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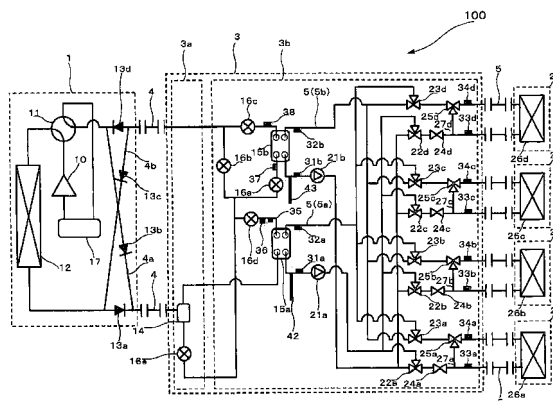
(54) **AIR CONDITIONER**

(57) An air-conditioning apparatus in which a labor required for system selection is simplified is provided.

An air-conditioning apparatus 100 according to the present invention has at least one intermediate heat exchanger 15 that exchanges heat between a refrigerant and a heat medium, a refrigeration cycle in which a compressor 10, a heat-source side heat exchanger 12, an expansion valve 16e, and a refrigerant-side channel of the intermediate heat exchanger 15 are connected through refrigerant pipelines 4 through which the refrigerant flows, and a heat medium circulation circuit in which

a heat medium-side channel of the intermediate heat exchanger 15, a pump 21, and a use-side heat exchanger 26 are connected through pipelines 5 through which the heat medium flows, in which the compressor 10 and the heat-source side heat exchanger 12 are contained in a heat source device 1, the intermediate heat exchanger 15 and the pump 21 in a relay unit 3, and the use-side heat exchanger 26 in an indoor unit 2, respectively, and an expansion tank 6 that absorbs volume change of the heat medium is connected to the heat medium circulation circuit.

FIG. 2



Description

Technical Field

5 **[0001]** The present invention relates to an air-conditioning apparatus applied to a multiple air conditioner for a building and the like.

Background Art

10 **[0002]** Hitherto, a multiple air conditioner for a building to which an air-conditioning apparatus that performs a cooling operation or a heating operation by circulating a refrigerant between an outdoor unit, which is a heat source machine arranged outside a room, and an indoor unit arranged inside the room so as to convey cooling energy or heating energy to a region to be air-conditioned such as an indoor space is applied has been present (See Patent Literature 1, for example). As the refrigerant used in such an air-conditioning apparatus, HFC refrigerants, for example, are widely used.

15 Also, a natural refrigerant such as carbon dioxide (CO₂) has begun to be used.

15 **[0003]** Also, an air-conditioning apparatus of other configurations represented by a chiller system is present. In this air-conditioning apparatus, cooling energy or heating energy is generated in a heat source machine arranged outside the room, the cooling energy or heating energy is transferred to a heat medium such as water, an antifreezing solution by a heat exchanger arranged in the outdoor unit, and the heat medium is conveyed to a fan coil unit, a panel heater or the like, which are an indoor unit arranged in a region to be air-conditioned, so as to perform the cooling operation or heating operation (See Patent Literature 2, for example). Moreover, there is known a waste heat recovery type chiller in which four water pipelines are connected to a heat source machine so as to supply cooling energy or heating energy.

[0004]

25 [Patent Literature 1] Japanese Unexamined Patent Application Publication No. 2-118372 (page 3, Fig. 1)

 [Patent Literature 2] Japanese Unexamined Patent Application Publication No. 2003-343936 (page 5, Fig. 1)

Disclosure of Invention

30 Problems to be Solved by the Invention

35 **[0005]** With a prior-art air-conditioning apparatus, since a high-pressure refrigerant is conveyed to an indoor unit, a refrigerant filled amount becomes extremely large, and if the refrigerant leaks from a refrigerant circuit, it might give a bad effect to the global environment such as deterioration of global warming. Particularly, R410A has as large global warming coefficient as 1970, and if such a refrigerant is to be used, reduction of the refrigerant filled amount becomes extremely important from the viewpoint of global environmental protection. Also, if the refrigerant leaks into a living space, chemical properties of the refrigerant might affect the human body. Thus, measures such as ventilation more than necessary, installation of a leakage sensor and the like are required, which leads to increases in costs and power consumption.

40 **[0006]** Such a problem can be solved by a chiller system described in Patent Literature 2. However, since heat exchange is performed between the refrigerant and water in the outdoor unit and the water is conveyed into the indoor unit, water conveying power becomes extremely large, and energy consumption is increased. Also, if both cooling energy and heating energy are to be supplied by water or the like, the number of connected pipelines needs to be increased, which results in increases in labor, time and costs required for the installation work.

45 **[0007]** Moreover, in a system using water, since water density is changed by a water temperature, a device that absorbs expansion of water is required, an expansion tank needs to be selected for each system to be installed, and a load required for the selection of the expansion tank is generated. In general, an expansion tank has a relatively big volume and cannot be contained under the roof or the like and needs to be installed in a machine room or the like. That is, a large installation space where the expansion tank can be installed needs to be ensured.

50 **[0008]** The present invention was made in order to solve the above problems and has an object to provide an air-conditioning apparatus with improved energy saving characteristics, in which a high-pressure refrigerant is not conveyed into an indoor unit, entry of a refrigerant into a living space can be prevented, an installation work can be performed easily, and space saving is realized. Means for Solving the Problems

55 **[0009]** An air-conditioning apparatus according to the present invention has at least one intermediate heat exchanger that exchanges heat between a refrigerant and a heat medium different from the refrigerant, a refrigeration cycle in which a compressor, an outdoor heat exchanger, at least one expansion valve, and a refrigerant-side channel of the intermediate heat exchanger are connected by pipelines through which the refrigerant flows, and a heat medium circulation circuit in which a heat medium side channel of the intermediate heat exchanger, a pump, and a use-side heat exchanger are

connected by pipelines through which the heat medium flows, in which the compressor and the outdoor heat exchanger are contained in an outdoor unit, the intermediate heat exchanger and the pump in a relay unit, and the use-side heat exchanger in an indoor unit, respectively, and an expansion absorption device that absorbs volume change in the heat medium is connected to the heat medium circulation circuit.

Advantages

[0010] According to the air-conditioning apparatus according to the present invention, an expansion absorption device for each article is made unnecessary, and a selection work of a system can be simplified.

Brief Description of Drawings

[0011]

[Fig. 1] Fig. 1 is an outline diagram illustrating an example of an installed state of an air-conditioning apparatus according to Embodiment 1.

[Fig. 2] Fig. 2 is an outline circuit diagram illustrating a configuration of the air-conditioning apparatus.

[Fig. 3] Fig. 3 is a partial circuit configuration diagram illustrating an example of a circuit configuration in which an expansion tank is connected.

[Fig. 4] Fig. 4 is a partial circuit configuration diagram illustrating another example of a circuit configuration in which the expansion tank is connected.

[Fig. 5] Fig. 5 is an internal perspective view illustrating an outline structure of the expansion tank.

[Fig. 6] Fig. 6 is a graph illustrating a relationship between a feed water pressure and a capacity of the expansion tank.

[Fig. 7] Fig. 7 is a refrigerant circuit diagram illustrating the flow of the refrigerant in cooling only operation mode of the air-conditioning apparatus.

[Fig. 8] Fig. 8 is the refrigerant circuit diagram illustrating the flow of the refrigerant in heating only operation mode of the air-conditioning apparatus.

[Fig. 9] Fig. 9 is the refrigerant circuit diagram illustrating the flow of the refrigerant in cooling main operation mode of the air-conditioning apparatus.

[Fig. 10] Fig. 10 is the refrigerant circuit diagram illustrating the flow of the refrigerant in heating main operation mode of the air-conditioning apparatus.

[Fig. 11] Fig. 11 is a circuit diagram illustrating a circuit configuration of an air-conditioning apparatus of Embodiment 2.

[Fig. 12] Fig. 12 is a refrigerant circuit diagram illustrating the flow of the refrigerant in cooling only operation mode of the air-conditioning apparatus.

[Fig. 13] Fig. 13 is the refrigerant circuit diagram illustrating the flow of the refrigerant in heating only operation mode of the air-conditioning apparatus.

[Fig. 14] Fig. 14 is the refrigerant circuit diagram illustrating the flow of the refrigerant in cooling main operation mode of the air-conditioning apparatus.

[Fig. 15] Fig. 15 is the refrigerant circuit diagram illustrating the flow of the refrigerant in heating main operation mode of the air-conditioning apparatus. Reference Numerals

[0012]

1 heat source device (outdoor unit)

2 indoor unit

2a indoor unit

2b indoor unit

2c indoor unit

2d indoor unit

3 relay unit

3a relay unit

3b relay unit

4 refrigerant pipeline

4a first connection pipeline

4b second connection pipeline

5 pipeline

5a pipeline

5b pipeline

	6	outdoor space
	7	living space
	9	building
	10	compressor
5	11	four-way valve
	12	heat-source side heat exchanger
	13a	check valve
	13b	check valve
	13c	check valve
10	13d	check valve
	14	gas-liquid separator
	15	intermediate heat exchanger
	15a	first intermediate heat exchanger
	15b	second intermediate heat exchanger
15	16	expansion valve
	16a	expansion valve
	16b	expansion valve
	16c	expansion valve
	16d	expansion valve
20	16e	expansion valve
	17	accumulator
	21	pump
	21a	first pump
	21b	second pump
25	22	channel switching valve
	22a	channel switching valve
	22b	channel switching valve
	22c	channel switching valve
	22d	channel switching valve
30	22e	channel switching valve
	22f	channel switching valve
	23	channel switching valve
	23a	channel switching valve
	23b	channel switching valve
35	23c	channel switching valve
	23d	channel switching valve
	23e	channel switching valve
	23f	channel switching valve
	24	stop valve
40	24a	stop valve
	24b	stop valve
	24c	stop valve
	24d	stop valve
	24e	stop valve
45	24f	stop valve
	25	flow regulating valve
	25a	flow regulating valve
	25b	flow regulating valve
	25c	flow regulating valve
50	25d	flow regulating valve
	25e	flow regulating valve
	25f	flow regulating valve
	26	use-side heat exchanger
	26a	use-side heat exchanger
55	26b	use-side heat exchanger
	26c	use-side heat exchanger
	26d	use-side heat exchanger
	26e	use-side heat exchanger

	26f	use-side heat exchanger
	27	bypass
	27a	bypass
	27b	bypass
5	27c	bypass
	27d	bypass
	27e	bypass
	27f	bypass
	31	first temperature sensor
10	31a	first temperature sensor
	31b	first temperature sensor
	32	second temperature sensor
	32a	second temperature sensor
	32b	second temperature sensor
15	33	third temperature sensor
	33a	third temperature sensor
	33b	third temperature sensor
	33c	third temperature sensor
	34	fourth temperature sensor
20	34a	fourth temperature sensor
	34b	fourth temperature sensor
	34c	fourth temperature sensor
	35	fifth temperature sensor
	36	first pressure sensor
25	37	sixth temperature sensor
	38	seventh temperature sensor
	39	eighth temperature sensor
	40	second pressure sensor
	42	heating-side expansion tank connection port
30	43	cooling-side expansion tank connection port
	50	non-living space
	51	pipe shaft
	60	expansion tank
	60a	heating-side expansion tank
35	60b	cooling-side expansion tank
	61	expansion valve
	62	water pipe
	65	connection pipeline
	65a	heating-side connection pipeline
40	65b	cooling-side connection pipeline
	66	bulkhead
	100	air-conditioning apparatus
	101	outdoor unit
	102	indoor unit
45	102a	indoor unit
	102b	indoor unit
	102c	indoor unit
	102d	indoor unit
	102e	indoor unit
50	102f	indoor unit
	103	relay unit
	104	three-way valve
	104a	three-way valve
	104b	three-way valve
55	105	heat-source side heat exchanger
	106	expansion valve
	107	two-way valve
	107a	two-way valve

107b two-way valve
 107c two-way valve
 108 refrigerant pipeline
 108a refrigerant pipeline
 5 108b refrigerant pipeline
 108c refrigerant pipeline
 110 compressor
 111 oil separator
 113 check valve
 10 200 air-conditioning apparatus
 203 expansion valve
 203a expansion valve
 203b expansion valve
 204 two-way valve
 15 204a two-way valve
 204b two-way valve
 205 two-way valve
 205a two-way valve
 205b two-way valve

20 Best Modes for Carrying Out the Invention

[0013] Embodiments of the present invention will be described below.

25 Embodiment 1.

[0014] Since an HFC refrigerant such as R410A, R407C, R404A has a large global warming coefficient, if the refrigerant leaks, a load on the environment is hazardous. Thus, a natural refrigerant such as carbon dioxide, ammonia, hydrocarbon or a refrigerant such as HFO has been examined as a refrigerant replacing the HFC refrigerant. However, these refrigerants might be flammable (ammonia and hydrocarbon, for example) or have small limit concentration of leakage. That is, though these refrigerants have small global warming coefficients, it is not preferable to have them in a living space in view of an influence and safety on the human body.

[0015] Table 1 illustrates an example of leakage limit concentration in a living space determined by the ISO standards.

35 [Table 1]

Refrigerant	Limit concentration [kg/m ³]
R410A	0.44
Carbon dioxide	0.07
Ammonia	0.0004
Propane	0.008

45 From Table 1, it is known that R410A, which is one of the HFC refrigerant, widely used in a direct expansion air-conditioning apparatus at present has a larger leakage limit concentration than the other refrigerants, and an influence in the case of leakage does not matter so much. On the other hand, the natural refrigerants such as ammonia, propane, which is one of hydrocarbon, carbon dioxide and the like have extremely small leakage limit concentrations, and in order to apply these refrigerants to an air-conditioning apparatus, there is a problem that measures against refrigerant leakage such that a circuit of a refrigerant part and a circuit of a water part are shut off, for example, should be taken.

50 **[0016]** Fig. 1 is an outline diagram illustrating an example of an installed state of the air-conditioning apparatus according to Embodiment 1 of the present invention. On the basis of Fig. 1, an outline configuration of the air-conditioning apparatus will be described. This air-conditioning apparatus performs a cooling operation or a heating operation using a refrigeration cycle (a refrigeration cycle and a heat medium circulation circuit) through which a refrigerant (a heat-source side refrigerant and a heat medium (water, antifreezing solution and the like)) are circulated. In the following figures including Fig. 1, a size relationship among each constituent member might be different from actual ones.

55 **[0017]** As shown in Fig. 1, this air-conditioning apparatus has one heat source device 1, which is a heat source device, a plurality of indoor units 2, and a relay unit 3 interposed between the heat source device 1 and the indoor units 2. The

relay unit 3 exchanges heat between the heat-source side refrigerant and the heat medium and has a first relay unit 3a and a second relay unit 3b. The heat source device 1 and the relay unit 3 are connected to each other by a refrigerant pipeline 4 through which the heat-source side refrigerant is conducted, and the relay unit 3 and the indoor unit 2 are connected to each other by a pipeline 5 through which the heat medium is conducted so that cooling energy or heating energy generated by the heat source device 1 is delivered to the indoor units 2. The numbers of connected heat source device 1, indoor units 2 and the relay units 3 are not limited to those illustrated.

[0018] The heat source device 1 is arranged in an outdoor space 6, which is a space outside the building 9 such as buildings, and supplies cooling energy or heating energy to the indoor unit 2 through the relay unit 3. The indoor unit 2 is arranged in a living space 7 such as a living room and a server room inside the building 9 to which the air for cooling or the air for heating can be conveyed, and supplies the air for cooling or the air for heating to the living space 7 to become a region to be air-conditioned. The relay unit 3 is constituted as a separate body from the heat source device 1 and the indoor unit 2, and is arranged at a position (hereinafter referred to as a non-living space 50) different from the outdoor space 6 and the living space 7, connecting the heat source device 1 and the indoor units 2 to each other to transfer cooling energy or heating energy supplied from the heat source device 1 to the indoor units 2.

[0019] As the outdoor space 6, a place located outside the building 9 such as a rooftop shown in Fig. 1, for example, is supposed. As the non-living space 50, spaces such as over corridors, which are places where people are not always present, and a place under the roof of a common zone, a common place where an elevator or the like is installed, a machine room, a server room, a warehouse or the like is supposed. Also, the living space 7 is a place where people are always present or a place where a large or a small number of people are present even temporarily, and an office, a classroom, a meeting room, a dining room, a server room or the like is supposed. A shaded portion shown in Fig. 1 indicates a pipe shaft 51 through which the pipeline 5 is made to pass.

[0020] The heat source device 1 and the first relay unit 3a are connected using two refrigerant pipelines 4. Also, the first relay unit 3a and the second relay unit 3b are connected by three refrigerant pipelines 4. Moreover, the second relay unit 3b and each indoor unit 2 are connected by two pipelines 5, respectively. By connecting the heat source device 1 to the relay unit 3 by the two refrigerant pipelines 4 and by connecting the indoor units 2 to the relay unit 3 by the two pipelines 5 as above, construction of the air-conditioning apparatus is made easy.

[0021] As mentioned above, by providing two relay units in the relay unit 3, that is, by dividing the unit into the first relay unit 3a and the second relay unit 3b, a plurality of the second relay units 3b can be connected to one first relay unit 3a (See Fig. 2). In Fig. 1, the indoor unit 2 is shown as a ceiling cassette type as an example, but not limited to that, and the unit may be any type as long as it can blow out cooling energy or heating energy directly or using a duct or the like to the living space 7 and may be a ceiling concealed type, a ceiling suspended type and the like.

[0022] Also, in Fig. 1, the case in which the heat source device 1 is installed in the outdoor space 6 is shown as an example, but not limited thereto. For example, the heat source device 1 may be installed in a surrounded space such as a machine room with a ventilation port, may be installed inside the building 9 only if waste energy can be discharged to the outside of the building 9 by an air discharge duct, or may be installed inside the building 9 if the heat source device 1 of a water-cooling type is used. Even if the heat source device 1 is installed in such a place, no particular problem will occur.

[0023] Fig. 2 is an outline circuit diagram illustrating a configuration of the air-conditioning apparatus 100. On the basis of Fig. 2, the detailed configuration of the air-conditioning apparatus 100 will be described. As shown in Fig. 2, the heat source device 1 and the relay unit 3 are connected through a first intermediate heat exchanger 15a and a second intermediate heat exchanger 15b disposed in the second relay unit 3b, and the relay unit 3 and the indoor unit 2 are also connected through the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b disposed in the second relay unit 3. The configuration and functions of each component disposed in the air-conditioning apparatus 100 will be described below.

[Heat source device 1]

[0024] In the heat source device 1, a compressor 10, a four-way valve 11, which is a refrigerant channel switching device, a heat-source side heat exchanger (outdoor heat exchanger) 12, and an accumulator 17 are connected and contained in series by the refrigerant pipeline 4. Also, in the heat source device 1, a first connection pipeline 4a, a second connection pipeline 4b, a check valve 13a, a check valve 13b, a check valve 13c, and a check valve 13d are disposed. By disposing the first connection pipeline 4a, the second connection pipeline 4b, the check valve 13a, the check valve 13b, the check valve 13c, and the check valve 13d, the flow direction of the heat-source side refrigerant made to flow into the relay unit 3 can be made constant regardless of an operation required by the indoor unit 2.

[0025] The compressor 10 is to suck in the heat-source side refrigerant and to compress the heat-source side refrigerant to bring it into a high-temperature and high-pressure state and is preferably composed of an inverter compressor or the like capable of capacity control, for example. The four-way valve 11 is to perform switching between the flow of the heat-source side refrigerant during a heating operation and the flow of the heat-source side refrigerant during the cooling

operation. The heat-source side heat exchanger 12 functions as an evaporator during the heating operation, while it functions as a condenser during the cooling operation so as to exchange heat between the air supplied from a blower such as a fan, not shown, and the heat-source side refrigerant and to evaporate and gasify the heat-source side refrigerant or to condense and liquefy the same. The accumulator 17 is disposed on the suction side of the compressor 10 and stores an excess refrigerant.

