5).The secondary refrigerant circuit (3) is configured over each heat exchange unit (5) and an indoor unit (6). The above each heat exchange unit (5) is installed in the vicinity of the indoor unit (6) with which each heat exchange unit (5) is connected. The above primary refrigerant circuit (2) is configured by performing piping connection of an outdoor compressor (7) , an outdoor four-way valve (8) , an outdoor heat exchanger (9), an outdoor expansion valve (10), and a refrigerant heat exchanger (11) in sequence. In the above primary refrigerant circuit (2), a primary refrigerant is filled. The above outdoor unit (4) is configured by the outdoor compressor (7), the outdoor four-way valve (8), the outdoor heat exchanger (9), and the outdoor expansion valve (10) of the above primary refrigerant circuit (2). The above secondary refrigerant circuits (3) is equipped with a main circuit (12) and a heat drive circuit (13) connected with the main circuit (12). In the above secondary refrigerant circuit (3), a secondary refrigerant is filled. The secondary refrigerant circulates to cause cold heat or hot heat to be delivered. Thereby, a circulation drive force is given to the secondary refrigerant passing through the heat drive circuit (13) to circulate while involving a phase change of the secondary refrigerant in the main circuit (12). The main circuit (12) of the above secondary refrigerant circuit (3) constitutes a circulation circuit. The main circuit (12) is configured by performing piping connection of an indoor four-way valve (14), an indoor expansion valve (15), an indoor heat exchanger (16), and the refrigerant heat exchanger (11) in sequence. The above indoor heat exchanger (16) is constituted by what is called a cross-fin type heat exchanger to perform heat exchange between the secondary refrigerant and indoor air. The above indoor unit (6) is configured by the indoor valve (15) of the above secondary refrigerant circuits (3) and the indoor heat exchanger (16). The heat exchange unit (5) is configured by the above refrigerant heat exchanger (11), and the heat drive circuit (13) of the secondary cooling circuits (3) and the indoor four-way valve (14)." (For example, refer to Patent Document 1)

Citation List

Patent Literature

[0003]

(Patent Document 1)
Japanese Unexamined Patent Application Publication No. 2001-289465 (paragraphs 0048, 0049, 0051 - 0053, Figs. 1 and 2)

Summary of Invention

Technical Problem

[0004] In consideration of an effect of such as toxicity of the refrigerant given to a human body and inflammability, a permissible concentration of the refrigerant that leaks into a space such as indoors is determined in an international standard. For example, the permissible concentration of the refrigerant that leaks into indoors is determined, 0.44 kg/m^3 for R410 that is one of CFC refrigerants, 0.07 kg/m^3 for CO_2, and 0.008 kg/m^3 for propane.
[0005] In a conventional multi-chambered air-conditioning apparatus described in Patent Document 1, when the refrigerant leaks into a space such as indoors, all the refrigerants in the secondary refrigerant circuit leak into the space. Since the refrigerant used for the secondary refrigerant circuit is the refrigerant whose permissible concentration is restricted, there is a problem that when the refrigerant leaks into the space such as indoors, the refrigerant concentration in the space may exceed the above permissible concentration.
[0006] The present invention is made to solve the above problems, and its purpose is to obtain a multi-chambered air-conditioning apparatus capable of preventing the refrigerant whose permissible concentration is restricted from leaking into the space such as indoors.

Solution to Problems

[0007] The air-conditioning apparatus according to the present invention comprises: a heat source side refrigerant circuit to which a compressor, an outdoor heat exchanger, a refrigerant flow amount control device and an intermediate heat exchanger are connected in sequence, and a use side refrigerant circuit having a circulation device connected to one end of the use side circuit which performs heat exchange with the heat source side refrigerant circuit of the intermediate heat exchanger and a plurality of indoor heat exchangers whose one end is connected with the circulation device and the other end being connected with the other end of the use side circuit of the intermediate heat exchanger,
wherein the compressor and the outdoor heat exchangers are provided in the outdoor unit, the refrigerant flow amount control device, the intermediate heat exchanger, and the circulation device are provided in the relay por-

tion, the indoor heat exchanger is provided in the indoor unit, and in the use side refrigerant circuit at least one of water and an antifreezing fluid circulates as a use side refrigerant.

Advantageous Effect of Invention

[0008] With the present invention, at least one of water and antifreezing fluid circulates in the use side refrigerant circuit. Thus, by circulating at least one of water and antifreezing fluid in the use side refrigerant circuit installed in a human-existing space (such as a living space, a space where people flows), leakage of the above refrigerant whose permissible concentration is restricted into the human-existing space can be prevented.

Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 1 of the present invention.
[Fig. 2] Fig. 2 is the refrigerant circuit diagram showing a refrigerant flow in a cooling operation mode of the air-conditioning apparatus according to Embodiment 1 of the present invention.
[Fig. 3] Fig. 3 is a p - h diagram showing changes of a heat source side refrigerant in Fig. 2.
[Fig. 4] Fig. 4 is the refrigerant circuit diagram showing a refrigerant flow in a heating operation mode of the air-conditioning apparatus according to Embodiment 1 of the present invention.
[Fig. 5] Fig. 5 is a p - h diagram showing changes of a heat source side refrigerant in Fig. 4.
[Fig. 6] Fig. 6 is the refrigerant circuit diagram of the air-conditioning apparatus according to Embodiment 2 of the present invention.
[Fig. 7] Fig. 7 is an installation schematic diagram of the air-conditioning apparatus according to Embodiment 3 of the present invention.

Reference Signs List

[0010]

1	air-conditioning apparatus
10	outdoor unit
11	compressor
12	four-way valve
13	outdoor heat exchanger
20	relay portion
21	intermediate heat exchanger
22	refrigerant flow amount control device
23	pump
24	first piping branch portion
25	second piping branch portion
30n	indoor unit
31n	indoor heat exchanger
41	first extension piping
42	second extension piping
43n	third extension piping
44n	fourth extension piping
50	first water flow amount control portion
51	intermediate heat exchanger inflow water temperature sensor
52	intermediate heat exchanger outflow water temperature sensor
53	inverter
60n	second water flow amount control portion
61n	indoor heat exchanger inflow water temperature sensor
62n	indoor heat exchanger outflow water temperature sensor
63n	water flow amount control valve
100	building
111 - 113	living space
121 - 123	shared space
130	piping installation space
A	heat source side refrigerant circuit
B	use side refrigerant circuit

Description of Embodiments

Embodiment 1

[0011] Fig. 1 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 1 of the present invention. The air-conditioning apparatus includes a heat source side refrigerant circuit A having such as an outdoor heat exchanger 13 performing heat exchange with outdoor air and a use side refrigerant circuit B having such as an indoor heat exchanger 31n (hereinafter, n is a natural number of 1 or more, denoting a number of units of the indoor heat exchanger) performing heat exchange with outdoor air. A heat source side refrigerant circulating in the heat source side refrigerant circuit A and a use side refrigerant circulating in the use side refrigerant circuit B perform heat exchange in an intermediate heat exchanger 21 each other. Each component of the heat source side refrigerant circuit A and the use side refrigerant circuit B is provided in an outdoor unit 10, a relay portion 20, and an indoor unit 30n. In Embodiment 1, water is used as the use side refrigerant.
[0012] With Embodiment 1, there are four units (N = 4) of the indoor unit 30n, however, two units or three units are allowable. Further, the relay portion 20 may be multiple units instead of one. That is, the present invention can be implemented for a configuration in which a plurality of indoor units is provided for each plurality of relay units. The outdoor unit may be installed in plural according to an output load, as well.
[0013] The heat source side refrigerant circuit A is composed of a compressor 11, a four-way valve 12, an intermediate heat exchanger 21, a refrigerant flow amount control device 22, and an outdoor heat exchang-

er by a piping-connection in sequence.

[0014] The use side refrigerant circuit B is composed of the intermediate heat exchanger 21, a pump 23, a first piping branch portion 24, a second piping branch portion 25, indoor heat exchangers 311 - 314, and so on. Here, the pump 23 corresponds to a circulation device of the present invention.

The intermediate heat exchanger 21 is connected with the pump 23. The pump 23 is connected with either of indoor heat exchangers 311 to 314 via a first piping branch portion 24 and the third extension piping 431 - 434. The other of indoor heat exchangers 311 to 314 is connected with the intermediate heat exchanger 21 via the fourth extension piping 441 - 444 and the second piping branch portion 25.

