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(54) REFRIGERATION CYCLE DEVICE

(57) A refrigeration cycle apparatus (1) includes a heat-source unit (2) and a utilization unit (4a, 4b) that are connected to each other via a gas-refrigerant connection pipe (5) and a liquid-refrigerant connection pipe (6) and thereby constitute a refrigerant circuit (7). Carbon dioxide is enclosed as a refrigerant in the refrigerant circuit (7). In the refrigeration cycle apparatus (1), to reduce the amount of the refrigerant enclosed in the refrigerant circuit (7), a pipe whose inner diameter is 6.2 mm or less is used as the gas-refrigerant connection pipe (5), and/or a pipe whose inner diameter is 3.6 mm or less is used as the liquid-refrigerant connection pipe (6).

RATED REFRIGERATING CAPACITY [kW]	R410A		R32		CARBON DIOXIDE	
	CONNECTION PIPE NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]		CONNECTION PIPE NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]		CONNECTION PIPE NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]	
	GAS	LIQUID	GAS	LIQUID	GAS	LIQUID
2.2	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
2.8	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
3.6	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
4.5	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
5.6	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	3/8, 7.4	1.5/8, 3.6
7.1	5/8, 14.3	3/8, 7.9	1/2, 11.1	1/4, 4.8	3/8, 7.4	1.5/8, 3.6
8.0	5/8, 14.3	3/8, 7.9	1/2, 11.1	1/4, 4.8	3/8, 7.4	1.5/8, 3.6
9.0	5/8, 14.3	3/8, 7.9	5/8, 14.3	3/8, 7.9	1/2, 9.9	1/4, 5.0
11.2	5/8, 14.3	3/8, 7.9	5/8, 14.3	3/8, 7.9	1/2, 9.9	1/4, 5.0
14.0	5/8, 14.3	3/8, 7.9	5/8, 14.3	3/8, 7.9	1/2, 9.9	1/4, 5.0
16.0	3/4, 17.1	3/8, 7.9	3/4, 17.1	3/8, 7.9	1/2, 9.9	1/4, 5.0
22.4	3/4, 17.1	3/8, 7.9	3/4, 17.1	3/8, 7.9	5/8, 12.3	2.5/8, 6.2
28.0	7/8, 20.2	3/8, 7.9	7/8, 20.2	3/8, 7.9	5/8, 12.3	2.5/8, 6.2

FIG. 2

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Description

Technical Field

[0001] The present disclosure relates to a refrigeration cycle apparatus including a heat-source unit and a utilization unit that are connected to each other via a connection pipe and thereby constitute a refrigerant circuit, the refrigeration cycle apparatus using carbon dioxide as a refrigerant enclosed in the refrigerant circuit.

Background Art

[0002] There is an air-conditioning apparatus (refrigeration cycle apparatus) including a heat-source unit and a utilization unit that are connected to each other via a connection pipe and thereby constitute a refrigerant circuit. As such a refrigeration cycle apparatus, there is a refrigeration cycle apparatus that uses carbon dioxide as a refrigerant enclosed in a refrigerant circuit, as described in PTL 1 (International Publication No. 2011/099063).

Summary of Invention

Technical Problem

[0003] When using carbon dioxide as a refrigerant enclosed in a refrigerant circuit, it is required to consider adverse effects (oxygen deficiency and the like) on a human body. Specifically, a safety measure is required to be taken in accordance with the concentration level of carbon dioxide in an indoor space when a refrigerant leaks from a refrigerant circuit. In particular, such tendency is remarkable in a refrigeration cycle apparatus, such as a multi air conditioner for a building, including a plurality of utilization units because the amount of a refrigerant enclosed in a refrigerant circuit is large and, when the refrigerant leaks in one of the plurality of utilization units, there is a possibility of the refrigerant enclosed in the refrigerant circuit all leaking into an indoor space corresponding to the utilization unit in which leak of the refrigerant has occurred.

[0004] Therefore, when using carbon dioxide as a refrigerant enclosed in a refrigerant circuit, it is preferable to reduce the amount of the refrigerant enclosed in the refrigerant circuit.

Solution to Problem

[0005] A refrigeration cycle apparatus according to a first aspect is a refrigeration cycle apparatus including a heat-source unit and a utilization unit that are connected to each other via a gas-refrigerant connection pipe and a liquid-refrigerant connection pipe and thereby constitute a refrigerant circuit. In the refrigeration cycle apparatus, a refrigerant enclosed in the refrigerant circuit is carbon dioxide, a pipe whose inner diameter is 6.2 mm or less is used as the gas-refrigerant connection pipe, and/or a pipe whose inner diameter is 3.6 mm or less is used as the liquid-refrigerant connection pipe.

[0006] Consequently, since the pipes having the inner diameters that are not conventionally used as the gas-refrigerant connection pipe and/or the liquid-refrigerant connection pipe are used here, it is possible to reduce the volume of the gas-refrigerant connection pipe and/or the liquid-refrigerant connection pipe and to reduce the amount of the refrigerant enclosed in the refrigerant circuit.

[0007] A refrigeration cycle apparatus according to a second aspect is the refrigeration cycle apparatus according to the first aspect in which a copper pipe (temper is 1/2H) whose nominal diameter is less than 1/4 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 8.0 kW or less is connected.

[0008] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the liquid-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the liquid-refrigerant connection pipe and possible to contribute to the optimization of the liquid-refrigerant connection pipe.

[0009] A refrigeration cycle apparatus according to a third aspect is the refrigeration cycle apparatus according to the first aspect in which a copper pipe (the temper is 1/2H) whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 8.0 kW or less is connected.

[0010] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the liquid-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the liquid-refrigerant connection pipe and possible to contribute to the optimization of the liquid-refrigerant connection pipe.

[0011] A refrigeration cycle apparatus according to a fourth aspect is the refrigeration cycle apparatus according to any one of the first to third aspects in which a copper pipe (the temper is 1/2H) whose nominal diameter is more than 1/4 inch and less than 3/8 inch is used as the gas-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 4.5 kW or less is connected.

[0012] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the gas-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the gas-refrigerant connection pipe and possible to contribute to the optimization of the gas-refrigerant connection pipe.

[0013] A refrigeration cycle apparatus according to a fifth aspect is the refrigeration cycle apparatus according to any one of the first to third aspects in which a copper pipe (the temper is 1/2H) whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection pipe to

which the utilization unit whose rated refrigerating capacity is 4.5 kW or less is connected.

[0014] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the gas-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the gas-refrigerant connection pipe and possible to contribute to the optimization of the gas-refrigerant connection pipe.

[0015] A refrigeration cycle apparatus according to a sixth aspect is the refrigeration cycle apparatus according to the first aspect in which a copper pipe (the temper is O) whose nominal diameter is less than 1/4 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 3.6 kW or less is connected.

[0016] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the liquid-refrigerant connection pipe is used, it is possible to increase the number of the sizes of the copper pipe usable as the liquid-refrigerant connection pipe and possible to contribute to the optimization of the liquid-refrigerant connection pipe.

[0017] A refrigeration cycle apparatus according to a seventh aspect is the refrigeration cycle apparatus according to the first aspect in which a copper pipe (the temper is O) whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 3.6 kW or less is connected.

[0018] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the liquid-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the liquid-refrigerant connection pipe and possible to contribute to the optimization of the liquid-refrigerant connection pipe.

[0019] A refrigeration cycle apparatus according to an eighth aspect is the refrigeration cycle apparatus according to any one of the first, sixth, and seventh aspects in which a copper pipe (the temper is O) whose nominal diameter is more than 1/4 inch and less than 3/8 inch is used as the gas-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 2.8 kW or less is connected.

[0020] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the gas-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the gas-refrigerant connection pipe and possible to contribute to the optimization of the gas-refrigerant connection pipe.

[0021] A refrigeration cycle apparatus according to a ninth aspect is the refrigeration cycle apparatus according to any one of the first, sixth, and seventh aspects in which a copper pipe (the temper is O) whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 2.8 kW or less is connected.

[0022] Consequently, since the copper pipe having the nominal diameter that is not conventionally used as the gas-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the gas-refrigerant connection pipe and possible to contribute to the optimization of the gas-refrigerant connection pipe.

[0023] A refrigeration cycle apparatus according to a tenth aspect is the refrigeration cycle apparatus according to any one of the first to ninth aspects in which the gas-refrigerant connection pipe and the liquid-refrigerant connection pipe each have an outer surface covered by a heat insulating material, the gas-refrigerant connection pipe and the liquid-refrigerant connection pipe being bundled together and constituting a pair connection pipe.

[0024] It is possible here to use the pair connection pipe when on-site connecting the heat-source unit and the utilization unit to each other, and it is thus possible to improve workability.

[0025] A refrigeration cycle apparatus according to an eleventh aspect is the refrigeration cycle apparatus according to any one of the first to tenth aspects in which, when a pipe whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe whose nominal diameter is less than 1/4 inch, a pipe end portion includes a different diameter portion enlarged to have a nominal diameter of 1/4 inch.

[0026] When the liquid-refrigerant connection pipe is elongated or branched, pipe joints, such as a socket pipe, a branch pipe, and the like, for connecting pipes to each other are required. However, pipe joints that are conventionally used as such pipe joints correspond to pipes having a nominal diameter in increments of 1/8 inch but do not correspond to pipes having a nominal diameter in increments of 0.5/8 inch.

[0027] Thus, the pipe end portion of the pipe whose nominal diameter is 1.5/8 inch and used as the liquid-refrigerant connection pipe includes here the different diameter portion enlarged to have the nominal diameter of 1/4 inch (= 2/8 inch).

[0028] Consequently, since it is possible here to use pipe joints that correspond to conventionally used pipes having nominal diameters in increments of 1/8 inch even when a pipe whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe whose nominal diameter is less than 1/4 inch, it is possible not to prepare pipe joints corresponding to pipes having nominal diameters in increments of 0.5/8 inch and possible to improve workability.

[0029] A refrigeration cycle apparatus according to a twelfth aspect is the refrigeration cycle apparatus according to any one of the first to eleventh aspects in which, when a pipe whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection pipe whose nominal diameter is more than 1/4 inch and less than 3/8 inch, a pipe end portion includes a different diameter portion enlarged to have a nominal diameter of 3/8 inch.

