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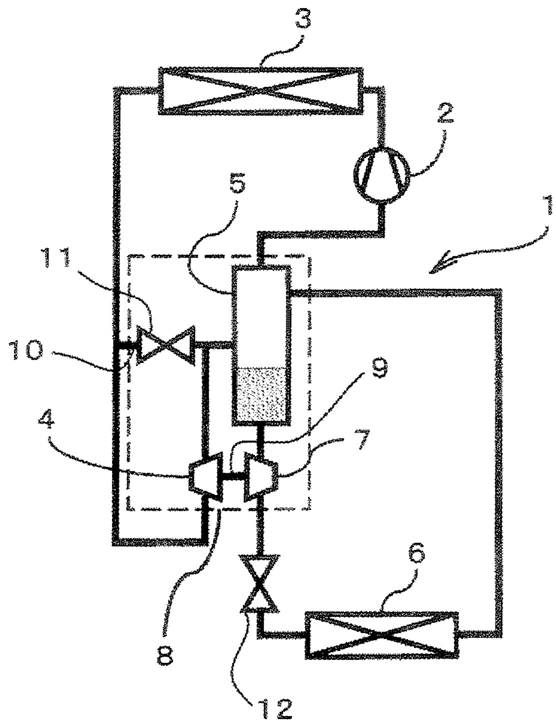
(54) Vapor compression refrigerating cycle

(57) A vapor compression refrigerating cycle (1) has an evaporator (6), a compressor (2), a radiator (3), an expander (4) and a gas/liquid separator (5) for separating refrigerant flowed out from the expander (4) and refrigerant flowed in from the evaporator (6) into gas-phase refrigerant and liquid-phase refrigerant, flowing out the liquid-phase refrigerant to the evaporator side and flowing out the gas-phase refrigerant to the compressor side, wherein a pumping means (7) for sending liquid-phase refrigerant flowed out from the gas/liquid separator (5) to the evaporator side is provided between the gas/liquid separator (5) and the evaporator (6), and at least the pumping means (7) is constructed integrally with the gas/liquid separator (5). In this structure, the number of parts of the refrigerating cycle (1) may be decreased and the cost, the size and the weight of refrigerating cycle (1) may be reduced.

FIG. 1



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Description

[0001] The present invention relates to a vapor compression refrigerating cycle, and specifically, to a vapor compression refrigerating cycle suitable for application to a refrigerating cycle using a natural-system refrigerant which is used also in its critical region.

2. <u>Description of Related Art</u>

[0002] A vapor compression refrigerating cycle obtains its refrigerating ability generally by cooling compressed refrigerant, reducing in pressure the refrigerant by a radiator (a gas cooler) and evaporating the pressure-reduced refrigerant by an evaporator (for example, JP-A-11-193967).

[0003] In such a vapor compression refrigerating cycle, as compared with a refrigerating cycle using a conventional Freon-group refrigerant, in a refrigerating cycle using a natural-system refrigerant such as carbon dioxide, because it is necessary to increase a refrigerant pressure of high-pressure side up to a critical pressure of the refrigerant or higher, the power required for a compressor becomes great, and there is a problem that the efficiency of the refrigerating cycle is low.

[0004] Further, in a refrigerating cycle using a conventional Freon-group refrigerant, it has been considered that it is desirable to control a degree of superheating of refrigerant at an exit of an evaporator in a range of 5 to 10 degrees in order to exhibit the performance of the evaporator efficiently. Therefore, an amount of refrigerant in the evaporator has been adjusted so that a degree of dryness of refrigerant at a position before the exit of the evaporator becomes 1. However, in a refrigerating cycle having a supercritical region such as a refrigerating cycle using carbon dioxide refrigerant, because of its different property of refrigerant, if the degree of dryness of refrigerant in the evaporator is adjusted to be great as in the conventional manner, the coefficient of heat transfer of the evaporator is reduced greatly, the cooling ability thereof deteriorates, and the efficiency of the refrigerating cycle also deteriorates, In such a circumstance, research of a refrigerating cycle having a supercritical region and its parts forming the refrigerating cycle has been carried out vigorously, and the properties with respect to the evaporator and the relationship between the degree of dryness and the coefficient of heat transfer have been being recognized.