[0015] In the outdoor unit 10, the compressor 11, the four-way valve 12, the outdoor heat exchanger 13, and so on are provided, which are a component of the heat source side refrigerant circuit A. In the relay portion 20, the intermediate heat exchanger 21 and the refrigerant flow amount control device 22 are provided, which are a component of the heat source side refrigerant circuit A. With the relay portion 20, there are provided the pump 23, the first piping branch portion 24, and the second piping branch portion 25, which are a component of the use side refrigerant circuit B. With the indoor units 301 - 304, indoor heat exchangers 311 - 314 that are a component of the use side refrigerant circuit B are provided.

[0016] With Embodiment 1, the refrigerant flow amount control device 22 is provided in the relay portion 20, however, it may be provided in the outdoor unit 10. By providing the refrigerant flow amount control device 22 in the outdoor unit 10, a control system of the use side refrigerant circuit B can be consolidated into the outdoor unit 10.

[0017] To make it possible to separate the outdoor unit 10 from the relay portion 20, first extension piping 41 is provided, which can be separated by a joining device such as a joint and a valve between a four-way valve 12 and the intermediate heat exchanger 21. Between the refrigerant flow amount control device 22 and the outdoor heat exchanger 13, second extension piping 42 is provided, which can be separated by the joining device such as the joint and the valve. In order to make it possible to separate the relay portion 20 from the indoor units 301 - 304, third extension piping 431 - 434 are provided, which can be separated by a joining device such as the joint and the valve between the first piping branch portion 24 and indoor heat exchangers 311 - 314. Between the indoor heat exchangers 311. - 314 and the second piping branch portion 25, fourth extension piping 441 - 444 is provided, which can be separated by the joining device such as the joint and the valve.

(Driving operations)

[0018] Next, descriptions will be given to driving operations of the air-conditioning apparatus 1 according to Embodiment 1. There are two modes for a driving operation of the air-conditioning apparatus 1, a cooling operation mode and a heating operation mode.

In the cooling operation mode, the indoor unit 30n can perform cooling operation. In the heating operation mode, the indoor unit 30n can perform heating operation.

(Cooling operation mode)

[0019] Firstly, descriptions will be given to the cooling operation mode.

Fig. 2 is a refrigerant circuit diagram showing a refrigerant flow in the cooling operation mode of the air-conditioning apparatus in Embodiment 1 of the present invention.

Fig. 3 is a p - h diagram showing changes of a heat source side refrigerant in the cooling operation mode.

In Fig. 2, piping represented by thick lines denotes piping through which the refrigerant circulates. Solid line arrows denote a flow direction of the heat source side refrigerant. Broken line arrows denote a flow direction of water, which is a use side refrigerant. Refrigerant conditions a - d shown in Fig. 3 are the refrigerant conditions at the portions shown by a - d in Fig. 2.

[0020] When all the indoor units 301 - 304 perform cooling operation, the four-way valve 12 switches so that the heat source side refrigerant discharged from the compressor 11 flows into the outdoor heat exchanger 13. That is , the four-way valve 12 switches so that the heat source side refrigerant discharged from the intermediate heat exchanger 21 of the relay portion 20 flows into the compressor 11. The refrigerant flow amount control device 22 decreases the opening degree. Under these conditions, the compressor 11 and the pump 23 start operation.

[0021] Firstly, a refrigerant flow in the heat source side refrigerant circuit A will be explained. A low-temperature low-pressure vapor-state refrigerant is compressed by the compressor 11 to turn into a high-temperature high-pressure refrigerant to be discharged. A refrigerant compression process of the compressor 11 is represented by an isentropic curve from "a" to "b" shown in Fig. 3 when no heat is output nor input to/from surroundings. The high-temperature high-pressure refrigerant discharged from the compressor 11 flows into the outdoor heat exchanger 13 via the four-way valve 12, turning into a high-pressure liquid refrigerant while dissipating heat to the outside air to be condensed and liquefied in the outdoor heat exchanger 13. Changes of the refrigerant in the outdoor heat exchanger 13 are performed under an almost constant pressure. The change in the refrigerant is represented by a little slanted nearly-horizontal straight line from "b" to "c" shown in Fig. 3 when considering a pressure loss in the outdoor heat exchanger 13.

[0022] A high-pressure liquid refrigerant discharged from the outdoor heat exchanger 13 flows into the refrigerant flow amount control device 22 via second extension piping 42. The high-pressure liquid refrigerant is squeezed in the refrigerant flow amount control device

22 to expand (be decompressed) to turn into a low-temperature low-pressure gas-liquid two-phase state. Changes in the refrigerant in the refrigerant flow amount control device 22 are performed under a condition of a constant enthalpy. Thereby, the refrigerant change is denoted by a vertical line from a point "c" to "d" in Fig. 3.

[0023] The low-temperature low-pressure gas-liquid two-phase state refrigerant discharged from the refrigerant flow amount control device 22 flows into the intermediate heat exchanger 21. Then, the refrigerant absorbs heat from the water flowing in the intermediate heat exchanger 21 to turn into a low-temperature low-pressure vapor state refrigerant. Changes in the heat source side refrigerant in the intermediate heat exchanger 21 are performed under an almost constant pressure. Thereby, the change in the refrigerant is represented by a little slanted nearly-horizontal straight line shown by a point "d" to "a" in Fig. 3. The low-temperature low-pressure vapor state refrigerant discharged from the intermediate heat exchanger 21 flows into the compressor 11 via the first extension piping 41 and the four-way valve 12 to be compressed.

[0024] The low-temperature low-pressure vapor state refrigerant flowing into the compressor 11 passes through piping, therefore, its pressure decreases a little compared with the low-temperature low-pressure vapor-state refrigerant immediately after flowing out the intermediate heat exchanger 21, however, it is represented by the same point "a" in Fig. 3. In the same way, the high-pressure liquid-state refrigerant flowing into the refrigerant flow amount control device 22 passes through piping, therefore, its pressure decreases a little compared with the high-pressure liquid-state refrigerant flowing out the outdoor heat exchanger 13, however, it is represented by the same point "c" in Fig. 3. Since such a decrease in refrigerant pressure when passing through piping and a pressure loss in the outdoor heat exchanger 13 and the intermediate heat exchanger 21 are the same with a heating operation mode to be shown in the following, descriptions will be omitted except at the time of in need.

[0025] Next, descriptions will be given to the refrigerant flow in the use side refrigerant circuit B.

The water cooled by the heat source side refrigerant flowing in the intermediate heat exchanger 21 flows into the first piping branch portion 24 via the pump 23. The water flowed into the first piping branch portion 24 is branched therein and flows into the indoor heat exchangers 311 to 314 via the third extension piping 431 to 434. Then, the water absorbs heat from the indoor air in the indoor heat exchangers 311 to 314 to perform indoor cooling operation where indoor units 301 to 304 (indoor heat exchangers 311 to 314) are provided. The water flowed out the indoor heat exchangers 311 to 314 flows into the second piping branch portion 25 via the fourth extension piping 441 to 444. Then, the water merged in the second piping branch portion 25 flows into the intermediate heat exchanger 21.

(Heating operation mode)

[0026] Next, the heating operation mode will be explained.

Fig. 4 is a refrigerant circuit diagram showing a refrigerant flow of a heating operation mode of an air-conditioning apparatus according to Embodiment 1 of the present invention. Fig. 5 is a p - h diagram showing changes of a heat source side refrigerant in the heating operation mode.

In Fig. 4, piping represented by thick lines denotes piping in which the refrigerant circulates. Solid line arrows denote a flow direction of the heat source side refrigerant. Broken line arrows denote a flow direction of water, which is a use side refrigerant. Refrigerant conditions a - d shown in Fig. 5 is the refrigerant conditions at the portions shown by a - d in Fig. 4.

[0027] When all the indoor units 301 - 304 perform the heating operation, the four-way valve 12 switches so that the heat source side refrigerant discharged from the compressor 11 flows into the intermediate heat exchanger 21of the relay portion 20 via the first extension piping 41. That is, the four-way valve 12 switches so that the heat source side refrigerant discharged from the outdoor heat exchanger 13 flows into the compressor 11. The refrigerant flow amount control device 22 decreases the opening degree. Under these conditions, the compressor 11 and pump 23 start operation.

