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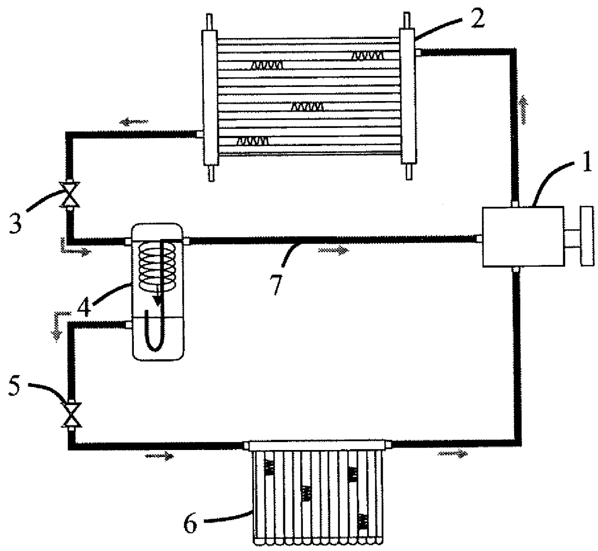
(54) **Vapor compression refrigerating system**

(57) A vapor compression refrigerating system includes a compressor (1), a radiator (2) connected to the compressor via a first tube, a first pressure reducing mechanism (3) connected to the radiator (2) via a second tube, and a separator (4) connected to the first pressure reducing mechanism (3) via a third tube and the compressor (1) via a fourth tube (7). The separator (4) includes an oil separator which is configured to separate an oil from the refrigerant, and a liquid and gas separator formed integral with the oil separator. The liquid and gas separator is configured to separate a liquid portion and a gas portion from the refrigerant, and the separator is further configured to transmit the oil and the gas portion to the compressor via the fourth tube (7). The system also includes a second pressure reducing mechanism (5) connected to the separator via a fifth tube, and an evaporator (6) connected to the second pressure reducing mechanism via a sixth tube and operationally coupled to the compressor via a seventh tube. The second pressure reducing mechanism is configured to receive the liquid portion from the separator.

FIG. 1



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Description

[0001] The present invention relates generally to vapor compression refrigerating systems. In particular, the present invention relates to vapor compression refrigerating systems in which a separator includes an oil separator integrated with a gas and liquid separator to form a single separator, and a gas portion of a refrigerant and an oil separated from the refrigerant flows from the separator to a compressor via the same tube, such that the size and the weight of the vapor compression refrigerating systems is reduced.

[0002] Fleon group refrigerants have been used in known air conditioning systems, Nevertheless, the use such fleon group refrigerants has begun to be restricted due to environmental concerns. In Europe, it has been proposed that carbon dioxide be used as a refrigerant in place of fleon. Carbon dioxide refrigerant is poisonless and incombustible, however, the theoretical energy efficiency of carbon dioxide as a refrigerant is relatively low, there are problems associated with improving the efficiency of carbon dioxide as a refrigerant. Moreover, when carbon dioxide is used as a refrigerant, because a high-pressure side may reach a supercritical condition which exceeds a critical pressure, it is necessary to use materials that may bear this pressure. Consequently, the thickness of the materials increases, which increases the weight of the air conditioner system.

[0003] One known method of improving the efficiency of carbon dioxide as a refrigerant, which is described in Japanese Patent Publication No. JP-A-2000-274890, is to use an oil separator to prevent the circulation of oil to components other than the compressor. Nevertheless, the oil separator increases the size of the air conditioner. Moreover, if oil flows into the evaporator, its heat transfer coefficient and its coefficient of heat exchange are reduced.

[0004] Therefore, a need has arisen for vapor compression refrigerating systems which overcome these and other shortcomings of the related art. A technical advantage of the present invention is that a separator may comprise an oil separator integrated with a gas and liquid separator to form a single separator, and a gas portion of the refrigerant and an oil separated from the refrigerant may flow from the separator to a compressor via the same tube, such that the size and the weight of the vapor compression refrigerating system may be reduced relative to the known vapor compression refrigerating systems.

[0005] According to an embodiment of the present invention, a vapor compression refrigerating system comprises a compressor configured to compress a refrigerant, and a radiator connected to the compressor via a first tube. The radiator is configured to receive the refrigerant from the compressor and to radiate the refrigerant. The system also comprises a first pressure reducing mechanism connected to the radiator via a second tube, and the first pressure reducing mechanism is configured to receive the refrigerant from the radiator and to reduce a pressure of the refrigerant. Moreover, the system comprises a separator connected to the first pressure reducing mechanism via a third tube and the compressor via a fourth tube, and the separator is configured to receive the refrigerant from the first pressure reducing mechanism. The separator comprises an oil separator which is configured to separate an oil from the refrigerant, and a liquid and gas separator formed integral with the oil separator. The liquid and gas separator is configured to separate a liquid portion and a gas portion from the refrigerant, and the separator is further configured to transmit the oil and the gas portion to the compressor via the fourth tube. The system also comprises a second pressure reducing mechanism connected to the separator via a fifth tube, and the second pressure reducing mechanism is configured to receive the liquid portion from the separator and to reduce a pressure of the liquid portion. Moreover, the system comprises an evaporator connected to the second pressure reducing mechanism via a sixth tube and operationally coupled to the compressor via at least a seventh tube. The evaporator is configured to receive the liquid portion from the second pressure reducing mechanism and to evaporate the liquid portion.