[0030] When the gas-refrigerant connection pipe is elongated or branched, pipe joints, such as a socket pipe, a branch pipe, and the like, for connecting pipes to each other are required. However, pipe joints that are conventionally used as such pipe joints correspond to pipes having a nominal diameter in increments of 1/8 inch but do not correspond to pipes having a nominal diameter in increments of 0.5/8 inch.

[0031] Thus, the pipe end portion of the pipe whose nominal diameter is 2.5/8 inch and used as the gas-refrigerant connection pipe includes here the different diameter portion enlarged to have the nominal diameter of 3/8 inch.

[0032] Consequently, since it is possible here to use pipe joints that correspond to conventionally used pipes having nominal diameters in increments of 1/8 inch even when a pipe whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection pipe whose nominal diameter is more than 1/4 inch and less than 3/8 inch, it is possible not to prepare pipe joints corresponding to pipes having nominal diameters in increments of 0.5/8 inch and possible to improve workability.

Brief Description of Drawings

[0033]

[Fig. 1] Fig. 1 is a general configuration diagram of an air-conditioning apparatus as a refrigeration cycle apparatus according to one embodiment of the present disclosure.

[Fig. 2] Fig. 2 is a table indicating a relationship between rated refrigerating capacity and the pipe diameters of connection pipes when R410A, R32, or carbon dioxide is used as a refrigerant.

[Fig. 3] Fig. 3 is an illustration (components constituting a heat-source unit and a utilization unit are not illustrated) of connection pipes constituting the refrigeration cycle apparatus in Fig. 1.

[Fig. 4] Fig. 4 is a table indicating a relationship between rated refrigerating capacity and the pipe diameters of connection pipes when the temper of a copper pipe is 1/2H or O.

[Fig. 5] Fig. 5 is a view of a main part of a pair connection pipe.

[Fig. 6] Fig. 6 is a view of pipe end portions of a connection pipe.

Description of Embodiments

[0034] Hereinafter, a refrigeration cycle apparatus will be described on the basis of the drawings.

(1) Configuration

<Outline>

[0035] Fig. 1 is a general configuration diagram of an air-conditioning apparatus 1 as a refrigeration cycle apparatus according to one embodiment of the present disclosure.

[0036] The air-conditioning apparatus 1 is an apparatus capable of performing cooling and heating of the inside of a room of a building or the like by a vapor compression refrigeration cycle. The air-conditioning apparatus 1 includes, mainly, a heat-source unit 2, utilization units 4a and 4b, and a gas-refrigerant connection pipe 5 and a liquid-refrigerant connection pipe 6 that connect the heat-source unit 2 and the utilization units 4a and 4b to each other. In other words, a vapor compression refrigerant circuit 7 of the air-conditioning apparatus 1 is constituted as a result of the heat-source unit 2 and the utilization units 4a and 4b being connected to each other via the gas-refrigerant connection pipe 5 and the liquid-refrigerant connection pipe 6. Carbon dioxide is enclosed as a refrigerant in the refrigerant circuit 7. Note that, when carbon dioxide is used as a refrigerant, the refrigerant may become in a supercritical state (a state in which a gas state and a liquid state are not distinguished from each other) in the process of a refrigeration cycle. However, regarding the names and the like of components, including the connection pipes 5 and 6, constituting the refrigerant circuit 7, the wordings "gas" and "liquid" are used in the name and the like of the components, as with when a refrigerant (R410A, R32, or the like) that does not become in a supercritical state in the process of a refrigeration cycle is used.

<Utilization Unit>

[0037] The utilization units 4a and 4b are installed inside a room or the like and constitute a portion of the refrigerant circuit 7. The utilization unit 4a includes, mainly, a utilization-side expansion mechanism 41a and a utilization heat exchanger 42a. The utilization unit 4b includes, mainly, a utilization-side expansion mechanism 41b and a utilization heat exchanger 42b. Here, since the utilization unit 4a and the utilization unit 4b have the same configuration, only the configuration of the utilization unit 4a will be described here, and, regarding the configuration of the utilization unit 4b, description of each portion is omitted by giving the character "b" to the portion instead of the character "a" indicating the portion of the utilization unit 4a.

[0038] The utilization-side expansion mechanism 41a is a mechanism for decompressing a refrigerant, and an expansion valve is used here. The utilization-side expansion mechanism 41a is connected at one end thereof to the utilization-side heat exchanger 42a and connected at the other end thereof to the liquid-refrigerant connection pipe 6.

[0039] The utilization-side heat exchanger 42a is a heat exchanger that functions as an evaporator or a radiator for a refrigerant. The utilization heat exchanger 42a is connected at one end thereof to the utilization-side expansion mechanism 41a and connected at the other

end thereof to the gas-refrigerant connection pipe 5.

[0040] The utilization unit 4a includes a utilization-side fan 43a for suctioning air into the unit and supplying the air to the inside of a room, thereby causing heat to be exchanged between the air and the refrigerant that flows in the utilization-side heat exchanger 42a.

<Heat-source Unit>

[0041] The heat-source unit 2 is installed outside a room or the like and constitutes a portion of the refrigerant circuit 7. The heat-source unit 2 includes, mainly, a compressor 21, a switching mechanism 22, a heat-source-side heat exchanger 23, a heat-source-side expansion mechanism 25, a subcooling heat exchanger 26, a suction return pipe 27, a liquid-side shutoff valve 29, a gas-side shutoff valve 30, and an accumulator 31.

[0042] The compressor 21 is an equipment that compresses a refrigerant. The suction side of the compressor 21 is provided with the accumulator 31 that stores a refrigerant temporarily.

[0043] The switching mechanism 22 is a mechanism for switching the flowing direction of a refrigerant in the refrigerant circuit 7, and a four-way switching valve is used here. During cooling operation, the switching mechanism 22 connects the discharge side of the compressor 21 and one end of the heat-source-side heat exchanger 23 to each other and connects the suction side of the compressor 21 and the gas-side shutoff valve 30 to each other (refer to the solid lines of the switching mechanism 22 in Fig. 1) to cause the heat-source-side heat exchanger 23 to function as a radiator for a refrigerant and the utilization-side heat exchangers 42a and 42b to function as evaporators for the refrigerant. During heating operation, the switching mechanism 22 connects the discharge side of the compressor 21 and the gas-side shutoff valve 30 to each other and connects the suction side of the compressor 21 and one end of the heat-source-side heat exchanger 23 to each other (refer to the broken lines of the switching mechanism 22 in Fig. 1) to cause the utilization-side heat exchangers 42 to function as the radiator for the refrigerant and the heat-source-side heat exchanger 23 to function as the evaporator for the refrigerant.

[0044] The heat-source-side heat exchanger 23 is a heat exchanger that functions as a radiator or an evaporator for the refrigerant. The heat-source-side heat exchanger 23 is connected at one end thereof to the switching mechanism 22 and connected at the other end thereof to the heat-source-side expansion mechanism 25.

[0045] The heat-source unit 2 includes a heat-source-side fan 24 for suctioning air into the unit and exhausting the air to the outside of a room, thereby causing heat to be exchanged between the air and the refrigerant that flows in the heat-source-side heat exchanger 23.

[0046] The heat-source-side expansion mechanism 25 is a mechanism for decompressing the refrigerant, and an expansion valve is used here. The heat-source-side expansion mechanism 25 is connected at one end thereof to the heat-source-side heat exchanger 23 and connected at the other end thereof to the subcooling heat exchanger 26.

[0047] The subcooling heat exchanger 26 is a heat exchanger that further cools the refrigerant that has radiated heat in the heat-source-side heat exchanger 23. The subcooling heat exchanger 26 is connected at one end thereof to the heat-source-side expansion mechanism 25 and connected at the other end thereof to the liquid-side shutoff valve 29. In addition, the refrigerant circuit 7 is provided with the suction return pipe 27 that decompresses a portion of the refrigerant flowing between the other end of the heat-source-side heat exchanger 23 and the liquid-side shutoff valve 29 through the heat-source-side expansion mechanism 25 and the subcooling heat exchanger 26 and then returns the portion of the refrigerant to the suction side of the compressor 21. Here, the suction return pipe 27 is provided in the refrigerant circuit 7 so as to cause a portion of the refrigerant that flows between the heat-source-side expansion mechanism 25 and the subcooling heat exchanger 26 to branch from the refrigerant circuit 7 and return to the suction side (more specifically, between the switching mechanism 22 and the accumulator 31) of the compressor 21. The suction return pipe 27 is provided with a suction-return expansion mechanism 28 for decompressing the refrigerant. An expansion valve is used here as the suction-return expansion mechanism 28. Consequently, a portion of the refrigerant cooled in the heat-source-side heat exchanger 23 is bypassed to the suction side of the compressor 21 by the suction return pipe 27, and the remaining refrigerant is cooled in the heat-source-side heat exchanger 26 by the refrigerant that flows in the suction return pipe 27.

[0048] The liquid-side shutoff valve 28 is a valve to which the liquid-refrigerant connection pipe 6 through which the refrigerant flows between the heat-source unit 2 and the utilization units 4a and 4b is connected, and the valve is connected to the subcooling heat exchanger 26.

[0049] The gas-side shutoff valve 30 is a valve to which the gas-refrigerant connection pipe 5 through which the refrigerant flows between the heat-source unit 2 and the utilization units 4a and 4b is connected, and the valve is connected to the switching mechanism 22.

<Connection Pipe>

[0050] The connection pipes 5 and 6 are refrigerant pipes that on-site connect the heat-source unit 2 and the utilization units 4a and 4b to each other when constituting the air-conditioning apparatus 1.

[0051] Describing by using the compression process, the radiation process, the expansion process, and the evaporation process of the refrigeration cycle, the gas-refrigerant connection pipe 5 is a refrigerant pipe in which the refrigerant from after the completion of the evapora-

tion process to the start of the compression process or the refrigerant from after the completion of the compression process to the start of the radiation process flows. Here, the gas-refrigerant connection pipe 5 connects between the gas-side shutoff valve 30 of the heat-source unit 2 and the other ends of the utilization-side heat exchangers 42a and 42b of the utilization units 4a and 4b. The gas-refrigerant connection pipe 5 includes, mainly, a gas-refrigerant connection branch pipe 52a connected to the utilization unit 4a, the gas-refrigerant connection branch pipe 52b connected to the utilization unit 4b, and a gas-refrigerant connection header 51 that connects between the merged portion of the gas-refrigerant connection branch pipes 52a and 52b and the heat-source unit 2.