[0028] Firstly, a refrigerant flow in the heat source side refrigerant circuit A will be explained. A low-temperature low-pressure vapor-state refrigerant is compressed by the compressor 11 to turn into a high-temperature high-pressure refrigerant to be discharged. A refrigerant compression process of the compressor 11 is represented by an isentropic curve from "a" to "b" shown in Fig. 5. The high-temperature high-pressure refrigerant discharged from the compressor 11 flows into the intermediate heat exchanger 21 via the four-way valve 12 and the first extension piping 41, turning into a high-pressure liquid-state refrigerant while dissipating heat to the water flowing in the intermediate heat exchanger 21 to be condensed and liquefied. The change in the refrigerant is represented by a little slanted nearly-horizontal straight line from a point "b" to "c" shown in Fig. 5.

[0029] The high-temperature liquid-state refrigerant flowed out the intermediate heat exchanger 21 flows into the refrigerant flow amount control device 22. Then, the high-pressure liquid-state refrigerant is squeezed in the refrigerant flow amount control device 22 to expand (be decompressed) to turn into a low-temperature low-pressure gas-liquid two-phase state. Changes in the refrigerant then are denoted by a vertical line from a point "c" to "d" in Fig. 5. The low-temperature low-pressure gas-liquid two-phase state refrigerant flowed out the refrigerant flow amount control device 22 flows into the outdoor heat exchanger 13 via the second extension piping 42. Then, the refrigerant absorbs heat from the outdoor air in the outdoor heat exchanger 13 to turn into the low-temperature low-pressure vapor-state refrigerant. Changes in the refrigerant are represented by a little slanted nearly-horizontal straight line from a point "d" to "a" shown in Fig. 5. The low-temperature low-pressure vapor-state refrigerant flowed out the outdoor heat exchanger 13 flows into the compressor 11 via the four-way valve 12 and is compressed to be a high-temperature high-pressure refrigerant.

[0030] The water heated by the heat source side refrigerant flowing in the intermediate heat exchanger 21 flows into the first piping branch portion 24 via the pump 23. The water flowed into the first piping branch portion 24 is branched therein and flows into the indoor heat exchangers 311 to 314 via the third extension piping 431 to 434. Then, the water dissipates heat there to perform indoor heating operation where indoor units 301 to 304 (indoor heat exchangers 311 to 314) are provided. The water flowed out the indoor heat exchangers 311 to 314 flows into the second piping branch portion 25 via the fourth extension piping 441 to 444. Then, the water merged in the second piping branch portion 25 flows into the intermediate heat exchanger 21.

[0031] With the air-conditioning apparatus 1 configured like above, the outdoor unit 10 is installed such as on a roof of a building and underground and the relay portion 20 in a shared space provided on each floor of a building, for example. That is, the outdoor unit 10 and the relay portion 20 are installed at a place other than the space where humans exist (such as a living space, a space where people flows). In a human-existing space, the use side refrigerant circuit B and indoor units 301 to 304 are installed, where water circulates. Accordingly, when the permissible concentration of the refrigerant to leak into the air is restricted, it is possible to prevent the refrigerant from leaking into the human-existing space.

[0032] Indoor units 301 to 304 are connected with a single relay portion 20. That is, since a relay portion for each indoor unit 301 to 304 is consolidated, maintenance for such as the pump 23 becomes easy. Water is used for the use side refrigerant. Since no refrigerant flows whose permissible concentration is restricted when leaking out into the air, there is no need to install the relay unit 20 in the vicinity of the indoor units 301 to 304, allowing installing it at any place.

[0033] The relay unit 20 and the indoor units 301 to 304 adopt a separable structure. Accordingly, when installing the air-conditioning apparatus 1 instead of equipment conventionally using the water refrigerant, the indoor units 301 to 304, the third extension piping 431 to 433, and the fourth extension piping 441 to 443 can be reused.

[0034] The heat source side refrigerant and water flowing in the intermediate heat exchanger 21 are an opposed flow, heat exchange performance of the intermediate heat exchanger 21 improves.

[0035] In Embodiment 1, no refrigerant kind is specified in particular for the heat source side refrigerant, however, a variety of refrigerants are available for the heat source side refrigerant without restrictions. For example, a zeotropic refrigerant mixture such as R407C, a pseudo-azeotropic refrigerant mixture such as R410A, a single refrigerant such as R22 may be used. A natural refrigerant such as carbon dioxide and hydrocarbon may be used. A refrigerant having a smaller global warming potential may be used than a chlorofluorocarbon refrigerant (such as R407C and R410A) such as the refrigerant whose main component is tetrafluoro propane. By using the natural refrigerant or the refrigerant having a smaller global warming potential than the chlorofluorocarbon refrigerant as the heat source side refrigerant, an effect to suppress a greenhouse effect of the earth by refrigerant leak is expected. Particularly, carbon dioxide performs heat exchange at a high-pressure side under a super-critical state without condensation. Therefore, heat exchange performance can be improved when heating water by configuring in such a way that water and carbon dioxide are made to perform heat exchange in an opposed flow form in the intermediate heat exchangers 251 to 253.

[0036] With Embodiment 1, water is used for a use side refrigerant, however, an antifreezing fluid, a mixed fluid of water and the antifreezing fluid, the mixed fluid of water and an additive having a high anti-corrosion effect may be used. With this configuration, a refrigerant leak can be prevented due to freezing and corrosion even when the outdoor air temperature is low, so that high reliability can be obtained.

[0037] With Embodiment 1, the four-way valve 12 is provided on a discharge side of the compressor 1 in order to perform the cooling operation mode and heating operation mode. However, the present invention can be implemented without the four-way valve 12 when only either operation mode is needed.

[0038] As mentioned above, embodiments of the present invention are described, however, it is not limited thereto, but various modifications and changes are possible without departing from limits and spirits of the present invention. For example, a configuration is allowable in which two units of three-way switching valves are provided instead of the four-way valve 12 provided with the outdoor unit 10.

[0039] In the present invention, the "unit" of the outdoor unit 10 and indoor unit 30n does not necessarily mean that all the components are provided in the same housing or on the same external wall of the housing. For example, when the refrigerant flow amount control device 22 and the pump 23 are arranged at a different portion from the housing of the relay portion 20, such a configuration is included within the limits of the present invention. A plurality of sets composed of such as the outdoor heat exchanger 13 and the compressor 11 may be provided in the outdoor unit 10 and the heat source side refrigerant flowed out of each set may be merged to flow into the relay portion 20.

[0040] In the above embodiment, a configuration is explained in which a refrigerant which dissipates heat while condensing is filled as the heat source side refrigerant. When filling the refrigerant such as carbon dioxide that dissipates heat under a supercritical condition into the heat source side refrigerant circuit A, the condenser operates as a radiator and the refrigerant does not condense but lowers its temperature while dissipating heat.

Embodiment 2

[0041] In Embodiment 1, the water flow amount flowing the use side refrigerant circuit B is not controlled, however, the circuit B can be configured such that the water flow amount flowing therein is controlled.

[0042] Fig. 6 is a refrigerant circuit diagram of an air-conditioning apparatus according to Embodiment 2 of the present invention. In the air-conditioning apparatus 1, the first water flow amount control portion 50 and the second water flow amount control portions 601 to 604 are provided in the side refrigerant circuit B of the air-conditioning apparatus 1 shown in Embodiment 1.

[0043] The first water flow amount control portion 50 is constituted by the intermediate heat exchanger inflow water temperature sensor 51, the intermediate heat exchanger outflow water temperature sensor 52, and the inverter 53. Here, the inverter 53 corresponds to the intermediate heat exchanger refrigerant flow amount control device of the present invention.

[0044] The intermediate heat exchanger inflow water temperature sensor 51 is provided in the inflow side piping (relay portion side) of the intermediate heat exchanger 21 to detect the temperature of water flowing therein. The intermediate heat exchanger outflow water temperature sensor 52 is provided in the outflow side piping (relay portion side) of the intermediate heat exchanger 21 to detect the temperature of water flowing therefrom. The inverter 53 is provided in the pump 23 to adjust the water flow amount flowing in the intermediate heat exchanger 21.