[0005] A conventional refrigerating cycle is formed, for example, as depicted in Fig. 5, and the refrigerating cycle 101 comprises a compressor 102 for compressing refrigerant, a radiator 103 for cooling refrigerant flowed out from compressor 102. an inside heat exchanger 105 for performing heat exchange between high-pressure refrigerant flowed out from radiator 103 and low-pressure refrigerant flowed out from an accumulator 104 (formed also as a gas/liquid separator) and supplying low-pressure refrigerant heat exchanged with high-pressure refrigerant to compressor 102, a pressure reducer 106 for reducing a pressure of high-pressure refrigerant flowed out from inside heat exchanger 105, an evaporator 107 for evaporating low-pressure refrigerant flowed out from pressure reducer 106, and accumulator 104 for storing two-phase refrigerant of liquid-phase refrigerant and gas-phase refrigerant flowed out from evaporator 107 and supplying gas-phase refrigerant to inside heat exchanger 105.

[0006] Paying attention to the above-described conventional technology, by the applicant of the present invention, previously proposed is a vapor compression refrigerating cycle wherein the refrigerating cycle has an evaporator for evaporating refrigerant, a compressor for compressing refrigerant, a radiator for cooling refrigerant compressed and discharged by the compressor, a first pressure reducer for reducing a pressure of refrigerant cooled by the radiator, and a gas/liquid separator for separating refrigerant flowed out from the first pressure reducer and refrigerant flowed in from the evaporator into gas-phase refrigerant and liquid-phase refrigerant, flowing out the liquid-phase refrigerant to evaporator side and flowing out the gas-phase refrigerant to compressor side, and a pumping means for sending liquid-phase refrigerant flowed out from the gas/liquid separator to evaporator side is provided between the gas/liquid separator and the evaporator (Japanese Patent Application 2005-358659, the number of the corresponding European Patent Application: 06125926.3).

[0007] In this refrigerating cycle according to the previous proposal, however, there remains a problem wherein, because it is necessary to add new parts for forming the pumping means and parts for connecting it in the refrigerant cycle such as pipes and seal members and the connection work thereof is required, it becomes difficult to reduce the cost of the refrigerating cycle and make the refrigerating cycle small and light in weight.

[0008] Accordingly, it would be desirable to provide a vapor compression refrigerating cycle, in particular, a vapor compression refrigerating cycle using carbon dioxide refrigerant, which, while exhibiting an advantage according to a basic structure of refrigerating cycle similar to that of the above-described previously proposed vapor compression refrigerating cycle, can reduce the number of parts for forming the refrigerating cycle, thereby reducing the cost of the refrigerating cycle and making the refrigerating cycle small and light in weight as a whole.

[0009] A vapor compression refrigerating cycle according to the present invention has an evaporator for evaporating refrigerant, a compressor for compressing refrigerant and discharging compressed refrigerant, a radiator for cooling refrigerant compressed and discharged by the compressor, an expander for reducing in pressure and expanding refrigerant cooled by the radiator, and a gas/liquid separator for separating refrigerant flowed out from the expander and refrigerant flowed in from the evaporator into gas-phase refrigerant and liquid-phase refrigerant, flowing out the liquid-phase refrigerant to evaporator side and flowing out the gas-phase refrigerant to compressor side, and is characterized in that a pumping means for sending liquid-phase refrigerant flowed out from the gas/liquid separator to evaporator side is provided between the gas/liquid separator and the evaporator, and at least the pumping means is constructed integrally with the gas/liquid separator. By integrally forming the gas/liquid separator and at least the pumping means, it becomes possible to omit pipes at this portion, and it becomes possible to reduce the cost at this portion and to make the size of the whole of the refrigerating cycle smaller and make the weight thereof smaller,

[0010] In this vapor compression refrigerating cycle, it is possible to employ a structure wherein the expander is also constructed integrally with the gas/liquid separator, and the expander and the pumping means are connected coaxially to each other by an identical shaft. In such an integral structure, further reduction of the number of parts for the refrigeration cycle, and the cost, the size and the weight of the refrigeration cycle becomes possible. Further, by the identical shaft connection structure between the expander and the pumping means, it becomes possible to utilize the expansion energy of refrigerant expanded by the expander as an energy for driving the pumping means. As a result, it becomes possible to reduce the consumption power of the refrigerating cycle, and it becomes possible to realize a refrigerating cycle having a higher efficiency.

