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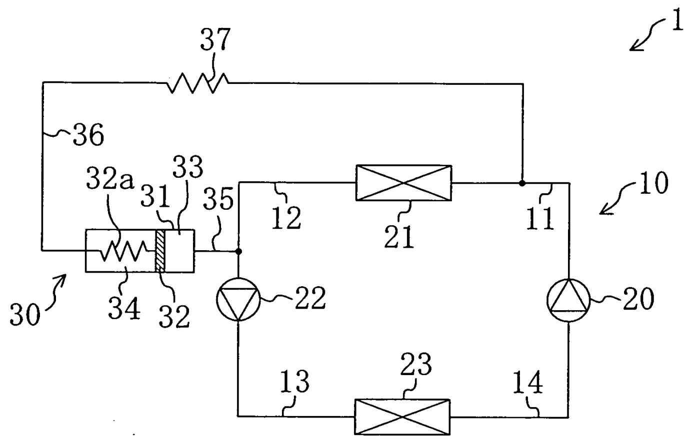
(54) **REFRIGERATION DEVICE**

(57) In a refrigerant circuit (10) of a refrigerating apparatus (1), a pulsation absorbing device (30) is provided. In the pulsation absorbing device (30), a piston (32) is accommodated in a cylinder member (31) to divide its cylinder chamber into a pressure buffering chamber (33) and a back pressure chamber (34). The pressure buffering chamber (33) is connected to a second high-pressure refrigerant pipe (12) on the inflow side of an expander (22) through a first connection pipe (35). The back pressure chamber (34) is connected to a first high-pressure refrigerant pipe (11) on the discharge side of a compressor (20) through a second connection pipe (36) and a capillary tube (37).

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a refrigerating apparatus performing a vapor compression refrigeration cycle by circulating refrigerant, and particularly relates to a measure to reduce pressure pulsation of the refrigerant flowing in a refrigerant circuit.

Background Art

[0002] Conventionally, refrigerating apparatuses including a refrigerant circuit performing a vapor compression refrigeration cycle have been known.

[0003] For example, Patent Document 1 discloses a refrigerating apparatus using carbon dioxide as the refrigerant. A compressor, a radiator, a positive displacement type expander, and an evaporator are connected to the refrigerant circuit of this refrigerating apparatus. In the compressor, the refrigerant is compressed to over its critical pressure. The refrigerant discharged from the compressor radiates heat in the radiator, and is expanded in the expander. Thereafter, the refrigerant is evaporated in the evaporator, and is then sucked into the compressor to be compressed again. For example, in a heating operation of this refrigerating apparatus, heat released from the radiator heats an indoor room.

[0004] In the refrigerating apparatus performing the refrigeration cycle by circulating the refrigerant, the refrigerant compressing operation by the compressor and the refrigerant expanding operation by the expander may accompany variation in pressure of the refrigerant to cause large pressure pulsation of the refrigerant. This may lead to noise generation or malfunction of instruments connected to the refrigerant pipes.

[0005] To tackle this problem, Patent Document 2 proposes provision of a pulsation absorbing mechanism inside the expander for reducing the pressure pulsation of the refrigerant. The pressure absorbing mechanism includes a hollow cylinder chamber formed in an expansion mechanism expanding the refrigerant, and a piston accommodated in the cylinder chamber. The cylinder chamber communicates with a refrigerant inflow-side passage formed in the casing of the expander. When the pressure of the refrigerant flowing in the inflow-side passage varies, the piston shifts to change the volume of the cylinder chamber. Thus, in the expander in Patent Document 2, the pressure variation of the refrigerant is reduced by changing the volume of the cylinder to reduce the aforementioned pressure pulsation.

Patent Document 1: Japanese Unexamined Patent Application Publication 2000-234814
Patent Document 2: Japanese Unexamined Patent Application Publication 2004-286880

DISCLOSURE OF THE INVENTION

PROBLEMS THAT THE INVENTION IS TO SOLVE

[0006] The larger the volume of the cylinder chamber is, the more effectively the pressure absorbing mechanism as in Patent Document 2 can absorb the pressure of the refrigerant. However, accommodation of the pressure absorbing mechanism inside the expander is restricted due to the present of other components of the expander, and therefore, the space for accommodating the pressure absorbing mechanism cannot be sufficiently secured. This might require minimization of the pressure absorbing mechanism to prevent the pressure absorbing mechanism from significantly reducing the pressure pulsation of the refrigerant.

[0007] The present invention has been made in view of the foregoing, and its objective is to significantly reduce the pressure pulsation of refrigerant in a refrigerating apparatus performing a vapor compression refrigeration cycle.

MEANS FOR SOLVING THE PROBLEMS

[0008] A first aspect of the present invention is directed to a refrigerating apparatus including a refrigerant circuit (10) to which a compressor (20) is connected and which performs a vapor compression refrigeration cycle by circulating refrigerant in refrigerant pipes (11, 12, 13 ,14). The refrigerating apparatus includes: a pulsation absorbing device (30) including: a hollow cylinder member (31); a piston (32) partitioning an internal space of the cylinder member (31) into a first chamber (33) and a second chamber (34) and shifting in the cylinder member (31) according to pressure variation in the first chamber (33), and a first connection pipe (35) connecting the first chamber (33) to a refrigerant pipe (11, 12, 13, 14).

[0009] In the first aspect, the pulsation absorbing device (30) is provided in the refrigerating apparatus performing the vapor compression refrigeration cycle. In the pulsation absorbing device (30), the cylinder member (31), the piston (32), and the first connection pipe (35) are provided. In the present invention, the first chamber (33) in the cylinder member (31) is connected to the refrigerant pipe (11, 12, 13, 14) through the first connection pipe (35). In other words, the pulsation absorbing device (30) in the present invention is mounted, rather than inside the expander as in Patent Document 2, to the refrigerant pipe (11, 12, 13, 14) for connecting the compressor, the expander, and the like to each other. Accordingly, in the present invention, this pressure absorbing mechanism, which can be comparatively large in size, can be mounted to the refrigerant pipe (11, 12, 13, 14) without restraint of other components, such as those of the compressor.

[0010] In the pulsation absorbing device (30), variation in pressure of the refrigerant flowing in the refrigerant pipe (11, 12, 13, 14) connected to the first connection pipe (35) accompanies shifting of the piston (32). Specifically, for example, when the pressure of the refrigerant in the refrigerant pipe (11, 12, 13, 14) increases, the piston (32) shifts toward the second chamber (34) to increase the volume of the first chamber (33). This reduces each pressure in the first chamber (33) and the refrigerant pipe (11, 12, 13, 14) communicating with the first chamber (33) through the first connection pipe (35) to suppress the pressure increase of the refrigerant. Reversely, for example, when the pressure of the refrigerant in the refrigerant pipe (11, 12, 13 14) lowers, the piston (32) shifts toward the first chamber (33) to reduce the volume of the first chamber (33). This increases each pressure in the first chamber (33) and the refrigerant pipe (11, 12, 13, 14) communicating with the first chamber (33) through the first connection pipe (35) to suppress the pressure lowering of the refrigerant.

[0011] Referring to a second aspect of the present invention, in the first aspect, the pulsation absorbing device (30) includes a second connection pipe (36) connecting the second chamber (34) and a refrigerant pipe (11, 12, 13, 14) and including a throttling mechanism (37), and the first connection pipe (35) and the second connection pipe (36) are connected to a refrigerant pipe (11, 12, 13, 14) at the same refrigerant pressure.

[0012] In the pulsation absorbing device (30) in the second aspect, the second connection pipe (36) and the throttling mechanism (37) are provided. The second connection pipe (36) and the first connection pipe (35) are connected to the refrigerant pipe(s) (11, 12, 13, 14) in which the refrigerant at the same pressure flows in the refrigerant circuit (10). Accordingly, the pressure in the refrigerant pipe (11, 12, 13, 14) works on the first chamber (33) from the first connection pipe (35), while the pressure in the refrigerant pipe (11, 12, 13, 14) from the second connection pipe (35) works on the second chamber (34) after being reduced by the throttling mechanism (37). In this aspect, the pressure of the refrigerant having reduced in the throttling mechanism (37) is allowed to work on the surface of the piston (32) in the second chamber (34) to absorb the pressure pulsation of the refrigerant in the first chamber (33).