[0052] Describing by using the compression process, the radiation process, the expansion process, and the evaporation process of the refrigeration cycle, the liquid-refrigerant connection pipe 6 is a refrigerant pipe in which the refrigerant from after the completion of the radiation process to the start of the evaporation process flows. Here, the liquid-refrigerant connection pipe 6 connects between the liquid-side shutoff valve 29 of the heat-source unit 2 and the utilization-side expansion mechanisms 41a and 41b of the utilization units 4a and 4b. The liquid-refrigerant connection pipe 6 includes, mainly, a liquid-refrigerant connection branch pipe 62a connected to the utilization unit 4a, a liquid-refrigerant connection branch pipe 62b connected to the utilization unit 4b, and a liquid-refrigerant connection header 61 that connects between the merged portion of the liquid-refrigerant connection branch pipes 62a and 62b and the heat-source unit 2.

(2) Operation

[0053] Next, the operation of the air-conditioning apparatus 1 will be described with reference to Fig. 1. Note that, although no illustration is provided here, the below-described operation of the air-conditioning apparatus 1 in the cooling operation, the heating operation, and the like is performed by a controller that is configured as a result of a control substrate, a remote controller, and the like provided in the utilization units 4a and 4b and the heat-source unit 2 being communication-connected to each other.

<Cooling Operation>

[0054] During the cooling operation, the switching mechanism 22 is in the state indicated by the solid lines in Fig. 1, that is, a state in which the discharge side of the compressor 21 is connected to the heat-source-side heat exchanger 23 and in which the suction side of the compressor 21 is connected to the gas-side shutoff valve 30.

[0055] In this state of the refrigerant circuit 7, a refrigerant having a low pressure of the refrigeration cycle is sucked by the compressor 21 and discharged from the compressor 21 after compressed to a high pressure of the refrigeration cycle. The high-pressure refrigerant discharged from the compressor 21 is sent to the heat-source-side heat exchanger 23 via the switching mechanism 22 and radiates heat by exchanging heat with outdoor air supplied by the heat-source-side fan 24. The high-pressure refrigerant that has radiated heat in the heat-source-side heat exchanger 23 flows into the subcooling heat exchanger 26 via the heat-source-side expansion mechanism 25 and is cooled by exchanging heat with the refrigerant that flows in the suction return pipe 27. At this time, a portion of the high-pressure refrigerant that has radiated heat in the heat-source-side heat exchanger 23 is branched to the suction return pipe 27 and decompressed by the suction-return expansion mechanism 28. The refrigerant that has been decompressed in the suction-return expansion mechanism 28 is returned to the suction side (here, between the switching mechanism 22 and the accumulator 31) of the compressor 21 after heated in the subcooling heat exchanger 26 by exchanging heat with the high-pressure refrigerant that flows on the side of the refrigerant circuit 7.

[0056] Then, the high-pressure refrigerant that has been cooled in the subcooling heat exchanger 26 is sent to the utilization units 4a and 4b via the liquid-side shutoff valve 29 and the liquid-refrigerant connection pipe 6. The high-pressure refrigerant that has been sent to the utilization units 4a and 4b is decompressed by the utilization-side expansion mechanisms 41a and 41b and becomes a low-pressure refrigerant in a gas-liquid two-phase state. The refrigerant that has been decompressed in the utilization-side expansion mechanisms 41a and 41b is sent to the utilization-side heat exchangers 42a and 42b and evaporates by exchanging heat in the utilization-side heat exchangers 42a and 42b with indoor air supplied by the utilization-side fans 43a and 43b. At this time, since the indoor air is cooled by exchanging heat with the refrigerant in the utilization-side heat exchangers 42a and 42b and sent to the inside of a room, cooling of the inside of the room is thereby performed.

[0057] Then the low-pressure refrigerant that has evaporated in the utilization-side heat exchangers 42a and 42b is sent to the heat-source unit 2 via the gas-refrigerant connection pipe 5. The low-pressure refrigerant that has been sent to the heat-source unit 2 is sucked into the compressor 21 again together with the refrigerant that is returned from the suction return pipe 27 via the gas shutoff valve 30, the switching mechanism 22, and the accumulator 31.

<Heating Operation>

[0058] During the heating operation, the switching mechanism 22 is in the state indicated by the broken lines in Fig. 1, that is, in a state in which the discharge side of the compressor 21 is connected to the gas-side shutoff valve 30 and in which the suction side of the compressor 21 is connected to the heat-source-side heat ex-

changer 23.

[0059] In this state of the refrigerant circuit 7, the refrigerant having the low-pressure of the refrigeration cycle is sucked by the compressor 21 and discharged from the compressor 21 after compressed to the high pressure of the refrigeration cycle. The high-pressure refrigerant that has been discharged from the compressor 21 is sent to the utilization units 4a and 4b via the switching mechanism 22, the gas-side shutoff valve 30, and the gas-refrigerant connection pipe 5.

[0060] Then, the high-pressure refrigerant that has been sent to the utilization units 4a and 4b radiates heat by exchanging heat in the utilization-side heat exchangers 42a and 42b with indoor air supplied by the utilization-side fans 43a and 43b. At this time, since the indoor air is heated by exchanging heat with the refrigerant in the utilization-side heat exchangers 42a and 42b and sent to the inside of a room, heating of the inside of the room is thereby performed. The high-pressure refrigerant that has radiated heat in the utilization-side heat exchangers 42a and 42b is decompressed by the utilization-side expansion mechanisms 41a and 41b.

[0061] Then, the refrigerant that has been decompressed in the utilization-side expansion mechanisms 41a and 41b is sent to the heat-source unit 2 via the liquid-refrigerant connection pipe 6. The refrigerant that has been sent to the heat-source unit 2 is sent to the heat-source-side expansion mechanism 25 via the liquid-side shutoff valve 29 and the subcooling heat exchanger 26. At this time, since the suction-return expansion mechanism 28 is closed, the refrigerant is not branched to the suction return pipe 27. The refrigerant that has been sent to the heat-source-side expansion mechanism 25 is further decompressed by the heat-source-side expansion mechanism 25 and becomes a low-pressure refrigerant in a gas-liquid two-phase state. The refrigerant that has been decompressed in the heat-source-side expansion mechanism 25 is sent to the heat-source-side heat exchanger 23 and evaporates in the heat-source-side heat exchanger 23 by exchanging heat with outdoor air supplied by the heat-source-side fan 24. The low-pressure refrigerant that has evaporated in the heat-source-side heat exchanger 23 is sucked by the compressor 21 again via the switching mechanism 22 and the accumulator 31.

(3) Selection of Pipe Diameters of Connection Pipes

[0062] In the air-conditioning apparatus 1, pipes having various pipe diameters and lengths are used as the connection pipes 5 and 6 in accordance with conditions of refrigerating capacity, conditions of the installation location, and the like of the air-conditioning apparatus 1.

[0063] As illustrated in Fig. 2, the pipe diameters of the connection pipes 5 and 6 are selected here in accordance with the rated refrigerating capacity of the utilization units 4a and 4b connected to the heat-source unit 2. Here, for example, when the refrigeration cycle apparatus is the air-conditioning apparatus 1, the "rated refrigerating capacity" means a value equivalent to the "rated cooling capacity" or the "nominal capacity" of the utilization units 4a and 4b or the heat-source unit 2 described in a product catalog or an instruction manual.

[0064] The values of the pipe diameters of the connection pipes 5 and 6 indicated in Fig. 2 indicate the pipe diameters of the connection pipes 5 and 6 (that is, the refrigerant connection branch pipes 52a, 52b, 62a, and 62b and the refrigerant connection headers 51 and 61) excluding pipe joints, such as socket pipes 53a and 63a and branch pipes 54a and 64a, and the like, illustrated in Fig. 3, for connecting pipes to each other. In addition, the values of the pipe diameters when a copper pipe (temper is 1/2H), such as a phosphorus deoxidized copper jointless copper pipe, is used as a pipe material of the connection pipes 5 and 6 are indicated here. Here, the "temper" means a type of thermal refining of a copper pipe defined in, for example, JIS H 3300, and "temper is 1/2H" indicates a degree of tensile strength obtained through work hardening treatment performed in manufacture. In addition to a case in which carbon dioxide is used as the refrigerant enclosed in the refrigerant circuit 7, there are presented here, as a comparative example, a case in which R410A, which is conventionally often used, or R32, which is recently started to be used, is used. Note that, in Fig. 2, nominal diameters and inner diameters are indicated as the values of the pipe diameters. Here, for the case in which carbon dioxide is used, in consideration of the high pressure of the refrigeration cycle, the values of the inner diameters when the design pressure of the connection pipes 5 and 6 is set to 12.3 MPa are indicated. However, when carbon dioxide is used, the design pressure of the connection pipes 5 and 6 may be set to a slightly high pressure, such as 13.7 MPa, and, in this case, the inner diameters may be smaller than the inner diameters indicated in Fig. 2 due to an increased pipe thickness.

[0065] According to Fig. 2, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is 8.0 kW or less are connected, a copper pipe whose nominal diameter is less than 1/4 inch (the outer diameter is less than 6.35 mm) is used. Specifically, as the liquid-refrigerant connection pipe 6 whose nominal diameter is less than 1/4 inch, a copper pipe whose nominal diameter is 1.5/8 inch (the outer diameter is 4.76 mm) is used. Here, the copper pipe whose nominal diameter is 1.5/8 inch has an inner diameter of 3.6 mm, which means that, as the liquid-refrigerant connection pipe 6, a pipe whose inner diameter is 3.6 mm or less is used. Note that "the liquid-refrigerant connection pipe 6 to which a utilization unit whose rated refrigerating capacity is 8.0 kW or less is connected" not only means the liquid-refrigerant connection pipe 6 to which only one utilization unit whose rated refrigerating capacity is 8.0 kW or less is connected. When, as with the configuration in Fig. 3, the liquid-refrigerant connection pipe 6 is branched and a plurality of the utilization units 4a and 4b are connected to the liquid-refrigerant

connection pipe 6, branched part (the liquid-refrigerant connection branch pipes 62a and 62b) of the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is 8.0 kW or less are connected, and a merged part (the liquid-refrigerant connection header 61) of the liquid-refrigerant connection pipe 6 where the rated refrigerating capacity of the plurality of utilization units 4a and 4b is 8.0 kW or less in total are also meant. In addition, "as the liquid-refrigerant connection pipe 6, a copper pipe whose nominal diameter is less than 1/4 inch (1.5/8 inch) (the inner diameter is 3.6 mm or less) is used" includes, not only a case in which only a copper pipe whose nominal diameter is less than 1/4 inch (1.5/8 inch) (the inner diameter is 3.6 mm or less) is used, cases in which a copper pipe whose nominal diameter is less than 1/4 inch (1.5/8 inch) (the inner diameter is 3.6 mm or less) and a copper pipe whose nominal diameter is 1/4 inch or more (more than 1.5/8 inch) (the inner diameter is more than 3.6 mm) are used.