[0011] The pumping means may be formed as an axial flow pump. By using an axial flow pump, as shown later in the embodiment, it becomes possible to form the integral structure of the pumping means and the gas/liquid separator as a further compact structure.

[0012] Further, in the vapor compression refrigerating cycle according to the present invention, a structure may be employed wherein a bypass passageway for flowing a part of refrigerant bypassing the expander is provided between the radiator and the gas/liquid separator, and the bypass passageway is also constructed integrally with the gas/liquid separator. In such a structure, for example, in a case where a refrigerant pressure before the expander becomes abnormally high, it becomes possible to avoid the increase of the refrigerant pressure to an abnormally high pressure by flowing (escaping) the refrigerant to the bypass passageway. Moreover, by forming the bypass passageway integrally with the gas/liquid separator, while realizing a high-efficiency refrigerating cycle, the number of parts (particularly, pipes), the cost, the size and the weight of the refrigerating cycle may be reduced as a whole. To this bypass passageway, a bypass flow rate adjusting means may be provided for adjusting a refrigerant flow rate of the bypass passageway based on a physical amount concerning a condition of the refrigerating cycle.

[0013] Further, in the vapor compression refrigerating cycle according to the present invention, a filter may be provided for preventing passage of foreign matters through a passageway between the radiator and the expander. This filter may be also constructed integrally with the gas/liquid separator. By this integral structure, while the function of the filter can be exhibited, the number of parts (particularly, pipes), the cost, the size and the weight of the refrigerating cycle may be reduced as a whole.

[0014] Further, in the vapor compression refrigerating cycle according to the present invention, a structure may be employed wherein a heat exchanger is provided for heat exchange between high-pressure refrigerant flowed out from the radiator and low-pressure refrigerant flowed into the compressor, similarly to an inside heat exchanger in the conventional technology. In such a structure, the thermal energy in the refrigerating cycle may be utilized more efficiently.

[0015] Such a vapor compression refrigerating cycle according to the present invention is suitable for application to a refrigerating cycle having a supercritical region, in particular, to a refrigerating cycle using carbon dioxide as refrigerant. Further, the vapor compression refrigerating cycle according to the present invention is suitable as a refrigerating cycle used for an air conditioning system for a vehicle.

[0016] Thus, in the vapor compression refrigerating cycle according to the present invention, by integrating the pumping means, preferably together with other equipment and other parts, with the gas/liquid separator, namely, by forming an integrated module including the gas/liquid separator and at least the pumping means, it becomes possible to decrease the number of parts of the refrigerating cycle using refrigerant which is operated in a supercritical region. Via this integrated module, the cost, the size and the weight of the refrigerating cycle may be reduced as a whole.

[0017] Further objects, features, and advantages of the present invention will be understood from the following detailed description of preferred embodiments of the present invention with reference to the accompanying figures.

[0018] Embodiments of the invention now are described with reference to the accompanying figures, which are given by way of example only, and are not intended to limit the present invention.

Fig. I is a schematic diagram of a vapor compression refrigerating cycle according to a first embodiment of the present invention.

Fig. 2 is a vertical sectional view of a gas/liquid separator integrated module in the refrigerating cycle depicted in Fig. 1.

Fig. 3 is a schematic cross-sectional view of the gas/liquid separator integrated module depicted in Fig. 2.

Fig. 4 is a schematic diagram of a vapor compression refrigerating cycle according to a second embodiment of the present invention.

Fig. 5 is a schematic diagram of a conventional vapor compression refrigerating cycle.

[0019] Fig. 1 depicts a vapor compression refrigerating cycle according to a first embodiment of the present invention, using carbon dioxide which is a natural-system refrigerant. Refrigerating cycle 1 depicted in Fig. 1 comprises a compressor 2 for compressing refrigerant and discharging the compressed refrigerant, a radiator 3 for cooling refrigerant compressed and discharged by compressor 2. an expander 4 for reducing in pressure and expanding refrigerant cooled by radiator 3, a gas/liquid separator 5 for separating refrigerant flowed out from expander 4 and refrigerant flowed in from an evaporator 6 into gas-phase refrigerant and liquid-phase refrigerant, flowing out the liquid-phase refrigerant to the evaporator side and flowing out the gas-phase refrigerant to the compressor side, and evaporator 6 for evaporating liquid-phase refrigerant flowed out from gas/liquid separator 5 to gas-phase refrigerant. Refrigerating cycle I has a pumping means 7 provided between gas/liquid separator 5 and evaporator 6 for sending liquid-phase refrigerant flowed out from the gas/liquid separator 5 to the evaporator side, and at least the pumping means 7 is constructed integrally with the gas/liquid separator 5.