[0026] The check valve 13d is disposed in the refrigerant pipeline 4 between the relay unit 3 and the four-way valve 11 so as to allow the flow of the heat-source side refrigerant only in a predetermined direction (direction from the relay unit 3 to the heat source device 1). The check valve 13a is disposed in the refrigerant pipeline 4 between the heat-source side heat exchanger 12 and the relay unit 3 so as to allow the flow of the heat-source side refrigerant only in a predetermined direction (direction from the heat source device 1 to the relay unit 3). The check valve 13b is disposed in the first connection pipeline 4a so as to allow the flow of the heat-source side refrigerant only in the direction from the upstream side of the check valve 13d to the upstream side of the check valve 13a. The check valve 13c is disposed in the second connection pipeline 4b so as to allow the flow of the heat-source side refrigerant only in the direction from the downstream side of the check valve 13d to the downstream side of the check valve 13a.

[0027] The first connection pipeline 4a connects the refrigerant pipeline 4 on the upstream side of the check valve 13d and the refrigerant pipeline 4 on the upstream side of the check valve 13a to each other in the heat source device 1. The second connection pipeline 4b connects the refrigerant pipeline 4 on the downstream side of the check valve 13d and the refrigerant pipeline 4 on the downstream side of the check valve 13a to each other in the heat source device 1. In Fig. 2, the case in which the first connection pipeline 4a, the second connection pipeline 4b, the check valve 13a, the check valve 13b, the check valve 13c, and the check valve 13d are disposed is shown as an example, but not limited to that, and they do not necessarily have to be disposed.

[Indoor unit 2]

[0028] On the indoor units 2, use-side heat exchangers 26 are mounted, respectively. This use-side heat exchanger 26 is connected to a stop valve 24 and a flow regulating valve 25 of the second relay unit 3b through the pipeline 5. This use-side heat exchanger 26 exchanges heat between the air supplied from the blower such as a fan, not shown, and a heat medium and generates heated air or cooled air to be supplied to a region to be air-conditioned.

[0029] In Fig. 2, a case in which four indoor units 2 are connected to the relay unit 3 is shown as an example, in which an indoor unit 2a, an indoor unit 2b, an indoor unit 2c, and an indoor unit 2d from the lower side of the paper are shown. In accordance with the indoor units 2a to 2d, the use-side heat exchanger 26 is also shown from the lower side of the paper as a use-side heat exchanger 26a, a use-side heat exchanger 26b, a use-side heat exchanger 26c, and a use-side heat exchanger 26d. Similarly to Fig. 1, the number of connected indoor units 2 is not limited to four shown in Fig. 2.

[Relay unit 3]

[0030] The relay unit 3 is composed of the first relay unit 3a and the second relay unit 3b with separate housings. By configuring as above, a plurality of the second relay units 3b can be connected to one first relay unit 3a. In the first relay unit 3a, a gas-liquid separator 14 and an expansion valve 16e are disposed. In the second relay unit 3b, two intermediate heat exchangers 15, four expansion valves 16, two pumps 21, four channel switching valves 22, four channel switching valves 23, four stop valves 24, and four flow regulating valves 25 are disposed.

[0031] The gas-liquid separator 14 is connected to the single refrigerant pipeline 4 connected to the heat source device 1 and the two refrigerant pipelines 4 connected to the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b of the second relay unit 3b so as to separate the heat-source side refrigerant supplied from the heat source device 1 to a vapor-state refrigerant and a liquid refrigerant. The expansion valve 16e is disposed between the refrigerant pipeline 4 that connects the expansion valve 16a and the expansion valve 16b to each other and the gas-liquid separator 14 and functions as a reducing valve or a throttle device so as to decompress and expand the heat-source side refrigerant. The expansion valve 16e is preferably composed of a valve with variably controllable opening-degree such as an electronic expansion valve, for example.

[0032] The two intermediate heat exchangers 15 (the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b) function as condensers or evaporators, exchange heat between the heat-source side refrigerant and the heat medium and supply cooling energy or heating energy generated in the heat-source device 1 to the indoor units 2. In the flow of the heat-source side refrigerant, the first intermediate heat exchanger 15a is disposed between the gas-liquid separator 14 and the expansion valve 16d. In the flow of the heat-source side refrigerant, the second intermediate heat exchanger 15b is disposed between the expansion valve 16a and the expansion valve 16c.

[0033] The four expansion valves 16 (the expansion valves 16a to 16d) function as a reducing valve or a throttle device to decompress and expand the heat-source-side refrigerant. The expansion valve 16a is disposed between the expansion valve 16b and the second intermediate heat exchanger 15b. The expansion valve 16b is disposed so as to be in parallel

with the expansion valve 16a. The expansion valve 16c is disposed between the second intermediate heat exchanger 15b and the first relay unit 3a. The expansion valve 16d is disposed between the first intermediate heat exchanger 15a and the expansion valve 16a and expansion valve 16b. The four expansion valves 16 are preferably composed of valves with variably controllable opening-degree such as electronic expansion valves, for example.

[0034] The two pumps 21 (the first pump 21a and the second pump 21b) are composed of pumps and the like and circulate the heat medium conducted through the pipeline 5. The first pump 21a is disposed in the pipeline 5 between the first intermediate heat exchanger 15a and the channel switching valve 22. The second pump 21b is disposed in the pipeline 5 between the second intermediate heat exchanger 15b and the channel switching valve 22. The types of the first pump 21a and the second pump 21b are not particularly limited but may be configured by a capacity-controllable pump or the like.

[0035] The four channel switching valves 22 (the channel switching valves 22a to 22d) are composed of three-way valves and switch the channels of the heat medium. The channel switching valves 22 are disposed in the number (four, here) according to the number of the installed indoor units 2. As for the channel switching valves 22, one of the three ways is connected to the first intermediate heat exchanger 15a, another one of the three ways to the second intermediate heat exchanger 15, and the rest of the three ways to the stop valve 24, respectively, and they are disposed on the inlet side of a heat medium channel of the use-side heat exchanger 26. In accordance with the indoor units 2, they are shown as the channel switching valve 22a, the channel switching valve 22b, the channel switching valve 22c, and the channel switching valve 22d from the lower side of the page.

[0036] The four channel switching valves 23 (the channel switching valves 23a to 23d) are composed of three-way valves and switch the channels of the heat medium. The channel switching valves 23 are disposed in the number (four, here) according to the number of the installed indoor units 2. As for the channel switching valves 23, one of the three ways is connected to the first intermediate heat exchanger 15a, another one of the three ways to the second intermediate heat exchanger 15, and the rest of the three ways to the flow regulating valve 25, respectively, and they are disposed on the outlet side of a heat medium channel of the use-side heat exchanger 26. In accordance with the indoor units 2, they are shown as the channel switching valve 23a, the channel switching valve 23b, the channel switching valve 23c, and the channel switching valve 23d from the lower side of the page.

[0037] The four stop valves 24 (the stop valves 24a to 24d) are composed of a two-way valve and open/close the pipeline 5. The stop valves 24 are disposed with the number (it is four, here) according to the number of the installed indoor units 2. As for the stop valve 24, one side is connected to the use-side heat exchanger 26, while the other side to the channel switching valve 22, respectively, and it is disposed on the inlet side of the heat medium channel of the use-side heat exchanger 26. Being corresponded with the indoor units 2, they are shown as the stop valve 24a, the stop valve 24b, the stop valve 24c, and the stop valve 24d from the lower side of the paper.

[0038] The four flow regulating valves 25 (the flow regulating valves 25a to 25d) are composed of three-way valves and switch the channels of the heat medium. The flow regulating valves 25 are disposed in the number (four, here) according to the number of the installed indoor units 2. As for the flow regulating valves 25, one of the three ways is connected to the use-side heat exchanger 26, another one of the three ways to a bypass 27, and the rest of the three ways to the channel switching valve 23, respectively, and they are disposed on the outlet side of a heat medium channel of the use-side heat exchanger 26. In accordance with the indoor units 2, they are shown as the flow regulating valve 25a, the flow regulating valve 25b, the flow regulating valve 25c, and the flow regulating valve 25d from the lower side of the page.

[0039] The bypass 27 is disposed so as to connect the pipeline 5 to the flow regulating valve 25 between the stop valve 24 and the use-side heat exchanger 26. The bypasses 27 are disposed in the number according to the installed number of the indoor units 2 (four, here, that is, a bypass 27a, a bypass 27b, a bypass 27c, and a bypass 27d). In accordance with the indoor units 2, they are shown as the bypass 27a, the bypass 27b, the bypass 27c, and the bypass 27d from the lower side of the page.

[0040] Also, in the second relay unit 3b, two first temperature sensors 31, two second temperature sensors 32, four third temperature sensors 33, four fourth temperature sensors 34, a fifth temperature sensor 35, a first pressure sensor 36, a sixth temperature sensor 37, and a seventh temperature sensor 38 are disposed. Information detected by these detecting means is sent to a controller, not shown, that controls the operation of the air-conditioning apparatus 100 and used for control of driving frequencies of the compressor 10 and the pump 21, switching of the channel for the heat medium flowing through the pipeline 5 and the like.

[0041] The two first temperature sensors 31 (a first temperature sensor 31a and a first temperature sensor 31b) detect the temperature of the heat medium flowing out of the intermediate heat exchanger 15, that is, the heat medium temperature at the outlet of the intermediate heat exchanger 15 and are preferably composed of thermistors or the like. The first temperature sensor 31a is disposed in the pipeline 5 on the inlet side of the first pump 21a. The second temperature sensor 31b is disposed in the pipeline 5 on the inlet side of the second pump 21b.

[0042] The two second temperature sensors 32 (a second temperature sensor 32a and a second temperature sensor 32b) detect the temperature of the heat medium flowing into the intermediate heat exchanger 15, that is, the heat medium

temperature at the inlet of the intermediate heat exchanger 15 and are preferably composed of thermistors or the like. The second temperature sensor 32a is disposed in the pipeline 5 on the inlet side of the first intermediate heat exchanger 15a. The second temperature sensor 32b is disposed in the pipeline 5 on the inlet side of the second intermediate heat exchanger 15b.

[0043] The four third temperature sensors 33 (third temperature sensors 33a to 33d) are disposed on the inlet side of the heat medium channel of the use-side heat exchanger 26 and detect the temperature of the heat medium flowing into the use-side heat exchanger 26, and the sensor is preferably composed of a thermistor or the like. The third temperature sensors 33 are disposed in number (four, here) according to the installed number of the indoor units 2. In accordance with the indoor units 2, they are shown as the third temperature sensor 33a, the third temperature sensor 33b, the third temperature sensor 33c, and the third temperature sensor 33d from the lower side of the page.

[0044] The four fourth temperature sensors 34 (fourth temperature sensors 34a to 34d) are disposed on the outlet side of the heat medium channel of the use-side heat exchanger 26 and detect the temperature of the heat medium flowing out of the use-side heat exchanger 26, and the sensor is preferably composed of a thermistor or the like. The fourth temperature sensors 34 are disposed in number (four, here) according to the installed number of the indoor units 2. In accordance with the indoor units 2, they are shown as the fourth temperature sensor 34a, the fourth temperature sensor 34b, the fourth temperature sensor 34c, and the fourth temperature sensor 34d from the lower side of the page.

[0045] The fifth temperature sensor 35 is disposed on the outlet side of the heat-source side refrigerant channel of the first intermediate heat exchanger 15a and detects the temperature of the heat-source side refrigerant flowing out of the first intermediate heat exchanger 15a, and is preferably composed of a thermistor or the like. The first pressure sensor 36 is disposed on the outlet side of the heat-source side refrigerant channel of the first intermediate heat exchanger 15a and detects the pressure of the heat-source side refrigerant flowing out of the first intermediate heat exchanger 15a.

[0046] The sixth temperature sensor 37 is disposed on the inlet side of the heat-source side refrigerant channel of the second intermediate heat exchanger 15b and detects the temperature of the heat-source side refrigerant flowing into the second intermediate heat exchanger 15b, and the sensor is preferably composed of a thermistor or the like. The seventh temperature sensor 38 is disposed on the outlet side of the heat-source side refrigerant channel of the second intermediate heat exchanger 15b and detects a temperature of the heat-source side refrigerant flowing out of the second intermediate heat exchanger 15b, and the sensor is preferably composed of a thermistor or the like.

[0047] The pipeline 5 through which the heat medium is conducted is composed of a pipeline connected to the first intermediate heat exchanger 15a (hereinafter referred to as a pipeline 5a) and a pipeline connected to the second intermediate heat exchanger 15b (hereinafter referred to as a pipeline 5b). The pipeline 5a and the pipeline 5b are branched in accordance with the number (here, branched to four each) of the indoor units 2 connected to the relay unit 3. And the pipeline 5a and the pipeline 5b are connected by the channel switching valve 22, the channel switching valve 23, and the flow regulating valve 25. By controlling the channel switching valve 22 and the channel switching valve 23, it is determined whether the heat medium conducted through the pipeline 5a is made to flow into the use-side heat exchanger 26 or the heat medium conducted through the pipeline 5b is made to flow into the use-side heat exchanger 26.

[0048] In this air-conditioning apparatus 100, the compressor 10, the four-way valve 11, the heat-source side heat exchanger 12, the first intermediate heat exchanger 15a, and the second intermediate heat exchanger 15b are connected by the refrigerant pipeline 4 in series in the order so as to constitute a refrigeration cycle. Also, the first intermediate heat exchanger 15a, the first pump 21a, and the use-side heat exchanger 26 are connected by the pipeline 5a in series in the order so as to constitute a heat medium circulation circuit. Similarly, the second intermediate heat exchanger 15b, the second pump 21b, and the use-side heat exchanger 26 are connected by the pipeline 5b in series in the order so as to constitute a heat medium circulation circuit. That is, a plurality of use-side heat exchangers 26 are connected in parallel to each of the intermediate heat exchangers 15 so as to form plural systems of the heat medium circulation circuits.

[0049] That is, in the air-conditioning apparatus 100, the heat source device 1 and the relay unit 3 are connected to each other through the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b disposed in the relay unit 3. And the relay unit 3 and the indoor units 2 are connected by the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b so that the heat-source side refrigerant, which is the primary-side refrigerant circulating through the refrigeration cycle in the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b, and the heat medium, which is the secondary-side refrigerant circulating through the heat medium circulation circuit exchange heat with each other.

[0050] Here, the type of the refrigerant used in the refrigeration cycle and the heat medium circulation circuit will be described.

For the refrigeration cycle, a nonazeotropic refrigerant mixture such as R407C, a pseudo azeotropic refrigerant such as R410A, a single refrigerant such as R22 and the like can be used. Also, a natural refrigerant such as carbon dioxide, hydrocarbon and the like may be used. By using the natural refrigerant as the heat-source side refrigerant, an effect that a global warming effect caused by leakage of the refrigerant can be suppressed is obtained. Particularly, since carbon dioxide performs heat exchange without being condensed in a supercritical state on the high pressure side, by setting the heat-source side refrigerant and the heat medium in a countercurrent format in the first intermediate heat

exchanger 15a and the second intermediate heat exchanger 15b as shown in Fig. 2, heat exchange performance when the heat medium is heated can be improved.

[0051] The heat medium circulation circuit is connected to the use-side heat exchanger 26 of the indoor unit 2 as described above. Thus, in the air-conditioning apparatus 100, considering the case of leakage of the heat medium into a room where the indoor unit 2 is installed or the like, use of the heat medium with high safety is premised. Therefore, for the heat medium, water, an antifreezing solution, a mixed liquid of water and the antifreezing solution and the like can be used, for example. According to this configuration, refrigerant leakage caused by freezing or corrosion can be prevented even at a low outside temperature, and high reliability can be obtained. Also, if the indoor unit 2 is installed in a place where water is disliked such as a computer room, a fluorine inactive liquid with high heat insulation can be used as the heat medium.

[0052] Fig. 3 is a partial circuit configuration diagram illustrating an example of a circuit configuration to which an expansion tank 60 is connected. Fig. 4 is a partial circuit configuration diagram illustrating another example of the circuit configuration to which the expansion tank 60 is connected. Fig. 5 is an internal perspective view illustrating an outline structure of the expansion tank 60. Fig. 6 is a graph illustrating a relationship between a charged water pressure and a capacity of the expansion tank 60. On the basis of Figs. 3 to 6, the expansion tank 60 will be described along with installation restrictions of the relay unit 3. As shown in Fig. 3 or Fig. 4, in the air-conditioning apparatus 100, the expansion tank 60, which is one of expansion absorption devices that absorb volume change in the heat medium, is connected to the second relay unit 3b. Also, a case in which the expansion tank 60 is contained in the relay unit 3 will be described as an example. In Fig. 6, the lateral axis denotes a water pipe water supply pressure [MPaG] and the vertical axis denotes a capacity (L) of the expansion tank 60.

[0053] A heat medium such as water has a characteristic that if the temperature is raised, the volume is increased, while if the temperature is lowered, the volume is decreased. Therefore, if the channel of the heat medium is a closed circuit as in the air-conditioning apparatus 100 according to Embodiment 1, without a mechanism that absorbs this volume change, the pipeline 5 might be blown out due to volumetric expansion. Thus, in the air-conditioning apparatus 100, two units of the expansion tank 60 as a device that absorbs expansion of the heat medium are disposed. The two expansion tanks 60 (a heating-side expansion tank 60a and a cooling-side expansion tank 60b) are connected to a heating-side expansion tank connection port 42 and a cooling-side expansion tank connection port 43 shown in Fig. 2 by connection pipelines 65 (a heating-side connection pipeline 65a and a cooling-side connection pipeline 65b), respectively.

[0054] The heating-side expansion tank 60a and the cooling-side expansion tank 60b have a bulkhead 66 such as rubber having flexibility inside, and each is configured such that an air reservoir is formed in a lower part with this bulkhead 66 as a boundary so that the heat medium flows into an upper part. That is, the heating-side connection pipeline 65a is connected to the upper part of the heating-side expansion tank 60a, and the cooling-side connection pipeline 65b is connected to the upper part of the cooling-side expansion tank 60b so that the bulkhead 66 is expanded by the volume of the flowing-in heat medium. If the temperature of the heat medium is low, the bulkhead 66 is located in the upper part, while if the temperature of the heat medium is raised and the volume of the heat medium is increased, the bulkhead 66 is expanded to the lower part so as to absorb the volumetric expansion.

[0055] Subsequently, the capacity of the expansion tank 60 will be described.

Suppose that a pressure of the air reservoir before the heat medium is expanded is P_0 and the capacity of the air reservoir is V_0 , and the heat medium is expanded, the pressure of the air reservoir becomes a limit pressure P_1 of the expansion tank 60 and the capacity of the air reservoir is decreased and the capacity of the air reservoir becomes V_1 . Then, according to Boyle-Charle's law, the following equation (1) holds true:

$$(1) \quad P_0 * V_0 = P_1 * V_1$$

$$V_1 = P_0 * V_0 / P_1$$

[0056] Supposing that an expansion amount of the heat medium is V_e , the following equation (2) holds true:

$$(2) \quad V_e = V_0 - V_1 = V_0 - P_0 * V_0 / P_1 = V_0 * (1 - P_0 / P_1)$$

Thus, a required capacity of the air reservoir can be expressed by the expansion amount and the pressure of the heat medium as in the following equation (3):

$$(3) \quad V_0 = V_e / (1 - P_0/P_1)$$

As is known from the equation (3), in order to decrease the capacity of the expansion tank 60, P_0/P_1 needs to be made small.

[0057] That is, as a specific device that reduces the capacity of the expansion tank 60, there can be a device that lowers a lowest pressure of the air reservoir or a device that raises a pressure resistance of the expansion tank 60 and the like. Particularly, considering the installation state of the relay unit 3, since the relay unit 3 is installed under the roof or the like in many cases, there is a restriction that the height of the relay unit 3 should be kept at approximately 300 mm or less. In view of such a background, size reduction of the expansion tank 60, that is, reduction of P_0/P_1 is in demand.

[0058] In order to increase P_0 (to raise the pressure resistance), the thickness of the container of the expansion tank 60 needs to be increased, whereby the expansion tank 60 becomes heavy and difficult to be contained under the roof. Also, in order to decrease P_1 (to reduce the initial pressure), the charged water pressure and the positions of the relay unit 3 and the indoor unit 2 need to be limited. From Fig. 6, it is known that the capacity of the expansion tank 60 is drastically different depending on the lowest pressure. That is, from Fig. 6, in order to keep the capacity of the expansion tank 60 to approximately 5 liters or less, the lowest pressure needs to be set approximately at 100 kPaG.