[0013] Specifically, in a normal state in which the pressure in the refrigerant pipe (11, 12, 13, 14) is constant, the piston (32) stays at a predetermined point in the cylinder member (31). When the pressure of the refrigerant in the refrigerant pipe (11, 12, 13, 14) increases from that in the normal state, the pressure in the first chamber (33) becomes abruptly higher than the that in the second chamber (34) due to no pressure reduction by the throttling mechanism (37) in the first connection pipe (35) to destroy the pressure balance between the chambers (33, 34). Accordingly, the piston (32) shifts to increase the volume of the first chamber (33), so that the refrigerant is sucked by the increased volume into the first chamber (33) through the first connection pipe (35). As a result, each pressure of the first chamber (33) and the refrigerant pipe (11, 12, 13, 14) communicating with the first chamber (33) lowers to suppress the pressure increase in the refrigerant pipe (11, 12, 13, 14). This accordingly decreases the volume of the second chamber (34). However, with the throttling mechanism (37) provided in the second connection pipe (36), it is hard for refrigerant in the second chamber (34) to flow into the refrigerant pipe (11, 12, 13, 14) through the second connection pipe (34). Accordingly, the volume decrease of the second chamber (34) gradually increases the pressure in the second chamber (34) to balance the pressure between the first chamber (33) and the second chamber (34) again.

[0014] Reversely, when the pressure of the refrigerant in the refrigerant pipe (11, 12, 13, 14) lowers from that in the normal state, the pressure in the first chamber (33) becomes abruptly lower than the that in the second chamber (34) due to no pressure reduction by the throttling mechanism (37) to destroy the pressure balance between the chambers (33, 34). Accordingly, the piston (32) shifts to decrease the volume of the first chamber (33), so that the refrigerant is pushed out by the decreased volume into the refrigerant pipe (11, 12, 13, 14) through the first connection pipe (35). As a result, each pressure of the first chamber (33) and the refrigerant pipe (11, 12, 13, 14) communicating with the first chamber (33) increases to suppress the pressure lowering of the refrigerant. In this time, the volume of the second chamber (34) increases. However, with the throttling mechanism (37) provided in the second connection pipe (36), it is hard for the refrigerant in the refrigerant pipe (11, 12, 13 , 14) to flow into the second chamber (34) through the second connection pipe (36). Accordingly, the volume increase of the second chamber (34) gradually lowers the pressure in the second chamber (34) to balance the pressure between the first chamber (33) and the second chamber (34) again.

[0015] Referring to a third aspect of the present invention, in the second aspect, a positive-displacement type expander (22) is connected to the refrigerant circuit (10), the first connection pipe (35) is connected to a refrigerant pipe (12) on an inflow side of the expander (22), and the second connection pipe (36) is connected to a refrigerant pipe (11) on a discharge side of the compressor (20).

[0016] In the third aspect, the compressor (20) and the expander (22) are connected to the refrigerant circuit (10). The refrigerant is compressed in the compressor (20) to be high-pressure refrigerant, radiates heat in a heat exchanger or the like, and then flows into the expander (22). In the expander (22), the high-pressure refrigerant is reduced in pressure to be low-pressure refrigerant. The low-pressure refrigerant then evaporates in a heat exchanger or the like. This refrigerant is compressed again in the compressor (20) to be high-pressure refrigerant.

[0017] In the present aspect, the first connection pipe (35) is connected to the refrigerant pipe (12) on the inflow side of the expander (22). The refrigerant on the inflow side of the expander (22) has comparatively higher density than high-pressure gas refrigerant and the like, and is therefore liable to cause large pressure pulsation. To tackle this problem, the first connection pipe (35) is connected to the refrigerant pipe (12) on the inflow side of the expander (22) in the present aspect to effectively reduce the pressure pulsation of the refrigerant in the refrigerant pipe (12).

[0018] Further, in the present aspect, the second connection pipe (36) is connected to the refrigerant pipe (11) on the discharge side of the compressor (20). Accordingly, the second chamber (34) is filled with the refrigerant discharged from the compressor (20). The refrigerant discharged from the compressor (20) is more compressive than high-pressure liquid refrigerant. Therefore, even when the piston (32) shifts accompanied by pressure variation of the refrigerant in the first chamber (33), the pressure in the second chamber (34) less varies. Accordingly, in the pulsation absorbing device (30) in the present aspect, the responsiveness of the piston (32) upon the pressure variation in the first chamber (33) can be enhanced to increase the efficiency of pressure pulsation absorption by the pulsation absorbing device (30).

[0019] Referring to a fourth aspect of the present invention, in the first aspect, a positive-displacement type expander (22) is connected to the refrigerant circuit (10), and both the first connection pipe (35) and the second connection pipe (36) are connected to one (13) of refrigerant pipes on an inflow side and an outflow side of the expander.

[0020] In the fourth aspect, the first connection pipe (35) and the second connection pipe (36) are connected to the refrigerant pipe (12) on the inflow side of the expander (22) or to the refrigerant pipe (13) on the outflow side of the expander (22). Since the refrigerant on the outflow side and the inflow side of the expander (22) has comparatively high density, large pressure pulsation of the refrigerant is liable to be caused. To tackle this problem, the pulsation absorbing device (30) is provided to the refrigerant pipes (12, 13) in the present aspect to effectively reduced the pressure pulsation of the refrigerant in the refrigerant pipes (12, 13).

[0021] Referring to a fifth aspect of the present invention, in the second aspect, a positive-displacement type expander (22) is connected to the refrigerant circuit (10), the first second connection pipe (35) is connected to a refrigerant pipe (13) on an outflow side of the expander (22), and the second connection pipe (36) is connected to a refrigerant pipe (14) on a suction side of the compressor (20).

[0022] In the fifth aspect, the first connection pipe (35) is connected to the refrigerant pipe (13) on the outflow side of the expander (22), so that the pulsation absorbing device (30) can effectively reduce the pressure pulsation on the outflow side of the expander (22) where comparatively large pressure pulsation is liable to be caused.

[0023] Further, in the present aspect, the second connection pipe (36) is connected to the refrigerant pipe (14) on the suction side of the compressor (20). Accordingly, the second chamber (34) is filled with low-pressure gas refrigerant on the suction side of the compressor (20). The low-pressure gas refrigerant is more compressive than low-pressure liquid refrigerant and the like. Therefore, even when the piston (32) shifts accompanied by the pressure variation of the refrigerant in the first chamber (33), the pressure in the second chamber (34) less varies. Accordingly, in the pulsation absorbing device (30) in the present aspect, the responsiveness of the piston (32) upon the pressure variation in the first chamber (33) is enhanced to increase the efficiency of pressure pulsation absorption by the pulsation absorbing device (30).

[0024] Referring to a sixth aspect of the present invention, in the second aspect, both the first connection pipe (35) and the second connection pipe (36) are connected to one of refrigerant pipes (11, 14) on a discharge side and a suction side of the compressor (20).

[0025] In the sixth aspect, the first connection pipe (35) and the second connection pipe (36) are connected to the refrigerant pipe (11) on the discharge side of the compressor (20) or to the refrigerant pipe (14) on the suction side of the compressor (20). The refrigerant compressing operation by the compressor (20) may accompany large pressure pulsation of the refrigerant on the suction side and the discharge side of the compressor (20). To tackle this problem, the pulsation absorbing device (30) are provided to the refrigerant pipes (11, 14) in the present aspect to effectively reduced the pressure pulsation of the refrigerant in the refrigerant pipes (11, 14).

[0026] Referring to a seventh aspect of the present invention, in any one of the first to sixth aspects, in the refrigerant circuit (10), carbon dioxide is used as the refrigerant, and the refrigeration cycle is performed while the refrigerant in the compressor (20) is compressed to over its critical pressure.

[0027] In the refrigerant circuit (10) in the seventh aspect, the refrigeration cycle is performed with the carbon dioxide compressed to over its critical pressure. When the refrigerant is compressed to over its critical pressure, large pressure pulsation of the refrigerant is liable to be caused. However, in the present aspect, the pressure pulsation of the refrigerant is suppressed by the pulsation absorbing device (30) effectively.