[0045] In Embodiment 2, the intermediate heat exchanger outflow water temperature sensor 52 is provided on the suction side of the pump 23, however, it may be provided on the discharge side thereof. That is, the intermediate heat exchanger outflow water temperature sensor 52 can only detect the temperature of water flowing from the intermediate heat exchanger 21.

[0046] The second water flow amount control portions 601 to 604 are constituted by indoor heat exchanger inflow water temperature sensors 611 to 614, indoor heat exchanger outflow water temperature sensors 621 to 624, and water flow amount control valves 631 to 634. Here, the water flow amount control valves 631 to 634 correspond to the indoor unit refrigerant flow amount control device according to the present invention.

[0047] The indoor heat exchanger inflow water temperature sensors 611 to 614 are provided in inflow side piping (relay portion side) of each indoor heat exchanger 311 to 314 to detect the temperature of water flowing therein, respectively. The indoor heat exchanger outflow water temperature sensors 621 to 624 are provided in outflow side piping (relay portion side) of each indoor heat exchanger 311 to 314 to detect the temperature of water flowing therefrom, respectively. The water flow amount control valves 631 to 634 are provided in inflow side piping (relay portion side) of each indoor heat exchanger 311 to 314 to adjust water flow amount flowing therein, respectively.

(Driving operations)

[0048] Descriptions will be given to an example of driving operations of the first water flow amount control portion 50 and the second water flow amount control portions 601 to 604. However, the driving operations of the second water flow amount control portions 601 to 604 are the same, the driving operation will be explained using the second water flow amount control portion 601.

[0049] Firstly, an example of driving operation of the first water flow amount control portion 50 will be explained.

When any of the indoor units 301 to 304 starts operation, the intermediate heat exchanger inflow water temperature sensor 51 detects the temperature (hereinafter, referred to as T1) of water flowing in the intermediate heat exchanger 21. The intermediate heat exchanger outflow water temperature sensor 52 detects the temperature (hereinafter, referred to as T2) of water flowing out from the intermediate heat exchanger 21. The inverter 53 adjusts the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23 based on the values of T1 and T2.

(Cooling operation)

[0050] Firstly, descriptions will be given to a cooling operation mode of the air-conditioning apparatus 1.

When a detection value T1 by the intermediate heat exchanger inflow water temperature sensor 51 is higher than a predetermined temperature T3, in order to increase the heat exchange amount between the water and the heat source side refrigerant, the inverter 53 increases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23. When T1 is lower than T3, in order to suppress a surplus heat exchange between the water and the heat source side refrigerant, the inverter 53 decreases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23.

Here, the predetermined temperature T3 is a value defined by such as: the number of the indoor units 301 to 304 in operation, a set temperature of the indoor units 301 to 304, a preset temperature of the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor units 301 to 304, or a correction temperature calculated by these temperatures and air volume of the fan.

[0051] When a detection value T2 by the intermediate heat exchanger outflow water temperature sensor 52 is higher than a predetermined temperature T4, in order to increase the heat exchange amount between the water and the heat source side refrigerant, the inverter 53 increases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23. When T2 is lower than T4, in order to suppress a surplus heat exchange between the water and the heat source side refrigerant, the inverter 53 decreases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23.
Here, the predetermined temperature T4 is a value defined by such as: the number of the indoor units 301 to 304 in operation, a set temperature of the indoor units 301 to 304, a preset temperature of the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor units 301 to 304, or a correction temperature calculated by these temperatures and air volume of the fan.

(Heating operation)

[0052] Next, a heating operation mode of the air-conditioning apparatus 1 will be explained.
When a detection value T1 by the intermediate heat exchanger inflow water temperature sensor 51 is higher than a predetermined temperature T5, in order to increase the heat exchange amount between the water and the heat source side refrigerant, the inverter 53 increases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23. When T1 is lower than T5, in order to suppress a surplus heat exchange between the water and the heat source side refrigerant, the inverter 53 decreases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23.
Here, the predetermined temperature T5 is a value defined by such as: the number of the indoor units 301 to 304 in operation, a set temperature of the indoor units 301 to 304, a preset temperature of the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor units 301 to 304, or a correction temperature calculated by these temperatures and air volume of the fan.

[0053] When a detection value T2 by the intermediate heat exchanger outflow water temperature sensor 52 is lower than a predetermined temperature T6, in order to increase the heat exchange amount between the water and the heat source side refrigerant, the inverter 53 increases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23. When T2 is high than T6, in order to suppress a surplus heat exchange between the water and the heat source side refrigerant, the inverter 53 decreases the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23.
Here, the predetermined temperature T6 is a value defined by such as: the number of the indoor units 301 to 304 in operation, a set temperature of the indoor units 301 to 304, a preset temperature of the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor units 301 to 304, or a correction temperature calculated by these temperatures and air volume of the fan.

[0054] In Embodiment 2, the inverter 53 adjusted the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) using both the detection values T1 and T2, however, it may adjust the amount using either T1 or T2. Without using the detection values T1 and T2, the discharge amount (water flow amount flowing in the intermediate heat exchanger 21) of the pump 23 can be adjusted based on the number of the indoor units 301 to 304 in operation and set temperature of the indoor units 301 to 304, an air volume of a fan (not shown) installed in the indoor units 301 to 304. The same effect can be obtained by providing a pressure sensor in place of the intermediate heat exchanger inflow water temperature sensor 51 and the intermediate heat exchanger outflow water temperature sensor 52 to adjust the water flow amount flowing in the use side refrigerant circuit B1 according to such as a pressure difference in the inlet and outlet of the pump 23.

[0055] In the air-conditioning apparatus 1 configured as the above, the water flow amount flowing in the intermediate heat exchanger 21 can be controlled according to the heat load of the indoor units 301 to 304 to reduce the power of the pump 23.

[0056] In Embodiment 2, the inverter 53 is used as an intermediate heat exchanger refrigerant flow amount control device, however, other configurations may be possible. For example, bypass piping can be provided connecting the refrigerant inflow side piping and refrigerant outflow side piping of the intermediate heat exchanger 21. By installing a flow amount control valve in the bypass piping to control the refrigerant flow amount in the bypass piping, the user side refrigerant flow amount flowing into the intermediate heat exchanger 21 can be adjusted. Further, for example, the pump 23 may be configured by a plurality of pumps to adjust the water flow amount flowing through the intermediate heat exchanger 21 by the number of pumps in operation.

[0057] Next, an example of driving operation of the second water flow amount control portion 601 will be explained.
When the indoor unit 301 starts operation, the indoor heat exchanger inflow water temperature sensor 611 detects the water temperature (hereinafter, referred to T7) flowing in the indoor heat exchanger 311. The indoor heat exchanger outflow water temperature sensor 621 detects the water temperature (hereinafter, referred to T8) flowing out of the indoor heat exchanger 311. The water flow amount control valve 631 adjusts the water

flow amount flowing in the indoor heat exchanger 311 based on the values T7 and T8.

(Cooling operation)

[0058] Firstly, descriptions will be given to when the indoor unit 301 is in the cooling operation.
When the detection value T7 by the indoor heat exchanger inflow water temperature sensors 611 is higher than a predetermined temperature T9, in order to increase the heat exchange amount between the water and the indoor air, the water flow amount control valves 631 increases the water flow amount flowing in the indoor heat exchanger 311. When the detection value T7 by the indoor heat exchanger inflow water temperature sensors 611 is lower than the predetermined temperature T9, in order to suppress a surplus heat exchange between the water and the indoor air, the water flow amount control valves 631 reduces the water flow amount flowing in the indoor heat exchanger 311.
Here, the predetermined temperature T9 is a value defined by such as a set temperature of the indoor unit 301, a preset temperature for the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor unit 301, or a correction temperature calculated by these temperatures and air volume of the fan.

[0059] When the detection value T8 by the indoor heat exchanger outflow water temperature sensor 621 is higher than a predetermined temperature T10, in order to increase the heat exchange amount between the water and the indoor air, the water flow amount control valve 631 increases the water flow amount flowing in the indoor heat exchanger 311. When T8 is high than T10, in order to suppress a surplus heat exchange between the water and the indoor air, the water flow amount control valve 631 decreases the water flow amount flowing in the indoor heat exchanger 311.
Here, the predetermined temperature T10 is a value defined by such as a set temperature of the indoor unit 301, a preset temperature for the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor unit 301, or a correction temperature calculated by these temperatures and air volume of the fan.