[0059] In order to prevent the head pressures of the first pump 21a and the second pump 21b from being applied to the expansion tank 60, the connection ports to the expansion tank 60 (the heating-side expansion tank connection port 42 and the cooling-side expansion tank connection port 43) need to be taken out from the suction sides of the first pump 21a and the second pump 21b as shown in Fig. 2. Also, here, a case in which examination is made with the limit pressure of the expansion tank 60 set at 490 kPaG will be described.

[0060] As shown in Fig. 3, if the relay unit 3 is installed higher than the indoor unit 2, since there is no head pressure applied to the expansion tank 60, P_0 gets as close as possible to 0, and the expansion tank 60 can be made small. However, the relay unit 3 is not always installed higher than the indoor unit 2 in actuality. That is, the relay unit 3 and the indoor unit 2 might be installed as in Fig. 4. Also, in the heat medium circulation circuit of the air-conditioning apparatus 100, a water pipe 62 is connected through an expansion valve 61 so that water is poured into the heat medium circulation circuit by the pressure of tap water.

[0061] That is, in an installation state as in Fig. 4, the pressure of the tap water supplied from the water pipe 62 is applied to the expansion tank 60. Therefore, by setting a height difference h between the indoor unit 2 and the relay unit 3 at 10 m and the feed water pressure of the tap water approximately at 100 kPaG as in Fig. 4, the capacity of the expansion tank 60 can be kept at approximately 5 liters as in Fig. 6 and the size can be made so as to be contained under the roof. Since the expansion tank 60 is disposed in advance in the air-conditioning apparatus 100 as above, the expansion tank 60 for each article is no longer needed as before, and a selection work of the system can be simplified. If the expansion tank 60 is not contained in the relay unit 3, the height difference h between the indoor unit 2 and the expansion tank 60 is set at 10 m.

[0062] Here, each operation mode executed by the air-conditioning apparatus 100 will be described.

This air-conditioning apparatus 100 is, on the basis of an instruction from each indoor unit 2, capable of the cooling operation or the heating operation with the indoor unit 2 thereof. That is, the air-conditioning apparatus 100 can perform the same operation with all the indoor units 2 or can perform different operations with each of the indoor units 2. Four operation modes executed by the air-conditioning apparatus 100, that is, a cooling only operation mode in which all the driving indoor units 2 perform the cooling operation, a heating only operation mode in which all the driving indoor units 2 perform the heating operation, a cooling-main operation mode in which a cooling load is larger, and a heating main operation mode in which a heating load is larger will be described below with the flow of the refrigerant.

[Cooling only operation mode]

[0063] Fig. 7 is a refrigerant circuit diagram illustrating the flow of the refrigerant in the cooling only operation mode of the air-conditioning apparatus 100. In Fig. 7, the cooling only operation mode will be described using the case in which a cooling load is generated only in the use-side heat exchanger 26a and the use-side heat exchanger 26b as an example. That is, in Fig. 7, the case in which the cooling load is not generated in the use-side heat exchanger 26c and the use-side heat exchanger 26d is illustrated. In Fig. 7, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0064] In the case of the cooling only operation mode shown in Fig. 7, in the heat source device 1, the four-way valve 11 is switched so that the heat-source side refrigerant discharged from the compressor 10 flows into the heat-source side heat exchanger 12. In the relay unit 3, the first pump 21a is stopped, the second pump 21b is driven, the stop valve 24a and the stop valve 24b are opened, and the stop valve 24c and the stop valve 24d are closed so that the heat

medium circulates between the second intermediate heat exchanger 15b and each use-side heat exchanger 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). In this state, the operation of the compressor 10 is started.

[0065] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described. A low-temperature and low-pressure refrigerant is compressed by the compressor 10, becomes a high-temperature and high-pressure gas refrigerant and is discharged. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the four-way valve 11 and flows into the heat-source side heat exchanger 12. Then, the refrigerant is condensed and liquefied while radiating heat to the outdoor air in the heat-source side heat exchanger 12 and becomes a high-pressure liquid refrigerant. The high-pressure liquid refrigerant having flowed out of the heat-source side heat exchanger 12 passes through the check valve 13a and flows out of the heat source device 1 and flows into the first relay unit 3a through the refrigerant pipeline 4. The high-pressure liquid refrigerant having flowed into the first relay unit 3a flows into the gas-liquid separator 14 and then, passes through the expansion valve 16e and flows into the second relay unit 3b.

[0066] The refrigerant having flowed into the second relay unit 3b is throttled by the expansion valve 16a and expanded and becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant. This gas-liquid two-phase refrigerant flows into the second intermediate heat exchanger 15b working as an evaporator, and while absorbing heat from the heat medium circulating in the heat medium circulation circuit so as to cool the heat medium, it becomes the low-temperature and low-pressure gas refrigerant. The gas refrigerant having flowed out of the second intermediate heat exchanger 15b passes through the expansion valve 16c, flows out of the second relay unit 3b and the first relay unit 3a and flows into the heat source device 1 through the refrigerant pipeline 4. The refrigerant having flowed into the heat source device 1 passes through the check valve 13d and is sucked into the compressor 10 again through the four-way valve 11 and the accumulator 17. The expansion valve 16b and the expansion valve 16d have small opening-degrees so that the refrigerant does not flow therethrough, while the expansion valve 16c is in the fully open state so that a pressure loss does not occur.

[0067] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described. In the cooling only operation mode, since the first pump 21a is stopped, the heat medium circulates through the pipeline 5b. The heat medium having been cooled by the heat-source side refrigerant in the second intermediate heat exchanger 15b is fluidized in the pipeline 5b by the second pump 21b. The heat medium flowing from and having been pressurized by the second pump 21b passes through the stop valve 24 (the stop valve 24a and the stop valve 24b) through the channel switching valve 22 (the channel switching valve 22a and the channel switching valve 22b) and flows into the use-side heat exchanger 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). Then, the heat medium absorbs heat from the indoor air in the use-side heat exchanger 26 and cools the region to be air-conditioned such as the inside of the room where the indoor unit 2 is installed.

[0068] After that, the heat medium having flowed out of each use-side heat exchanger 26 flows into the flow regulating valve 25 (the flow regulating valve 25a and the flow regulating valve 25b). At this time, by means of the action of the flow regulating valve 25, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned such as the inside of the room flows into the use-side heat exchanger 26, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26 through the bypass 27 (the bypass 27a and the bypass 27b).

[0069] The heat medium passing through the bypass 27 does not contribute to the heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26, passes through the channel switching valve 23 (the channel switching valve 23a and the channel switching valve 23b), flows into the second intermediate heat exchanger 15b and is sucked into the second pump 21b again. The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by means of control such that a temperature difference between the third temperature sensor 33 and the fourth temperature sensor 34 is kept at a target value.

[0070] At this time, since there is no need to make the heat medium flow into the use-side heat exchanger 26 (including thermo off) not having a air-conditioning load, the channel is closed by the stop valve 24 so that the heat medium does not flow into the use-side heat exchanger 26. In Fig. 7, since there is a air-conditioning load in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium is made to flow, but there is no air-conditioning load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, and the corresponding stop valve 24c and the stop valve 24d are in the closed state. In the case of occurrence of a cooling load from the use-side heat exchanger 26c or the use-side heat exchanger 26d, it is only necessary to open the stop valve 24c or the stop valve 24d so that the heat medium is circulated.

[Heating only operation mode]

[0071] Fig. 8 is a refrigerant circuit diagram illustrating the flow of the refrigerant in the heating only operation mode of the air-conditioning apparatus 100. In Fig. 8, the heating only operation mode will be described using the case in

which a heating load is generated only in the use-side heat exchanger 26a and the use-side heat exchanger 26b as an example. That is, in Fig. 8, the case in which the heating load is not generated in the use-side heat exchanger 26c and the use-side heat exchanger 26d is shown. In Fig. 8, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0072] In the case of the heating only operation mode shown in Fig. 8, in the heat source device 1, the four-way valve 11 is switched so that the heat-source side refrigerant discharged from the compressor 10 flows into the relay unit 3 without going through the heat-source side heat exchanger 12. In the relay unit 3, the first pump 21a is driven, the second pump 21b is stopped, the stop valve 24a and the stop valve 24b are opened, and the stop valve 24c and the stop valve 24d are closed so that the heat medium circulates between the first intermediate heat exchanger 15a and each use-side heat exchanger 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). In this state, the operation of the compressor 10 is started.

[0073] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described.

A low-temperature and low-pressure refrigerant is compressed by the compressor 10, becomes a high-temperature and high-pressure gas refrigerant and is discharged. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the four-way valve 11, is conducted through the first connection pipeline 4a, passes through the check valve 13b and flows out of the heat source device 1. The high-temperature and high-pressure gas refrigerant having flowed out of the heat source device 1 flows into the first relay unit 3a through the refrigerant pipeline 4. The high-temperature and high-pressure gas refrigerant having flowed into the first relay unit 3a flows into the gas-liquid separator 14 and then, flows into the first intermediate heat exchanger 15a. The high-temperature and high-pressure gas refrigerant having flowed into the first intermediate heat exchanger 15a is condensed and liquefied while radiating heat to the heat medium circulating through the heat medium circulation circuit and becomes a high-pressure liquid refrigerant.

[0074] The high-pressure liquid refrigerant having flowed out of the first intermediate heat exchanger 15a is throttled by the expansion valve 16d and expanded to turn into a low-temperature and low-pressure gas-liquid two-phase state. The refrigerant in the gas-liquid two-phase state having been throttled by the expansion valve 16d passes through the expansion valve 16b, is conducted through the refrigerant pipeline 4, and flows into the heat source device 1 again. The refrigerant having flowed into the heat source device 1 passes through the second connection pipeline 4b through the check valve 13d and flows into the heat-source side heat exchanger 12 working as an evaporator. Then, the refrigerant having flowed into the heat-source side heat exchanger 12 absorbs heat from the outdoor air in the heat-source side heat exchanger 12 so as to become a low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant having flowed out of the heat-source side heat exchanger 12 returns to the compressor 10 through the four-way valve 11 and the accumulator 17. The expansion valve 16a, the expansion valve 16c, and the expansion valve 16e have small opening-degrees so that no refrigerant flow therethrough.

[0075] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described.

In the heating only operation mode, since the second pump 21b is stopped, the heat medium circulates through the pipeline 5a. The heat medium having been heated by the heat-source side refrigerant in the first intermediate heat exchanger 15a is fluidized in the pipeline 5a by the first pump 21a. The heat medium flowing from and having been pressurized by the first pump 21a passes through the stop valve 24 (the stop valve 24a and the stop valve 24b) through the channel switching valve 22 (the channel switching valve 22a and the channel switching valve 22b) and flows into the use-side heat exchanger 26 (the use-side heat exchanger 26a and the use-side heat exchanger 26b). Then, the heat medium gives heat to the indoor air in the use-side heat exchanger 26 and heats the region to be air-conditioned such as the inside of the room where the indoor unit 2 is installed.

[0076] After that, the heat medium having flowed out of the use-side heat exchanger 26 flows into the flow regulating valve 25 (the flow regulating valve 25a and the flow regulating valve 25b). At this time, by means of the action of the flow regulating valve 25, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned such as the inside of the room flows into the use-side heat exchanger 26, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26 through the bypass 27 (the bypass 27a and the bypass 27b).

[0077] The heat medium passing through the bypass 27 does not contribute to the heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26, passes through the channel switching valve 23 (the channel switching valve 23a and the channel switching valve 23b), flows into the first intermediate heat exchanger 15a and is sucked into the first pump 21a again. The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by means of control such that a temperature difference between the third temperature sensor 33 and the fourth temperature sensor 34 is kept at a target value.

[0078] At this time, since there is no need to make the heat medium flow into the use-side heat exchanger 26 (including thermo off) not having a air-conditioning load, the channel is closed by the stop valve 24 so that the heat medium does not flow into the use-side heat exchanger 26. In Fig. 8, since there is a air-conditioning load in the use-side heat exchanger

26a and the use-side heat exchanger 26b, the heat medium is made to flow, but there is no air-conditioning load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, and the corresponding stop valve 24c and the stop valve 24d are in the closed state. In the case of occurrence of a heating load from the use-side heat exchanger 26c or the use-side heat exchanger 26d, it is only necessary to open the stop valve 24c or the stop valve 24d so that the heat medium is circulated.

[Cooling-main operation mode]

[0079] Fig. 9 is a refrigerant circuit diagram illustrating the flow of the refrigerant during the cooling-main operation mode of the air-conditioning apparatus 100. In Fig. 9, using a case in which a heating load is generated in the use-side heat exchanger 26a and a cooling load is generated in the use-side heat exchanger 26b as an example, the cooling-main operation mode will be described. That is, in Fig. 9, the case in which neither of the heating load nor the cooling load is generated in the use-side heat exchanger 26c and the use-side heat exchanger 26d is shown. In Fig. 9, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0080] In the case of the cooling-main operation mode shown in Fig. 9, in the heat source device 1, the four-way valve 11 is switched so that the heat-source side refrigerant discharged from the compressor 10 flows into the heat-source side heat exchanger 12. In the relay unit 3, the first pump 21a and the second pump 21b are driven, the stop valve 24a and the stop valve 24b are opened, the stop valve 24c and the stop valve 24d are closed, and the heat medium is made to circulate between the first intermediate heat exchanger 15a and the use-side heat exchanger 26a as well as the second intermediate heat exchanger 15b and the use-side heat exchanger 26b. In this state, the operation of the compressor 10 is started.

[0081] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described.

The low-temperature and low-pressure refrigerant is compressed by the compressor 10 and discharged as the high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the four-way valve 11 and flows into the heat-source side heat exchanger 12. Then, the refrigerant is condensed while radiating heat to the outdoor air in the heat-source side heat exchanger 12 and becomes a gas-liquid two-phase refrigerant. The gas-liquid two-phase refrigerant having flowed out of the heat-source side heat exchanger 12 flows out of the heat source device 1 through the check valve 13a and flows into the first relay unit 3a through the refrigerant pipeline 4. The gas-liquid two-phase refrigerant having flowed into the first relay unit 3a flows into the gas-liquid separator 14 and is separated to a gas refrigerant and a liquid refrigerant, which flow into the second relay unit 3b.

[0082] The gas refrigerant having been separated in the gas-liquid separator 14 flows into the first intermediate heat exchanger 15a. The gas refrigerant having flowed into the first intermediate heat exchanger 15a is condensed and liquefied while radiating heat to the heat medium circulating through the heat medium circulation circuit to turn into a liquid refrigerant. The liquid refrigerant having flowed out of the second intermediate heat exchanger 15b passes through the expansion valve 16d. On the other hand, the liquid refrigerant separated in the gas-liquid separator 14 passes through the expansion valve 16e, merges with the liquid refrigerant condensed and liquefied in the first intermediate heat exchanger 15a and passed through the expansion valve 16d, being throttled by the expansion valve 16a and expanded, and turns into a low-temperature and low-pressure gas-liquid two-phase refrigerant to flow into the second intermediate heat exchanger 15b.

[0083] This gas-liquid two-phase refrigerant absorbs heat from the heat medium circulating through the heat medium circulation circuit in the second intermediate heat exchanger 15b working as an evaporator so as to cool the heat medium and becomes a low-temperature and low-pressure gas refrigerant. The gas refrigerant having flowed out of the second intermediate heat exchanger 15b passes through the expansion valve 16c and then, flows out of the second relay unit 3b and the first relay unit 3a and flows into the heat source device 1 through the refrigerant pipeline 4. The refrigerant having flowed into the heat source device 1 passes through the check valve 13d and is sucked into the compressor 10 again through the four-way valve 11 and the accumulator 17. The expansion valve 16b has a small opening-degree so that the refrigerant does not flow therethrough, and the expansion valve 16c is in the full open state so that a pressure loss does not occur.

[0084] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described.

In the cooling-main operation mode, since the first pump 21a and the second pump 21b are both driven, the heat medium is circulated through both the pipeline 5a and the pipeline 5b. The heat medium heated by the heat-source side refrigerant in the first intermediate heat exchanger 15a is fluidized in the pipeline 5a by the first pump 21a. Also, the heat medium cooled by the heat-source side refrigerant in the second intermediate heat exchanger 15b is fluidized in the pipeline 5b by the second pump 21b.

[0085] The heat medium flowing from and having been pressurized by the first pump 21a passes through the stop

valve 24a through the channel switching valve 22a and flows into the use-side heat exchanger 26a. Then, in the use-side heat exchanger 26a, the heat medium gives heat to the indoor air and heats the region to be air-conditioned such as the inside of the room where the indoor unit 2 is installed. Also, the heat medium flowing from and having been pressurized by the second pump 21b passes through the stop valve 24b through the channel switching valve 22b and flows into the use-side heat exchanger 26b. Then, in the use-side heat exchanger 26b, the heat medium absorbs heat from the indoor air and cools the region to be air-conditioned such as the inside of the room where the indoor unit 2 is installed.

[0086] The heat medium having performed heating flows into the flow regulating valve 25a. At this time, by means of the action of the flow regulating valve 25a, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned flows into the use-side heat exchanger 26a, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26a through the bypass 27a. The heat medium passing through the bypass 27a does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26a, flows into the first intermediate heat exchanger 15a through the channel switching valve 23a and is sucked into the first pump 21a again.

[0087] Similarly, the heat medium having performed cooling flows into the flow regulating valve 25b. At this time, by means of the action of the flow regulating valve 25b, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned flows into the use-side heat exchanger 26b, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26b through the bypass 27b. The heat medium passing through the bypass 27b does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26b, flows into the second intermediate heat exchanger 15b through the channel switching valve 23b and is sucked into the second pump 21b again.

[0088] During that period, the heated heat medium (the heat medium used for the heating load) and the cooled heat medium (the heat medium used for the cooling load) flow into the use-side heat exchanger 26a having the heating load or the use-side heat exchanger 26b having the cooling load without mixing by means of the actions of the channel switching valve 22 (the channel switching valve 22a and the channel switching valve 22b) and the channel switching valve 23 (the channel switching valve 23a and the channel switching valve 23b). The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by executing control such that a difference in temperatures between the third temperature sensor 33 and the fourth temperature sensor 34 is kept at a target value.

[0089] At this time, since there is no need to make the heat medium flow into the use-side heat exchanger 26 (including thermo off) having no air-conditioning load, the channel is closed by the stop valve 24 so that no heat medium flows into the use-side heat exchanger 26. In Fig. 9, since there is a air-conditioning load in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium is made to flow. However, since there is no air-conditioning load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, the corresponding stop valve 24c and the stop valve 24d are in the closed state. In the case of occurrence of a heating load or e of a cooling load from the use-side heat exchanger 26c or the use-side heat exchanger 26d, it is only necessary to open the stop valve 24c or the stop valve 24d so that the heat medium is circulated.

[Heating-main operation mode]

[0090] Fig. 10 is a refrigerant circuit diagram illustrating the flow of the refrigerant during the heating-main operation mode of the air-conditioning apparatus 100. In Fig. 10, using a case in which a heating load is generated in the use-side heat exchanger 26a and a cooling load is generated in the use-side heat exchanger 26b as an example, the heating-main operation mode will be described. That is, in Fig. 10, the case in which neither of the heating load nor the cooling load is generated in the use-side heat exchanger 26c and the use-side heat exchanger 26d is shown. In Fig. 10, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0091] In the case of the heating-main operation mode shown in Fig. 10, in the heat source device 1, the four-way valve 11 is switched so that the heat-source side refrigerant discharged from the compressor 10 flows into the relay unit 3 without passing through the heat-source side heat exchanger 12. In the relay unit 3, the first pump 21a and the second pump 21b are driven, the stop valve 24a and the stop valve 24b are opened, the stop valve 24c and the stop valve 24d are closed, and the heat medium is made to circulate between the first intermediate heat exchanger 15a and the use-side heat exchanger 26a as well as the second intermediate heat exchanger 15b and the use-side heat exchanger 26b. In this state, the operation of the compressor 10 is started.

[0092] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described.