ADVANTAGES OF THE INVENTION

[0028] In the present invention, the pulsation absorbing device (30) is connected to the refrigerant pipe (11, 12, 13, 14) through the first connection pipe (35). In other words, in the present invention, the pulsation absorbing device (30) is mounted directly to the refrigerant pipe (11, 12, 13, 14) unlike a pulsation absorbing mechanism provided inside the expander as in Patent Document 2. Accordingly, the present invention can contemplate enlarging the pulsation absorbing device (30), and in turn, can contemplate increasing the volume of the first chamber (33) in the cylinder member (31). This can lead to remarkable suppression of the pressure pulsation of the refrigerant by the pulsation absorbing device (30). Provision of the pulsation absorbing device (30) to the refrigerant pipe (11, 12, 13, 14) facilitates maintenance and replacement of the pulsation absorbing device (30), which is the difference from the case where it is incorporated inside the expander.

[0029] In the second aspect of the present invention, the first connection pipe (35) and the second connection pipe (36) are connected to the refrigerant pipe(s) (11, 12, 13, 14) at the same pressure, and the throttling mechanism (37) is provided in the second connection pipe (36). Accordingly, the pressure pulsation of the refrigerant in the refrigerant pipe (11, 12, 13, 14) communicating with the first connection pipe (35) can be suppressed effectively by utilizing the pressure of the refrigerant working on the second chamber (34) through the second connection pipe (36).

[0030] In the third aspect of the present invention, the first chamber (33) communicates with the refrigerant pipe (12) on the inflow side of the expander (22), and the refrigerant discharged from the compressor (20) is introduced into the second chamber (34). Accordingly, the responsiveness of the piston (32) upon the pressure variation on the inflow side of the expander (22) is enhanced when compared with that in the case, for example, where liquid refrigerant works on the second chamber (34), thereby effectively absorbing the pressure pulsation of the refrigerant in the refrigerant pipe (12) on the inflow side of the expander (22).

[0031] In the fourth aspect of the present invention, the first connection pipe (35) and the second connection pipe (36) are connected to the refrigerant pipe (12) on the inflow side of the expander (22) or to the refrigerant pipe (13) on the outflow side of the expander (22). Accordingly, in the present aspect, the pressure pulsation of the refrigerant can be suppressed effectively at a part where large pressure pulsation of the refrigerant is liable to be caused due to comparatively large refrigerant density.

[0032] Further, in the present aspect, since there is little temperature difference between the refrigerant flowing in the first connection pipe (35) and the refrigerant flowing in the second connection pipe (36), less or no heat exchange of the refrigerant may occur between the first chamber (33) and the second chamber (34). Hence, according to the present aspect, heat loss in the refrigerant circuit (10) accompanied by heat exchange of the refrigerant in the pulsation absorbing device (30) can be avoided.

[0033] In the fifth aspect of the present invention, the first chamber (33) communicates with the refrigerant pipe (13) on the outflow side of the expander (22), and the gas refrigerant on the suction side of the compressor (20) is introduced into the second chamber (20). Accordingly, the responsiveness of the piston (32) upon the the pressure variation on the outflow side of the expander (22) is enhanced when compared with that in the case, for example, where liquid refrigerant works on the second chamber (34), thereby effectively absorbing the pressure pulsation of the refrigerant in the refrigerant pipe (13) on the outflow side of the expander (22).

[0034] In the sixth aspect of the present invention, the first connection pipe (35) and the second connection pipe (36) are connected to the refrigerant pipe (11) on the discharge side of the compressor (20) or to the refrigerant pipe (14) on the outflow side of the compressor (20). Accordingly, in the present aspect, the pressure pulsation of the refrigerant can be suppressed effectively at a part where large pressure pulsation of the refrigerant is liable to be caused due to comparatively large refrigerant density.

[0035] Further in the present aspect, since there is little temperature difference between the refrigerant flowing in the first connection pipe (35) and the refrigerant flowing in the second connection pipe (36), less or no heat exchange of the refrigerant may occur between the first chamber (33) and the second chamber (34). Hence, according to the present aspect, heat loss in the refrigerant circuit (10) accompanied by heat exchange of the refrigerant in the pulsation absorbing device (30) can be avoided.

[0036] In the seventh aspect of the present invention, the pulsation absorbing device (30) according to any one of the first to sixth aspects is applied to the refrigerant circuit (10) performing the refrigeration cycle in which carbon dioxide is compressed to over its critical pressure. When carbon dioxide is compressed to over its critical pressure, large pressure pulsation of the refrigerant is liable to be caused. However, the present aspect can suppress the pressure pulsation effectively.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037]

[FIG. 1] FIG. 1 is a schematic diagram showing a construction of a refrigerant circuit of a refrigerating apparatus in accordance with Embodiment 1.

[FIG. 2] FIG. 2(A) is a schematic diagram showing a construction of a pulsation absorbing device in a normal state; FIG. 2(B) is a schematic diagram showing a construction of the pulsation absorbing device when the pressure of refrigerant in a refrigerant pipe increases; and FIG. 2(C) is a schematic diagram showing a construction of the pulsation absorbing device when the pressure of the refrigerant in the refrigerant pipe lowers.

[FIG. 3] FIG. 3 is a schematic diagram showing a construction of a refrigerant circuit of a refrigerating apparatus in accordance with a modified example of Embodiment 1.

[FIG. 4] FIG. 4 is a schematic diagram showing a construction of a refrigerant circuit of a refrigerating apparatus in accordance with Embodiment 2.

[FIG. 5] FIG. 5 is a schematic diagram showing a construction of a refrigerant circuit of a refrigerating apparatus in accordance with a modified example of

Embodiment 2.

[FIG. 6] FIG. 6 is a schematic diagram showing a construction of a refrigerant circuit of a refrigerating apparatus in accordance with Embodiment 3.

[FIG. 7] FIG. 7 is a schematic diagram showing a construction of a refrigerant circuit of a refrigerating apparatus in accordance with Embodiment 4.

[FIG. 8] FIG. 8 is a schematic diagram showing a construction of a refrigerant circuit of a refrigerating apparatus in accordance with another embodiment.

INDEX OF REFERENCE NUMERALS

[0038]

1	air conditioner (refrigerating apparatus)
10	refrigerant circuit
11	first high-pressure refrigerant pipe (refrigerant pipe)
12	second high-pressure refrigerant pipe (refrigerant pipe)
13	first low-pressure refrigerant pipe (refrigerant pipe)
14	second low-pressure refrigerant pipe (refrigerant pipe)
20	compressor
22	expander
30	pulsation absorbing device
31	cylinder member
32	piston
33	pressure buffering chamber (first chamber)
34	back pressure chamber (second chamber)
35	first connection pipe
36	second connection pipe

BEST MODE FOR CARRYING OUT THE INVENTION

[0039] Embodiments of the present invention will be described below in detail with reference to the accompanying drawings.

<EMBODIMENT 1>

[0040] Embodiment 1 of the present invention will be described.

[0041] A refrigerating apparatus in accordance with Embodiment 1 composes an air conditioner (1) for indoor air conditioning. The refrigerating apparatus (1) includes a refrigerant circuit (10) performing a vapor compression refrigeration cycle by circulating refrigerant. The refrigerant circuit (10) is filled with carbon dioxide as the refrigerant. The refrigeration cycle in which the refrigerant is compressed to over its critical pressure is performed in the refrigerant circuit (10).

[0042] In the refrigerant circuit (10), a compressor (20), a radiator (21), an expander (22), and an evaporator (23) are connected to one another by means of refrigerant pipes (11, 12, 13, 14). Specifically, to the discharge side of the compressor (20), one end of a first high-pressure refrigerant pipe (11) is connected. The other end of the first high-pressure refrigerant pipe (11) is connected to one end of the radiator (21). The other end of the radiator (21) is connected to one end of a second high-pressure refrigerant pipe (12). The other end of the second high-pressure refrigerant pipe (12) is connected to the inflow side of the expander (22). The outflow side of the expander (22) is connected to one end of a first low-pressure refrigerant pipe (13). The other end of the first low-pressure refrigerant pipe (13) is connected to one end of the evaporator (23). The other end of the evaporator (23) is connected to one end of a second low-pressure refrigerant pipe (14). The other end of the second low-pressure refrigerant pipe (14) is connected to the suction side of the compressor (20).