(Heating operation)

[0060] Next, descriptions will be given to when the indoor unit 301 is in the heating operation.
When the detection value T7 by the indoor heat exchanger inflow water temperature sensors 611 is lower than a predetermined temperature T11, in order to increase the heat exchange amount between the water and the indoor air, the water flow amount control valves 631 increases the water flow amount flowing in the indoor heat exchanger 311. When the detection value T7 by the indoor heat exchanger inflow water temperature sensors 611 is higher than a predetermined temperature T11, in order to suppress a surplus heat exchange between the water and the indoor air, the water flow amount control valves 631 reduces the water flow amount flowing in the indoor heat exchanger 311.
Here, the predetermined temperature T11 is a value defined by such as a set temperature of the indoor unit 301, a preset temperature for the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor unit 301, or a correction temperature calculated by these temperatures and air volume of the fan.

[0061] When the detection value T8 by the indoor heat exchanger outflow water temperature sensor 621 is lower than a predetermined temperature T12, in order to increase the heat exchange amount between the water and the indoor air, the water flow amount control valve 631 increases the water flow amount flowing in the indoor heat exchanger 311. When T8 is higher than T12, in order to suppress a surplus heat exchange between the water and the indoor air, the water flow amount control valve 631 decreases the water flow amount flowing in the indoor heat exchanger 311.
Here, the predetermined temperature T12 is a value defined by such as a set temperature of the indoor unit 301, a preset temperature for the air-conditioning apparatus 1, a value (such as a differential temperature) calculated based on the above temperature information, an air volume of a fan (not shown) installed in the indoor unit 301, or a correction temperature calculated by these temperatures and air volume of the fan.

[0062] In Embodiment 2, the water flow amount control valve 631 adjusts the water flow amount flowing in the indoor heat exchanger 311 using both detection values T7 and T8, however, the water flow amount flowing therethrough may be adjusted using either T7 or T8. Without using detection values T7 and T8, the water flow amount flowing through the use side refrigerant circuit B1 may be adjusted based on such as a set temperature of the indoor unit 301 and an air volume of the fan (not shown) provided in the indoor unit 301.

[0063] In the air-conditioning apparatus 1 configured like the above, the water flow amount can be controlled according to the heat load of the indoor units 301 to 304 to reduce the power of the pump 23.

[0064] Unlike a conventional multi-chambered air-conditioning apparatus, no need for providing a refrigerant flow amount control device (an indoor expansion valve in Patent Document 1, for example) with the indoor units 301 to 304. Accordingly, noises can be reduced from the indoor unit.

[0065] With the conventional multi-chambered air-conditioning apparatus, the refrigerant temperature flowing into the indoor heat exchanger and the refrigerant temperature flowing from the outdoor heat exchanger are detected and based on these temperatures, a throttle amount of the refrigerant flow amount control device is controlled to adjust the indoor temperature. Therefore, in order to adjust the indoor temperature, in addition to a communication between the outdoor unit and the relay portion, a communication is required between the replay portion and the indoor unit. However, the air-conditioning apparatus according to Embodiment 2 only have to control the water flow amount flowing through the indoor units 301 to 304 to adjust the indoor temperature based on detection values (T7 and T8) of the indoor heat exchanger inflow water temperature sensors 611 to 614 and indoor heat exchanger outflow water temperature sensors 621 to 624 provided in the relay portion 20. Accordingly, no communication is required between the relay portion 20 and the indoor units 301 to 304 in order to adjust the indoor temperature, so that control of the air-conditioning apparatus 1 becomes simple.

[0066] In Embodiments 1 and 2, no strainer for capturing dusts in water, no expansion tank for preventing piping damage due to expansion of water, no constant-pressure valve for adjusting a discharging pressure of the pump 23 are provided with the user side refrigeration circuit B, however, an auxiliary machine may be equipped for preventing valve clogging of the pump 23.

Embodiment 3

[0067] In embodiment 3, an example of a method for installing the air-conditioning apparatus 1 shown in Embodiments 1 and 2 into a building is shown.

[0068] Fig. 7 is an installation schematic diagram of the air-conditioning apparatus in Embodiment 3. The outdoor unit is installed on the roof of the building 100. The relay unit 20 is installed in the shared space 121 provided on the first floor of the building 100. Four indoor units 301 to 304 are installed in the living space 111 provided on the first floor of the building 100. In the same way, on the second and third floors of the building 100, the relay unit 20 is installed in the shared spaces 122 and 123, and four indoor units 301 to 304 are installed in the living spaces 112 and 113. Here, the shared space 12n denotes such as a machine room, a shared corridor, a lobby provided on each floor of the building 100. That is, the shared space 12n denotes spaces but the living space 11n provided on each floor of the building 100.

[0069] The relay unit 20 installed in the shared space on each floor is connected with the outdoor unit 10 by the first extension piping 41 and the second extension piping 42 provided in the piping installation space 130. The indoor units 301 to 304 installed in the living space on each floor are connected with the relay unit 20 installed in the shared space on each floor by the third extension piping 431 to 433 and the fourth extension piping 441 to 443.

[0070] In the air-conditioning apparatus 1 configured like the above, water flows through piping installed in the living space 111 to 113, so that it is possible to prevent the refrigerant whose permissible concentration of the refrigerant which leaks into the space is restricted from leaking into the living space 111 to 113.

[0071] Since the indoor units 301 to 304 are connected with a single relay portion 20, that is, the relay portion of the indoor units 301 to 304 is consolidated, maintenance of such as the pump 23 becomes easy. Further, water is used for the use side refrigerant circuit B and no refrigerant flows whose permissible concentration of the refrigerant which leaks into the space is restricted, therefore, the relay portion 20 needs not to be installed in the vicinity of the indoor units 301 to 304 but can be installed at any place.

[0072] Since the relay portion 20 and the indoor units 301 to 304 have a separable structure, when installing the air-conditioning apparatus 1 instead of the conventional equipment using a water refrigerant, the indoor units 301 to 304, the third extension piping 431 to 433, and the fourth extension piping 441 to 443 can be reused.

[0073] The indoor unit 10 is not necessarily installed on the roof of the building 100, but may be installed such as on the ground and in a machine room of each floor.

Claims

1. An air-conditioning apparatus comprising:

   a heat source side refrigerant circuit to which a compressor, an outdoor heat exchanger, a refrigerant flow amount control device, and an intermediate heat exchanger are connected in sequence,
   a circulation device connected with one end of a use side circuit that performs heat exchange between the intermediate heat exchanger and the heat source side refrigerant circuit, and
   a use side refrigerant circuit having a plurality of indoor heat exchangers whose one end is connected with the circulation device and the other end is connected with the other end of the use side circuit of the intermediate heat exchanger,
   wherein, the compressor and the outdoor heat exchanger are installed in an outdoor unit,
   the refrigerant flow amount control device, the intermediate heat exchanger, and the circulation device are provided at a relay portion,
   the indoor heat exchanger is provided in an indoor unit, and
   in the use side refrigerant circuit, at least one of water and an antifreezing fluid circulates as a use side refrigerant.

2. The air-conditioning apparatus of claim 1, wherein in the outdoor unit, a second refrigerant flow path switching device is provided that is provided on a discharge side of the compressor to switch the heat source side refrigerant circuit into a circuit into which

a heat source side refrigerant that the compressor discharges flows into the intermediate heat exchanger to flow from the outdoor heat exchanger or a circuit into which the heat source side refrigerant that the compressor discharges flows into the outdoor heat exchanger to flow from the intermediate heat exchanger.

3. The air-conditioning apparatus of claim 1 or 2, wherein
in the use side refrigerant circuit, an indoor unit refrigerant flow amount control device is provided that controls a flow amount of the use side refrigerant flowing in the indoor heat exchanger for each indoor heat exchanger.