[0020] In this embodiment, expander 4 is also constructed integrally with gas/liquid separator 5 (it is incorporated into a gas/liquid separator integrated module 8), and the expander 4 and pumping means 7 are connected coaxially to each other by an identical shaft 9 to utilize the expansion energy of refrigerant recovered in the expander 4 as an energy for driving the pumping means 7. Further, in this embodiment, a bypass passageway 10 for flowing a part of refrigerant bypassing expander 4 is provided between radiator 3 and gas/liquid separator 5. This bypass passageway 10 is also constructed integrally with gas/liquid separator 5 and it is incorporated into gas/liquid separator integrated module 8. To this bypass passageway 10, a bypass valve 1 I is provided as a bypass flow rate adjusting means for adjusting a refrigerant flow rate of bypass passageway 10 based on a physical amount concerning a condition of refrigerating cycle 1. Where, a pressure reducer 12 may be provided between pumping menas 7 and evaporator 6 for adjusting refrigerant being flowed into evaporator 6 to a lower-pressure refrigerant more suitable for being evaporated. This pressure reducer 12 may be structured as one having a mechanism in which a degree of pressure reduction is determined based on information concerning a condition of refrigerating cycle 1. In this case, this mechanism may be either an autonomous mechanism operating based on a pressure difference of refrigerant between pressures before and after the mechanism, or a mechanism operated by an external electric signal or a pressure signal.

[0021] The structure of the above-described gas/liquid separator integrated module 8 will be explained in more detail, referring to Figs. 2 and 3.

[0022] An introduction port 22 for introducing refrigerant 21 from radiator 3 and a discharge port 24 for sending at a pressurized condition and flowing out refrigerant 23 to the side of evaporator 6 are provided to gas/liquid separator integrated module 8. A flowing-in port 26 for flowing in refrigerant 25 from evaporator 6 and a discharge port 28 for flowing out gas-phase refrigerant 27 separated by gas/liquid separator 5 to the side of compressor 2 are provided to gas/liquid separator 5. In this embodiment, a filter 29 is provided at a position downstream of introduction port 22 in gas/liquid separator integrated module 8 for preventing passage of foreign matters through a refrigerant passageway between radiator 3 and expander 4, and the filter 29 is also incorporated into gas/liquid separator integrated module 8. Although expander 4 is provided at a position downstream of filter 29, the aforementioned bypass passageway 10 is formed by being diverged from the refrigerant passageway reaching expander 4, and in this bypass passageway 10, the aforementioned bypass valve 11 is provided. This bypass valve 11 is formed as a refrigerant flow rate adjusting type bypass valve for changing a refrigerant flow rate in accordance with a pressure difference between before and after it. When the pressure of high-pressure refrigerant exceeds its threshold value, bypass valve 11 communicates by short cut between the high-pressure side refrigerant passageway at the upstream side of bypass valve 11 and the low -pressure side refrigerant passageway formed in the inside of gas/liquid separator 5, or bypass valve 11 adjusts the pressure of the low -pressure side refrigerant passageway.

[0023] The refrigerant, which is not bypassed by bypass passageway 10, is sent to expander 4, and the refrigerant expanded by expander 4 is joined to the refrigerant sent from bypass passageway 10, and thereafter, introduced into gas/liquid separator 5 through inlet port 30 of gas/liquid separator 5. introduced refrigerant 31 is joined to refrigerant 25 introduced from evaporator 6, and the joined refrigerant is separated in gas/liquid separator 5 into gas-phase refrigerant 32 and liquid-phase refrigerant 33. The separated gas-phase refrigerant 32 is sent from discharge port 28 to the side of compressor 2 through a U-shaped inside pipe 34, and the separated liquid-phase refrigerant 33 is sent from discharge port 35 to pumping means 7. This discharged refrigerant 36 is pressurized and sent to the side of evaporator 6 through discharge port 24 by pumping means 7. In this embodiment, pumping means 7 is formed as an axial flow pump, and as aforementioned, it is connected to expander 4 by identical shaft 9. This connection shaft 9 is supported, for example, by a bearing 43, and further, it may be supported by a guide impeller of the axial flow pump provided as pumping means 7. This portion incorporated with pumping means 7 and the inside of gas/liquid separator 5 communicating with this portion are formed as a low-pressure chamber at a pressure lower than a supercritical pressure. Further, although refrigerating machine oil 37, which has been contained in refrigerant, is stored in the bottom portion in gas/liquid separator 5 at a position lower than separated liquid-phase refrigerant 33, this refrigerating machine oil 37 is returned to the side of compressor