[0043] The compressor (20) is of positive displacement type. The compressor (20) accommodates in its casing a rotary compression mechanism. The compression mechanism of the compressor (20) compresses gas refrigerant up to a pressure over its critical pressure. The radiator (21) is disposed in an indoor space, for example, and is composed of a fin-and-tube type heat exchanger. In the radiator (21), heat is radiated from the high-pressure gas refrigerant indoors. The expander (22) is of positive displacement type. The expander (22) accommodates in its casing a rotary expansion mechanism. The expansion mechanism of the expander (22) reduces the pressure of the high-pressure refrigerant to allow it to be low-pressure refrigerant. The evaporator (23) is disposed in an outdoor space, for example, and is composed of a fin-and-tube heat exchanger. In the evaporator (23), the low-pressure liquid refrigerant absorbs heat from the outdoor air to be evaporated.

[0044] As one of the significant features of the present invention, a pulsation absorbing device (30) is provided in the refrigerant circuit (10). The pulsation absorbing device (30) includes a cylinder member (31) and a piston (32). The cylinder member (31) is in a hollow cylindrical shape to form a column-shaped cylinder chamber thereinside. The piston (32) is in a column shape, and is accommodated in the cylinder chamber of the cylinder member (31). The piston (32) divides the cylinder chamber into a pressure buffering chamber (33) as a first chamber and a back pressure chamber (34) as a second chamber. The piston (32) is made of a comparatively lightweight aluminum material.

[0045] A spring (32a) is provided in the back pressure chamber (34) of the cylinder chamber in the cylinder member (31). The spring (32a) is connected at one end thereof to the inner wall of the cylinder member (31) while being connected at the other end thereof to the piston (32). The spring (32a) is composed of as an elastic member for pushing the piston (32) from the back pressure chamber (34) toward the pressure buffering chamber (33).

[0046] The pulsation absorbing device (30) includes a first connection pipe (35) and a second connection pipe (36). The first connection pipe (35) is connected at one end thereof to the pressure buffering chamber (33), while being connected at the other end thereof to the second high-pressure refrigerant pipe (12). In other words, the pressure buffering chamber (33) communicates with the second high-pressure refrigerant pipe (12) through the first connection pipe (35). The second connection pipe (36) is connected at one end thereof to the back pressure chamber (34) while being connected at the other end thereof to the first high-pressure refrigerant pipe (11). In other words, the back pressure chamber (34) communicates with the first high-pressure refrigerant pipe (11) through the second connection pipe (36). In the second connection pipe (36), a capillary tube (37) is provided. The capillary tube (37) serves as a throttling mechanism for reducing the pressure of the refrigerant. Thus, the first connection pipe (35) and the second connection pipe (36) are connected to the refrigerant pipes (11, 12), respectively, in which the refrigerant flows at the same pressure.

[0047] In the pulsation absorbing device (30), the pressure buffering chamber (33) is filled with high-pressure refrigerant in a gas-liquid two-phase state, while the back pressure chamber (34) is filled with the refrigerant having been reduced in pressure by the capillary tube (37). The piston (32) shifts in the cylinder chamber according to pressure variation of the refrigerant flowing in the second high-pressure refrigerant pipe (12) to change the volume of the pressure buffering chamber (33).

- Operation Behavior -

[0048] Operation behavior of the air conditioner (1) in accordance with Embodiment 1 of the present invention will be described next. During the operation of the air conditioner (1), the compression mechanism of the compressor (20) and the expansion mechanism of the expander (22) are driven. In the compression mechanism of the compressor (20), the gas refrigerant is compressed to over its critical pressure. The refrigerant compressed in the compressor (20) is discharged into the first high-pressure refrigerant pipe (11). The refrigerant flowing in the first high-pressure refrigerant pipe (11) flows into the radiator (21). In the radiator (21), the refrigerant radiates heat indoors to heat the indoor air. The refrigerant having radiated the heat in the radiator (21) flows into the second high-pressure refrigerant pipe (12), and flows then into the expander (22).

[0049] In the expansion mechanism of the expander (22), the high-pressure refrigerant is reduced in pressure to be low-pressure refrigerant in a gas-liquid two-phase state. The refrigerant having been reduced in pressure in the expander (22) flows out into the first low-pressure refrigerant pipe (13). The refrigerant flowing in the first low-pressure refrigerant pipe (13) flows into the evaporator (23). In the evaporator (23), the liquid refrigerant absorbs heat from the outdoor air to be evaporated. The gas refrigerant having been evaporated in the evaporator (23) flows into the second low-pressure refrigerant pipe (14), and is then sucked into the compressor (20). In the compression mechanism of the compressor (20), the refrigerant is compressed again to over its critical pressure.

- Pressure Pulsation Suppressing Behavior of Pressure Absorbing Mechanism -

[0050] In the operation of the above-described air conditioner, refrigerant compression by the compressor (20) and refrigerant expansion by the expander (22) may accompany variation in pressure of the refrigerant flowing in the refrigerant circuit (10), which can cause pressure pulsation of the refrigerant in any of the refrigerant pipes (11, 12, 13, 14). Particularly, in the second high-pressure refrigerant pipe (12) on the inflow side of the expander (22), the refrigerant of which the density is comparatively large flows, and therefore, large pressure pulsation is liable to be caused. To tackle this problem, in the air conditioner (1) of Embodiment 1, the pressure pulsation of the refrigerant flowing in the second high-pressure refrigerant pipe (12) is suppressed by the pulsation absorbing device (30).

[0051] Description will be given of pressure pulsation suppressing behavior by the pulsation absorbing device (30) with reference to FIG. 2(A) to FIG. 2(C).

[0052] In a normal state in which the pressure of the refrigerant does not vary in the second high-pressure refrigerant pipe (12), the piston (32) is in the state shown in FIG. 2(A), for example. In this state, the balance is kept between the pressure of the refrigerant working on the surface of the piston (32) on the side of the pressure buffering chamber (33) from the first high-pressure refrigerant pipe (11) through the first connection pipe (35) and the pressure of the refrigerant working on the piston (32) on the side of the back pressure chamber (34) from the second high-pressure refrigerant pipe (12) through the second connection pipe (36) and the capillary tube (37) plus the spring force of the spring (32a) against the piston (32).

[0053] When the pressure of the refrigerant flowing in the second high-pressure refrigerant pipe (12) increases from that in the state shown in FIG. 2(A), since the refrigerant in the first connection pipe (35) is not reduced in pressure by the capillary tube (37) unlike that in the second connection pipe (36), the pressure in the pressure buffering chamber (33) increases abruptly higher than that in the back pressure chamber (34). Accordingly, the piston (32) shifts toward the back pressure chamber (34), as shown in FIG. 2(B), to increase the volume of the pressure buffering chamber (33). As a result, the refrigerant is sucked from the second high-pressure refrigerant pipe (12) into the pressure buffering chamber (33) by the increased volume of the pressure buffering chamber (33). Hence, the pressure of the refrigerant flowing in the second high-pressure refrigerant pipe (12) lowers to suppress the pressure increase of the refrigerant.

[0054] On other hand, the volume of the back pressure chamber (34) decreases at that time. However, since the capillary tube (37) is provided in the second connection pipe (36) communicating with the back pressure chamber (34), it is hard for the refrigerant in the back pressure chamber (34) to flow into the first high-pressure refrigerant pipe (11) through the second connection pipe (36). Thus, the decrease in volume of the back pressure chamber (34) leads to a gradual increase in pressure in the back pressure chamber (34) to balance the forces working on the piston (32).

[0055] When the pressure of the refrigerant flowing in the second high-pressure refrigerant pipe (12) lowers from that in the state shown in FIG. 2(A), since the refrigerant in the first connection pipe (35) is not reduced in pressure by the capillary tube (37) unlike that in the second connection pipe (36), the pressure in the pressure buffering chamber (33) abruptly becomes lower than that in the back pressure chamber (34). Accordingly, the piston (32) shifts toward the pressure buffering chamber (33), as shown in FIG. 2(C), to reduce the volume of the pressure buffering chamber (33). As a result, the refrigerant is discharged from the pressure buffering chamber (33) to the second high-pressure refrigerant pipe (12) by the reduced volume of the pressure buffering chamber (33). Hence, the pressure of the refrigerant flowing in the second high-pressure refrigerant pipe (12) increases to suppress the pressure lowering of the refrigerant.