4. The air-conditioning apparatus of claim 3, wherein
the indoor unit refrigerant flow amount control device controls the flow amount of the use side refrigerant flowing in the indoor heat exchanger based on the temperature of the use side refrigerant flowing into the indoor heat exchanger and the temperature of the use side refrigerant flowing from the indoor heat exchanger.

5. The air-conditioning apparatus of claim 3 or 4, wherein
the indoor unit refrigerant flow amount control device is provided at the relay portion.

6. The air-conditioning apparatus of claim 1, wherein
in the use side refrigerant circuit, an intermediate heat exchanger refrigerant flow amount control device is provided that controls the flow amount of the use side refrigerant flowing in the intermediate heat exchanger.

7. The air-conditioning apparatus of claim 6, wherein
the intermediate heat exchanger refrigerant flow amount control device controls the flow amount of the use side refrigerant flowing in the intermediate heat exchanger based on the temperature of the use side refrigerant flowing into the intermediate heat exchanger and the temperature of the use side refrigerant flowing out from the intermediate heat exchanger.

8. The air-conditioning apparatus of claim 1, wherein
the relay portion and the indoor unit are separable by the piping connecting the circulation device and the indoor heat exchanger and a joining device that connects the indoor heat exchanger and the intermediate heat exchanger.

9. The air-conditioning apparatus of claim 1, wherein
the heat source side refrigerant circulating in the heat source side refrigerant circuit is a natural refrigerant or a refrigerant having a smaller global warming potential than a chlorofluorocarbon refrigerant.

10. The air-conditioning apparatus of claim 1, wherein
in the intermediate heat exchanger, the heat source side refrigerant circulating in the heat source side refrigerant circuit heats the second refrigerant without condensing under a supercritical state.

11. The air-conditioning apparatus of claim 1, wherein
the indoor unit is installed indoors provided for each floor of a building and the outdoor unit and the relay portion being installed outdoors.

12. The air-conditioning apparatus of claim 11, wherein
the relay portion is installed in a shared space provided on each floor of the building.

FIG.1

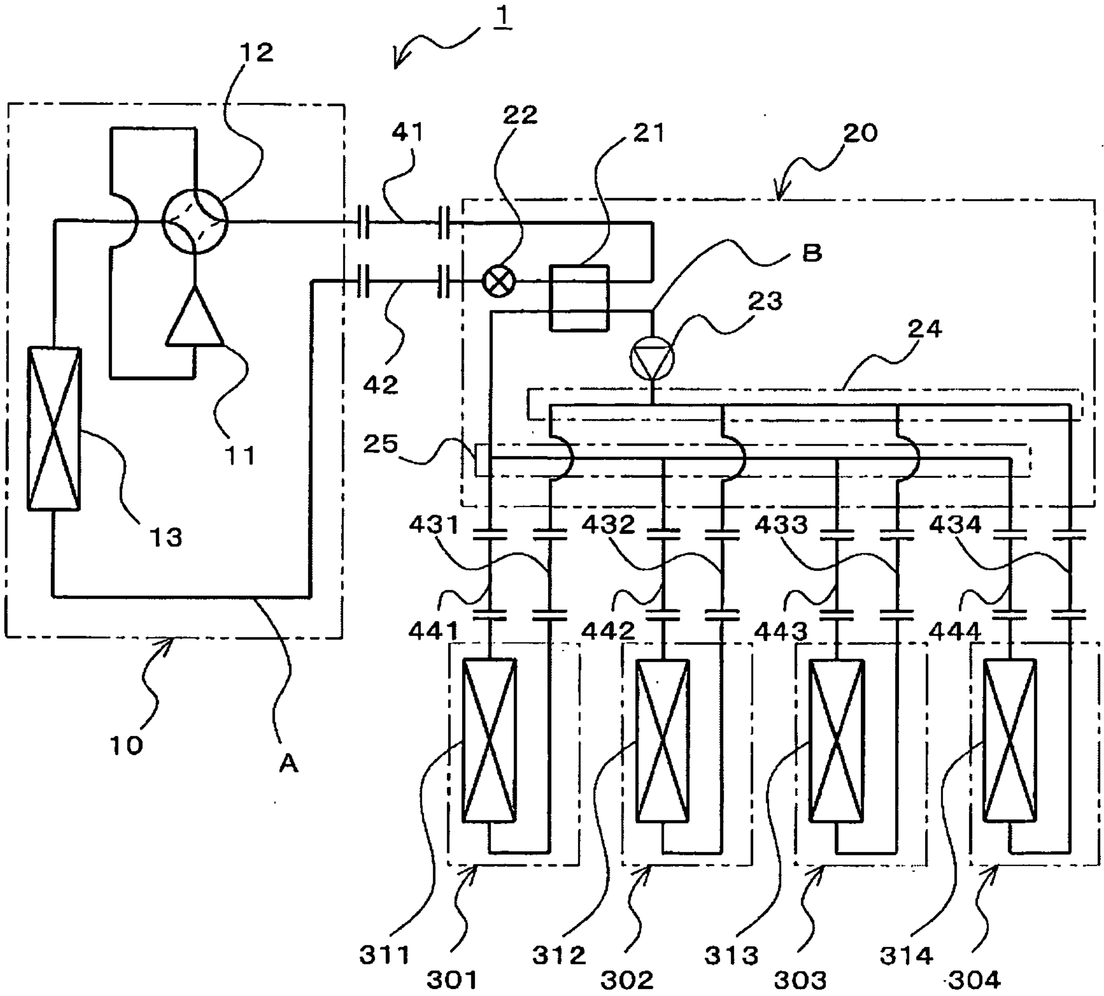
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FIG.2

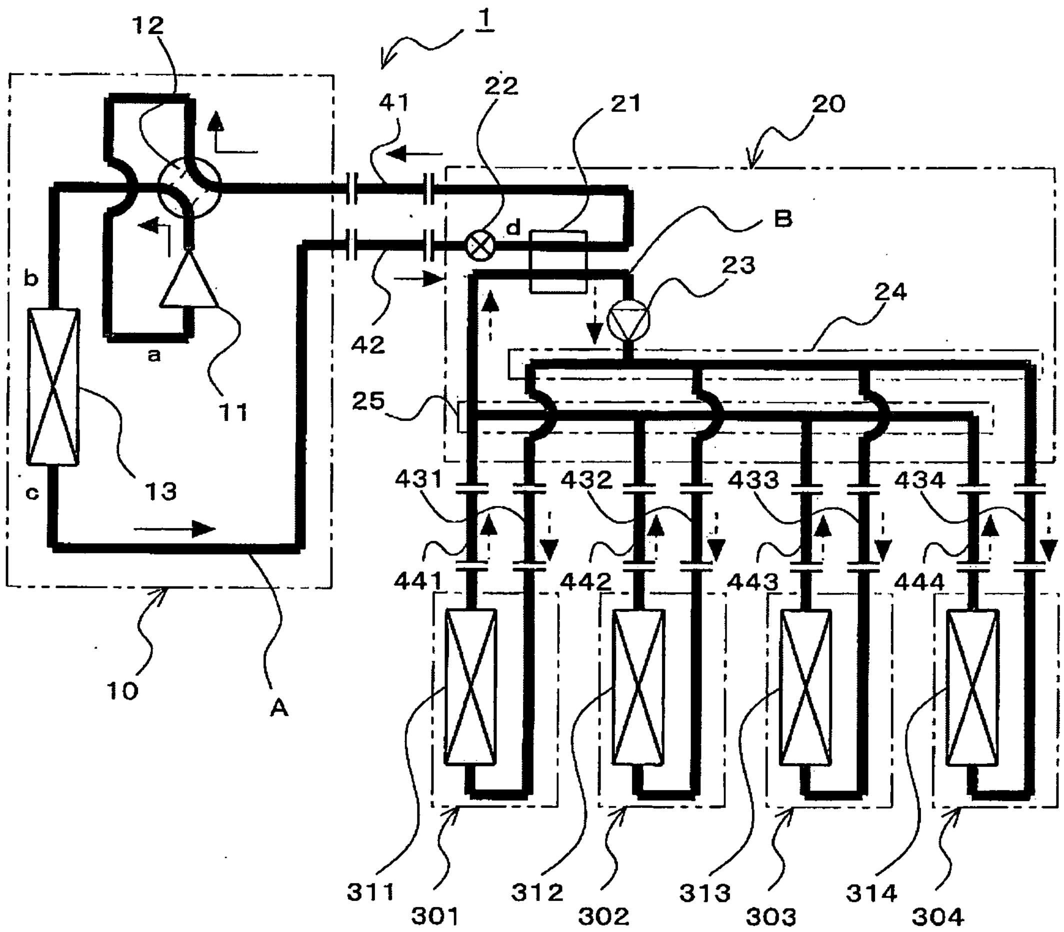
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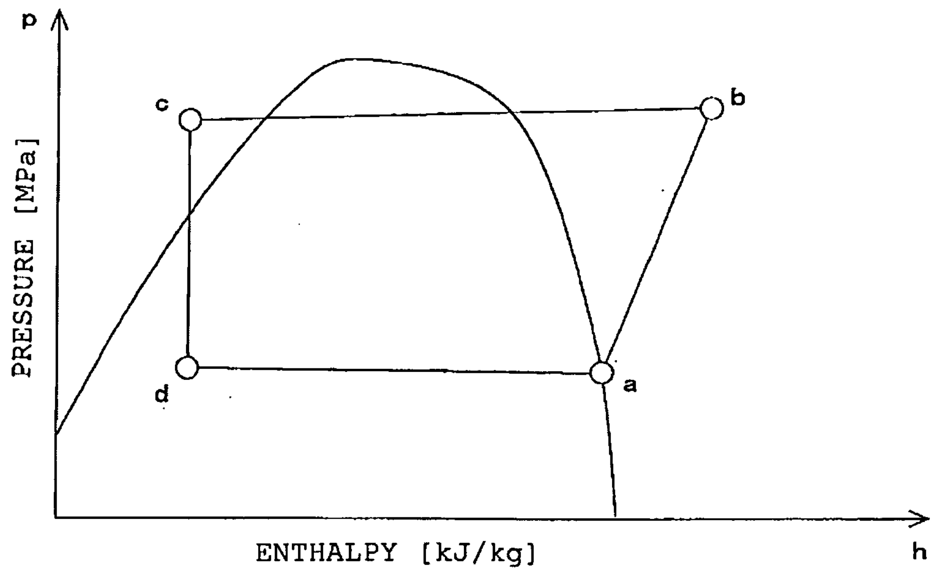
FIG.3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ENTHALPY [kJ/kg]
h