2 through an oil return hole 38 provided on the bottom part of inside pipe 34, and served for lubrication.

[0024] In refrigerating cycle 1 thus constructed, by the structure in which gas/liquid separator 5 and at least pumping means 7 are integrated as gas/liquid separator integrated module 8, at least pipes at this portion, which have been needed in the conventional technology, can be omitted, and it becomes possible to decrease the number of parts and to reduce the cost, the size and the weight of refrigerating cycle 1 as a whole. Further, as in the above-described embodiment, by incorporating other parts (at least any of filter 29, bypass passageway 10 and expander 4) integrally into gas/liquid separator integrated module 8, it becomes possible to further decrease the number of parts and to further the cost, the size and the weight of refrigerating cycle 1.

[0025] Fig. 4 depicts a vapor compression refrigerating cycle 41 according to a second embodiment of the present invention. In this refrigerating cycle 41, a refrigerant heat exchanger 42 for exchanging in heat between the high-pressure refrigerant flowed out from radiator 3 and the low-pressure refrigerant flowed into compressor 2 is provided to the refrigerating cycle having a structure similar to that of the first embodiment. In such a structure, the thermal energy in refrigerating cycle 41 is utilized more effectively, and it becomes possible to realize a refrigerating cycle having a better efficiency in consumption power or energy. The advantage according to the integration structure due to gas/liquid separator integrated module 8 similar to that in the first embodiment may be obtained also in this embodiment.

[0026] The vapor compression refrigerating cycle according to the present invention is suitable, in particular, for a refrigerating cycle using carbon dioxide which is a natural-system refrigerant, and especially, suitable as a refrigerating cycle used for an air conditioning system for vehicles.

Claims

1. A vapor compression refrigerating cycle having an evaporator for evaporating refrigerant, a compressor for compressing refrigerant and discharging compressed refrigerant, a radiator for cooling refrigerant compressed and discharged by said compressor, an expander for reducing in pressure and expanding refrigerant cooled by said radiator, and a gas/liquid separator for separating refrigerant flowed out from said expander and refrigerant flowed in from said evaporator into gas-phase refrigerant and liquid-phase refrigerant, flowing out said liquid-phase refrigerant to evaporator side and flowing out said gas-phase refrigerant to compressor side, **characterized in that** a pumping means for sending liquid-phase refrigerant flowed out from said gas/liquid separator to evaporator side is provided between said gas/liquid separator and said evaporator, and at least said pumping means is constructed integrally with said gas/liquid separator.

2. The vapor compression refrigerating cycle according to claim 1, wherein said expander is also constructed integrally with said gas/liquid separator, and said expander and said pumping means are connected coaxially to each other by an identical shaft.

3. The vapor compression refrigerating cycle according to claim 1 or 2, wherein said pumping means is formed as an axial flow pump.

4. The vapor compression refrigerating cycle according to any preceding claim, wherein a bypass passageway for flowing a part of refrigerant bypassing said expander is provided between, said radiator and said gas/liquid separator, and said bypass passageway is also constructed integrally with said gas/liquid separator,

5. The vapor compression refrigerating cycle according to claim 4, wherein a bypass flow rate adjusting means for adjusting a refrigerant flow rate of said bypass passageway based on a physical amount concerning a condition of said refrigerating cycle is provided to said bypass passageway.

6. The vapor compression refrigerating cycle according to any preceding claim, wherein a filter is provided for preventing passage of foreign matters through a passageway between said radiator and said expander, and said filter is also constructed integrally with said gas/liquid separator.