[0056] On the other hand, the volume of the back pressure chamber (34) increases at that time. However, since the capillary tube (37) is provided in the second connection pipe (36), it is hard for the refrigerant flowing in the first high-pressure refrigerant pipe (11) to flow into the back pressure chamber (34) through the second connection pipe (36). Thus, the increase in volume of the back pressure chamber (34) leads to a gradual decrease in pressure in the back pressure chamber (34) to balance the forces working on the piston (32).

[0057] Thus, accompanied by the pressure variation of the refrigerant flowing in the second high-pressure refrigerant pipe (12), the pulsation absorbing device (30) moves the piston (32) ahead or behind, as shown in FIG. 2(B) or FIG. 2(C). As a result, in the air conditioner (1), increase and decrease in pressure of the refrigerant flowing in the second high-pressure refrigerant pipe (12) can be suppressed to contemplate suppression of the pressure pulsation of the refrigerant.

- ADVANTAGES OF EMBODIMENT 1 -

[0058] In Embodiment 1, the pulsation absorbing device (30) is connected to the refrigerant pipes (11, 12) by means of the first connection pipe (35) and the second connection pipe (36). In other words, in Embodiment 1, rather than provision of a pulsation absorbing mechanism inside the expander as in Patent Document 2, the pulsation absorbing device (30) is mounted directly to the refrigerant pipes (11, 12). Accordingly, in Embodiment 1, it can be contemplated to increase the size of the pulsation absorbing device (30), and in turn to increase the volume of the cylinder chamber in the cylinder member (31), thereby enabling the pulsation absorbing device (30) to remarkably reducing the pressure pulsation of the refrigerant. Further, provision of the pulsation absorbing device (30) to the refrigerant pipes (11, 12) facilitates maintenance and replacement of the pulsation absorbing device (30) unlike the case where it is incorporated in the expander.

[0059] Furthermore, in Embodiment 1, the first connection pipe (35) and the second connection pipe (36) are connected to the refrigerant pipes (11, 12) at the same pressure, respectively, and the capillary tube (37) is provided in the second connection pipe (36). Accordingly, the pressure pulsation of the refrigerant in the second high-pressure refrigerant pipe (12) can be absorbed effectively by utilizing the pressure of the refrigerant working on the back pressure chamber (34) through the second connection pipe (36).

[0060] In addition, in Embodiment 1, the pressure buffering chamber (33) communicates with the second high-pressure refrigerant pipe (12) on the inflow side of the expander (22), while the back pressure chamber (34) communicates with the first high-pressure refrigerant pipe (11) on the discharge side of the compressor (20) for introducing the refrigerant discharged from the compressor (20) into the back pressure chamber (34). The refrigerant discharged from the compressor (20) is more compressive than, for example, high-pressure liquid refrigerant. Therefore, even when the piston (32) shifts accompanied by the pressure variation of the refrigerant in the pressure buffering chamber (33), the pressure in the back pressure chamber (34) hardly varies. Hence, according to Embodiment 1, the responsiveness of the piston (32) upon the pressure variation in the pressure buffering chamber (33) is enhanced when compared with the case where liquid refrigerant is introduced into the back pressure chamber (34), thereby achieving effective absorption of the pressure pulsation of the refrigerant in the second high-pressure refrigerant pipe (12).

<MODIFIED EXAMPLE OF EMBODIMENT 1>

[0061] An air conditioner (1) in accordance with a modified example of Embodiment 1 is different from that in Embodiment 1 in the connection point of the second connection pipe (36) of the pulsation absorbing device (30). Specifically, as shown in FIG. 3, in the pulsation absorbing device (30) in the present modified example, the other end of the second connection pipe (36) is connected to the second high-pressure refrigerant pipe (12) as well as that of the first connection pipe (35) is. Further, in the pulsation absorbing device (30), the refrigerant in the second high-pressure refrigerant pipe (12) is introduced into both the pressure buffering chamber (33) and the back pressure chamber (34).

[0062] In the present modified example, similarly to Embodiment 1, the piston (32) shifts according to the pressure variation of the refrigerant flowing in the second high-pressure refrigerant pipe (12) to increase or decrease the volume of the pressure buffering chamber (33). As a result, the pressure pulsation of the refrigerant flowing in the second high-pressure refrigerant pipe (12) is suppressed, similarly to the case in Embodiment 1.

[0063] In the present modified example, both the first connection pipe (35) and the second connection pipe (36) are connected to the second high-pressure refrigerant pipe (12), and therefore, there is little temperature difference between the refrigerant flowing in the respective connection pipes (11, 12). Accordingly, in the present modified example, heat exchange of the refrigerant between the pressure buffering chamber (33) and the back pressure chamber (34) via the piston (32) can be prevented. Hence, according to the present modified example, heat loss in the refrigerant circuit (10), which is accompanied by heat exchange of the refrigerant in the pulsation absorbing device (30), can be avoided.

<EMBODIMENT 2 OF THE INVENTION>

[0064] In an air conditioner (1) in accordance with Embodiment 2 of the present invention, as shown in FIG. 4, the first connection pipe (35) of the pulsation absorbing device (30) is connected to the first low-pressure refrigerant pipe (13) on the outflow side of the expander (22), while the second connection pipe (36) is connected to the second low-pressure refrigerant pipe (14) on the suction side of the compressor (20). In other words, in the pulsation absorbing device (30) in Embodiment 2, the low-pressure refrigerant flowing out from the expander (22) is introduced into the pressure buffering chamber (33), while the low-pressure gas refrigerant on the suction side of the compressor (20) is introduced into the back pressure chamber (34).

[0065] In Embodiment 2, the piston (32) shifts according to the pressure variation of the refrigerant flowing in the first low-pressure refrigerant pipe (13) to suppress, similarly to the case in Embodiment 1, the pressure pulsation of the refrigerant flowing in the first low-pressure refrigerant pipe (13).

[0066] In Embodiment 2, the back pressure chamber (34) is filled with the low-pressure gas refrigerant. Accordingly, the responsiveness of the piston (32) that shifts accompanied by the pressure variation in the pressure buffering chamber (33) is enhanced when compared with the case, for example, where the back pressure chamber (34) is filled with liquid refrigerant. Hence, according to Embodiment 2, the pressure pulsation of the refrigerant in the first low-pressure refrigerant pipe (13) can be absorbed effectively.

<MODIFIED EXAMPLE OF EMBODIMENT 2>

[0067] An air conditioner (1) in accordance with a modified example of Embodiment 2 is different from that in Embodiment 2 in the connection point of the second connection pipe (36) of the pulsation absorbing device (30). Specifically, as shown in FIG. 5, in the pulsation absorbing device (30) in the present modified example, the other end of the second connection pipe (36) is connected to the first low-pressure refrigerant pipe (13), as well as that of the first connection pipe (35) is. Further, in the pulsation absorbing device (30), the refrigerant in the first low-pressure refrigerant pipe (13) is introduced into both the pressure buffering chamber (33) and the back pressure chamber (34).

[0068] In the present modified example, similarly to the case in Embodiment 2, the piston (32) shifts according to the pressure variation of the refrigerant flowing in the first low-pressure refrigerant pipe (13) to increase or decrease the volume of the pressure buffering chamber (33). As a result, the pressure pulsation of the refrigerant flowing in the first low-pressure refrigerant pipe (13) is suppressed in a similar manner to that in Embodiment 2.

[0069] In the present modified example, both the first connection pipe (35) and the second connection pipe (36) are connected to the first low-pressure refrigerant pipe (13), and accordingly, there is little temperature difference between the refrigerant flowing in the connection pipes (35, 36). Accordingly, less or no heat exchange of the refrigerant may occur between the pressure buffering chamber (33) and the back pressure chamber (34) via the piston (32). Hence, according to the present modified example, heat loss in the refrigerant circuit (10), which is accompanied by heat exchange of the refrigerant in the pulsation absorbing device (30), can be avoided.

<EMBODIMENT 3>

[0070] In an air conditioner (1) in accordance with Embodiment 3, as shown in FIG. 6, the first connection pipe (35) and the second connection pipe (36) of the pulsation absorbing device (30) are connected to the first high-pressure refrigerant pipe (11) on the discharge side of the compressor (20). In other words, in the pulsation absorbing device (30) in Embodiment 3, the refrigerant discharged from the compressor (20) is introduced into both the pressure buffering chamber (33) and the back pressure chamber (34).