The low-temperature and low-pressure refrigerant is compressed by the compressor 10 and becomes a high-temperature and high-pressure gas refrigerant and is discharged. The high-temperature and high-pressure gas refrigerant discharged from the compressor 10 passes through the four-way valve 11, is conducted through the first connection pipeline 4a,

passes through the check valve 13b and flows out of the heat source device 1. The high-temperature and high-pressure gas refrigerant having flowed out of the heat source device 1 flows into the first relay unit 3a through the refrigerant pipeline 4. The high-temperature and high-pressure gas refrigerant having flowed into the first relay unit 3a flows into the gas-liquid separator 14 and then, flows into the first intermediate heat exchanger 15a. The high-temperature and high-pressure gas refrigerant having flowed into the first intermediate heat exchanger 15a is condensed and liquefied while radiating heat to the heat medium circulating through the heat medium circulation circuit and becomes a high-pressure liquid refrigerant.

[0093] The high-pressure liquid refrigerant having flowed out of the first intermediate heat exchanger 15a is throttled by the expansion valve 16d and expanded to turn into a low-temperature and low-pressure gas-liquid two-phase state. The refrigerant in the gas-liquid two-phase state having been throttled by the expansion valve 16d is divided into a channel through the expansion valve 16a and a channel through the expansion valve 16b. The refrigerant having passed through the expansion valve 16a is further expanded by this expansion valve 16a and becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant to flow into the second intermediate heat exchanger 15b working as an evaporator. The refrigerant having flowed into the second intermediate heat exchanger 15b absorbs heat from the heat medium in the second intermediate heat exchanger 15b and becomes a low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant having flowed out of the second intermediate heat exchanger 15b passes through the expansion valve 16c.

[0094] On the other hand, the refrigerant having been throttled by the expansion valve 16d and flowed to the expansion valve 16b merges with the refrigerant having passed through the second intermediate heat exchanger 15b and the expansion valve 16c and becomes a low-temperature and low-pressure refrigerant with larger quality. Then, the merged refrigerant flows out of the second relay unit 3b and the first relay unit 3a and flows into the heat source device 1 through the refrigerant pipeline 4. The refrigerant having flowed into the heat source device 1 passes through the second connection pipeline 4b through the check valve 13c and flows into the heat-source side heat exchanger 12 working as an evaporator. The refrigerant having flowed into the heat-source side heat exchanger 12 absorbs heat from the outdoor air in the heat-source side heat exchanger 12 and becomes a low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant having flowed out of the heat-source side heat exchanger 12 returns to the compressor 10 through the four-way valve 11 and the accumulator 17. The expansion valve 16e has a small opening-degree so that the refrigerant does not flow therethrough.

[0095] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described.

In the heating-main operation mode, since the first pump 21a and the second pump 21b are both driven, the heat medium is circulated through both the pipeline 5a and the pipeline 5b. The heat medium heated by the heat-source side refrigerant in the first intermediate heat exchanger 15a is fluidized in the pipeline 5a by the first pump 21a. Also, the heat medium cooled by the heat-source side refrigerant in the second intermediate heat exchanger 15b is fluidized in the pipeline 5b by the second pump 21b.

[0096] The heat medium flowing from and having been pressurized by the first pump 21a passes through the stop valve 24a through the channel switching valve 22a and flows into the use-side heat exchanger 26a. Then, in the use-side heat exchanger 26a, the heat medium gives heat to the indoor air and heats the region to be air-conditioned such as the inside of the room where the indoor unit 2 is installed. Also, the heat medium flowing from and having been pressurized by the second pump 21b passes through the stop valve 24b through the channel switching valve 22b and flows into the use-side heat exchanger 26b. Then, in the use-side heat exchanger 26b, the heat medium absorbs heat from the indoor air and cools the region to be air-conditioned such as the inside of the room where the indoor unit 2 is installed.

[0097] The heat medium having flowed out of the use-side heat exchanger 26a flows into the flow regulating valve 25a. At this time, by means of the action of the flow regulating valve 25a, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned such as the inside of a room flows into the use-side heat exchanger 26a, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26a through the bypass 27a. The heat medium passing through the bypass 27a does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26a, flows into the first intermediate heat exchanger 15a through the channel switching valve 23a and is sucked into the first pump 21a again.

[0098] Similarly, the heat medium having flowed out of the use-side heat exchanger 26b flows into the flow regulating valve 25b. At this time, by means of the action of the flow regulating valve 25b, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned such as the inside of the room flows into the use-side heat exchanger 26b, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26b through the bypass 27b. The heat medium passing through the bypass 27b does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26b, flows into the second intermediate heat exchanger 15b through the channel switching valve 23b and is sucked into the second pump 21b again.

[0099] During that period, the heated heat medium and the cooled heat medium flow into the use-side heat exchanger

26a having the heating load or the use-side heat exchanger 26b having the cooling load without mixing by means of the actions of the channel switching valve 22 (the channel switching valve 22a and the channel switching valve 22b) and the channel switching valve 23 (the channel switching valve 23a and the channel switching valve 23b). The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by executing control such that a difference in temperatures between the third temperature sensor 33 and the fourth temperature sensor 34 is kept at a target value.

[0100] At this time, since there is no need to make the heat medium flow into the use-side heat exchanger 26 (including thermo off) having no air-conditioning load, the channel is closed by the stop valve 24 so that no heat medium flows into the use-side heat exchanger 26. In Fig. 10, since there is a air-conditioning load in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium is made to flow. However, since there is no air-conditioning load in the use-side heat exchanger 26c and the use-side heat exchanger 26d, the corresponding stop valve 24c and the stop valve 24d are in the closed state. In the case of occurrence of a heating load or a cooling load from the use-side heat exchanger 26c or the use-side heat exchanger 26d, it is only necessary to open the stop valve 24c or the stop valve 24d so that the heat medium is circulated.

[0101] As described above, since it is configured that the gas-liquid separator 14 is installed in the first relay unit 3a so that the gas refrigerant and the liquid refrigerant are separated, the cooling operation and the heating operation can be performed at the same time by connecting the heat source device 1 and the first relay unit 3a to each other by the two refrigerant pipelines 4. Also, since cooling energy or heating energy generated in the heat source device 1 can be supplied to the load side through the heat medium by switching and control of the channel switching valve 22, the channel switching valve 23, the stop valve 24, and the flow regulating valve 25 on the heat medium side, cooling energy or heating energy can be freely supplied to the respective use-side heat exchangers 26 by the two pipelines 5 also on the load side.

[0102] Moreover, since the relay units 3 (the first relay unit 3a and the second relay unit 3b) have housings different from those of the heat source device 1 and the indoor unit 2, they can be installed at different positions, and by installing the first relay unit 3a and the second relay unit 3b in the non-living space 50 as shown in Fig. 1, the heat-source side refrigerant and the heat medium can be shut off, and inflow of the heat-source side refrigerant into the living space 7 can be suppressed, whereby safety and reliability of the air-conditioning apparatus 100 are improved.

[0103] In the first intermediate heat exchanger 15a on the heating side, the heat medium temperature at the outlet of the first intermediate heat exchanger 15a detected by the first temperature sensor 31a does not become higher than the heat medium temperature at the inlet of the first intermediate heat exchanger 15a detected by the second temperature sensor 32a, and a heating amount in an superheat gas region of the heat-source side refrigerant is small. Thus, the heat medium temperature at the outlet of the first intermediate heat exchanger 15a is restricted by a condensing temperature substantially acquired from a saturation temperature of the first pressure sensor 36. Also, in the second intermediate heat exchanger 15b on the cooling side, the heat medium temperature at the outlet of the second intermediate heat exchanger 15b detected by the first temperature sensor 31b does not become lower than the heat medium temperature at the inlet of the second intermediate heat exchanger 15b detected by the second temperature sensor 32b.

[0104] Therefore, in the air-conditioning apparatus 100, it is effective to handle an increase or decrease of a air-conditioning load on a secondary side (use side) by changing a condensing temperature or an evaporating temperature on the refrigeration cycle side. Thus, it is preferable that a control target value of the condensing temperature and/or evaporating temperature of the refrigeration cycle stored in the controller (not shown) is changed in accordance with the size of the air-conditioning load on the use side. As a result, the change in the size of the heat air-conditioning load on the use side can be easily followed.

[0105] Grasping of the change in the air-conditioning load on the use side is made by a controller connected to the second relay unit 3b. On the other hand, the control target values of the condensing temperature and the evaporating temperature are stored in a controller connected to the heat source device 1 incorporating the compressor 10 and the heat-source side heat exchanger 12. Thus, a signal line is connected between the controller connected to the second relay unit 3b and the controller connected to the heat source device 1, and the target control value of the condensing temperature and/or evaporating temperature is transmitted via communication so as to change the control target value of the condensing temperature and/or evaporating temperature stored in the controller connected to the heat source device 1. Alternatively, the control target value may be changed by communicating a deviation value of the control target value.

[0106] By executing the above control, the change in the air-conditioning load on the use side can be handled appropriately. That is, if the controller grasps that the air-conditioning load on the use side is lowered, the controller can control the driving frequency of the compressor 10 so as to lower a work load of the compressor 10. Therefore, the air-conditioning apparatus 100 becomes capable of a more energy-saving operation. The controller connected to the second relay unit 3b and the controller connected to the heat source device 1 may be handled by one controller.

[0107] In Embodiment 1, explanation was made using the case in which a pseudo azeotropic refrigerant mixture such as R410A, R404A, a nonazeotropic refrigerant mixture such as R407C, a refrigerant whose global warming coefficient

value is relatively small such as $\text{CF}_3\text{CF}=\text{CH}_2$ containing a double bond in its chemical formula or its mixture, or a natural refrigerant such as carbon dioxide, propane can be used as an example as described above as the heat-source side refrigerant, but the refrigerant is not limited thereto. Also, in Embodiment 1, the case in which the accumulator 17 is disposed in the heat source device 1 was described as an example, but the similar operation and the similar effects can be obtained even without disposing the accumulator 17.

[0108] Also, in general, a blowing device such as a fan is installed in the heat-source side heat exchanger 12 and the use-side heat exchanger 26 so that condensation or evaporation is promoted by blowing in many cases, but not limited to that. For example, a heat exchanger such as a panel heater using radiation can be used as the use-side heat exchanger 26, while a water-cooling heat exchanger in which heat is moved by water or an antifreezing solution can be used as the heat-source side heat exchanger 12, and any type of heat exchanger can be used as long as it has a structure capable of heat radiation or heat absorption.

[0109] The case in which the channel switching valve 22, the channel switching valve 23, the stop valve 24, and the flow regulating valve 25 are disposed in accordance with each of the use-side heat exchangers 26 was described as an example, but not limited to that. For example, each of them may be connected in plural to one unit of the use-side heat exchanger 26, and in that case, it is only necessary that the channel switching valve 22, the channel switching valve 23, the stop valve 24, and the flow regulating valve 25 connected to the same use-side heat exchanger 26 are operated in the same way. Also, the case in which the two intermediate heat exchangers 15 are disposed was described as an example, but it is natural that the number of the units is not limited, but three or more may be disposed as long as they are configured so that the heat medium can be cooled and/or heated.

[0110] Moreover, the case in which the flow regulating valve 25, the third temperature sensor 33, and the fourth temperature sensor 34 are arranged inside the second relay unit 3b was shown, but a part of or all of them may be arranged inside the indoor unit 2. If they are arranged inside the second relay unit 3b, the valves, the pumps and the like on the heat medium side can be collected in the same housing, which gives an advantage that maintenance is easy. On the other hand, if they are arranged inside the indoor unit 2, they can be handled similarly to the expansion valve in the prior-art direct expansion indoor unit, which is easy to be handled, and since they are arranged in the vicinity of the use-side heat exchanger 26, it gives an advantage that they are not affected by a heat loss of an extended pipeline and controllability of the air-conditioning load in the indoor unit 2 is better.

[0111] As described above, since the air-conditioning apparatus 100 according to Embodiment 1 is configured such that the heating energy and/or cooling energy in the refrigeration cycle is transferred to the use-side heat exchanger 26 through the plurality of intermediate heat exchangers 15, the outdoor-side housing (heat source device 1) can be installed in the outdoor space 6 on the outdoor side, the indoor-side housing (indoor unit 2) in the living space 7 on the indoor side, and the heat medium conversion housing (relay unit 3) in the non-living space 50, respectively, entry of the heat-source side refrigerant into the living space 7 can be prevented, and safety and reliability of the system can be improved.

[0112] Also, since the air-conditioning apparatus 100 is configured such that the heat medium such as water, brine and the like flows through the heat medium circulation circuit, the heat-source side refrigerant volume can be drastically reduced, and an influence on the environment at refrigerant leakage can be drastically lowered. Moreover, in the air-conditioning apparatus 100, by connecting the relay unit 3 to each of the plurality of indoor units 2 by the two heat medium pipelines (pipeline 5), conveyance power of water can be reduced, which can save energy and facilitate the installation work. Still further, in the air-conditioning apparatus 100, by restricting a relation between the relay unit 3 and the indoor unit 2 or a feed water pressure of the tap water from the water pipe 62, the size of the expansion tank 60 can be made compact, and the size of the relay unit 3 can be reduced in the end, which improves handling.

Embodiment 2

[0113] Fig. 11 is a circuit diagram illustrating a circuit configuration of an air-conditioning apparatus 200 according to Embodiment 2 of the present invention. On the basis of Fig. 11, the circuit configuration of the air-conditioning apparatus 200 will be described. This air-conditioning apparatus 200 performs a cooling operation or a heating operation using a refrigeration cycle (refrigeration cycle and a heat medium circulation circuit) through which a refrigerant (heat-source side refrigerant and a heat medium (water, antifreezing solution and the like)) is circulated similarly to the air-conditioning apparatus 100. This air-conditioning apparatus 200 is different from the air-conditioning apparatus 100 according to Embodiment 1 in the point that a refrigerant pipeline of the air-conditioning apparatus 200 is a three-pipeline type. The difference from Embodiment 1 will be mainly described in Embodiment 2, the same portions as those in Embodiment 1 are given the same reference numerals, and the description will be omitted.

[0114] As shown in Fig. 11, the air-conditioning apparatus 200 has one heat source device 101, which is a heat source machine, a plurality of indoor units 102, and relay units 103 interposed between the heat source device 101 and the indoor units 102. The relay units 103 exchange heat between the heat-source side refrigerant and the heat medium. The heat source device 101 and the relay unit 103 are connected by a refrigerant pipeline 108 through which a heat-source side refrigerant is conducted, and the relay unit 103 and the indoor unit 102 are connected by the pipeline 5

through which the heat medium is conducted so that cooling energy or heating energy generated in the heat source device 101 is delivered to the indoor units 102. The numbers of the connected heat source devices 101, the indoor units 102, and the relay units 103 are not limited to the numbers shown in the figure.

[0115] The heat source device 101 is arranged in the outdoor space 6 as shown in Fig. 1 so as to supply cooling energy or heating energy to the indoor unit 102 through the relay unit 103. The indoor unit 102 is arranged in the living space 7 as shown in Fig. 1 so as to supply cooling air or heating air to the living space 7 to become a region to be air-conditioned. The relay unit 103 is configured separately from the heat source device 101 and the indoor unit 102, arranged in the nonliving space 50, connects the heat source device 101 to the indoor unit 102 and transfers cooling energy or heating energy supplied from the heat source device 101 to the indoor unit 102.

[0116] The heat source device 101 and the relay unit 103 are connected to each other using three refrigerant pipelines 108 (refrigerant pipelines 108a to 108c). Also, the relay unit 103 and each of the indoor units 102 are connected to each other by the two pipelines 5, respectively. As a result, construction of the air-conditioning apparatus 200 is facilitated. That is, the heat source device 101 and the relay unit 103 are connected through the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b disposed in the relay unit 103, and the relay unit 103 and the indoor unit 102 are also connected through the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b. The configuration and functions of each component disposed in the air-conditioning apparatus 200 will be described below.

[Heat source device 101]

[0117] In the heat source device 101, a compressor 110, an oil separator 111, a check valve 103, a three-way valve 104, which is a refrigerant channel switching device (a three-way valve 104a and a three-way valve 104b), a heat-source side heat exchanger 105, and an expansion valve 106 are connected by a refrigerant pipeline 108 and contained. Also, in the heat source device 101, a two-way valve 107 (a two way valve 107a, a two-way valve 107b, and a two-way valve 107c) are disposed. In this heat source device 101, the flow direction of the heat-source side refrigerant is determined by controlling the three-way valve 104a and the three-way valve 104b.

[0118] The compressor 110 sucks the heat-source side refrigerant and compresses the heat-source side refrigerant into a high-temperature and high-pressure state and is preferably composed of an inverter compressor and the like, capable of capacity control, for example. The oil separator 111 is disposed on the discharge side of the compressor 110 and separates oil contained in the refrigerant discharged from the compressor 110. The check valve 103 is disposed on the downstream side of the oil separator 111 and allows the flow of the heat-source side refrigerant having passed through the oil separator 111 only to a predetermined direction (direction from the oil separator 111 to the three-way valve 104).

[0119] The three-way valve 104 makes switching between the flow of the heat-source side refrigerant during the heating operation and the flow of the heat-source side refrigerant during the cooling operation. The three-way valve 104a is disposed on one of the refrigerant pipelines 108 branching on the downstream side of the check valve 103, and one of the three ways is connected to the check valve 103, another of the three ways to the intermediate heat exchanger 15 through the two-way valve 107b, and the rest of the three ways to the intermediate heat exchanger 15 through the two-way valve 107c, respectively. The three-way valve 104b is disposed on the other of the refrigerant pipeline 108 branching on the downstream side of the check valve 103, and one of the three ways is connected to the check valve 103, another of the three ways to the heat-source side heat exchanger 105, and the rest of the three ways to the compressor 110 and the refrigerant pipeline 108 between the three-way valve 104a and the two-way valve 107c, respectively.

[0120] The heat-source side heat exchanger 105 functions as an evaporator during the heating operation and functions as a condenser during the cooling operation, exchanges heat between the air supplied from a blower such as a fan, not shown, and the heat-source side refrigerant and evaporates and gasifies or condenses and liquefies the heat-source-side refrigerant. The expansion valve 106 is disposed in the refrigerant pipeline 108 connecting the heat-source side heat exchanger 105 and the intermediate heat exchanger 15 to each other, functions as a reducing valve or a throttling device and decompresses and expands the heat-source side refrigerant. The expansion valve 106 is preferably composed of a valve with variably controllable opening-degree such as an electronic expansion valve, for example.

[0121] The two-way valve 107 opens/closes the refrigerant pipeline 108. The two-way valve 107a is disposed on the refrigerant pipeline 108a between the expansion valve 106 and an expansion valve 203, which will be described later. The two-way valve 107b is disposed on the refrigerant pipeline 108b between the three-way valve 104a and a two-way valve 204b, which will be described later. The two-way valve 107c is disposed on the refrigerant pipeline 108c between the three-way valve 104a and a two-way valve 205b, which will be described later. The refrigerant pipeline 108a a high-pressure liquid pipeline, the refrigerant pipeline 108b is a high-pressure gas pipeline, and the refrigerant pipeline 108c a low-pressure gas pipeline.

[Indoor unit 102]

[0122] On the indoor units 102, the use-side heat exchanger 26 is mounted, respectively. This use-side heat exchanger 26 is connected to the stop valve 24 and the flow regulating valve 25 in the relay unit 103 through the pipeline 5. In Fig. 11, a case in which six indoor units 102 are connected to the relay unit 103 is shown as an example, and an indoor unit 102a, an indoor unit 102b, an indoor unit 102c, an indoor unit 102d, an indoor unit 102e, and an indoor unit 102f are shown from the lower side of the page.

[0123] Also, in accordance with the indoor units 102a to 102f, the use-side heat exchanger 26 is also shown as the use-side heat exchanger 26a, the use-side heat exchanger 26b, the use-side heat exchanger 26c, the use-side heat exchanger 26d, the use-side heat exchanger 26e, and the use-side heat exchanger 26f from the lower side of the page. Similarly to Embodiment 1, the number of connected indoor units 102 is not limited to six as shown in Fig. 11. Also, the use-side heat exchanger 26 is the same as the one contained in the indoor unit 2 of the air-conditioning apparatus 100 according to Embodiment 1.