7. The vapor compression refrigerating cycle according to any preceding claim, wherein a heat exchanger is provided for heat exchange between high-pressure refrigerant flowed out from said radiator and low-pressure refrigerant flowed into said compressor.

8. The vapor compression refrigerating cycle according to any preceding claim, wherein carbon dioxide is used as refrigerant for said vapor compression refrigerating cycle.

9. The vapor compression refrigerating cycle according to any preceding claim, wherein said vapor compression refrigerating cycle is used for an air conditioning system for a vehicle.

FIG. 1

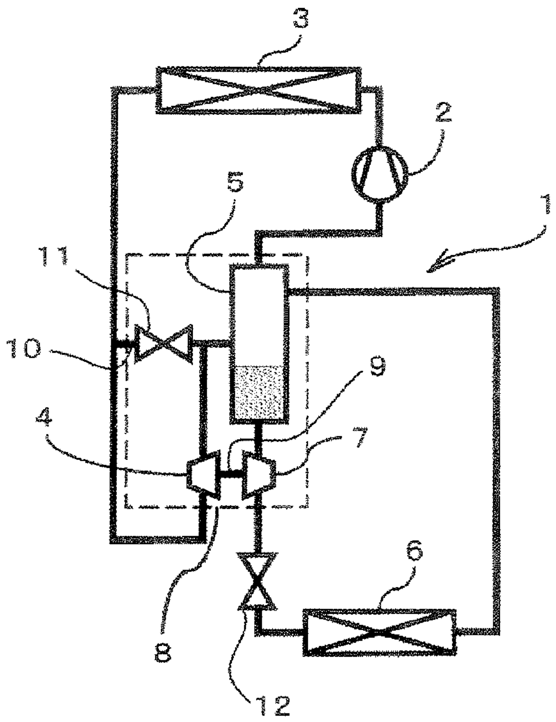
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FIG. 2

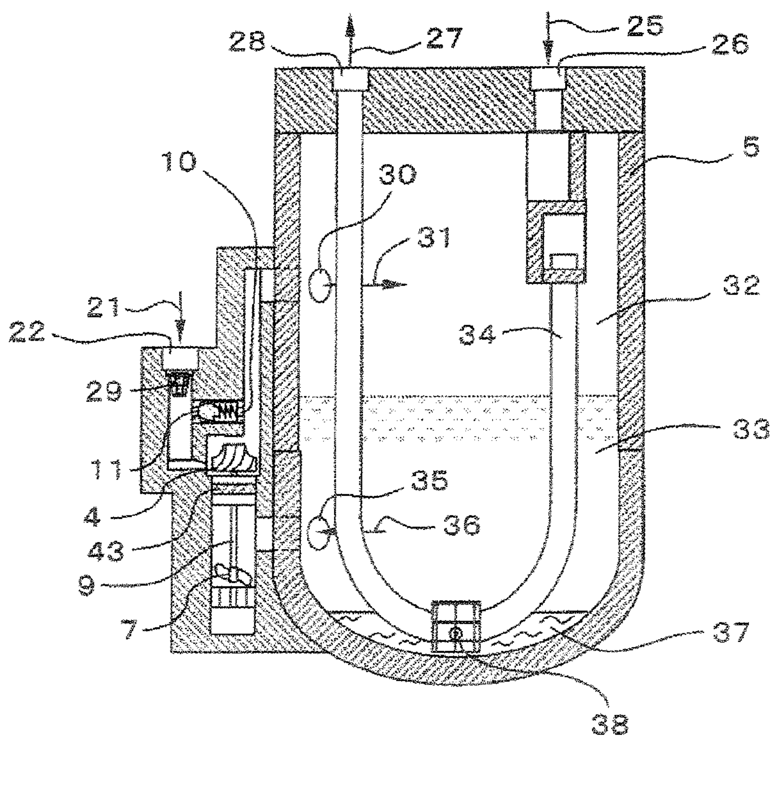
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FIG. 3