[0071] In Embodiment 3, the piston (32) shifts according to the pressure variation of the refrigerant flowing in the first high-pressure refrigerant pipe (11) to suppress the pressure pulsation of the refrigerant flowing in the first high-pressure refrigerant pipe (11) in a similar manner to that in each of the above embodiments.

[0072] In Embodiment 3, both the first connection pipe (35) and the second connection pipe (36) are connected to the first high-pressure refrigerant pipe (11), and accordingly, there is little temperature difference between the refrigerant flowing in the connection pipes (35, 36). Hence, also in Embodiment 3, heat loss in the refrigerant circuit (10), which is accompanied by heat exchange of the refrigerant in the pulsation absorbing device (30), can be avoided.

<EMBODIMENT 4 OF THE INVENTION>

[0073] In an air conditioner (1) in accordance with Embodiment 4, as shown in FIG. 7, the first connection pipe (35) and the second connection pipe (36) of the pulsation absorbing device (30) are connected to the second low-pressure refrigerant pipe (14) on the suction side of the compressor (20). In other words, in the pulsation absorbing device (30) in Embodiment 4, the refrigerant on the suction side of the compressor (20) is introduced into both the pressure buffering chamber (33) and the back pressure chamber (34).

[0074] In Embodiment 4, the piston (32) shifts according to the pressure variation of the refrigerant flowing in the second low-pressure refrigerant pipe (14) to suppress the pressure pulsation of the refrigerant flowing in the second low-pressure refrigerant pipe (14) in a similar manner to that in each of the above embodiments.

[0075] In Embodiment 4, both the first connection pipe (35) and the second connection pipe (36) are connected to the second low-pressure refrigerant pipe (14), and accordingly, there is little temperature difference between the refrigerant flowing in the connection pipes (35, 36). Hence, also in Embodiment 4, heat loss in the refrigerant circuit (10), which is accompanied by heat exchange of the refrigerant in the pulsation absorbing device (30), can be avoided.

<OTHER EMBODIMENTS>

[0076] Any of the above embodiments may employ any of the following configurations.

[0077] In each of the above embodiments, the air conditioner (1) may be switchable between a cooling operation and a heating operation, as shown in, for example, FIG. 8. Specifically, in the example shown in FIG. 8, a four-way switching valve (50) and a bridge circuit (60) are provided in the refrigerant circuit (10). In this case, the four-way switching valve (50) is switchable between the state indicated by the solid lines and the state indicated by the broken lines in FIG. 8 to revere the refrigerant circulating direction, thereby enabling switching between the heating operation and the cooling operation. In this configuration, also, provision of the pulsation absorbing device (30) of the present invention to the refrigerant pipes as shown in FIG. 8 leads to suppression of the pressure pulsation of the refrigerant in both the cooling operation and the heating operation.

[0078] In each of the above embodiments, carbon dioxide is used as the refrigerant in the refrigerant circuit (10), and the refrigeration cycle is performed while the carbon dioxide is compressed to over its critical pressure. The refrigerant circuit (10) may use another refrigerant, such as R410A or the like. In this case, the refrigerant may not be necessarily compressed to over its critical pressure.

[0079] In each of the above embodiments, the compression mechanism of the compressor (20) and the expansion mechanism of the expander (22) may be connected to each other by means of a rotary shaft to compose a generally-called single shaft expander-compressor unit.

[0080] In addition, in each of the above embodiments, the pulsation absorbing device (30) in the present invention is applied to an air conditioner utilizing heat radiated in the radiator (21) for indoor heating. While, the pulsation absorbing device (30) in the present invention may be applied to any of a water heater for heating water by heat radiated in the radiator (21), a refrigerating apparatus performing indoor cooling or refrigerator cooling by heat from the evaporator (23), and the like, for example.

[0081] Each of the above embodiments is a mere essentially preferable example, and is not intended to limit the scopes of the present invention, applicable subjects, and uses.

INDUSTRIAL APPLICABILITY

[0082] As described above, the present invention is useful in measures for suppressing the pressure pulsation of refrigerant in a refrigerating apparatus performing a vapor compression refrigeration cycle by circulating the refrigerant.

Claims

1. A refrigerating apparatus including a refrigerant circuit to which a compressor is connected and which performs a vapor compression refrigeration cycle by circulating refrigerant in refrigerant pipes, the refrigerating apparatus comprising:

   a pulsation absorbing device including:

   a hollow cylinder member;
   a piston partitioning an internal space of the cylinder member into a first chamber and a second chamber and shifting in the cylinder member according to pressure variation in the first chamber, and
   a first connection pipe connecting the first chamber to a refrigerant pipe.

2. The refrigerating apparatus of claim 1, wherein the pulsation absorbing device includes a second connection pipe connecting the second chamber and a refrigerant pipe and including a throttling mechanism, and
   the first connection pipe and the second connection pipe are connected to a refrigerant pipe at the same refrigerant pressure.

3. The refrigerating apparatus of claim 2, wherein a positive-displacement type expander is connected to the refrigerant circuit,

the first connection pipe is connected to a refrigerant pipe on an inflow side of the expander, and
the second connection pipe is connected to a refrigerant pipe on a discharge side of the compressor.

4. The refrigerating apparatus of claim 2, wherein
a positive-displacement type expander is connected to the refrigerant circuit, and
both the first connection pipe and the second connection pipe are connected to one of refrigerant pipes on an inflow side and an outflow side of the expander.

5. The refrigerating apparatus of claim 2, wherein
a positive-displacement type expander is connected to the refrigerant circuit,
the first second connection pipe is connected to a refrigerant pipe on an outflow side of the expander, and
the second connection pipe is connected to a refrigerant pipe on a suction side of the compressor.

6. The refrigerating apparatus of claim 2, wherein
both the first connection pipe and the second connection pipe are connected to one of refrigerant pipes on a discharge side and a suction side of the compressor.

7. The refrigerating apparatus of any one of claims 1 to 6, wherein
in the refrigerant circuit, carbon dioxide is used as the refrigerant, and the refrigeration cycle is performed while the refrigerant in the compressor is compressed to over its critical pressure.