[0006] Other objects, features, and advantage will be apparent to persons of ordinary skill in the art from the following detailed description of the invention and the accompanying drawings.

[0007] For a more complete understanding of the present invention, needs satisfied thereby, and the objects, features, and advantages thereof, reference now is made to the following description taken in connection with the accompanying drawings.

[0008] In the Drawings ;

Fig. 1 is a circuit diagram of a vapor compression refrigerating system, according to an embodiment of the present invention.

Fig. 2 is a Mollier chart of carbon dioxide refrigerant in the vapor compression refrigerating system of Fig. 1.

Fig. 3 is a circuit diagram of a vapor compression refrigerating system, according to another embodiment of the present invention.

Fig. 4 is a Mollier chart of carbon dioxide refrigerant in the vapor compression refrigerating system of Fig. 3.

Fig. 5 is an exemplary separator in which oil is separated from refrigerant by centrifugal separation, in which Fig. 5A is a vertical, sectional view of the separator; and Fig. 5B is a cross-sectional view of the separator as viewed along line A-A of Fig. 5A.

Fig. 6 is an exemplary separator in which oil is separated from refrigerant by collision separation, in which Fig. 6A is a vertical, sectional view of the separator; and Fig. 5B is a cross-sectional view of the separator as viewed along line A-A of Fig. 6A.

Fig. 7 is an exemplary refrigerant heat exchanging means in a vapor compression refrigerating system, according to an embodiment of the present invention, in which Fig. 7A is an elevational view;

Fig. 7B is a plan view thereof; and Fig. 7C is an enlarged, sectional view of a tube for heat exchange thereof.

Fig. 8 is a perspective view of an exemplary refrigerant heat exchanging means in a vapor compression refrigerating system, according to another embodiment of the present invention.

[0009] Embodiments of the present invention, and their features and advantages, may be understood by referring to Figures 1-8, like numerals being used for like corresponding parts in the various drawings.

[0010] Fig. 1 depicts a vapor compression refrigerating system according to an embodiment of the present invention. The vapor compression refrigerating system may comprise a compressor 1, a radiator 2 connected to compressor 1, a first pressure reducing mechanism 3 connected to radiator 2, and a separator 4 connected to compressor 1 and to first pressure reducing mechanism 3. For example, separator 4 may comprise an oil separator integrated with a gas and liquid separator to form a single separator, and the radiator 2 may be a gas cooler. The vapor compression refrigerating system also may comprise a second pressure reducing mechanism 5 connected to separator 4, and an evaporator 6 connected to compressor I and to second pressure reducing mechanism 5. Each of the connections between the elements of the vapor compression refrigerating system may be made via a tube 7.

[0011] In operation, a refrigerant, such as a carbon dioxide refrigerant, may be compressed by compressor 1, which contracts the refrigerant and increases the temperature of the refrigerant. The refrigerant then may flow from compressor 1 to radiator 2, and radiator 2 may radiate the refrigerant to decrease the temperature of the refrigerant. The refrigerant then may flow from radiator 2 to first pressure reducing mechanism 3, and first pressure reducing mechanism 3 may expand the refrigerant and may reduce the pressure of the refrigerant. The refrigerant then may flow from first pressure reducing mechanism 3 to separator 4, and separator 4 may separate the refrigerant into a gas portion and a liquid portion, and may separate an oil from the refrigerant. For example, the oil may be separated from the refrigerant by centrifugal separation or collision separation. The oil and the gas portion then may flow from separator 4 to compressor 1, such that the oil and the gas portion flow from separator 4 to compressor 1 via the same tube 7. Nevertheless, the liquid portion may flow from separator 4 to second pressure reducing mechanism 5, and second pressure reducing mechanism 5 may further expand and further reduce the pressure of the liquid portion. The liquid portion then may flow from second pressure reducing mechanism 5 to evaporator 6, and evaporator 6 may evaporate the liquid portion into a gas. The gas then may flow from evaporator 6 to compressor 7.

[0012] In the above-described embodiment of the present invention, because separator 4 may comprise an oil separator integrated with a gas and liquid separator to form a single separator, and/or because the gas portion of the refrigerant and the oil may flow from separator 4 to compressor 1 via the same tube 7, the size and/or the weight of the vapor compression refrigerating system may be reduced.

[0013] Fig. 2 is a Mollier chart of carbon dioxide refrigerant in the vapor compression refrigerating system of Fig. 1. In the Mollier chart of Fig. 2, state points of the respective components are connected to each other by lines. A curve 11 represents a saturated liquid curve and a saturated vapor curve of carbon dioxide refrigerant, and a curve connecting both lines is referred to as a saturation curve. A curve 12 represents an isothermal line passing through a critical point of carbon dioxide refrigerant. Moreover, numerals labeled in Fig. 2 express the respective components depicted in Fig. 1, and they show operations of the respective components.