[Relay unit 103]

[0124] In the relay unit 103, the two expansion valves 203, the two intermediate heat exchangers 15, the two two-way valves 204, the two two-way valves 205, the two pumps 21, the six channel switching valves 22, the six channel switching valves 23, the six stop valves 24, and the six flow regulating valves 25 are disposed. The intermediate heat exchangers 15, the pumps 21, the channel switching valves 22, the channel switching valves 23, the stop valves 24, and the flow regulating valves 25 are the same as those contained in the second relay unit 3b of the air-conditioning apparatus 100 according to Embodiment 1.

[0125] Each of the two expansion valves 203 (an expansion valve 203a and an expansion valve 203b) functions as a reducing valve or a throttling device and decompresses and expands the heat-source side refrigerant. The expansion valve 203a is disposed between the two-way valve 107a and the first intermediate heat exchanger 15a. The expansion valve 203b is disposed between the two-way valve 107a and the second intermediate heat exchanger 15b so as to be parallel with the expansion valve 203a. Each of the two expansion valves 203 is preferably composed of a valve with variably controllable opening-degree such as an electronic expansion valve, for example.

[0126] The two two-way valves 204 (a two-way valve 204a and a two-way valve 204b) open/close the refrigerant pipeline 108. The two-way valve 204a is disposed in the refrigerant pipeline 108b between the two-way valve 107b and the first intermediate heat exchanger 15a. The two-way valve 204b is disposed in the refrigerant pipeline 108b between the two-way valve 107b and the second intermediate heat exchanger 15b so as to be parallel with the two-way valve 204a. The two-way valve 204a is disposed in the refrigerant pipeline 108b branching from the refrigerant pipeline 108b between the two-way valve 107b and the two-way valve 204b.

[0127] The two two-way valves 205 (the two-way valve 205a and the two-way valve 205b) open/close the refrigerant pipeline 108. The two-way valve 205a is disposed in the refrigerant pipeline 108c between the two-way valve 107c and the first intermediate heat exchanger 15a. The two-way valve 205b is disposed in the refrigerant pipeline 108c between the two-way valve 107c and the second intermediate heat exchanger 15b so as to be in parallel with the two-way valve 205a. The two-way valve 205a is disposed in the refrigerant pipeline 108c branching from the refrigerant pipeline 108c between the two-way valve 107c and the two-way valve 205b.

[0128] Also, in the relay unit 103, the two first temperature sensors 31, the two second temperature sensors 32, the six third temperature sensors 33, the six fourth temperature sensors 34, the fifth temperature sensor 35, the first pressure sensor 36, the sixth temperature sensor 37, and the seventh temperature sensor 38 are disposed as in the second relay unit 3b of the air-conditioning apparatus 100 according to Embodiment 1. In addition, in the relay unit 103, an eighth temperature sensor 39 and a second pressure sensor 40 are disposed. Information detected by these detecting means is sent to the controller, not shown, that controls the entire operation of the air-conditioning apparatus 200 and used for control of the driving frequencies of the compressor 110 and the pump 21, switching of the channel for the heat medium flowing through the pipeline 5 and the like.

[0129] The eighth temperature sensor 39 is disposed on the inlet side of the heat-source side refrigerant channel of the first heat exchanger 15a and detects the temperature of the heat-source side refrigerant flowing into the first intermediate heat exchanger 15a and may be composed of a thermistor or the like. The second pressure sensor 40 is disposed on the outlet side of the heat-source side refrigerant channel of the second intermediate heat exchanger 15b and detects the pressure of the heat-source side refrigerant having flowed out of the second intermediate heat exchanger 15b. The first pressure sensor 36 functions as a heating pressure detecting sensor and the second pressure sensor 40 as cooling pressure detecting means, respectively.

[0130] In this air-conditioning apparatus 200, the compressor 110, the oil separator 111, the heat-source side heat exchanger 105, the expansion valve 106, the first intermediate heat exchanger 15a, and the second intermediate heat exchanger 15b are connected in series by the refrigerant pipeline 108 and form a refrigeration cycle. Also, the first

intermediate heat exchanger 15a, the first pump 21a, and the use-side heat exchanger 26 are connected in series in the order by the pipeline 5a and form a heat medium circulation circuit. Similarly, the second intermediate heat exchanger 15b, the second pump 21b, and the use-side heat exchanger 26 are connected in series in the order by the pipeline 5b and form the heat medium circulation circuit.

[0131] That is, in the air-conditioning apparatus 200, the heat source device 101 and the relay unit 103 are connected to each other through the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b disposed in the relay unit 103, and the relay unit 103 and the indoor unit 102 are connected to each other through the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b so that the heat-source side refrigerant, which is the primary side refrigerant circulating through the refrigeration cycle, and the heat medium, which is the secondary side refrigerant circulating through the heat medium circulation circuit, exchange heat in the first intermediate heat exchanger 15a and the second intermediate heat exchanger 15b.

[0132] Here, each operation mode executed by the air-conditioning apparatus 200 will be described.

This air-conditioning apparatus 200 is capable of the cooling operation or the heating operation with the indoor units 102 thereof on the basis of an instruction from each indoor unit 102. That is, the air-conditioning apparatus 200 can perform the same operation with all the indoor units 102 or can perform different operations with each of the indoor units 102. The four operation modes executed by the air-conditioning apparatus 200, that is, the cooling only operation mode, the heating only operation mode, the cooling-main operation mode, and the heating-main operation mode will be described below with the flow of the refrigerant.

[Cooling only operation mode]

[0133] Fig. 12 is a refrigerant circuit diagram illustrating the flow of the refrigerant during the cooling only operation mode of the air-conditioning apparatus 200. In Fig. 12, the cooling only operation mode will be described using a case in which a cooling load is generated in all the use-side heat exchangers 26a to 26f as an example. In Fig. 12, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0134] In the case of the cooling only operation mode shown in Fig. 12, in the heat source device 101, the three-way valve 104b is switched so that the heat-source side refrigerant discharged from the compressor 110 flows into the heat-source side heat exchanger 105, the three-way valve 104b is switched so that the heat-source side refrigerant having passed through the second intermediate heat exchanger 15b is sucked into the compressor 110, the two-way valve 107a and the two-way valve 107c are opened, and the two-way valve 107b is closed. In the relay unit 103, the first pump 21a is stopped, the second pump 21b is driven, and the stop valve 24 is opened so that the heat medium circulates between the second intermediate heat exchanger 15b and each use-side heat exchanger 26. In this state, the operation of the compressor 110 is started.

[0135] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described.

A low-temperature and low-pressure refrigerant is compressed by the compressor 110 and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 110 flows into the heat-source side heat exchanger 105 through the three-way valve 104b. Then, the refrigerant is condensed and liquefied while radiating heat to the outdoor air in the heat-source side heat exchanger 105 and becomes a high-pressure liquid refrigerant. The high-pressure liquid refrigerant having flowed out of the heat-source side heat exchanger 105 flows out of the heat source device 101 through the two-way valve 107a and flows into the relay unit 103 through the refrigerant pipeline 108a. The high-pressure liquid refrigerant having flowed into the relay unit 103 is throttled and expanded by expansion valve 203b and becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant.

[0136] This gas-liquid two-phase refrigerant flows into the second intermediate heat exchanger 15b working as an evaporator and absorbs heat from the heat medium circulating through the heat medium circulation circuit while cooling the heat medium to turn into a low-temperature and low-pressure gas refrigerant. The gas refrigerant having flowed out of the second intermediate heat exchanger 15b passes through the two-way valve 205b, flows out of the relay unit 103 to flow into the heat source device 101 through the refrigerant pipeline 108c. The refrigerant having flowed into the heat source device 101 passes through the two-way valve 107c and is sucked into the compressor 110 again.

[0137] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described.

In the cooling only operation mode, since the first pump 21a is stopped, the heat medium circulates through the pipeline 5b. The heat medium having been cooled by the heat-source side refrigerant in the second intermediate heat exchanger 15b is fluidized in the pipeline 5b by the second pump 21b. The heat medium having been pressurized by the second pump 21b and flowed out passes through the stop valve 24 through the channel switching valve 22 and flows into each use-side heat exchanger 26. Then, the heat medium absorbs heat from the indoor air in the use-side heat exchanger 26 and cools the region to be air-conditioned such as the inside of the room where the indoor unit 102 is installed.

[0138] After that, the heat medium having flowed out of each use-side heat exchanger 26 flows into the flow regulating valve 25. At this time, by means of the action of the flow regulating valve 25, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned such as the inside of the room flows into the use-side heat exchanger 26, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26 through the bypass 27. The heat medium passing through the bypass 27 does not contribute to the heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26, passes through the channel switching valve 23, flows into the second intermediate heat exchanger 15b and is sucked into the second pump 21b again. The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by means of control such that a temperature difference between the third temperature sensor 33 and the fourth temperature sensor 34 is kept at a target value.

[Heating only operation mode]

[0139] Fig. 13 is a refrigerant circuit diagram illustrating the flow of the refrigerant during the heating only operation mode of the air-conditioning apparatus 200. In Fig. 13, the heating only operation mode will be described using a case in which a heating load is generated in all the use-side heat exchangers 26a to 26f as an example. In Fig. 8, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0140] In the case of the heating only operation mode shown in Fig. 13, in the heat source device 101, the three-way valve 104a is switched so that the heat-source side refrigerant discharged from the compressor 110 flows into the first intermediate heat exchanger 15a, the three-way valve 104b is switched so that the heat-source side refrigerant having passed through the heat-source side heat exchanger 105 is sucked into the compressor 110, the two-way valve 107a and the two-way valve 107b are opened, and the two-way valve 107c is closed. In the relay unit 103, the first pump 21a is driven, the second pump 21b is stopped, and the stop valve 24 is opened so that the heat medium circulates between the second intermediate heat exchanger 15b and each use-side heat exchanger 26. In this state, the operation of the compressor 110 is started.

[0141] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described.

A low-temperature and low-pressure refrigerant is compressed by the compressor 110 and is discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant discharged from the compressor 110 flows out of the heat source device 101 through the three-way valve 104a and the two-way valve 107b and flows into the relay unit 103 through the refrigerant pipeline 108b. The refrigerant having flowed into the relay unit 103 passes through the two-way valve 204a and flows into the first intermediate heat exchanger 15a. The high-temperature and high-pressure gas refrigerant having flowed into the first intermediate heat exchanger 15a is condensed and liquefied while radiating heat to the heat medium circulating through the heat medium circulation circuit and becomes a high-pressure liquid refrigerant.

[0142] The high-pressure liquid refrigerant having flowed out of the first intermediate heat exchanger 15a passes through the expansion valve 203a and flows out of the relay unit 103 to flow into the heat source device 101 through the refrigerant pipeline 108a. The refrigerant having flowed into the heat source device 101 passes through the two-way valve 107a and flows into the expansion valve 106, being throttled by the expansion valve 106 and expanded to turn into a low-temperature and low-pressure gas-liquid two-phase state. The gas-liquid two-phase state refrigerant having been throttled by the expansion valve 106 flows into the heat-source side heat exchanger 105 working as an evaporator. Then, the refrigerant having flowed into the heat-source side heat exchanger 105 absorbs heat from the outdoor air in the heat-source side heat exchanger 105 and turns into a low-temperature and low-pressure gas refrigerant. The low-temperature and low-pressure gas refrigerant having flowed out of the heat-source side heat exchanger 105 returns to the compressor 10 through the three-way valve 104b.

[0143] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described.

In the heating only operation mode, since the second pump 21b is stopped, the heat medium circulates through the pipeline 5a. The heat medium having been heated by the heat-source side refrigerant in the first intermediate heat exchanger 15a is fluidized in the pipeline 5a by the first pump 21a. The heat medium having been pressurized by the first pump 21a and flowed out passes through the stop valve 24 through the channel switching valve 22 and flows into each use-side heat exchanger 26. Then, the heat medium gives heat to the indoor air in the use-side heat exchanger 26 and heats the region to be air-conditioned such as the inside of the room where the indoor unit 2 is installed.

[0144] After that, the heat medium having flowed out of the use-side heat exchanger 26 flows into the flow regulating valve 25. At this time, by means of the action of the flow regulating valve 25, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned such as the inside of the room flows into the use-side heat exchanger 26, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26 through the bypass 27. The heat medium passing through the bypass 27 does not contribute to the heat exchange

but merges with the heat medium having passed through the use-side heat exchanger 26, passes through the channel switching valve 23, flows into the first intermediate heat exchanger 15a and is sucked into the first pump 21a again. The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by means of control such that a temperature difference between the third temperature sensor 33 and the fourth temperature sensor 34 is kept at a target value.

[Cooling-main operation mode]

[0145] Fig. 14 is a refrigerant circuit diagram illustrating the flow of the refrigerant during the cooling-main operation mode of the air-conditioning apparatus 200. In Fig. 14, using a case in which a heating load is generated in the use-side heat exchanger 26a and the use-side heat exchanger 26b, and a cooling load is generated in the use-side heat exchangers 26c to 26f as an example, the cooling-main operation mode will be described. In Fig. 14, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0146] In the cooling-main operation mode shown in Fig. 14, in the heat source device 101, the three-way valve 104a is switched so that the heat-source side refrigerant discharged from the compressor 110 flows into the first intermediate heat exchanger 15a, the three-way valve 104b is switched so that the heat-source side refrigerant discharged from the compressor 110 flows into the heat-source side heat exchanger 105, and the two-way valves 107a to 107c are opened. In the relay unit 103, the first pump 21a and the second pump 21b are driven, the stop valve 24 is opened, and the heat medium is made to circulate between the first intermediate heat exchanger 15a and the use-side heat exchanger 26a and the use-side heat exchanger 26b as well as the second intermediate heat exchanger 15b and the use-side heat exchangers 26c to 26f. In this state, the operation of the compressor 110 is started.

[0147] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described.

The low-temperature and low-pressure refrigerant is compressed by the compressor 110 and becomes a high-temperature and high-pressure gas refrigerant and is discharged. The high-temperature and high-pressure gas refrigerant discharged from the compressor 110 is divided on the downstream side of the check valve 103. One of the divided refrigerants flows into the heat-source side heat exchanger 105 through the three-way valve 104b. Then, the refrigerant is condensed and liquefied while radiating heat to the outdoor air in the heat-source side heat exchanger 105 and becomes a high-pressure liquid refrigerant. The high-pressure liquid refrigerant having flowed out of the heat-source side heat exchanger 105 flows out of the heat source device 101 through the two-way valve 107a and flows into the relay unit 103 through the refrigerant pipeline 108a.

[0148] The other divided refrigerants flows through the refrigerant pipeline 108b through the three-way valve 104a and the two-way valve 107b to flow into the relay unit 103. The gas refrigerant having flowed into the relay unit 103 passes through the two-way valve 204a to flow into the first intermediate heat exchanger 15a. The high-temperature and high-pressure gas refrigerant having flowed into the first intermediate heat exchanger 15a is condensed and liquefied while radiating heat to the heat medium circulating through the heat medium circulation circuit to turn into a high-pressure liquid refrigerant. This liquid refrigerant merges with the refrigerant having flowed into the relay unit 103 through the refrigerant pipeline 108a.

[0149] The merged liquid refrigerant is throttled and expanded by the expansion valve 203b and becomes a low-temperature and low-pressure gas-liquid two-phase refrigerant and then, flows into the second intermediate heat exchanger 15b working as an evaporator and absorbs heat from the heat medium circulating through the heat medium circulation circuit in the second intermediate heat exchanger 15b while cooling the heat medium so as to become a low-temperature and low-pressure gas refrigerant. The gas refrigerant having flowed out of the second intermediate heat exchanger 15b flows out of the relay unit 103 through the two-way valve 205b and flows into the heat source device 101 through the refrigerant pipeline 108c. The refrigerant having flowed into the heat source device 101 is sucked into the compressor 10 again through the two-way valve 107c.

[0150] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described.

In the cooling-main operation mode, since the first pump 21a and the second pump 21b are both driven, the heat medium is circulated through both the pipeline 5a and the pipeline 5b. The heat medium heated by the heat-source side refrigerant in the first intermediate heat exchanger 15a is fluidized in the pipeline 5a by the first pump 21a. Also, the heat medium cooled by the heat-source side refrigerant in the second intermediate heat exchanger 15b is fluidized in the pipeline 5b by the second pump 21b.

[0151] The heat medium having been pressurized by the first pump 21a and flowed out passes through the stop valve 24a and the stop valve 24b through the channel switching valve 22a and the channel switching valve 22b and flows into the use-side heat exchanger 26a and the use-side heat exchanger 26b. Then, in the use-side heat exchanger 26a and the use-side heat exchanger 26b, the heat medium gives heat to the indoor air and heats the region to be air-conditioned such as the inside of the room where the indoor unit 102 is installed. Also, the heat medium having been pressurized

by the second pump 21b and flowed out passes through the stop valves 24c to 24f and flows into the use-side heat exchangers 26c to 26f. Then, in the use-side heat exchangers 26c to 26f, the heat medium absorbs heat from the indoor air and cools the region to be air-conditioned such as the inside of the room where the indoor unit 102 is installed.

[0152] The heat medium having performed the heating flows into the flow regulating valve 25a and the flow regulating valve 25b. At this time, by means of the action of the flow regulating valve 25a and the flow regulating valve 25b, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned flows into the use-side heat exchanger 26a and the use-side heat exchanger 26b, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26a and the use-side heat exchanger 26b through the bypass 27a and the bypass 27b. The heat medium passing through the bypass 27a and the bypass 27b does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26a and the use-side heat exchanger 26b, flows into the first intermediate heat exchanger 15a through the channel switching valve 23a and the channel switching valve 23b and is sucked into the first pump 21a again.

[0153] Similarly, the heat medium having performed the cooling flows into the flow regulating valves 25c to 25f. At this time, by means of the action of the flow regulating valves 25c to 25f, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned flows into the use-side heat exchangers 26c to 26f, while the remaining heat medium flows so as to bypass the use-side heat exchangers 26c to 26f through the bypasses 27c to 27f. The heat medium passing through the bypasses 27c to 27f does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchangers 26c to 26f, flows into the second intermediate heat exchanger 15b through the channel switching valves 23c to 23f and is sucked into the second pump 21b again.

[0154] During that period, the heated heat medium (the heat medium used for the heating load) and the cooled heat medium (the heat medium used for the cooling load) flow into the use-side heat exchanger 26a and the use-side heat exchanger 26b having the heating load or the use-side heat exchangers 26c to 26f having the cooling load without mixing by means of the actions of the channel switching valves 22a to 22f and the channel switching valves 23a to 23f. The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by executing control such that a difference in temperatures between the third temperature sensor 33 and the fourth temperature sensor 34 is kept at a target value.

[Heating-main operation mode]

[0155] Fig. 15 is a refrigerant circuit diagram illustrating the flow of the refrigerant at the time of the heating-main operation mode of the air-conditioning apparatus 200. In Fig. 15, using a case in which a heating load is generated in the use-side heat exchangers 26a to 26d, and a cooling load is generated in the use-side heat exchanger 26e and the use-side heat exchanger 26f as an example, the heating-main operation mode will be described. In Fig. 15, the pipeline expressed by a bold line indicates a pipeline through which the refrigerant (heat-source side refrigerant and the heat medium) circulates. Also, the flow direction of the heat-source side refrigerant is indicated by a solid-line arrow, while the flow direction of the heat medium by a broken-line arrow.

[0156] In the heating-main operation mode shown in Fig. 15, in the heat source device 101, the three-way valve 104a is switched so that the heat-source side refrigerant discharged from the compressor 110 flows into the first intermediate heat exchanger 15a, the three-way valve 104b is switched so that the heat-source side refrigerant having passed through the heat-source side heat exchanger 105 is sucked into the compressor 110, and the two-way valves 107a to 107c are opened. In the relay unit 103, the first pump 21a and the second pump 21b are driven, the stop valve 24 is opened, and the heat medium is made to circulate between the first intermediate heat exchanger 15a and the use-side heat exchangers 26a to 26d as well as between the second intermediate heat exchanger 15b and the use-side heat exchanger 26e as well as the use-side heat exchanger 26f. In this state, the operation of the compressor 110 is started.

[0157] First, the flow of the heat-source side refrigerant in the refrigeration cycle will be described.