FIG. 1

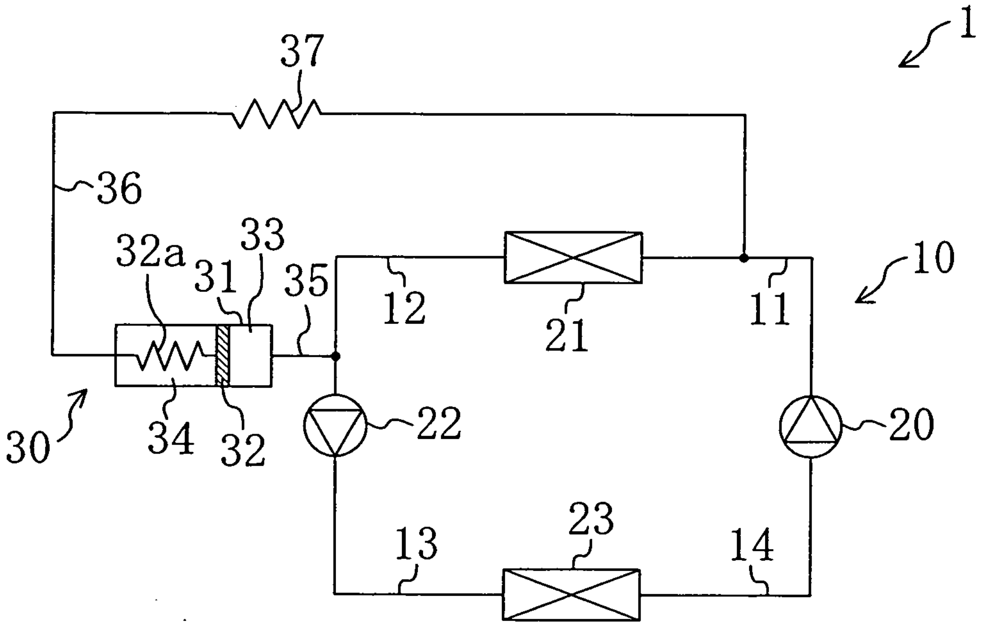

FIG. 2A

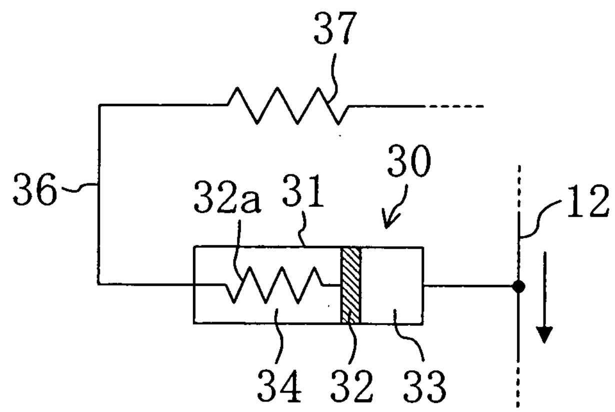

FIG. 2B

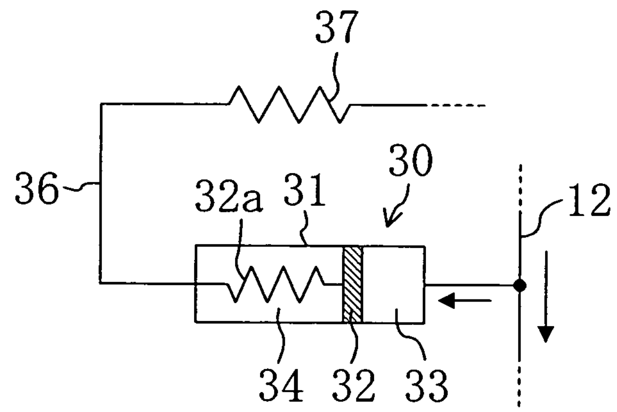

FIG. 2C

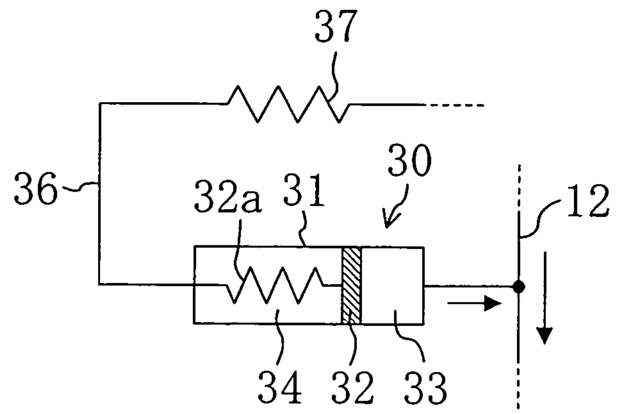

FIG. 3

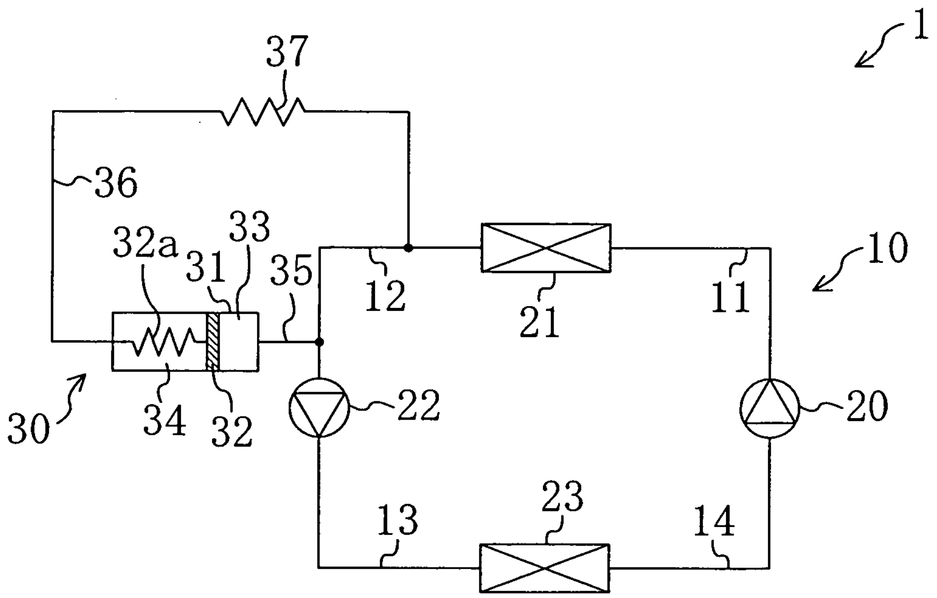
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FIG. 4

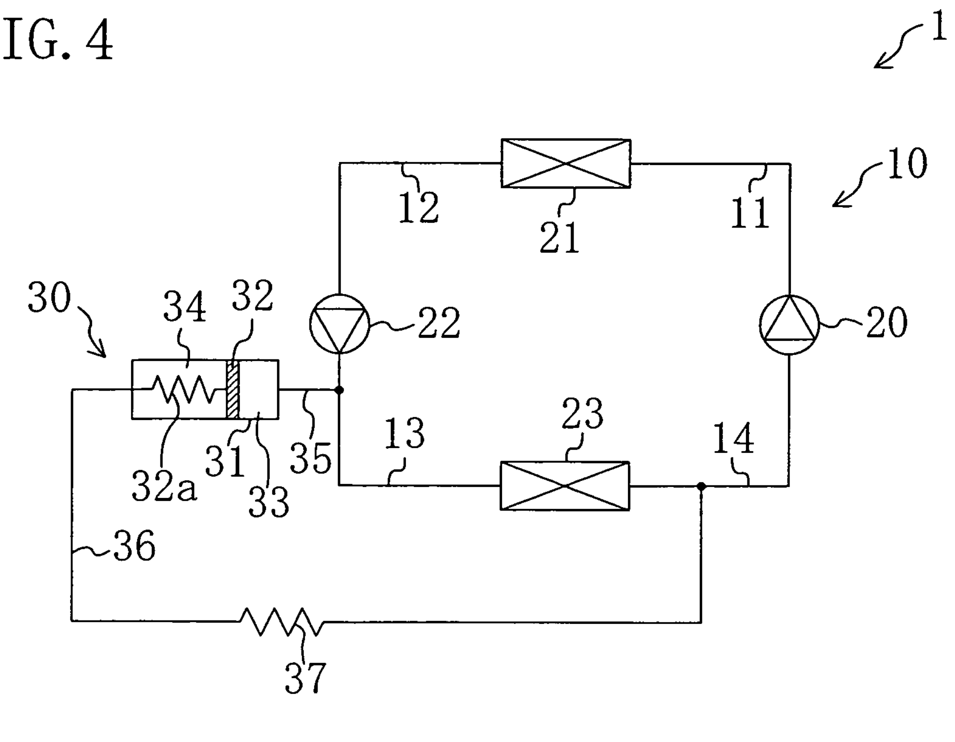
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FIG. 5

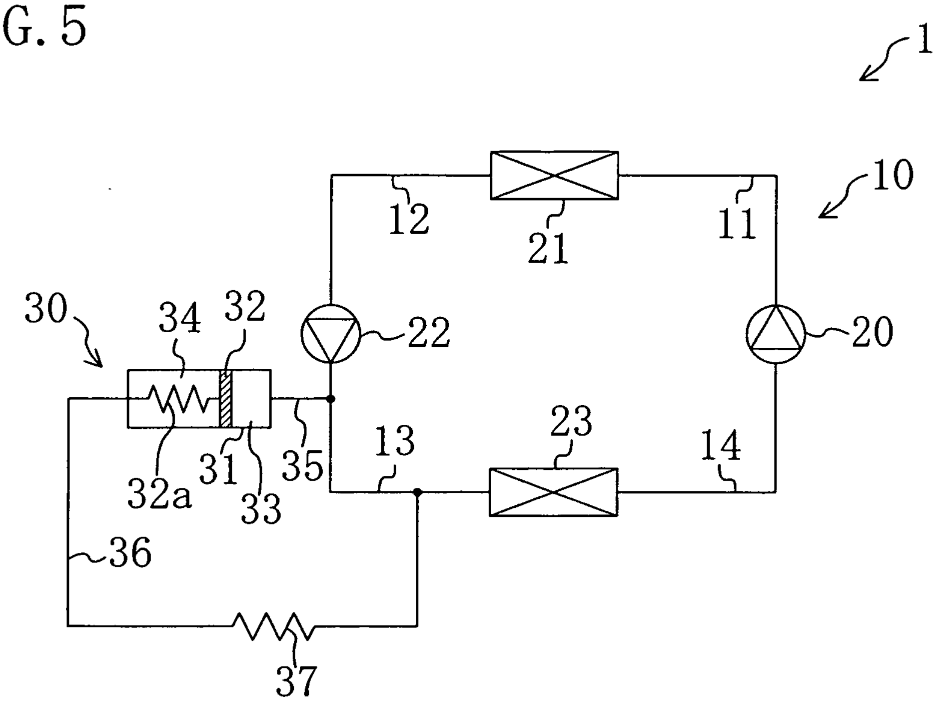
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FIG. 6