[0066] According to Fig. 2, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 8.0 kW and less than or equal to 16.0 kW are connected, a copper pipe whose nominal diameter is 1/4 inch (the outer diameter is 6.35 mm, and the inner diameter is 5.0 mm) is used.

[0067] According to Fig. 2, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 16.0 kW and less than or equal to 28.0 kW are connected, a copper pipe whose nominal diameter is more than 1/4 inch (the outer diameter is more than 6.35 mm) and less than 3/8 inch (the outer diameter is less than 9.52 mm) is used. Specifically, as the liquid-refrigerant connection pipe 6 whose nominal diameter is more than 1/4 inch and less than 3/8 inch, a copper pipe whose nominal diameter is 2.5/8 inch (the outer diameter is 7.94 mm, and the inner diameter is 6.2 mm) is used.

[0068] According to Fig. 2, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is 4.5 kW or less are connected, a copper pipe whose nominal diameter is more than 1/4 inch (the outer diameter is more than 6.35 mm) and less than 3/8 inch (the outer diameter is less than 9.52 mm) is used. Specifically, a copper pipe whose nominal diameter is 2.5/8 inch (the outer diameter is 7.94 mm) is used as the gas-refrigerant connection pipe 5 whose nominal diameter is more than 1/4 inch and less than 3/8 inch. Here, the copper pipe whose nominal diameter is 2.5/8 inch has an inner diameter of 6.2 mm or less, which means that, as the gas-refrigerant connection pipe 5, a pipe whose inner diameter is 6.2 mm or less is used. Note that "the gas-refrigerant connection pipe 5 to which a utilization unit whose rated refrigerating capacity is 4.5 kW or less is connected" not only means the gas-refrigerant connection pipe 6 to which only one utilization unit whose rated refrigerating capacity is 4.5 kW or less is connected. When, as with the configuration in Fig. 3, the gas-refrigerant connection pipe 5 is branched and the plurality of utilization units 4a and 4b are connected to the gas-refrigerant connection pipe 5, branched part (the gas-refrigerant connection branch pipes 52a and 52b) of the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is 4.5 kW or less are connected, and a merged part (the gas-refrigerant connection header 51) of the gas-refrigerant connection pipe 5 where the rated refrigerating capacity of the plurality of utilization units 4a and 4b is 4.5 kW or less in total are also meant. In addition, "as the gas-refrigerant connection pipe 5, a copper pipe whose nominal diameter is more than 1/4 inch and less than 3/8 inch (2.5/8 inch) (the inner diameter is 6.2 mm or less) is used" includes, not only a case in which only a copper pipe whose nominal diameter is more than 1/4 inch and less than 3/8 inch (2.5/8 inch) (the inner diameter is 6.2 mm or less) is used, cases in which a copper pipe whose nominal diameter is more than 1/4 inch and less than 3/8 inch (2.5/8 inch) (the inner diameter is 6.2 mm or less) and a copper pipe whose nominal diameter is 3/8 inch or more (more than 2.5/8 inch) (the inner diameter is more than 6.2 mm) are used.

[0069] According to Fig. 2, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 4.5 kW and less than or equal to 8.0 kW are connected, a copper pipe whose nominal diameter is 3/8 inch (the outer diameter is 9.52 mm, and the inner diameter is 7.4 mm) is used.

[0070] According to Fig. 2, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 8.0 kW and less than or equal to 16.0 kW are connected, a copper pipe whose nominal diameter is 1/2 inch (the outer diameter is 12.70 mm, and the inner diameter is 9.9 mm) is used.

[0071] According to Fig. 2, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 16.0 kW and less than or equal to 28.0 kW are connected, a copper pipe whose nominal diameter is 5/8 inch (the outer diameter is 15.88 mm, and the inner diameter is 12.3 mm) is used.

[0072] According to Fig. 2, it is found that a small pipe diameter is selected for the connection pipes 5 and 6 when carbon dioxide is used, compared with when a conventional refrigerant, such as R410A or R32, is used with the same rated refrigerating capacity.

[0073] When the table of the pipe diameters of the connection pipes 5 and 6 in Fig. 2 is used, the pipe diameters of the connection pipes 5 and 6 can be selected as follows.

[0074] For example, when the utilization units 4a and 4b both have a rated refrigerating capacity of 2.8 kW, copper pipes whose nominal diameter is 2.5/8 inch are used as the gas-refrigerant connection branch pipes 52a

and 52b, and copper pipes whose nominal diameter is 1.5/8 inch are used as the liquid-refrigerant connection branch pipes 62a and 62b. After the utilization units 4a and 4b are merged together, the total rated refrigerating capacity becomes 5.6 kW, and thus, a copper pipe whose nominal diameter is 3/8 inch is used as the gas-refrigerant connection header 51, and a copper pipe whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection header 61.

[0075] For example, when the utilization units 4a and 4b both have a rated refrigerating capacity of 11.2 kW, copper pipes whose nominal diameter is 1/2 inch are used as the gas-refrigerant connection branch pipes 52a and 52b, and copper pipes whose nominal diameter is 1/4 inch are used as the liquid-refrigerant connection branch pipes 62a and 62b. After the utilization units 4a and 4b are merged together, the total rated refrigerating capacity becomes 22.4 kW, and thus, a copper pipe whose nominal diameter is 5/8 inch is used as the gas-refrigerant connection header 51, and a copper pipe whose nominal diameter is 2.5/8 inch is used as the liquid-refrigerant connection header 61.

[0076] For example, when the utilization unit 4a has a rated refrigerating capacity of 2.2 kW and the utilization unit 4b has a rated refrigerating capacity of 9.0 kW, a copper pipe whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection branch pipe 52a, a copper pipe whose nominal diameter is 1/2 inch is used as the gas-refrigerant connection branch pipe 52b, a copper pipe whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection branch pipe 62a, and a copper pipe whose nominal diameter is 1/4 inch is used as the liquid-refrigerant connection branch pipe 62b. After the utilization units 4a and 4b are merged together, the total rated refrigerating capacity becomes 11.2 kW, and thus, a copper pipe whose nominal diameter is 1/2 inch is used as the gas-refrigerant connection header 51, and a copper pipe whose nominal diameter is 1/4 inch is used as the liquid-refrigerant connection header 61.

(4) Features

[0077] Next, features of the air-conditioning apparatus 1 will be described.

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[0078] Here, as mentioned above, in the air-conditioning apparatus 1 (refrigeration cycle apparatus) in which the heat-source unit 2 and the utilization units 4a and 4b are connected to each other via the gas-refrigerant connection pipe 5 and the liquid-refrigerant connection pipe 6 and thereby constitute the refrigerant circuit 7, the refrigerant enclosed in the refrigerant circuit 7 is carbon dioxide, a pipe whose inner diameter is 6.2 mm or less is used as the gas-refrigerant connection pipe 5, and/or a pipe whose inner diameter is 3.6 mm or less is used as the liquid-refrigerant connection pipe 6 (refer to Fig. 2).

[0079] Since carbon dioxide whose refrigerating capacity per unit volume is higher than those of conventional refrigerants (R410A, R32, and the like) is used here, it is possible to reduce the flow rate (refrigerant circulation amount) of the refrigerant that circulates in the refrigerant circuit 7. Thus, it is possible here to use, as the connection pipes 5 and 6, pipes whose inner diameter is smaller than those of pipes used for conventional refrigerants while avoiding flow-path resistance of the refrigerant that flows in the connection pipes 5 and 6 from becoming excessively large.

[0080] Specifically, with conventional refrigerants, a pipe whose inner diameter is less than 11.1 mm is not used as the gas-refrigerant connection pipe, and a pipe whose inner diameter is less than 4.7 mm is not used as the liquid-refrigerant connection pipe (refer to Fig. 2), in consideration of flow-path resistance. In contrast, as mentioned above, a pipe (a pipe whose inner diameter is 6.2 mm or less) that is not used as the gas-refrigerant connection pipe due to the inner diameter that is too small for conventional refrigerants is used here as the gas-refrigerant connection pipe 5, and/or a pipe (a pipe whose inner diameter is. 3.6 mm or less) that is not used as the liquid-refrigerant connection pipe due to the inner diameter that is too small for conventional refrigerants is used here as the liquid-refrigerant connection pipe 6.

[0081] Consequently, it is possible here to reduce the volume of the gas-refrigerant connection pipe 5 and/or the liquid-refrigerant connection pipe 6 and reduce the amount of the refrigerant enclosed in the refrigerant circuit 7.

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[0082] As mentioned above, as the liquid-refrigerant connection pipe 6 whose inner diameter is 3.6 mm or less, a copper pipe (the temper is 1/2H) whose nominal diameter is less than 1/4 inch (the outer diameter is less than 6.35 mm) is used here (refer to Fig. 2). Specifically, a copper pipe (the temper is 1/2H) whose nominal diameter is 1.5/8 inch (the outer diameter is 4.76 mm) is used here (refer to Fig. 2) .

[0083] Here, with conventional refrigerants (R410A, R32, and the like), a copper pipe whose nominal diameter is less than 1/4 inch (1.5/8 inch here) is not used as the liquid-refrigerant connection pipe (refer to Fig. 2). Copper pipes for conventionally used refrigerants have nominal diameters in increments of 1/8 inch, such as 1/4 (= 2/8) inch, 3/8 inch, 1/2 (= 4/8) inch, 5/8 inch, and 3/4 (= 6/8) inch, and, nominal diameters in increments of 0.5/8 inch are not used. In other words, a copper pipe (the temper is 1/2H) that has an inner diameter of 3.6 mm or less and that is not used as the liquid-refrigerant connection pipe due to having a too small nominal diameter (outer diameter) for conventional refrigerants, and that has a nominal diameter of less than 1/4 inch (1.5/8 inch here) (the outer diameter is less than 6.35 mm) and that is not conventionally used is used here as the liquid-refrigerant con-

nection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is 8.0 kW or less are connected.