FIG.4

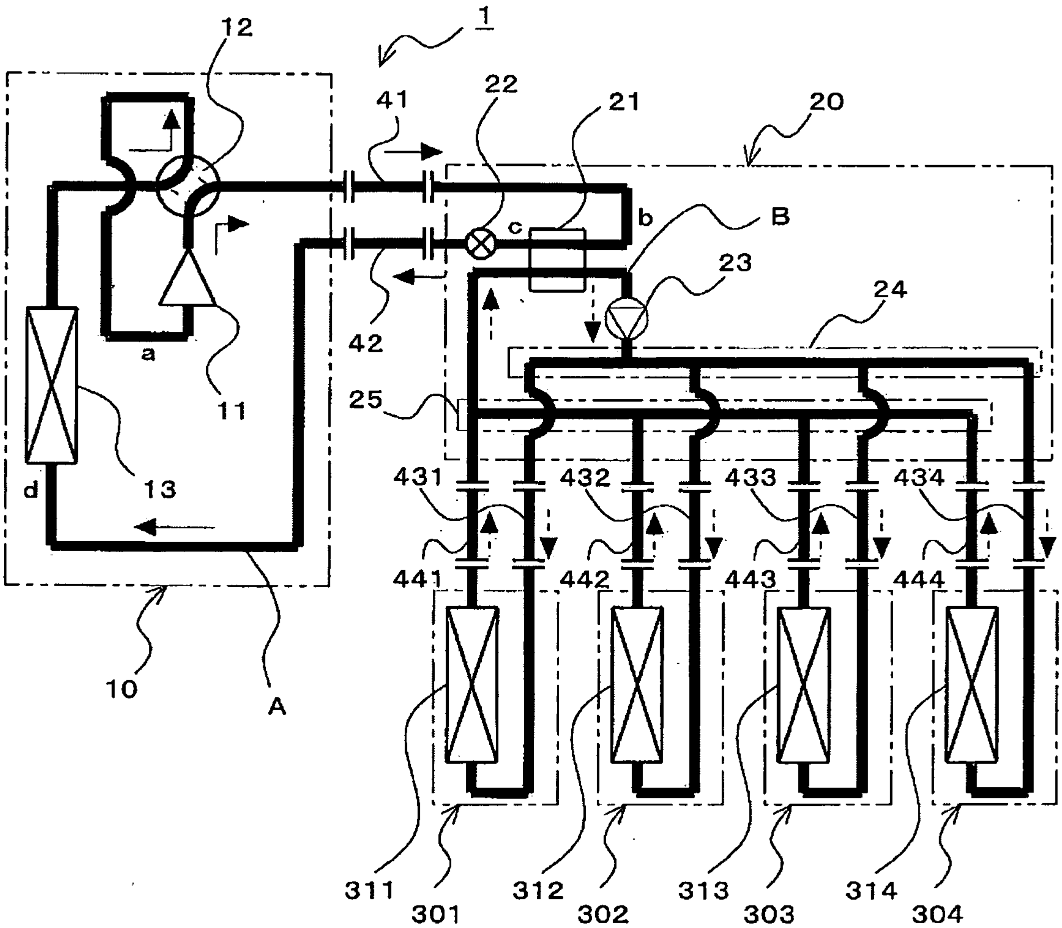
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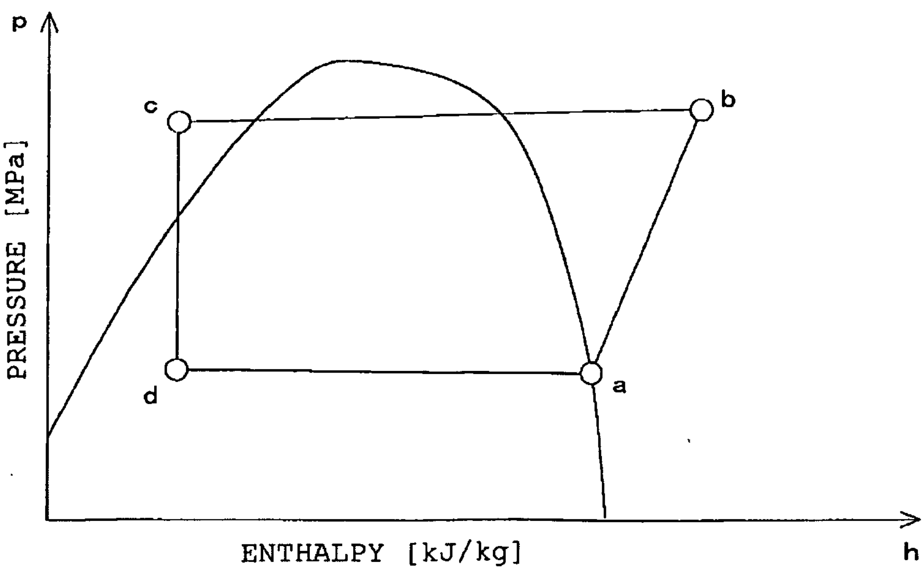
FIG.5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b
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ENTHALPY [kJ/kg]
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FIG.6