A low-temperature and low-pressure refrigerant is compressed by the compressor 110 and discharged as a high-temperature and high-pressure gas refrigerant. The high-temperature and high-pressure gas refrigerant having been discharged from the compressor 110 flows out of the heat source device 101 through the three-way valve 104a and the two-way valve 107b and flows into the relay unit 103 through the refrigerant pipeline 108b. The high-temperature and high-pressure gas refrigerant having flowed into the first intermediate heat exchanger 15a is condensed and liquefied while radiating heat to the heat medium circulating in the heat medium circulation circuit and becomes a high-pressure liquid refrigerant. The refrigerant having flowed out of the first intermediate heat exchanger 15a passes through the fully opened expansion valve 203a and then, is divided into the refrigerant returning to the heat source device 101 through the refrigerant pipeline 108a and the refrigerant flowing into the second intermediate heat exchanger 15b.

[0158] The refrigerant flowing into the second intermediate heat exchanger 15b is expanded by the expansion valve 203b and becomes a low-temperature and a low-pressure two-phase refrigerant and then, flows into the second intermediate heat exchanger 15b working as an evaporator and absorbs heat from the heat medium circulating in the heat

medium circulation circuit while cooling the heat medium so as to become a low-temperature and low-pressure gas refrigerant. The gas refrigerant having flowed out of the second intermediate heat exchanger 15b flows out of the relay unit 103 through the two-way valve 205b and flows into the heat source device 101 through the refrigerant pipeline 108c.

[0159] On the other hand, the refrigerant returning to the heat source device 101 through the refrigerant pipeline 108a is decompressed in the expansion valve 106 and becomes a gas-liquid two-phase refrigerant and then, flows into the heat-source side heat exchanger 105 working as an evaporator. Then, the refrigerant having flowed into the heat-source side heat exchanger 105 absorbs heat from the outdoor air in the heat-source side heat exchanger 105 and becomes a low-temperature and low-pressure gas refrigerant. This gas refrigerant passes through the three-way valve 104b, merges with the low-pressure gas refrigerant having flowed into the heat source device 101 through the refrigerant pipeline 108c and is sucked into the compressor 10 again.

[0160] Subsequently, the flow of the heat medium in the heat medium circulation circuit will be described.

In the heating-main operation mode, since the first pump 21a and the second pump 21b are both driven, the heat medium is circulated through both the pipeline 5a and the pipeline 5b. The heat medium heated by the heat-source side refrigerant in the first intermediate heat exchanger 15a is fluidized in the pipeline 5a by the first pump 21a. Also, the heat medium cooled by the heat-source side refrigerant in the second intermediate heat exchanger 15b is fluidized in the pipeline 5a by the second pump 21b.

[0161] The heat medium having been pressurized by the first pump 21a and flowed out passes through the stop valves 24a to 24d through the channel switching valves 22a to 22d and flows into the use-side heat exchangers 26a to 26d. Then, in the use-side heat exchangers 26a to 26d, the heat medium gives heat to the indoor air and heats the region to be air-conditioned such as the inside of the room where the indoor unit 102 is installed. Also, the heat medium having been pressurized by the second pump 21b and flowed out passes through the stop valve 24e and the stop valve 24f through the channel switching valve 22e and the channel switching valve 22f and flows into the use-side heat exchanger 26e and the use-side heat exchanger 26f. Then, in the use-side heat exchanger 26e and the use-side heat exchanger 26f, the heat medium absorbs heat from the indoor air and cools the region to be air-conditioned such as the inside of the room where the indoor unit 102 is installed.

[0162] The heat medium having flowed out of the use-side heat exchangers 26a to 26d flows into the flow regulating valves 25a to 25d. At this time, by means of the action of the flow regulating valves 25a to 25d, the heat medium required to cover an air-conditioning load necessary in the region to be air-conditioned such as the inside of a room flows into the use-side heat exchangers 26a to 26d, while the remaining heat medium flows so as to bypass the use-side heat exchangers 26a to 26d through the bypasses 27a to 27d. The heat medium passing through the bypasses 27a to 27d does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchangers 26a to 26d, flows into the first intermediate heat exchanger 15a through the channel switching valves 23a to 23d to be sucked into the first pump 21a again.

[0163] Similarly, the heat medium having flowed out of the use-side heat exchanger 26e and the use-side heat exchanger 26f flows into the flow regulating valve 25e and the flow regulating valve 25f. At this time, by means of the action of the flow regulating valve 25e and the flow regulating valve 25f, the heat medium only in a flow rate required to cover an air-conditioning load required in the region to be air-conditioned flows into the use-side heat exchanger 26e and the use-side heat exchanger 26f, while the remaining heat medium flows so as to bypass the use-side heat exchanger 26e and the use-side heat exchanger 26f through the bypass 27e and the bypass 27f. The heat medium passing through the bypass 27e and the bypass 27f does not contribute to heat exchange but merges with the heat medium having passed through the use-side heat exchanger 26e and the use-side heat exchanger 26f, flows into the second intermediate heat exchanger 15b through the channel switching valve 23e and the channel switching valve 23f and is sucked into the second pump 21b again.

[0164] During that period, the heated heat medium and the cooled heat medium flow into the use-side heat exchangers 26a to 26d having the heating load or the use-side heat exchanger 26e and the use-side heat exchanger 26f having the cooling load without mixing by means of the actions of the channel switching valve 22 (the channel switching valves 22a to 22f) and the channel switching valves 23a to 23f. The air-conditioning load required in the region to be air-conditioned such as the inside of the room can be covered by executing control such that a difference in temperatures between the third temperature sensor 33 and the fourth temperature sensor is kept at a target value.

[0165] As described above, since the relay unit 103 has a housing different from those of the heat source device 101 and the indoor unit 102, it can be installed at a different position, and by installing the relay unit 103 in the non-living space 50 as shown in Fig. 1, the heat-source side refrigerant and the heat medium can be shut off, and inflow of the heat-source side refrigerant into the living space 7 can be prevented, whereby safety and reliability of the air-conditioning apparatus 200 are improved.

[0166] In the first intermediate heat exchanger 15a on the heating side, the heat medium temperature at the outlet of the first intermediate heat exchanger 15a detected by the first temperature sensor 31a does not become higher than the heat medium temperature at the inlet of the first intermediate heat exchanger 15a detected by the second temperature sensor 32a, and a heating amount in an overheat gas region of the heat-source side refrigerant is small. Thus, the heat

medium temperature at the outlet of the first intermediate heat exchanger 15a is restricted by a condensing temperature substantially acquired from a saturation temperature of the first pressure sensor 36. Also, in the second intermediate heat exchanger 15b on the cooling side, the heat medium temperature at the outlet of the second intermediate heat exchanger 15b detected by the first temperature sensor 31b does not become lower than the heat medium temperature at the inlet of the second intermediate heat exchanger 15b detected by the second temperature sensor 32b.

[0167] Therefore, in the air-conditioning apparatus 200, it is effective to handle an increase or decrease of a air-conditioning load on the secondary side (use side) by changing a condensing temperature or an evaporating temperature on the refrigerant cycle side. Thus, it is preferable that a control target value of the condensing temperature and/or evaporating temperature of the refrigeration cycle stored in the controller (not shown) is changed in accordance with the size of the air-conditioning load on the use side. As a result, the change in the size of the air-conditioning load on the use side can be easily followed.

[0168] Grasping of the change in the air-conditioning load on the use side is made by a controller connected to the second relay unit 3b. On the other hand, the control target values of the condensing temperature and the evaporating temperature are stored in the controller connected to the heat source device 101 incorporating the compressor 110 and the heat-source side heat exchanger 105. Thus, a signal line is connected between the controller connected to the second relay unit 3b and the controller connected to the heat source device 101, and the control target value of the condensing temperature and/or evaporating temperature is transmitted via communication so as to change the control target value of the condensing temperature and/or evaporating temperature stored in the controller connected to the heat source device 101. Alternatively, the control target value may be changed by communicating a deviation value of the control target value.

[0169] By executing the above control, the change in the air-conditioning load on the use side can be handled appropriately. That is, if the controller grasps that the air-conditioning load on the use side is lowered, the controller can control the driving frequency of the compressor 110 so as to lower a work load of the compressor 110. Therefore, the air-conditioning apparatus 200 becomes capable of more energy-saving operation. The controller connected to the second relay unit 3b and the controller connected to the heat source device 101 may be handled by one controller.

[0170] In the air-conditioning apparatus 200 according to Embodiment 2, too, the expansion tank 60 described in Embodiment 1 is supposed to be connected through the heating-side expansion tank connection port 42 and a cooling-side expansion tank connection port 43 shown in Fig. 11. Also, in Embodiment 2, the case in which the three-way valve is used is described as an example, but not limited to that, and the similar function can be provided by combining a four-way valve, an electromagnetic valve and the like. Moreover, the usable heat-source side refrigerant and heat medium are the same as those described in Embodiment 1.

Claims

1. An air-conditioning apparatus comprising:

at least one intermediate heat exchanger that exchanges heat between a refrigerant and a heat medium different from said refrigerant;
a refrigeration cycle in which a compressor, an outdoor heat exchanger, at least one expansion valve, and a refrigerant-side channel of said intermediate heat exchanger are connected by pipelines through which said refrigerant flows; and
a heat medium circulation circuit in which a heat medium-side channel of said intermediate heat exchanger, a pump, and a use-side heat exchanger are connected by pipelines through which said heat medium flows, wherein said compressor and said outdoor heat exchanger are contained in an outdoor unit;
said intermediate heat exchanger and said pump are contained in a relay unit;
said use-side heat exchanger is contained in an indoor unit, respectively; and
an expansion absorption device that absorbs volume change in said heat medium is connected to said heat medium circulation circuit.

2. The air-conditioning apparatus of claim 1, further comprising:

an intermediate heat exchanger for heating of said heat medium and an intermediate heat exchanger for cooling of said heat medium as said intermediate heat exchanger.

3. The air-conditioning apparatus of claim 1 or 2, wherein

said relay unit is divided into a first relay unit and a second relay unit;

a gas-liquid separator that separates the refrigerant into a gas and a liquid is contained in said first relay unit; and

said intermediate heat exchanger and said pump are contained in said second relay unit, respectively.

4. The air-conditioning apparatus of claim 3, wherein
said outdoor unit and said first relay unit are connected by two pipelines, which are inbound and outbound paths
for the refrigerant; and
said second relay unit and each of said indoor units are connected by two pipelines, which are inbound and outbound
paths for the heat medium.
5. The air-conditioning apparatus of claim 1 or 2, wherein
said outdoor unit and said relay unit are connected by at least three pipelines, which are inbound and outbound
paths for the refrigerant; and
said relay unit and each of said indoor units are connected by two pipelines, which are inbound and outbound paths
for the heat medium.
6. The air-conditioning apparatus of any one of claims 1 to 5, wherein
said expansion absorption device is connected so as to communicate with a suction side of said pump.
7. The air-conditioning apparatus of any one of claims 1 to 6, wherein
said expansion absorption device is an expansion tank.
8. The air-conditioning apparatus of claim 7, wherein
a capacity of said expansion tank is 5 liters or less.
9. The air-conditioning apparatus of claim 7 or 8, wherein
in the air-conditioning apparatus having said expansion tank arranged higher than said indoor unit, a height difference
between said expansion tank and said indoor unit is 10 m or less.
10. The air-conditioning apparatus of any one of claims 1 to 9, wherein
the pressure of the heat medium when being supplied to said heat medium circulation circuit is 100 kPaG.