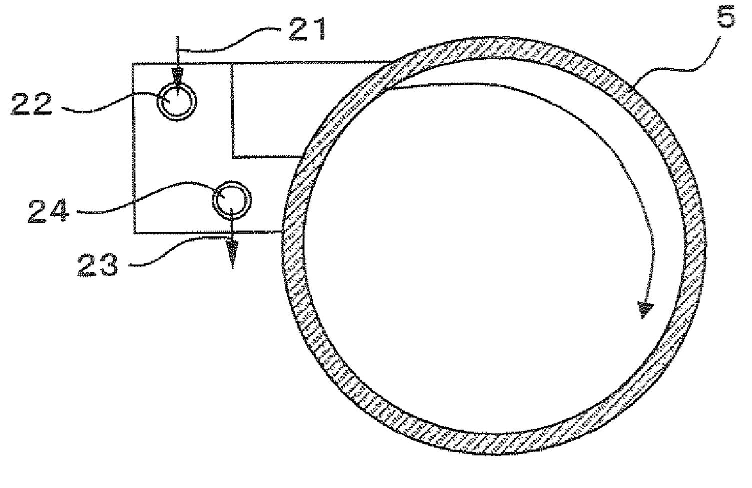


FIG. 4

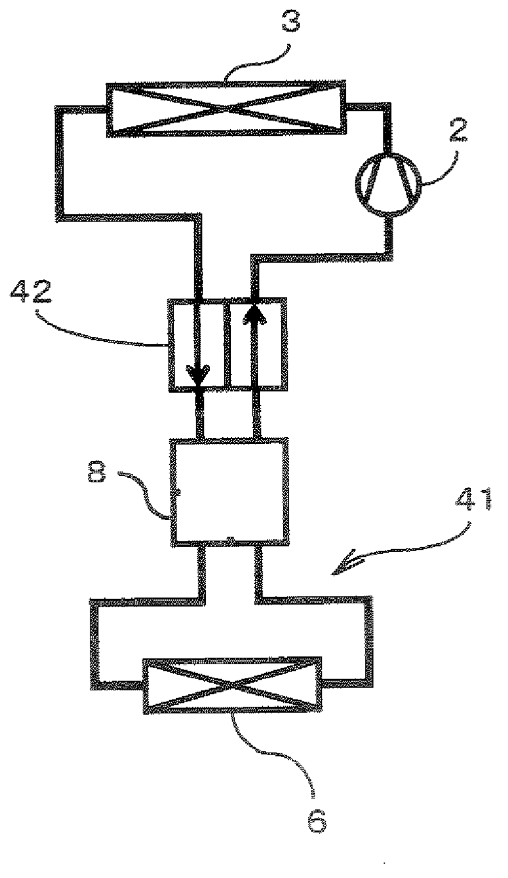
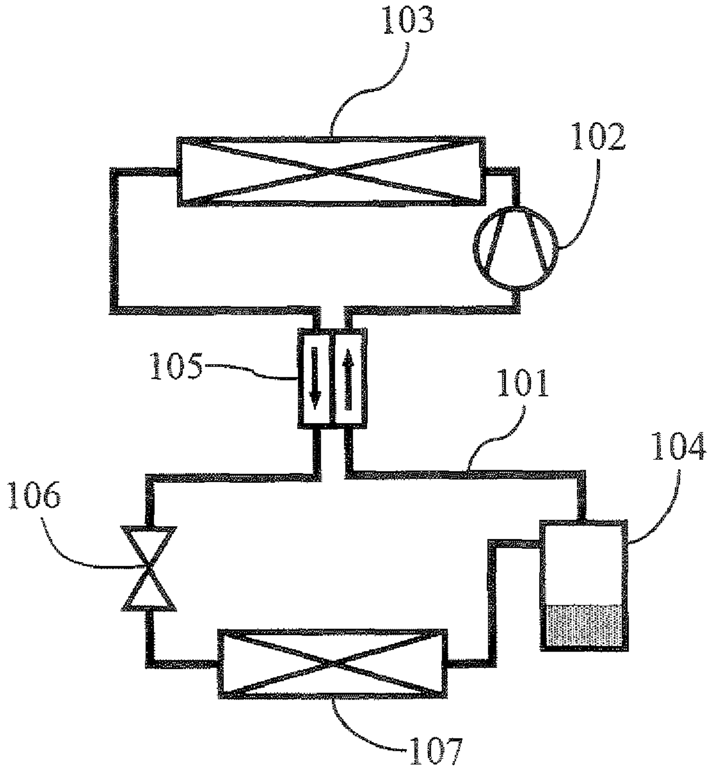


FIG. 5



REFERENCES CITED IN THE DESCRIPTION

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