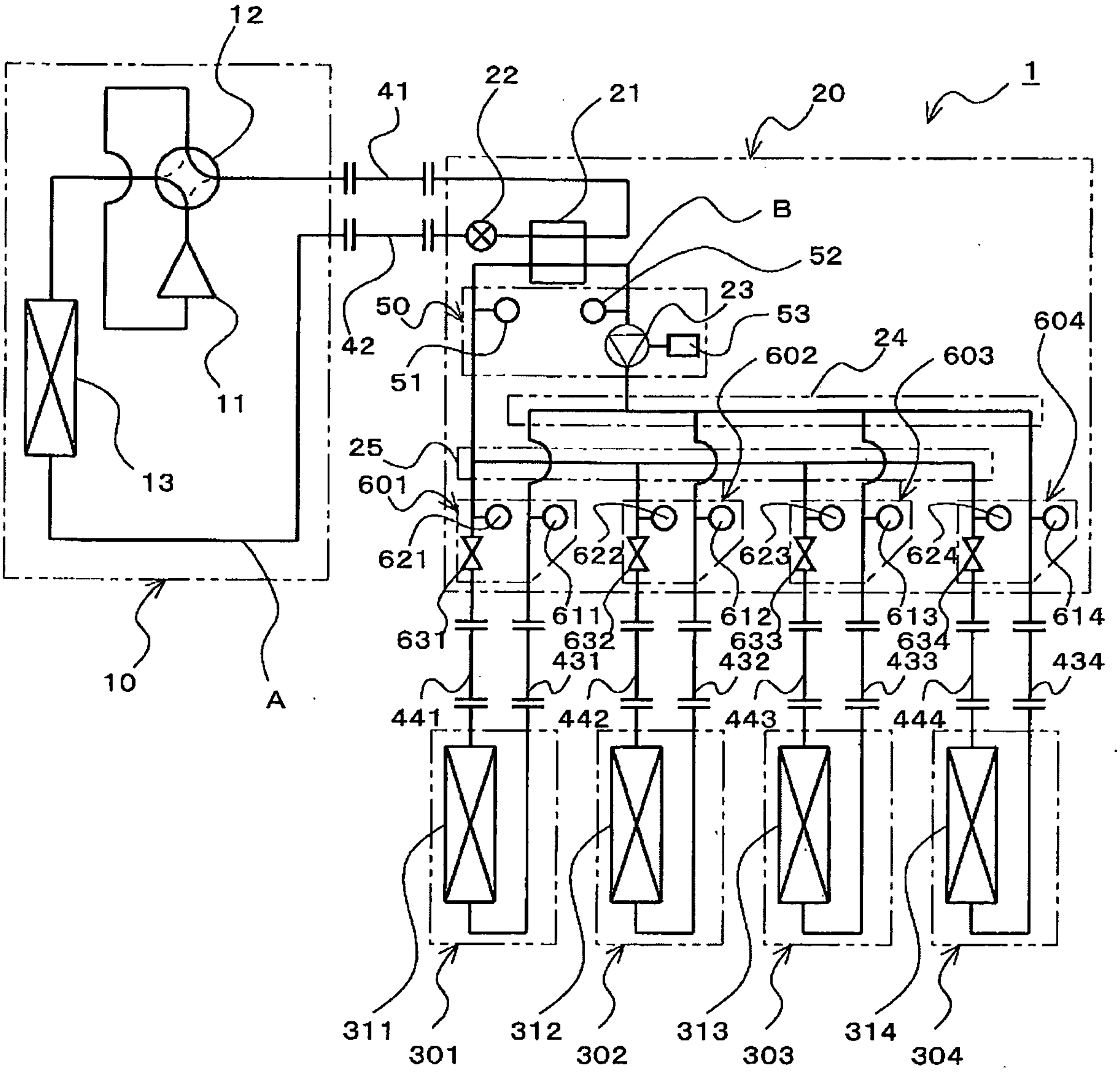
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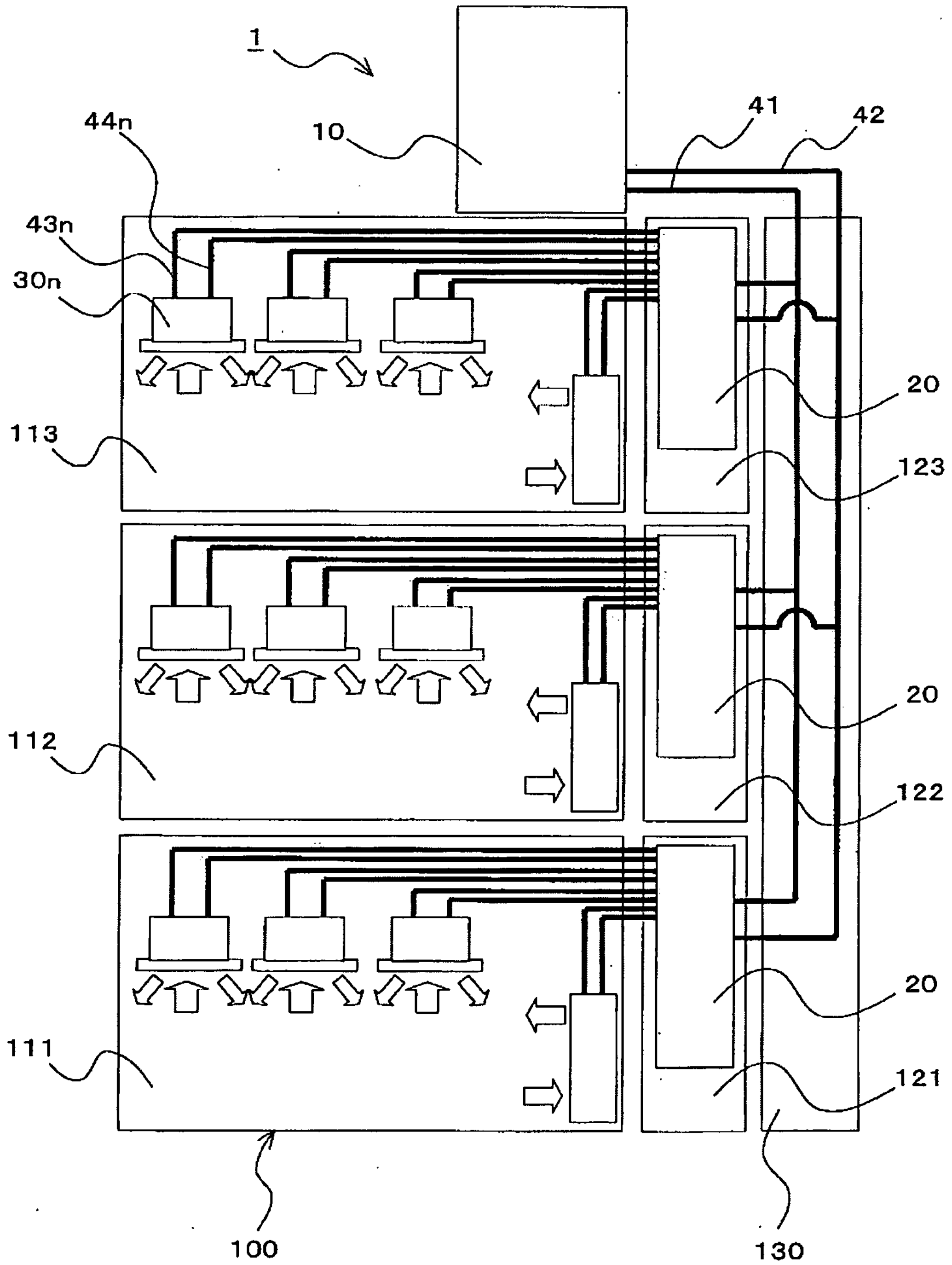
FIG.7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070452

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

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

B. FIELDS SEARCHED

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

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2008
Kokai Jitsuyo Shinan Koho	1971-2008	Toroku Jitsuyo Shinan Koho	1994-2008

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.
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Y	JP 2005-140444 A (Matsushita Electric Industrial Co., Ltd.), 02 June, 2005 (02.06.05), Claim 2; Fig. 1 & CN 001614328 A	1-12
Y	JP 2003-343936 A (Mitsubishi Electric Corp.), 03 December, 2003 (03.12.03), Par. Nos. [0027], [0066] to [0068]; Fig. 5 (Family: none)	1-12

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

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Date of the actual completion of the international search	Date of mailing of the international search report
28 November, 2008 (28.11.08)	09 December, 2008 (09.12.08)

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/070452

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 7-91753 A (Sanyo Electric Co., Ltd.), 04 April, 1995 (04.04.95), Par. Nos. [0033] to [0034]; Figs. 1, 6 (Family: none)	7
Y	JP 5-302737 A (Matsushita Refrigeration Co.), 16 November, 1993 (16.11.93), Par. No. [0007]; Fig. 1 (Family: none)	8
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Y	JP 2001-289465 A (Daikin Industries, Ltd.), 19 October, 2001 (19.10.01), Figs. 1, 10 (Family: none)	11,12

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REFERENCES CITED IN THE DESCRIPTION

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