FIG. 1

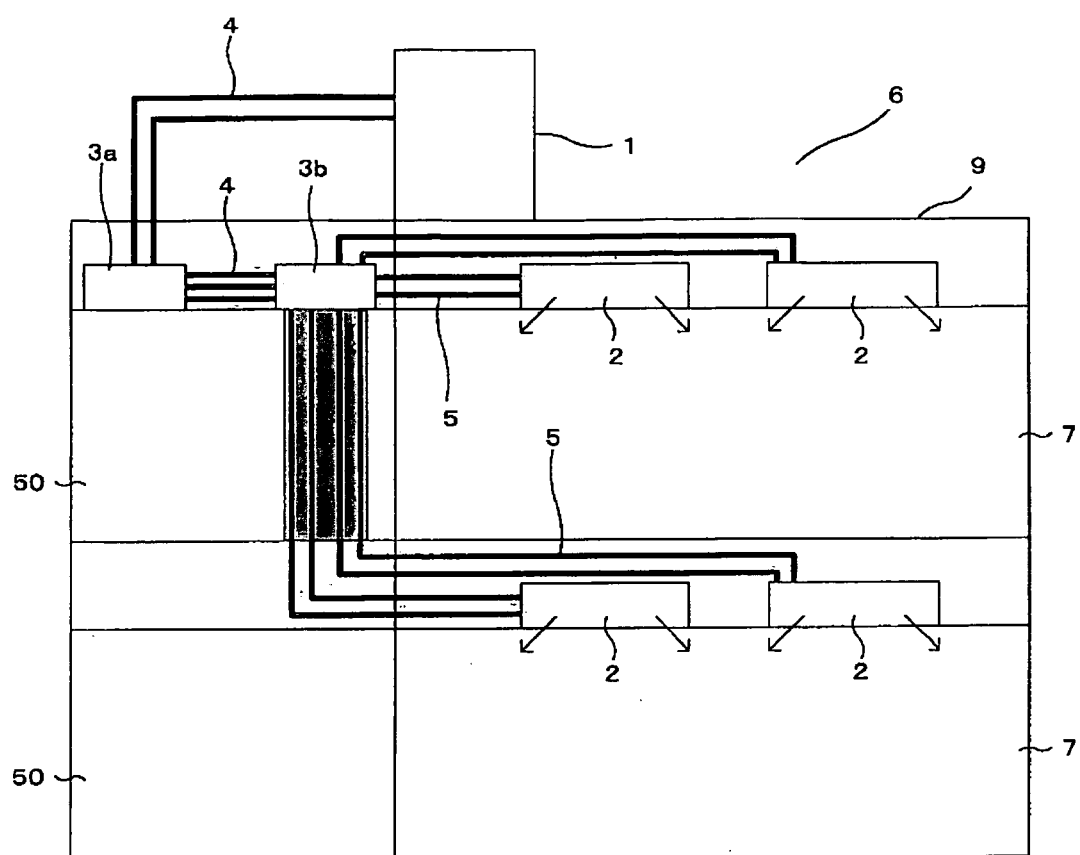


FIG 2

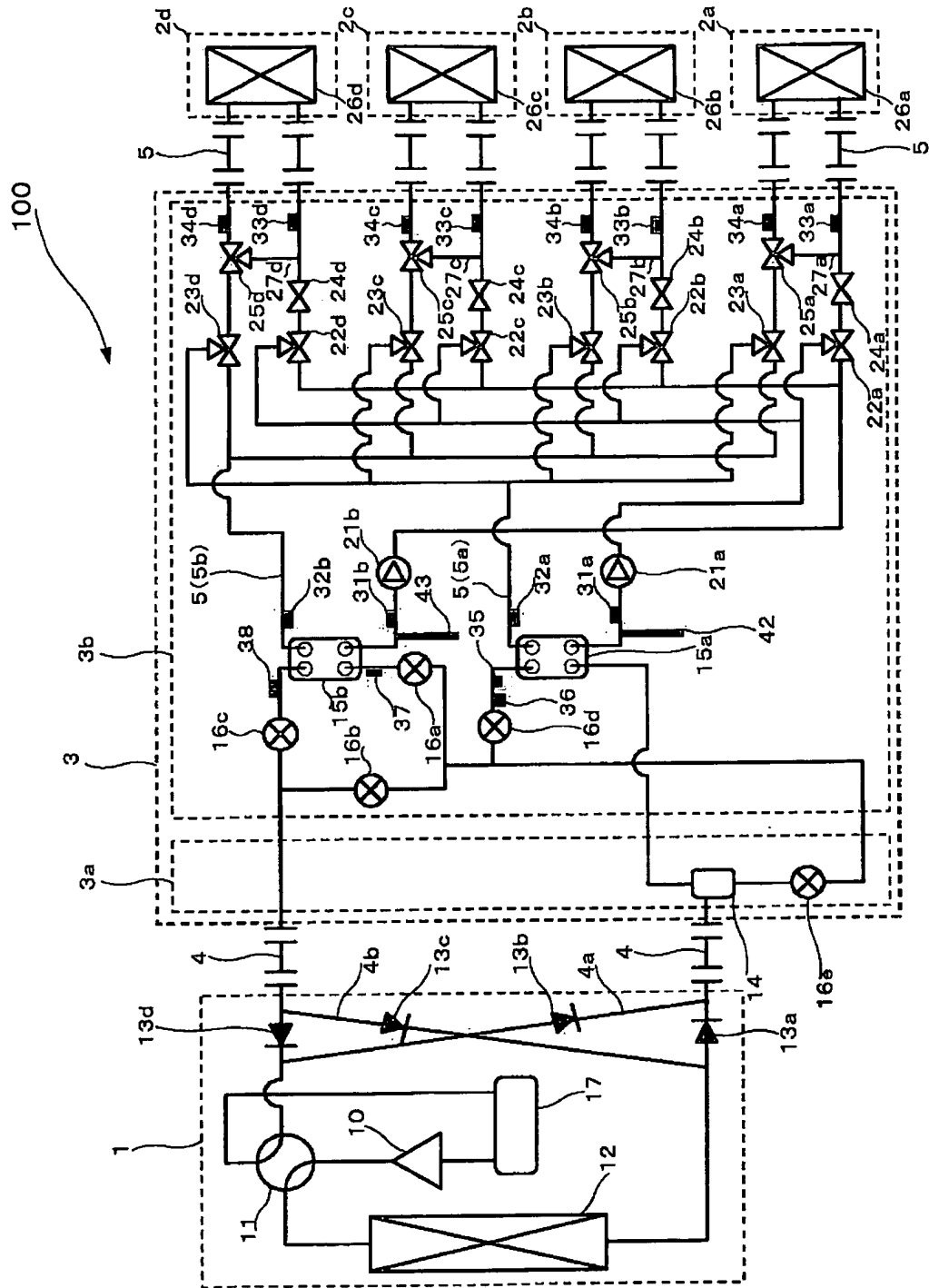


FIG. 3

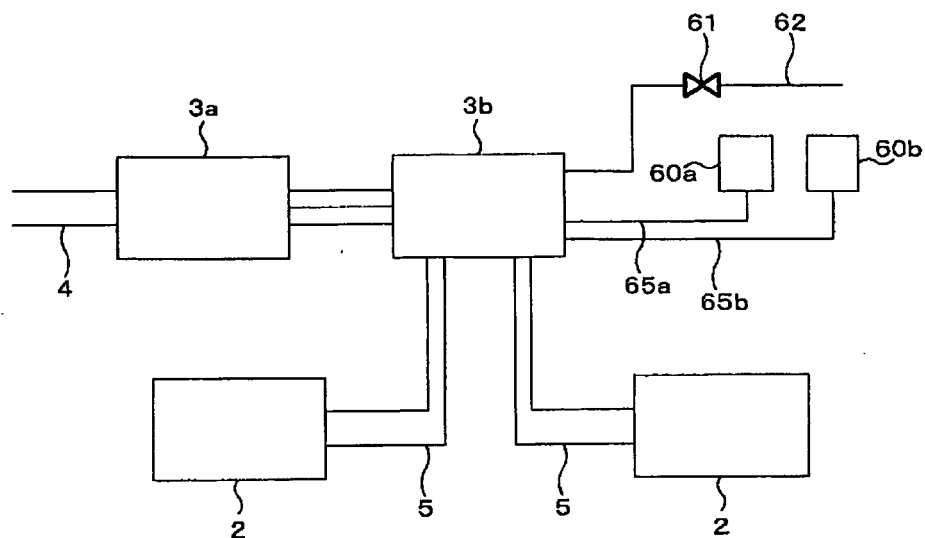


FIG. 4

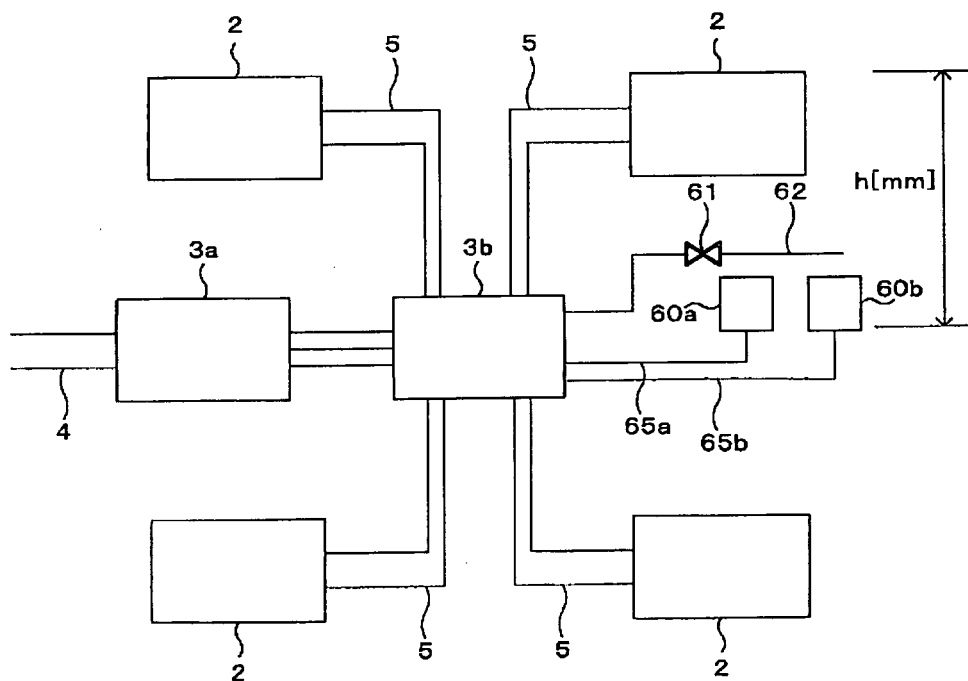


FIG. 5

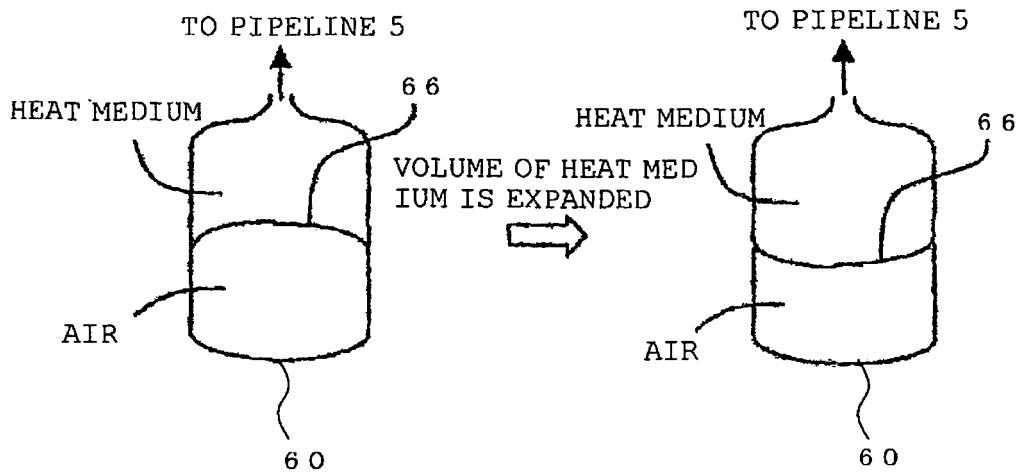


FIG. 6

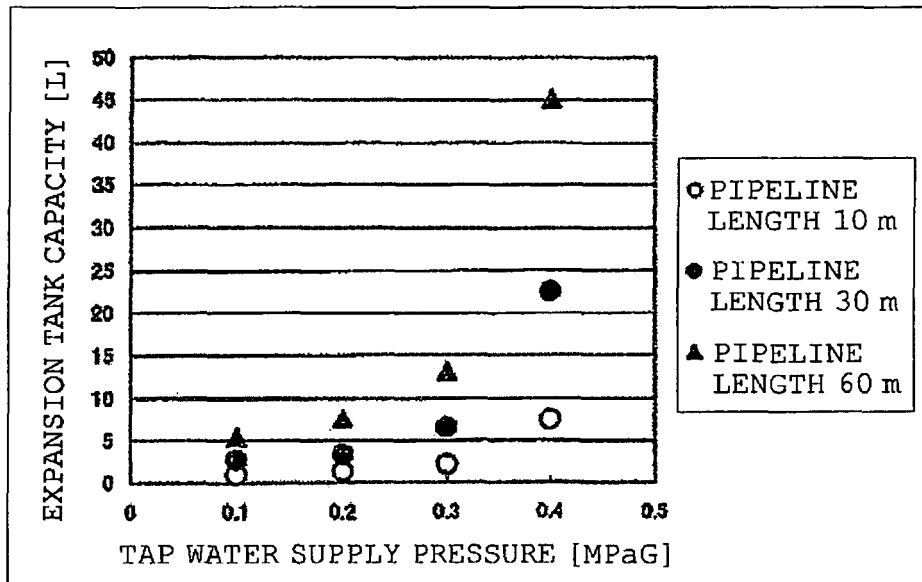


FIG. 7

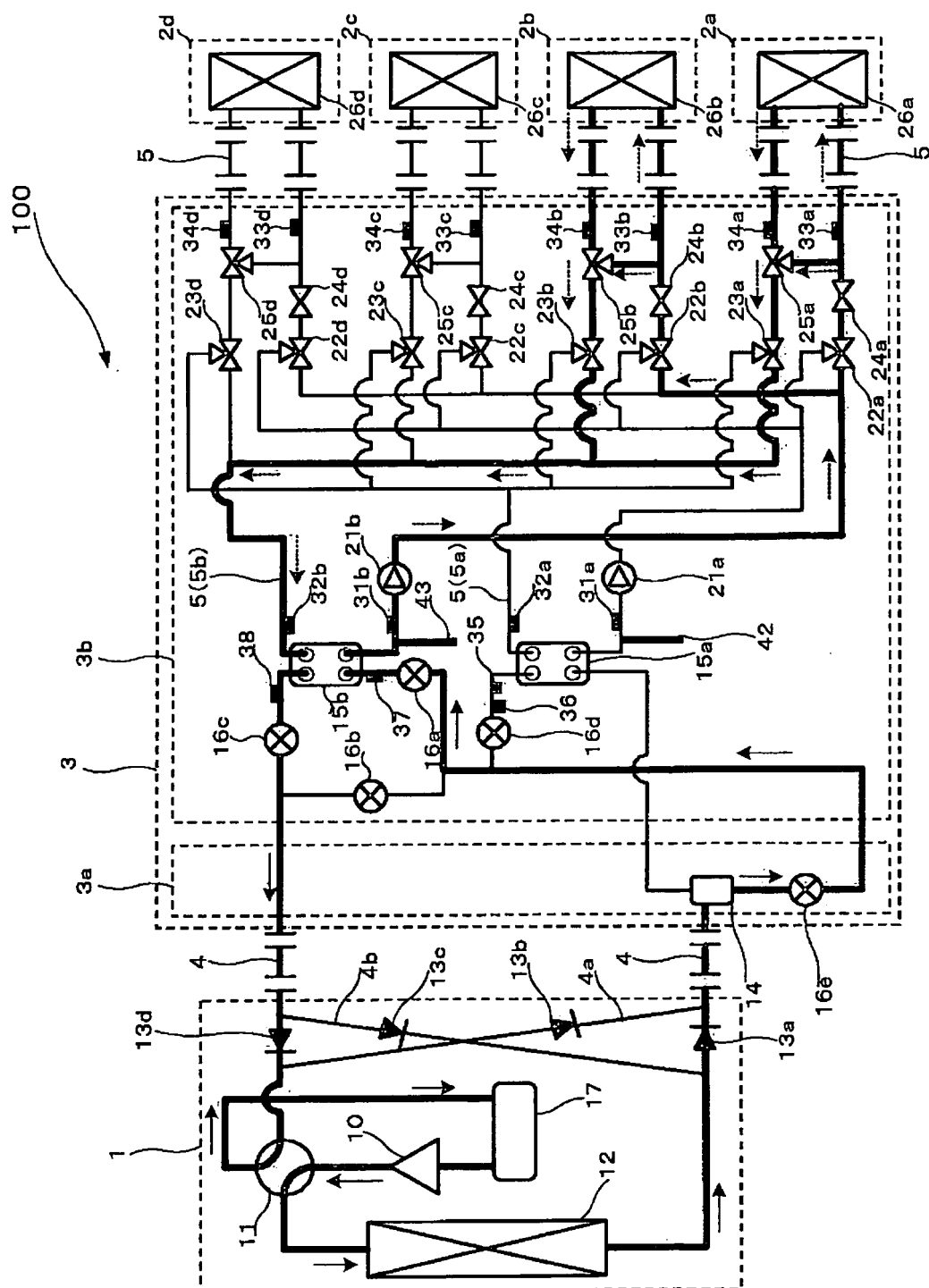


FIG. 8

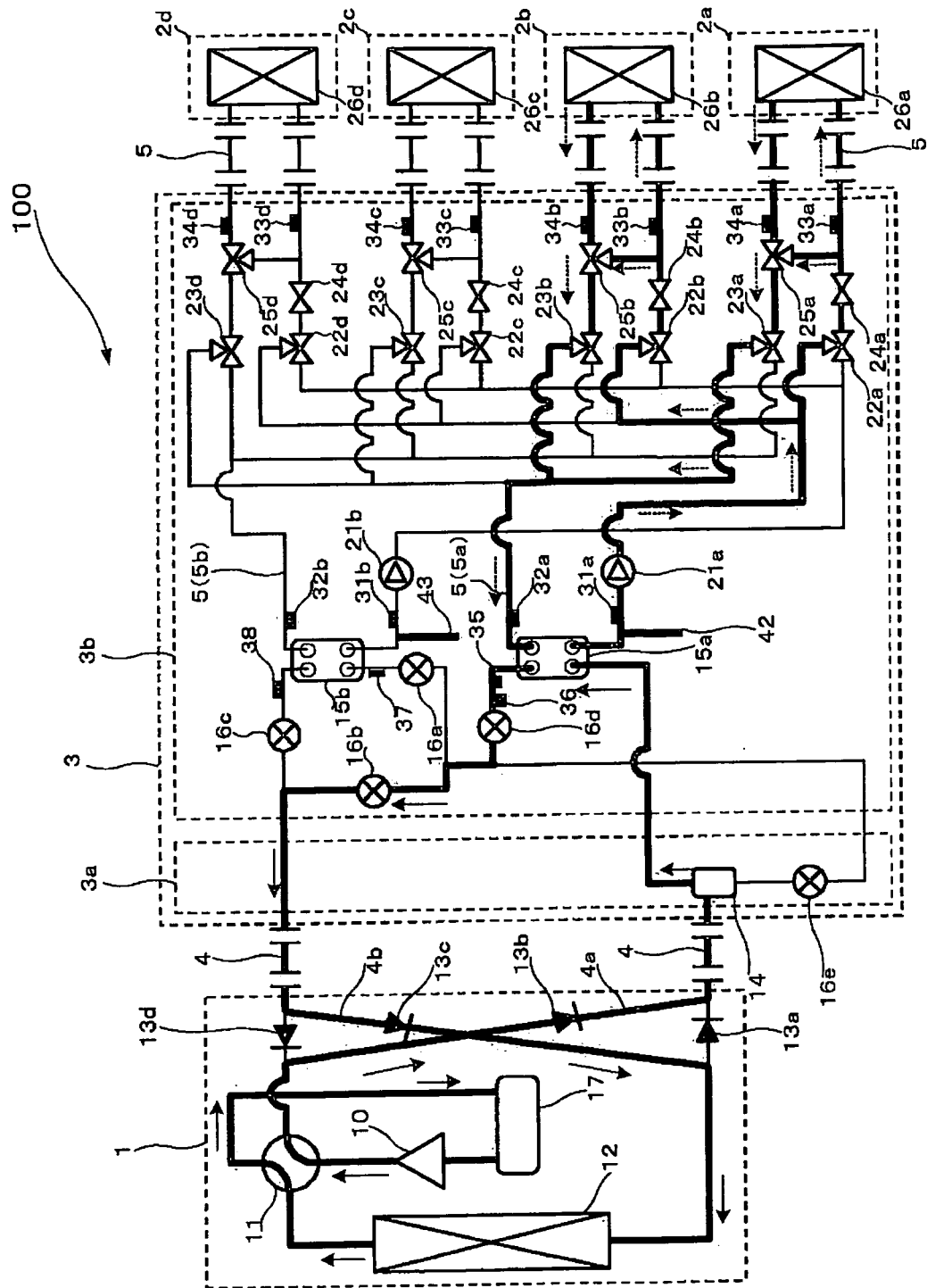


FIG. 9

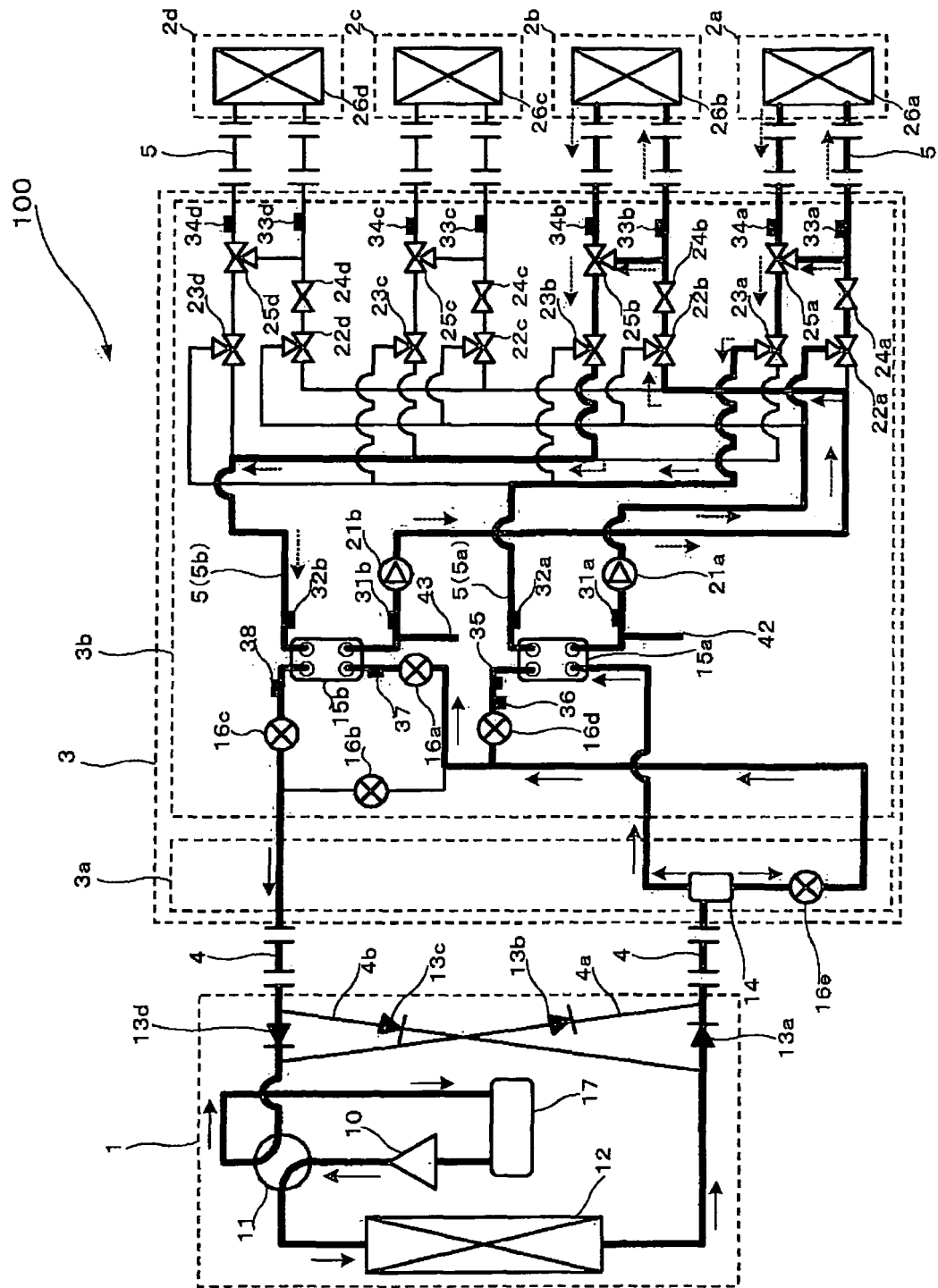


FIG. 10

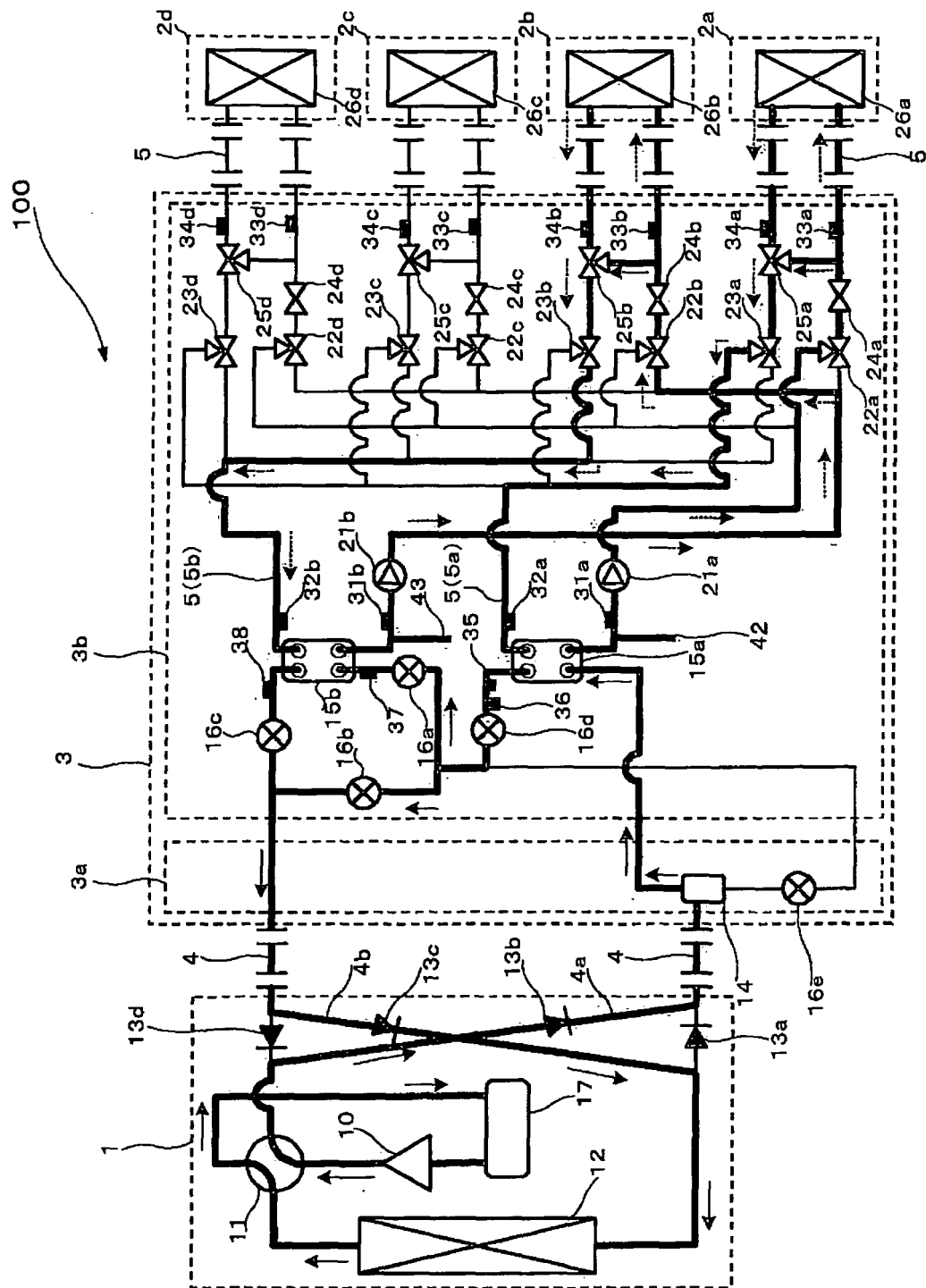


FIG. 11

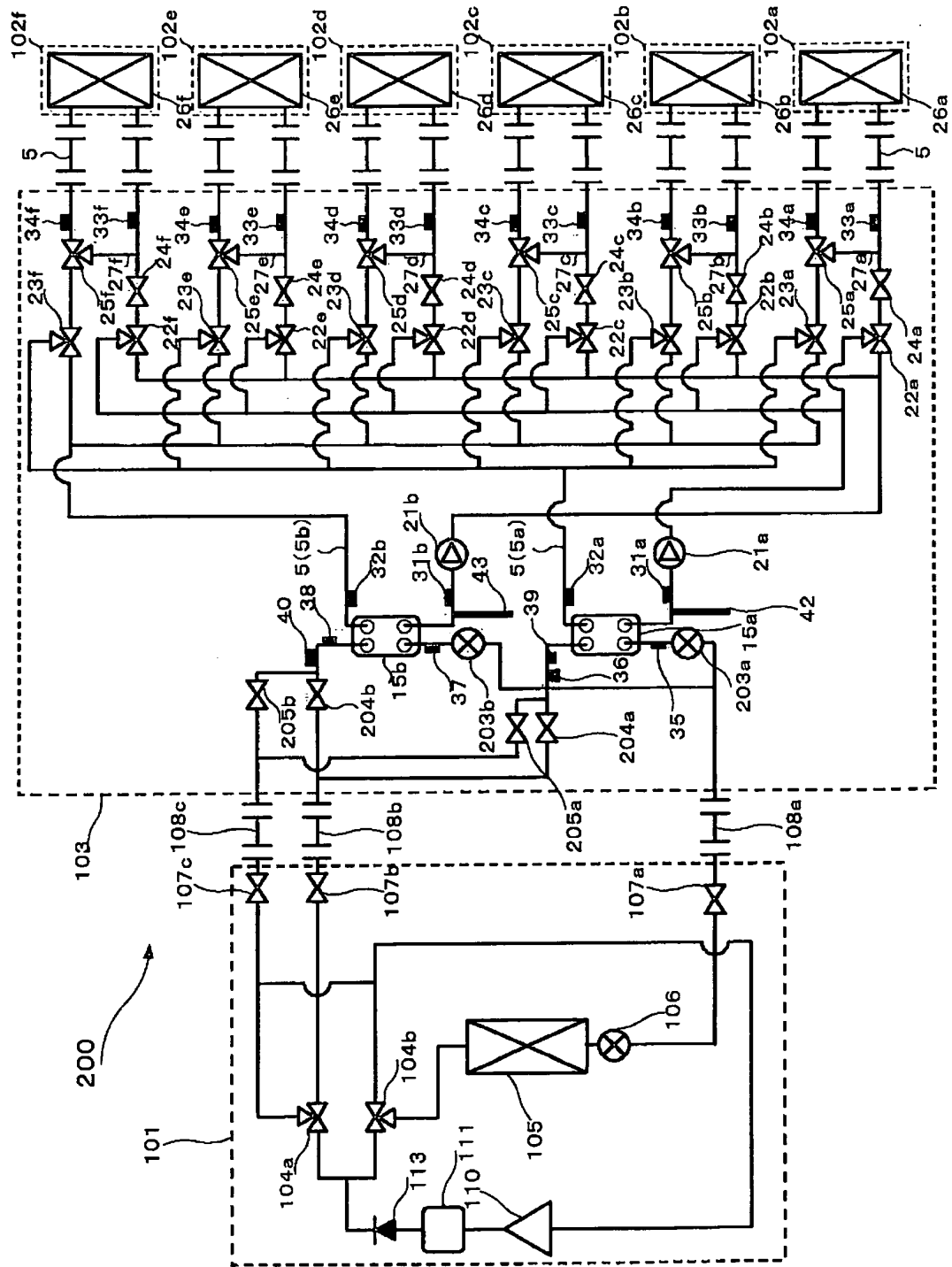


FIG. 12

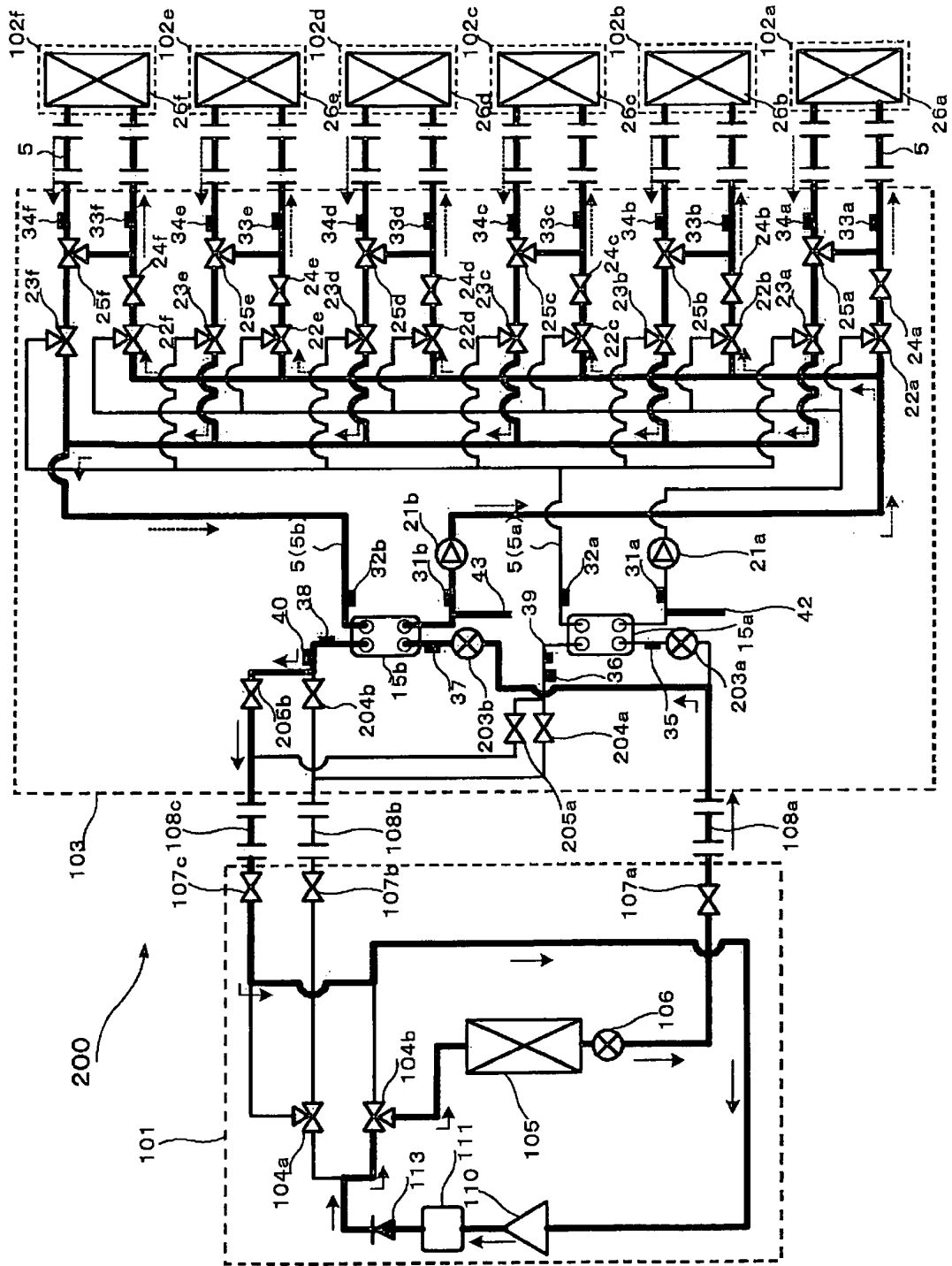


FIG. 13

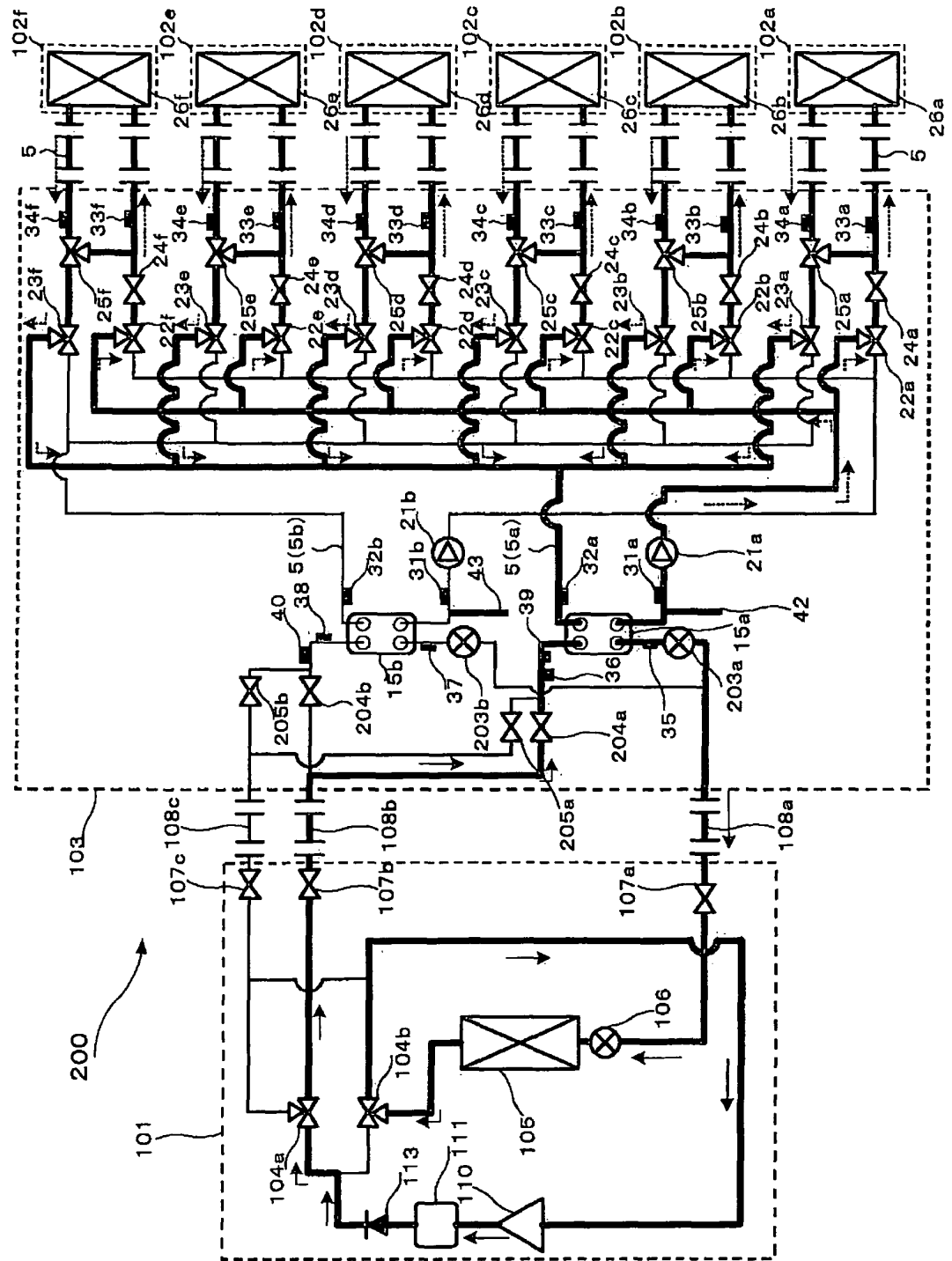


FIG. 14

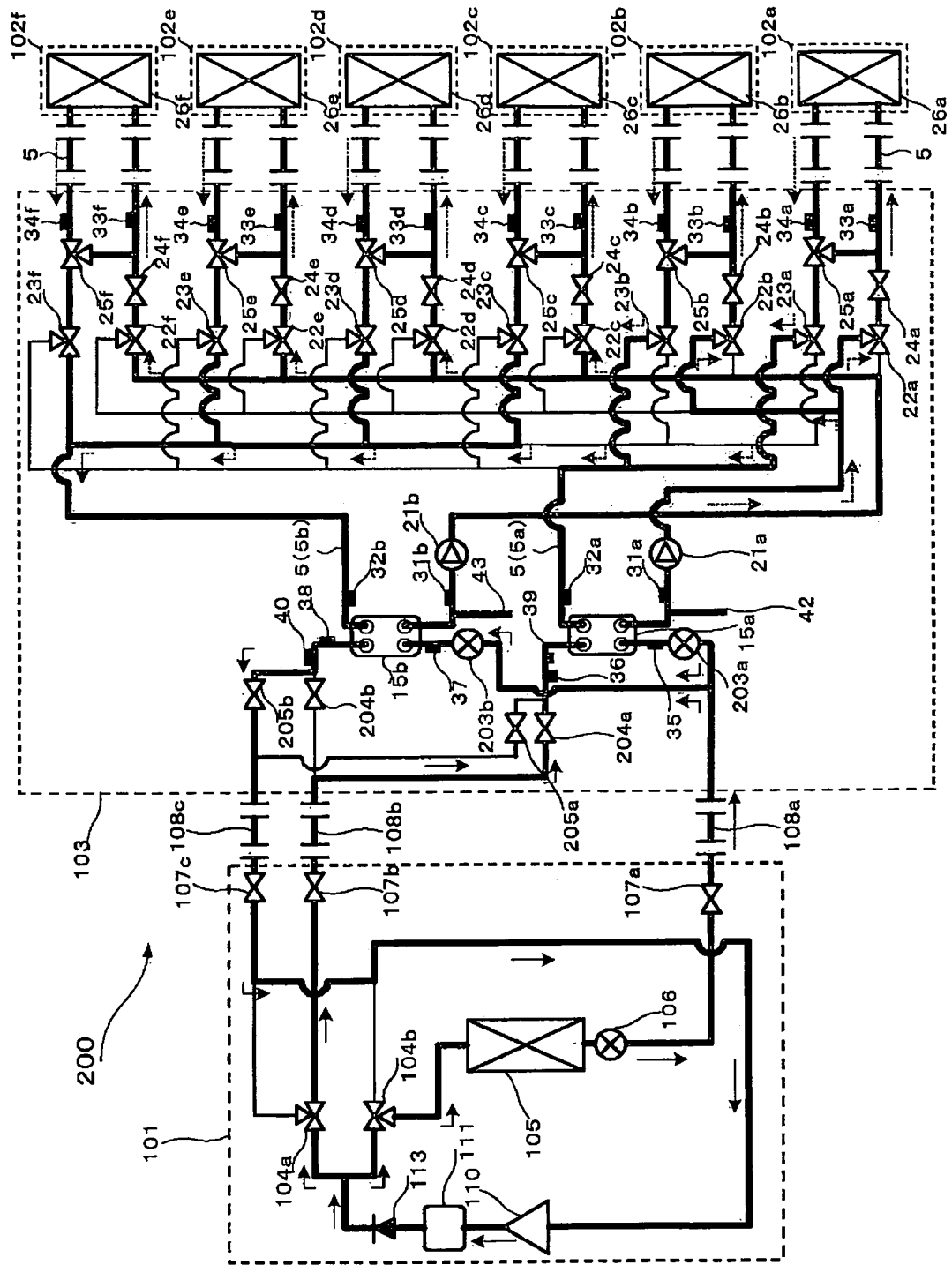
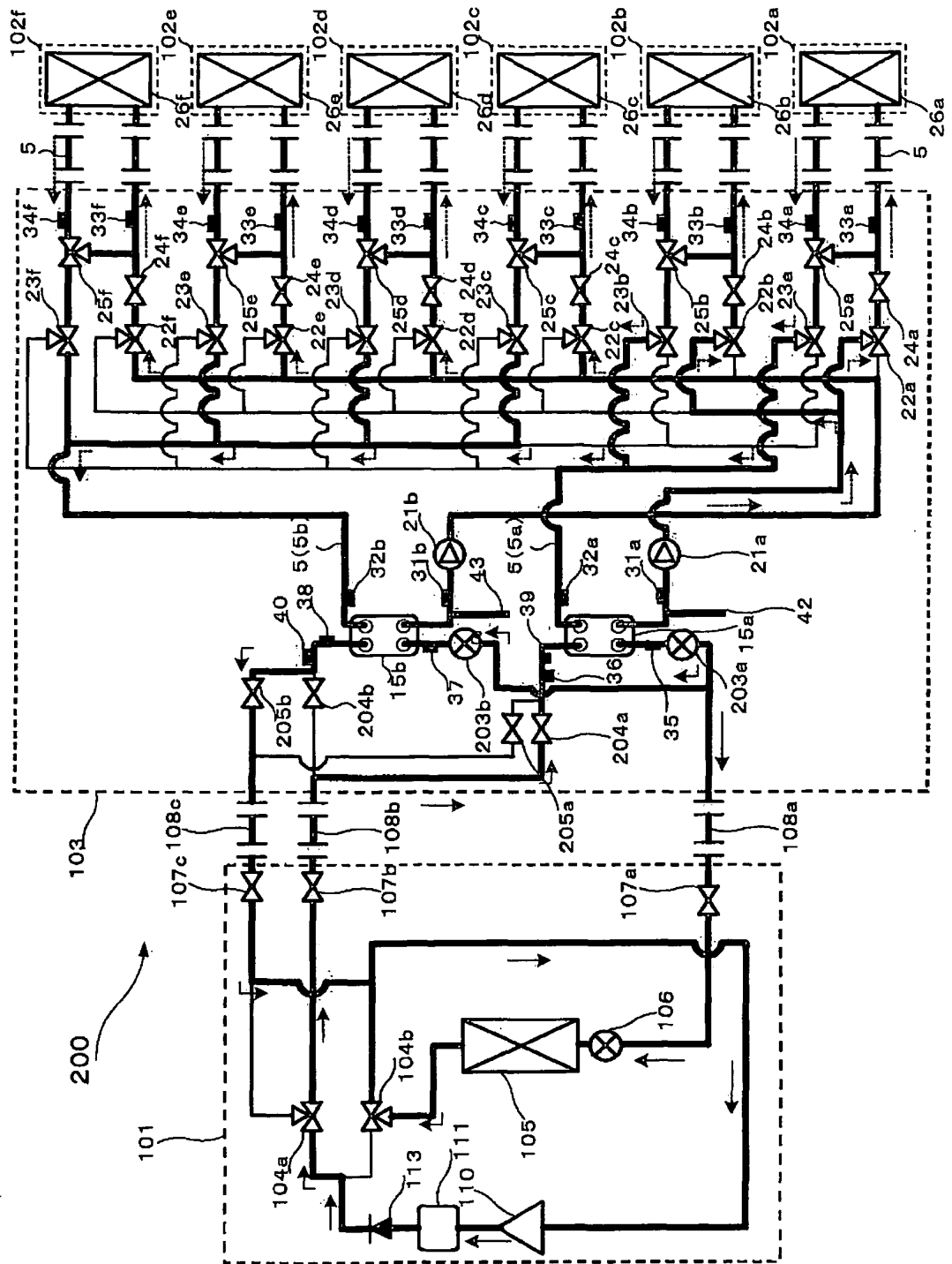


FIG. 15



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/069613

A. CLASSIFICATION OF SUBJECT MATTER <i>F24F5/00 (2006.01) i</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) <i>F24F5/00</i>		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009 Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 5-280818 A (Matsushita Refrigeration Co.), 29 October, 1993 (29.10.93), Par. Nos. [0031], [0032], [0048]; Fig. 3 (Family: none)	1-10
Y	JP 11-344240 A (Hitachi, Ltd.), 14 December, 1999 (14.12.99), Claim 1; Fig. 1 (Family: none)	1-10
Y	JP 2008-196829 A (Mitsubishi Electric Corp.), 28 August, 2008 (28.08.08), Par. No. [0056]; Fig. 7 (Family: none)	3, 4, 6-10
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Date of the actual completion of the international search 06 January, 2009 (06.01.09)		Date of mailing of the international search report 27 January, 2009 (27.01.09)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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Patent documents cited in the description

- JP 2118372 A [0004]
- JP 2003343936 A [0004]