[0084] Consequently, it is possible here to reduce the volume of the liquid-refrigerant connection pipe 6 and possible to reduce the amount of the refrigerant enclosed in the refrigerant circuit 7. Moreover, since the copper pipe having the nominal diameter that is not conventionally used as the liquid-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the liquid-refrigerant connection pipe 6 and possible to contribute to the optimization of the liquid-refrigerant connection pipe 6.

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[0085] As mentioned above, as the gas-refrigerant connection pipe 5 whose inner diameter is 6.2 mm or less, a copper pipe (the temper is 1/2H) whose nominal diameter is more than 1/4 inch (the outer diameter is more than 6.35 mm) and less than 3/8 inch (the outer diameter is less than 9.52 mm) is used here (refer to Fig. 2). Specifically, a copper pipe (the temper is 1/2H) whose nominal diameter is 2.5/8 inch (the outer diameter is 7.94 mm) is used here (refer to Fig. 2).

[0086] Here, with conventional refrigerants (R410A, R32, and the like), a copper pipe whose nominal diameter is less than 1/2 inch is not used as the gas-refrigerant connection pipe 5 (refer to Fig. 2). Copper pipes for conventionally used refrigerants have nominal diameters in increments of 1/8 inch, such as 1/2 (= 4/8) inch, 5/8 inch, 3/4 (= 6/8) inch, 7/8 inch, and 1 (= 8/8) inch, and nominal diameters in increments of 0.5/8 inch are not used. In other words, a copper pipe (the temper is 1/2H) that has an inner diameter of 6.2 mm or less and that is not used as the gas-refrigerant connection pipe due to having a too small nominal diameter (outer diameter) for conventional refrigerants, and that has a nominal diameter of more than 1/4 inch (the outer diameter is more than 6.35 mm) and less than 3/8 inch (2.5/8 inch here) (the outer diameter is less than 9.52 mm) and that is not conventionally used is used here as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is 4.5 kW or less are connected.

[0087] Consequently, it is possible here to reduce the volume of the gas-refrigerant connection pipe 5 and possible to reduce the amount of the refrigerant enclosed in the refrigerant circuit 7. Moreover, since the copper pipe having a nominal diameter that is not conventionally used as the gas-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the gas-refrigerant connection pipe 5 and possible to contribute to the optimization of the gas-refrigerant connection pipe 5.

(5) Modification

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[0088] In the aforementioned embodiment, a copper pipe (the temper is 1/2H), such as a phosphorus deoxidized copper jointless pipe, is used as the pipe material of the connection pipes 5 and 6 (refer to Fig. 2). However, the temper of the copper pipe is various, and, as the temper used as the copper pipe for the refrigerant, there are "H", in which the copper pipe has been subjected to work hardening treatment to have a tensile force higher than "1/2H", and "O", in which the copper pipe is not subjected to work hardening treatment in manufacture and is in an annealed state (the tensile force is low), in addition to "1/2H".

[0089] As illustrated in Fig. 4, a copper pipe whose temper is O is used here as the pipe material of the connection pipes 5 and 6. In Fig. 4, cases in which a copper pipe whose temper is 1/2H is used are also indicated as comparative examples.

[0090] According to Fig. 4, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is 3.6 kW or less are connected, a copper pipe whose nominal diameter is less than 1/4 inch (the outer diameter is less than 6.35 mm) is used. Specifically, a copper pipe whose nominal diameter is 1.5/8 inch (the outer diameter is 4.7 mm) is used as the liquid-refrigerant connection pipe 6 whose nominal diameter is less than 1/4 inch. Here, the copper pipe whose nominal diameter is 1.5/8 inch has an inner diameter of 2.8 mm, which means that, as with when the temper is 1/2H, a pipe whose inner diameter is 3.6 mm or less is used as the liquid-refrigerant connection pipe 6.

[0091] According to Fig. 4, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 3.6 kW and less than or equal to 7.1 kW are connected, a copper pipe whose nominal diameter is 1/4 inch (the outer diameter is 6.35 mm, and the inner diameter is 3.8 mm) is used.

[0092] According to Fig. 4, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 7.1 kW and less than or equal to 14.0 kW are connected, a copper pipe whose nominal diameter is more than 1/4 inch (the outer diameter is more than 6.35 mm) and less than 3/8 inch (the outer diameter is less than 9.52 mm) is used. Specifically, a copper pipe whose nominal diameter is 2.5/8 inch (the outer diameter is 7.94 mm, and the inner diameter is 4.8 mm) is used as the liquid-refrigerant connection pipe 6 whose nominal diameter is more than 1/4 inch and less than 3/8 inch.

[0093] According to Fig. 4, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 14.0 kW and less than or equal to 22.4 kW are connected, a copper pipe whose nominal diameter is 3/8 inch (the outer diam-

eter is 9.52 mm, and the inner diameter is 5.8 mm) is used.

[0094] According to Fig. 4, as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 22.4 kW and less than or equal to 28.0 kW are connected, a copper pipe whose nominal diameter is 1/2 inch (the outer diameter is 12.70 mm, and the inner diameter is 7.7 mm) is used.

[0095] According to Fig. 4, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is 2.8 kW or less are connected, a copper pipe whose nominal diameter is more than 1/4 inch (the outer diameter is more than 6.35 mm) and less than 3/8 inch (the outer diameter is less than 9.52 mm) is used. Specifically, a copper pipe whose nominal diameter is 2.5/8 inch (the outer diameter is 7.94 mm) is used as the gas-refrigerant connection pipe 5 whose nominal diameter is more than 1/4 inch and less than 3/8 inch. Here, the copper pipe whose nominal diameter is 2.5/8 inch has an inner diameter of 4.8 mm or less, which means that, as with when the temper is 1/2H, a pipe whose inner diameter is 6.2 mm or less is used as the gas-refrigerant connection pipe 5.

[0096] According to Fig. 4, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 2.8 kW and less than or equal to 4.5 kW are connected, a copper pipe whose nominal diameter is 3/8 inch (the outer diameter is 9.52 mm) is used. Here the copper pipe whose nominal diameter is 3/8 inch has an inner diameter of 5.8 mm or less, which means that, as with when the temper is 1/2H, a pipe whose inner diameter is 6.2 mm or less is used as the gas-refrigerant connection pipe 5.

[0097] According to Fig. 4, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 4.5 kW and less than or equal to 9.0 kW are connected, a copper pipe whose nominal diameter is 1/2 inch (the outer diameter is 12.70 mm, and the inner diameter is 7.7 mm) is used.

[0098] According to Fig. 4, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 9.0 kW and less than or equal to 16.0 kW are connected, a copper pipe whose nominal diameter is 5/8 inch (the outer diameter is 15.88 mm, and the inner diameter is 9.7 mm) is used.

[0099] According to Fig. 4, as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is more than 16.0 kW and less than or equal to 28.0 kW are connected, a copper pipe whose nominal diameter is 3/4 inch (the outer diameter is 19.05 mm, and the inner diameter is 11.7 mm) is used.

[0100] According to Fig. 4, it is found that, as the inner diameters of the gas-refrigerant connection pipes 5 and 6 when a copper pipe whose temper is O is used, inner diameters equivalent to those when copper pipes whose temper is 1/2H are used with the same rated refrigerating capacity are selected.

[0101] When the table of the pipe diameters of the connection pipes 5 and 6 in Fig. 4 is used, the pipe diameters of the connection pipes 5 and 6 when copper pipes whose temper is O are used can be selected as follows.

[0102] For example, when the utilization units 4a and 4b both have a rated refrigerating capacity of 2.8 kW, copper pipes whose nominal diameter is 2.5/8 inch are used as the gas-refrigerant connection branch pipes 52a and 52b, and copper pipes whose nominal diameter is 1.5/8 inch are used as the liquid-refrigerant connection branch pipes 62a and 62b. After the utilization units 4a and 4b are merged together, the total rated refrigerating capacity becomes 5.6 kW, and thus, a copper pipe whose nominal diameter is 1/2 inch is used as the gas-refrigerant connection header 51, and a copper pipe whose nominal diameter is 1/4 inch is used as the liquid-refrigerant connection header 61.

[0103] For example, when the utilization units 4a and 4b both have a rated refrigerating capacity of 11.2 kW, copper pipes whose nominal diameter is 5/8 inch are used as the gas-refrigerant connection branch pipes 52a and 52b, and copper pipes whose nominal diameter is 2.5/8 inch are used as the liquid-refrigerant connection branch pipes 62a and 62b. After the utilization units 4a and 4b are merged together, the total rated refrigerating capacity becomes 22.4 kW, and thus, a copper pipe whose nominal diameter is 3/4 inch is used as the gas-refrigerant connection header 51, and a copper pipe whose nominal diameter is 3/8 inch is used as the liquid-refrigerant connection header 61.

[0104] For example, when the utilization unit 4a has a rated refrigerating capacity of 2.2 kW and the utilization unit 4b has a rated refrigerating capacity of 9.0 kW, a copper pipe whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection branch pipe 52a, a copper pipe whose nominal diameter is 1/2 inch is used as the gas-refrigerant connection branch pipe 52b, a copper pipe whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection branch pipe 62a, and a copper pipe whose nominal diameter is 2.5/8 inch is used as the liquid-refrigerant connection branch pipe 62b. After the utilization units 4a and 4b are merged together, the total rated refrigerating capacity becomes 11.2 kW, and thus, a copper pipe whose nominal diameter is 5/8 inch is used as the gas-refrigerant connection header 51, and a copper pipe whose nominal diameter is 2.5/8 inch is used as the liquid-refrigerant connection header 61.

[0105] Here, as mentioned above, in the air-conditioning apparatus 1 (refrigeration cycle apparatus) in which the heat-source unit 2 and the utilization units 4a and 4b are connected to each other via the gas-refrigerant connection pipe 5 and the liquid-refrigerant connection pipe 6 and thereby constitute the refrigerant circuit 7, the refrigerant enclosed in the refrigerant circuit 7 is carbon dioxide, a pipe whose inner diameter is 6.2 mm or less

is used as the gas-refrigerant connection pipe 5, and/or a pipe whose inner diameter is 3.6 mm or less is used as the liquid-refrigerant connection pipe 6 (refer to Fig. 4), as with when copper pipes whose temper is 1/2H are used.