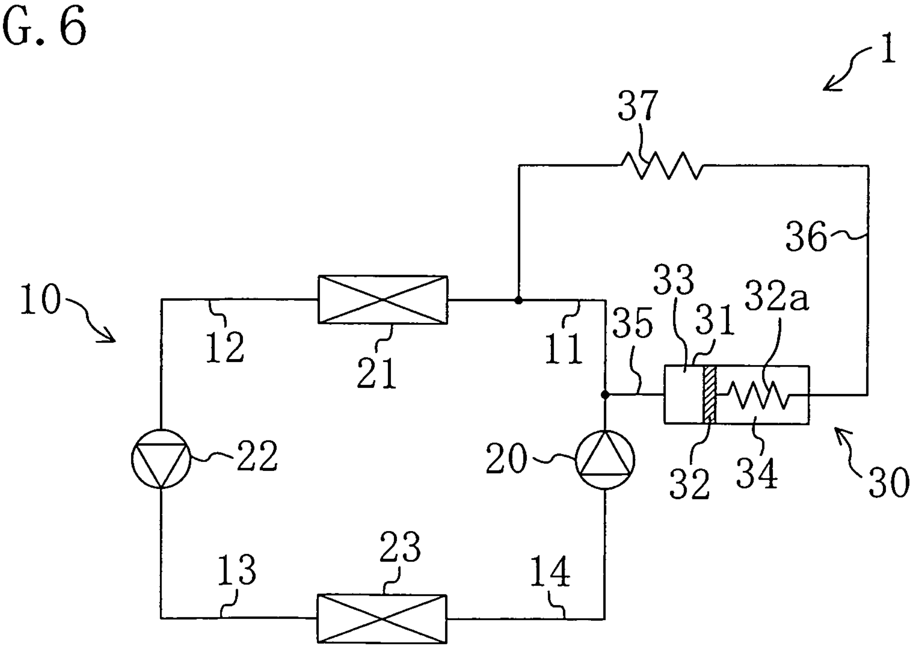
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FIG. 7

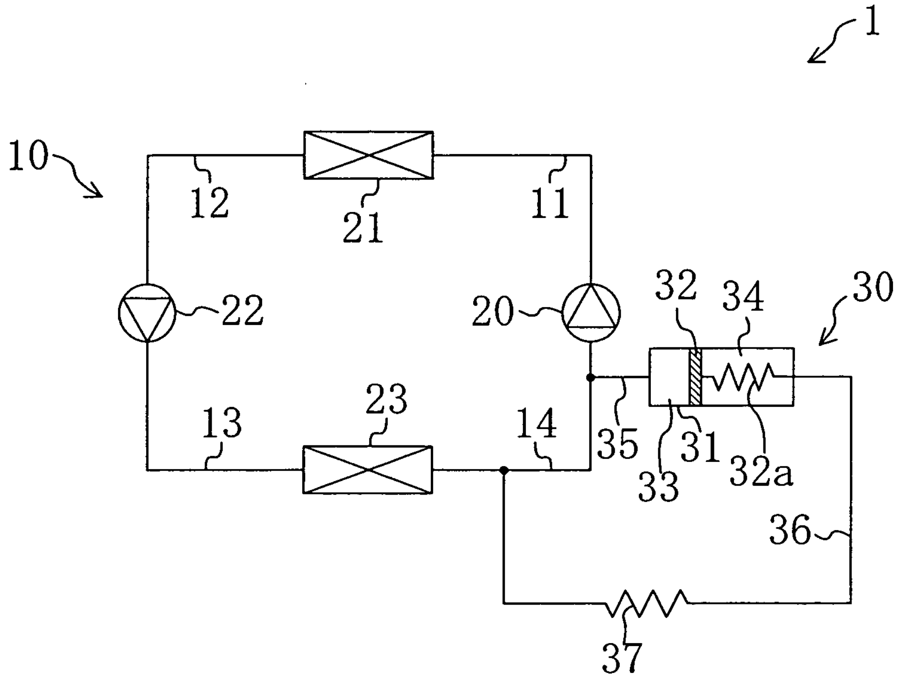
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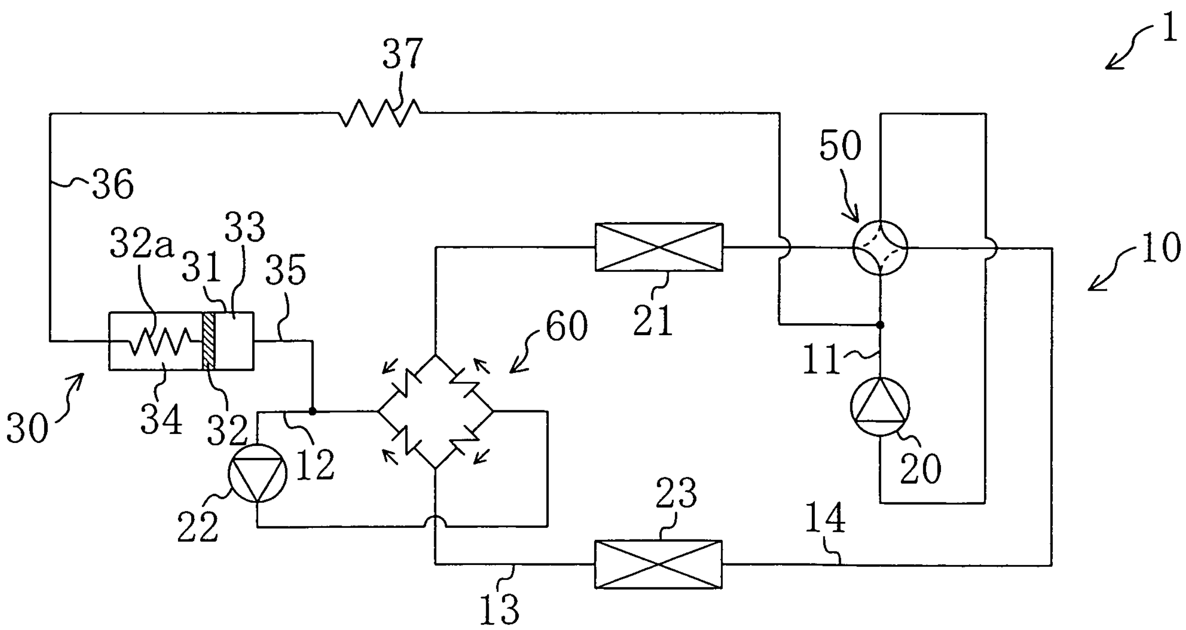
FIG. 8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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/064112

A. CLASSIFICATION OF SUBJECT MATTER
F25B41/00(2006.01)i, *F25B1/00*(2006.01)i, *F25B11/02*(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)
F25B41/00, F25B1/00, F25B11/02

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	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2006-97636 A (Daikin Industries, Ltd.), 13 April, 2006 (13.04.06), Fig. 9 & WO 2006/035935 A1	1-7
A	JP 2004-190938 A (Daikin Industries, Ltd.), 08 July, 2004 (08.07.04), Claims 1, 2 (Family: none)	4

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 August, 2007 (09.08.07)	21 August, 2007 (21.08.07)

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

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2007/064112

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	JP 10-159719 A (Hitachi Construction Machinery Co., Ltd.), 16 June, 1998 (16.06.98), Fig. 1 (Family: none)	1,2,6

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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