[0106] Consequently, as with when copper pipes whose temper is 1/2H are used, it is possible here to reduce the volume of the gas-refrigerant connection pipe 5 and/or the liquid-refrigerant connection pipe 6 and possible to reduce the amount of the refrigerant enclosed in the refrigerant circuit 7.

[0107] As mentioned above, as with when copper pipes whose temper is 1/2H are used, a copper pipe (the temper is O) whose nominal diameter is less than 1/4 inch (the outer diameter is less than 6.35 mm) is used here as the liquid-refrigerant connection pipe 6 whose inner diameter is 3.6 mm or less (refer to Fig. 4). Specifically, a copper pipe (the temper is O) whose nominal diameter is 1.5/8 inch (the outer diameter is 4.76 mm) is used here (refer to Fig. 4). The copper pipe having this nominal diameter is, however, used as the liquid-refrigerant connection pipe 6 to which the utilization units 4a and 4b whose rated refrigerating capacity is 3.6 kW or less are connected, differently from when a copper pipe whose temper is 1/2H is used.

[0108] Consequently, as with when a copper pipe whose temper is 1/2H is used, it is possible here to reduce the volume of the liquid-refrigerant connection pipe 6 and possible to reduce the amount of the refrigerant enclosed in the refrigerant circuit 7. Moreover, since the copper pipe having the nominal diameter that is not conventionally used as the liquid-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the liquid-refrigerant connection pipe 6 and possible to contribute to the optimization of the liquid-refrigerant connection pipe 6. In addition, since the copper pipe whose temper is O is used here as the liquid-refrigerant connection pipe 6, handling, such as bending and the like, is easy compared with when a copper pipe whose temper is 1/2H is used, and it is possible to improve workability when the heat-source unit 2 and the utilization units 4a and 4b are on-site connected to each other.

[0109] As mentioned above, as with when a copper pipe whose temper is 1/2H is used, a copper pipe (the temper is O) whose nominal diameter is more than 1/4 inch (the outer diameter is more than 6.35 mm) and less than 3/8 inch (the outer diameter is less than 9.52 mm) is used here as the gas-refrigerant connection pipe 5 whose inner diameter is 6.2 mm or less (refer to Fig. 4). Specifically, a copper pipe (the temper is O) whose nominal diameter is 2.5/8 inch (the outer diameter is 7.94 mm) is used here (refer to Fig. 4). The copper pipe having this nominal diameter is, however, used as the gas-refrigerant connection pipe 5 to which the utilization units 4a and 4b whose rated refrigerating capacity is 2.8 kW or less are connected, differently from when a copper pipe whose temper is 1/2H is used.

[0110] Consequently, as with when a copper pipe whose temper is 1/2H is used, it is possible here to reduce the volume of the gas-refrigerant connection pipe 5 and possible to reduce the amount of the refrigerant enclosed in the refrigerant circuit 7. Moreover, since the copper pipe having a nominal diameter that is not conventionally used as the gas-refrigerant connection pipe is used here, it is possible to increase the number of the sizes of the copper pipe usable as the gas-refrigerant connection pipe 5 and possible to contribute to the optimization of the gas-refrigerant connection pipe 5. In addition, since the copper pipe whose temper is O is used here as the gas-refrigerant connection pipe 5, handling, such as bending and the like, is easy compared with when a copper pipe whose temper is 1/2H is used, and it is possible to improve workability when the heat-source unit 2 and the utilization units 4a and 4b are on-site connected to each other.

<B>

[0111] In the embodiment and the modification mentioned above, the gas-refrigerant connection pipe 5 and the liquid-refrigerant connection pipe 6 may constitute a pair connection pipe 8, as illustrated in Fig. 5, to improve workability when the heat-source unit 2 and the utilization units 4a and 4b are on-site connected to each other.

[0112] Here, the pair connection pipe 8 has a structure in which the outer surfaces of the connection pipes 5 and 6 are covered by heat insulating materials 9 and 10 and in which the connection pipes 5 and 6 are bundled together. Here, the connection pipes 5 and 6 are respectively covered by the heat insulating materials 9 and 10 each having a two-layer structure, and the connection pipes 5 and 6 are bundled together due to bonding between the outer surfaces of the heat insulating materials 9 and 10. Such a pair connection pipe 8 is prepared for each rated refrigerating capacity. For example, in accordance with the table of the pipe diameters in Fig. 4, when copper pipes whose temper is 1/2H are used as the connection pipes 5 and 6, the pair connection pipe 8 in which the gas-refrigerant connection pipe 5 is 2.5/8 inch and in which the liquid-refrigerant connection pipe 6 is 1.5/8 inch is prepared for the rated refrigerating capacity of 2.2 to 4.5 kW. The pair connection pipe 8 in which the gas-refrigerant connection pipe 5 is 3/8 inch and in which the liquid-refrigerant connection pipe 6 is 1.5/8 inch is prepared for the rated refrigerating capacity of 5.6 to 8.0 kW. The pair connection pipe 8 in which the gas-refrigerant connection pipe 5 is 1/2 inch and in which the liquid-refrigerant connection pipe 6 is 1/4 inch is prepared for the rated refrigerating capacity of 9.0 to 16.0 kW. The pair connection pipe 8 in which the gas-refrigerant connection pipe 5 is 5/8 inch and in which the liquid-refrigerant connection pipe 6 is 2.5/8 inch is prepared for the rated refrigerating capacity of 22.4 to 28.0 kW. Although details are not described, the same pair connection pipe 8 (the application range of the rated refrigerating capacity

is however different) as those when copper pipes whose temper is 1/2H are used as the connection pipes 5 and 6 can be also prepared when copper pipes whose temper is O are used as the connection pipes 5 and 6.

[0113] Consequently, it is possible here to use the pair connection pipe 8 such as those mentioned above when on-site connecting the heat-source unit 2 and the utilization units 4a and 4b, and it is thus possible to improve workability. In particular, since the pipes that have the nominal diameters in increments of 0.5/8 inch (1.5/8 inch and 2.5/8 inch here) and that are not used for conventional refrigerants (R410A, R32, and the like) may be used here, it is extremely useful for improvement in workability to prepare the pair connection pipe 8 including pipes having such nominal diameters.

<C>

[0114] In the embodiment and the modification mentioned above, when the connection pipes 5 and 6 are elongated or branched, pipe joints, such as the socket pipes 53a and 63a and the branch pipes 54a and 64a, for connecting pipes to each other are required, as illustrated in Fig. 3. However, pipe joints that are conventionally used as such pipe joints correspond to pipes having a nominal diameter in increments of 1/8 inch but do not correspond to pipes having a nominal diameter in increments of 0.5/8 inch, such as a pipe whose nominal diameter is 1.5/8 inch or 2.5/8 inch (refer to Fig. 4).

[0115] Thus, as illustrated in Fig. 6, pipe end portions of a pipe having a nominal diameter of 1.5/8 inch and used as the liquid-refrigerant connection pipe 6 whose nominal diameter is less than 1/4 inch here each have a different diameter portion 6a enlarged to have a nominal diameter of 1/4 inch (= 2/8 inch). In addition, as illustrated in Fig. 6, pipe end portions of pipes having a nominal diameter of 2.5/8 inch and used as the gas-refrigerant connection pipe 5 and the liquid-refrigerant connection pipe 6 whose nominal diameter is more than 1/4 inch and less than 3/8 inch have different diameter portions 5a and 6a enlarged to have a nominal diameter of 3/8 inch.

[0116] Consequently, even when a pipe whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe 6 whose nominal diameter is less than 1/4 inch, it is possible here to use pipe joints corresponding to a conventionally used pipe having a nominal diameter in increments of 1/8 inch. In other words, in Fig. 3, even when pipes whose nominal diameter is 1.5/8 are used as the liquid-refrigerant connection branch pipes 62a and 62b and the liquid-refrigerant connection header 61, it is possible to use, as the socket pipes 63a and the branch pipe 64a, pipe joints corresponding to a pipe whose nominal diameter is 1/4 inch. Thus, it is possible not to prepare pipe joints corresponding to a pipe having a nominal diameter in increments of 0.5/8 inch and possible to improve workability. In addition, even when pipes whose nominal diameter is 2.5/8 inch are used as the gas-refrigerant connection pipe 5 and the liquid-refrigerant connection pipe 6 whose nominal diameter is more than 1/4 inch and less than 3/8 inch, it is possible to use pipe joints corresponding to a conventionally used pipe having a nominal diameter in increments of 1/8 inch. In other words, in Fig. 3, even when pipes whose nominal diameter is 2.5/8 inch are used as the refrigerant connection branch pipes 52a, 52b, 62a, and 62b and the refrigerant connection headers 51 and 61, it is possible to use, as the socket pipes 53a and 63a and the branch pipes 54a and 64a, pipe joints corresponding to a pipe whose nominal diameter is 3/8 inch. Thus, it is possible not to prepare pipe joints corresponding to a pipe having a nominal diameter in increments of 0.5/8 inch and possible to improve workability.

<D>

[0117] Description of the embodiment and the modification mentioned above has been provided by presenting, as an example of the refrigeration cycle apparatus, the air-conditioning apparatus 1 including the two utilization units 4a and 4b and capable of cooling and heating; however, the refrigeration cycle apparatus is not limited thereto. For example, the refrigeration cycle apparatus may be an air-conditioning apparatus dedicated to cooling or may be an air-conditioning apparatus including one or three or more of the utilization units.

[0118] An embodiment of the present disclosure has been described above; however, it should be understood that various changes in forms and details are possible without deviating from the gist and the scope of the present disclosure described in the claims.

Industrial Applicability

[0119] The present disclosure is widely applicable to a refrigeration cycle apparatus in which a heat-source unit and a utilization unit are connected to each other via a connection pipe and thereby constitute a refrigerant circuit and in which carbon dioxide is used as a refrigerant enclosed in the refrigerant circuit.

Reference Signs List

[0120]

1 air-conditioning apparatus (refrigeration cycle apparatus)
2 heat-source unit
4a, 4b utilization unit
5 gas-refrigerant connection pipe
5a different diameter portion
6 liquid-refrigerant connection pipe
6a different diameter portion
7 refrigerant circuit
8 pair connection pipe

Citation List

Patent Literature

[0121] PTL 1: International Publication No. 2011/099063

Claims

1. A refrigeration cycle apparatus (1) including a heat-source unit (2) and a utilization unit (4a, 4b) that are connected to each other via a gas-refrigerant connection pipe (5) and a liquid-refrigerant connection pipe (6) and thereby constitute a refrigerant circuit (7),
Wherein
a refrigerant enclosed in the refrigerant circuit is carbon dioxide, and
a pipe whose inner diameter is 6.2 mm or less is used as the gas-refrigerant connection pipe and/or a pipe whose inner diameter is 3.6 mm or less is used as the liquid-refrigerant connection pipe.

2. The refrigeration cycle apparatus according to claim 1, wherein a copper pipe (temper is 1/2H) whose nominal diameter is less than 1/4 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 8.0 kW or less is connected.

3. The refrigeration cycle apparatus according to claim 1,
wherein a copper pipe (temper is 1/2H) whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 8.0 kW or less is connected.

4. The refrigeration cycle apparatus according to any one of claims 1 to 3,
wherein a copper pipe (temper is 1/2H) whose nominal diameter is more than 1/4 inch and less than 3/8 inch is used as the gas-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 4.5 kW or less is connected.

5. The refrigeration cycle apparatus according to any one of claims 1 to 3,
wherein a copper pipe (temper is 1/2H) whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 4.5 kW or less is connected.

6. The refrigeration cycle apparatus according to claim 1,
wherein a copper pipe (temper is O) whose nominal diameter is less than 1/4 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 3.6 kW or less is connected.

7. The refrigeration cycle apparatus according to claim 1,
wherein a copper pipe (temper is O) whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 3.6 kW or less is connected.

8. The refrigeration cycle apparatus according to any one of claims 1, 6, and 7,
wherein a copper pipe (temper is O) whose nominal diameter is more than 1/4 inch and less than 3/8 inch is used as the gas-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 2.8 kW or less is connected.

9. The refrigeration cycle apparatus according to any one of claims 1, 6, and 7,
wherein a copper pipe (temper is O) whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection pipe to which the utilization unit whose rated refrigerating capacity is 2.8 kW or less is connected.

10. The refrigeration cycle apparatus according to any one of claims 1 to 9,
wherein the gas-refrigerant connection pipe and the liquid-refrigerant connection pipe each have an outer surface covered by a heat insulating material, the gas-refrigerant connection pipe and the liquid-refrigerant connection pipe being bundled together and constituting a pair connection pipe (8).

11. The refrigeration cycle apparatus according to any one of claims 1 to 10,
wherein, when a pipe whose nominal diameter is 1.5/8 inch is used as the liquid-refrigerant connection pipe whose nominal diameter is less than 1/4 inch, a pipe end portion includes a different diameter portion (6a) enlarged to have a nominal diameter of 1/4 inch.

12. The refrigeration cycle apparatus according to any one of claims 1 to 11,
wherein, when a pipe whose nominal diameter is 2.5/8 inch is used as the gas-refrigerant connection pipe whose nominal diameter is more than 1/4 inch and less than 3/8 inch, a pipe end portion includes a different diameter portion (5a) enlarged to have a nominal diameter of 3/8 inch.

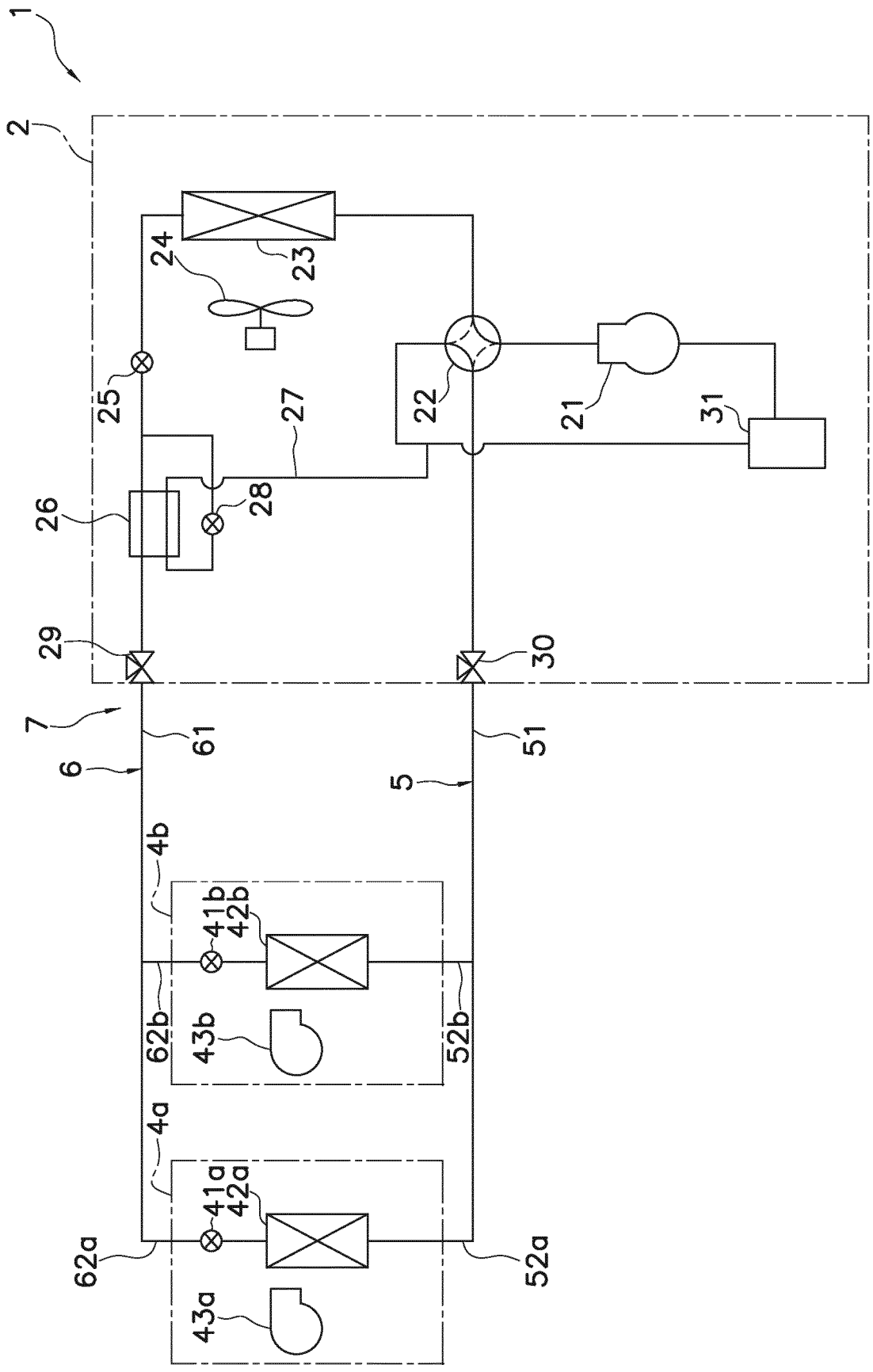
1
2
24
23
25
27
22
21
31
26
28
29
30
7
61
51
6
5
4b
41b
42b
62b
43b
52b
4a
41a
42a
62a
52a
43a

FIG. 1

RATED REFRIGERATING CAPACITY [kW]	R410A		R32		CARBON DIOXIDE	
	CONNECTION PIPE NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]		CONNECTION PIPE NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]		CONNECTION PIPE NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]	
	GAS	LIQUID	GAS	LIQUID	GAS	LIQUID
2.2	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
2.8	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
3.6	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
4.5	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	2.5/8, 6.2	1.5/8, 3.6
5.6	1/2, 11.1	1/4, 4.8	1/2, 11.1	1/4, 4.8	3/8, 7.4	1.5/8, 3.6
7.1	5/8, 14.3	3/8, 7.9	1/2, 11.1	1/4, 4.8	3/8, 7.4	1.5/8, 3.6
8.0	5/8, 14.3	3/8, 7.9	1/2, 11.1	1/4, 4.8	3/8, 7.4	1.5/8, 3.6
9.0	5/8, 14.3	3/8, 7.9	5/8, 14.3	3/8, 7.9	1/2, 9.9	1/4, 5.0
11.2	5/8, 14.3	3/8, 7.9	5/8, 14.3	3/8, 7.9	1/2, 9.9	1/4, 5.0
14.0	5/8, 14.3	3/8, 7.9	5/8, 14.3	3/8, 7.9	1/2, 9.9	1/4, 5.0
16.0	3/4, 17.1	3/8, 7.9	3/4, 17.1	3/8, 7.9	1/2, 9.9	1/4, 5.0
22.4	3/4, 17.1	3/8, 7.9	3/4, 17.1	3/8, 7.9	5/8, 12.3	2.5/8, 6.2
28.0	7/8, 20.2	3/8, 7.9	7/8, 20.2	3/8, 7.9	5/8, 12.3	2.5/8, 6.2

FIG. 2

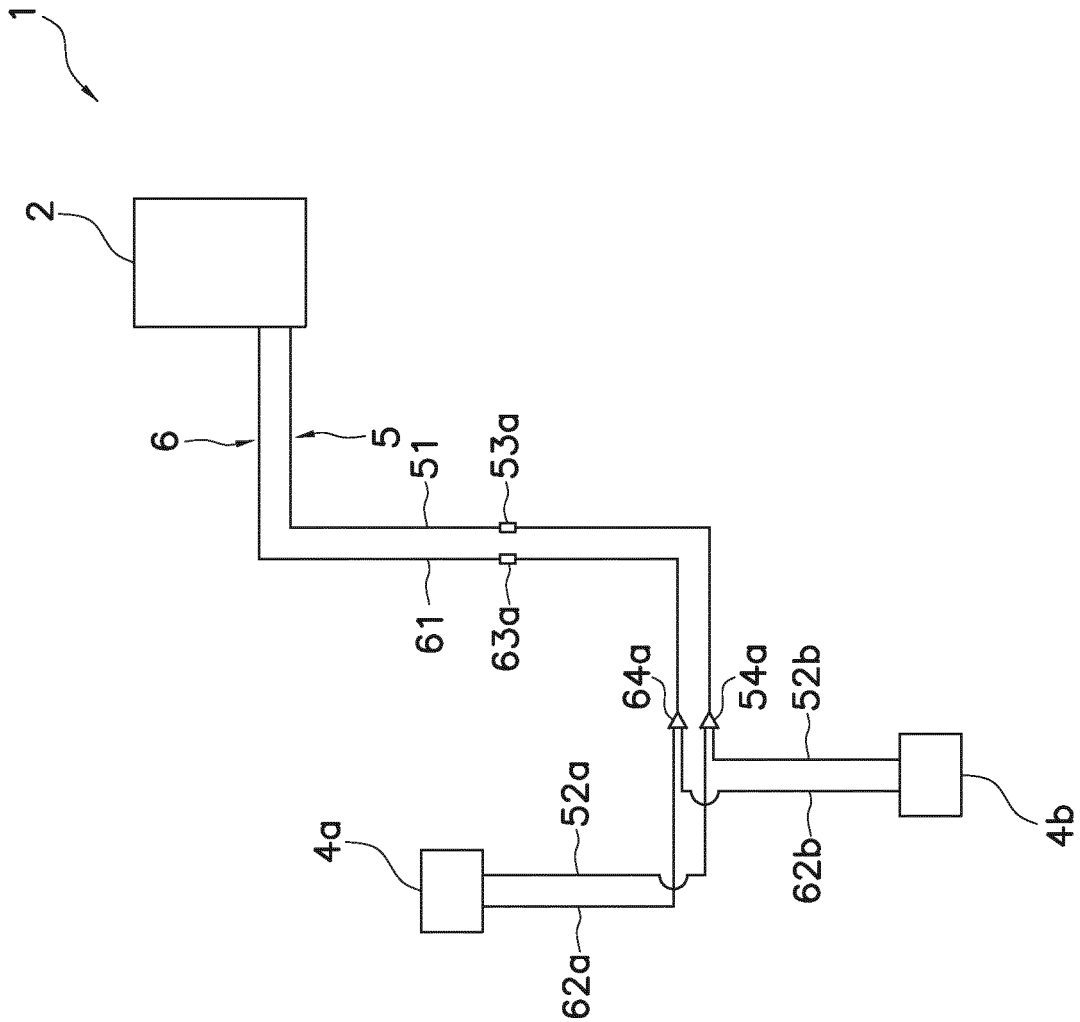

FIG. 3

RATED REFRIGERATING CAPACITY [kW]	CARBON DIOXIDE		CARBON DIOXIDE	
	CONNECTION PIPE (TEMPER 1/2H COPPER PIPE) NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]		CONNECTION PIPE (TEMPER O COPPER PIPE) NOMINAL DIAMETER [INCH], INNER DIAMETER [mm]	
	GAS	LIQUID	GAS	LIQUID
2.2	2.5/8, 6.2	1.5/8, 3.6	2.5/8, 4.8	1.5/8, 2.8
2.8	2.5/8, 6.2	1.5/8, 3.6	2.5/8, 4.8	1.5/8, 2.8
3.6	2.5/8, 6.2	1.5/8, 3.6	3/8, 5.8	1.5/8, 2.8
4.5	2.5/8, 6.2	1.5/8, 3.6	3/8, 5.8	1/4, 3.8
5.6	3/8, 7.4	1.5/8, 3.6	1/2, 7.7	1/4, 3.8
7.1	3/8, 7.4	1.5/8, 3.6	1/2, 7.7	1/4, 3.8
8.0	3/8, 7.4	1.5/8, 3.6	1/2, 7.7	2.5/8, 4.8
9.0	1/2, 9.9	1/4, 5.0	1/2, 7.7	2.5/8, 4.8
11.2	1/2, 9.9	1/4, 5.0	5/8, 9.7	2.5/8, 4.8
14.0	1/2, 9.9	1/4, 5.0	5/8, 9.7	2.5/8, 4.8
16.0	1/2, 9.9	1/4, 5.0	5/8, 9.7	3/8, 5.8
22.4	5/8, 12.3	2.5/8, 6.2	3/4, 11.7	3/8, 5.8
28.0	5/8, 12.3	2.5/8, 6.2	3/4, 11.7	1/2, 7.7

FIG. 4

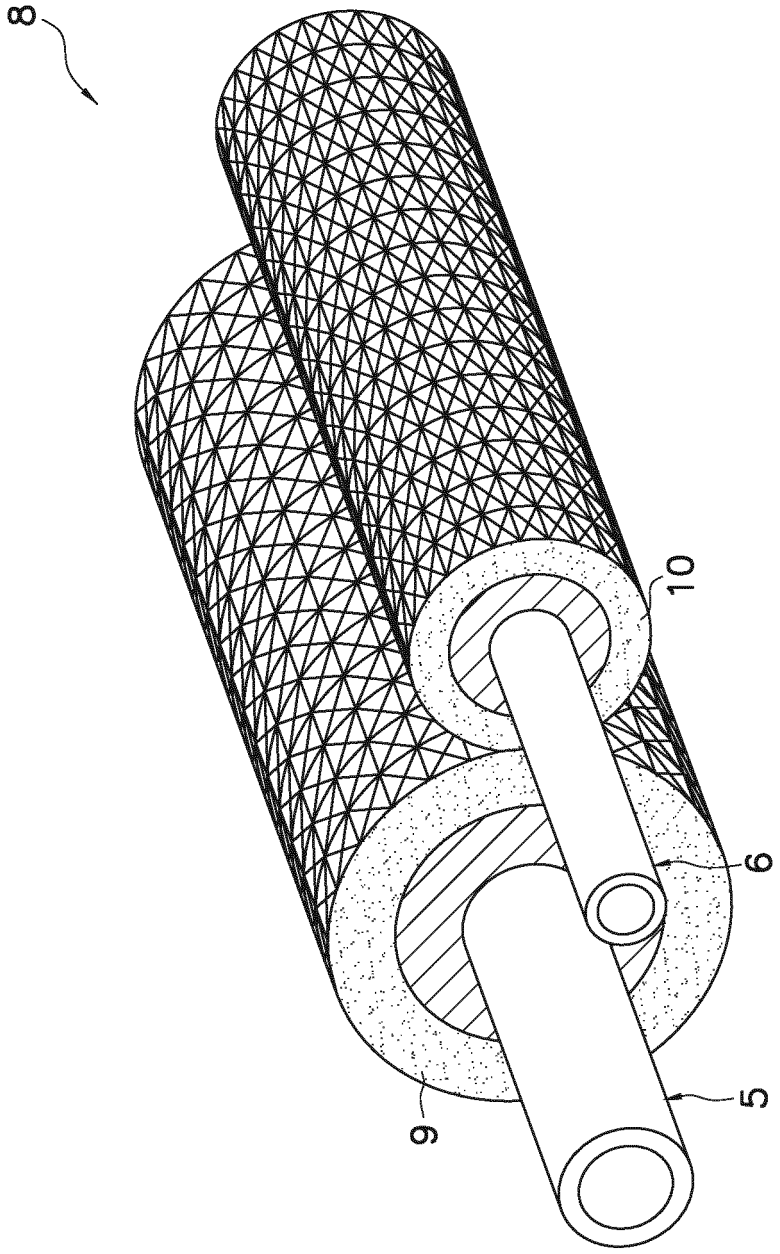

FIG. 5

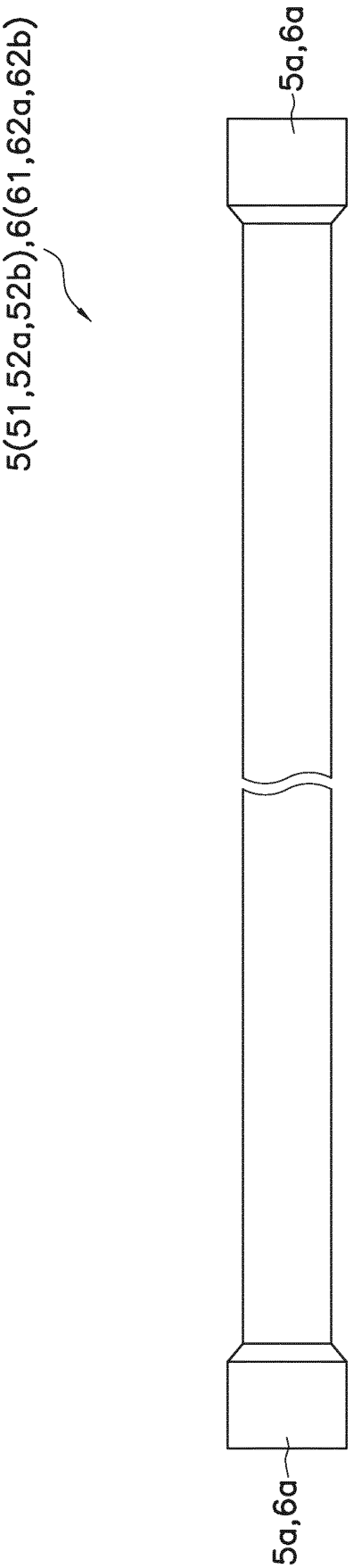

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/025058

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. F25B41/00(2006.01)i, F24F1/32(2011.01)i, F25B1/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. F25B41/00, F24F1/32, F25B1/00

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2008-32275 A (DAIKIN INDUSTRIES, LTD.) 14 February 2008, paragraphs [0027], [0047]-[0055], fig. 1-2 & WO 2008/013105 A1	1 2-12
Y	JP 2011-27346 A (IWASAKI INDUSTRIAL CO., LTD.) 10 February 2011, paragraphs [0007]-[0011] (Family: none)	2-12
Y	JP 11-257689 A (KAMIMURA, Yuji) 21 September 1999, paragraphs [0004]-[0005] (Family: none)	10-12

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

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Date of the actual completion of the international search	Date of mailing of the international search report
29 August 2019 (29.08.2019)	10 September 2019 (10.09.2019)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/025058

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 43914/1986 (Laid-open No. 156714/1987) (TOSHIBA CORP.) 05 October 1987, specification, page 4, line 3 to page 5, line 2, page 7, line 5 to page 9, line 10, fig. 3-5 (Family: none)	11-12
A	WO 2015/140827 A1 (MITSUBISHI ELECTRIC CORP.) 24 September 2015, entire text, all drawings & US 2017/0121581 A1 & EP 3128259 A1 & CN 106415152 A	1-12
A	JP 2003-139422 A (DAIKIN INDUSTRIES, LTD.) 14 May 2003, entire text, all drawings (Family: none)	1-12
A	JP 2000-105027 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.) 11 April 2000, entire text, all drawings (Family: none)	1-12

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2011099063 A **[0002] [0121]**