[0014] Fig. 3 depicts a vapor compression refrigerating system according to another embodiment of the present invention. In this embodiment, a refrigerant heat exchanging means, e.g., a heat exchanging tube 8, is provided for exchanging heat between the liquid refrigerant in separator 4 or/and the refrigerant which flows out of separator 4, and the refrigerant which flows out of evaporator 6. In this embodiment, super cooling is possible by lowering the temperature of the refrigerant immediately before the refrigerant flows to second pressure reducing mechanism 5. Moreover, super heating is possible for preventing liquid compression in compressor 1, and the refrigerating ability and the reliability of the vapor compression refrigerating system may be increased.

[0015] Fig. 4 is a Mollier chart of carbon dioxide refrigerant in the vapor compression refrigerating system depicted in Fig. 3. In the Mollier chart depicted in Fig. 4, state points of the respective components are connected to each other by lines. Similarly to Fig. 2, curve 11 represents a saturated liquid curve and a saturated vapor curve of carbon dioxide refrigerant, and a curve connecting both lines is referred to as a saturation curve. A curve 12 represents an isothermal line passing through a critical point of carbon dioxide refrigerant. One difference between Figs. 2 and 4 is that there is an effect of heat exchange caused by the heat exchange between liquid refrigerant in separator 4 and/or refrigerant which flows out of separator 4, and refrigerant which flows out of evaporator 6. Specifically, because the refrigerant immediately before second pressure reducing mechanism 5 is the liquid portion of the refrigerant, the liquid portion of the refrigerant moves to a position above the saturation curve. In Fig. 4, $\Delta h2$ shows a degree of super cooling, $\Delta h1$ shows a degree of superheating, and the effect of heat exchange due to the above-described refrigerant heat exchanging means may be expressed as about $\Delta h1 \fallingdotseq \Delta h2$.

[0016] Referring to Figs. 5A and 5B, according to an embodiment of the present invention, the separation of the refrigerant and the oil is performed by a centrifugal separation system. For example, the gas and liquid portion of the refrigerant may flow from first pressure reducing mechanism 3 into the separator from a refrigerant flow passage 22, and the refrigerant rotates in the circumferential direction around a gas refrigerant and oil flow passage 22 to compressor 1. Refrigerant and oil then are separated from each other by the centrifugal force (centrifugal flow: 31). Specifically, because the pressure of the refrigerant has been reduced to a pressure which is less than the critical pressure, the refrigerant and the oil are not dissolved in each other, and because the density of oil is greater than the density of refrigerant, the oil is stored in the lowest layer, which is an oil layer 29. Moreover, the liquid portion of the refrigerant has a greater density and is stored as a liquid refrigerant layer 28 at a position above the oil layer 29, and the gas portion of the refrigerant is present in a gas refrigerant layer 27, which is a space above the liquid refrigerant layer 28, together with a small amount of liquid refrigerant at a condition of gas/liquid mixture. A refrigerant flow passage 23 to second pressure reducing mechanism 5 is positioned lower than oil layer 29, and an oil flowing out prevention plate 30 is positioned above refrigerant flow passage 23, such that a fine amount of oil existing in liquid refrigerant layer 28 does not flaw out together with the liquid portion of the refrigerant. The gas portion of the refrigerant in gas refrigerant layer 27 passes through a diffuser or tube support 26, and liquid present in the gas portion of the refrigerant is removed, such that only gas refrigerant flows into oil flow passage 24 to compressor 1. At the same time, oil is sucked through an oil returning hole 25, and the sucked oil flows out together with the gas refrigerant. Such a structure is contained in a container 21.

[0017] Referring to Figs. 6A and 6B, according to an embodiment of the present invention, the separation of the refrigerant and the oil is performed by a collision separation system. For example, the gas and liquid portion of the refrigerant may flow from first pressure reducing mechanism into the separator from refrigerant flow passage 22, and the refrigerant and the oil are separated from each other by collision with diffuser or tube support 26 (collision flow for separation: 32). Because diffuser or tube support 26 also is provided in Figs. 5A and 58, and refrigerant and oil are separated from each other by diffuser or tube support 26, the structure depicted in Figs. 5A and 5B is a structure in which the centrifugal separation system is mainly employed and the collision separation system is added thereto.

[0018] Figs. 7A-7C show an example of a structure configured to be employed in the system of Fig. 3, in which a heat exchanging tube 41, e.g.. a flat tube, is provided at a storage part of liquid refrigerant of separator 4 for exchanging heat between the refrigerant present in separator 4 and the refrigerant which flows from evaporator 6. Heat exchanging tube 41 may be wound at a tight contact condition at the position and its vicinity of liquid refrigerant layer 28 of separator 4, and heat exchange may be performed. In this example, by forming heat exchanging tube 41 as a parallel multi-hole flat tube 42, the efficiency of the heat exchange may be improved. In such a structure, processing to the container 21 with a pressure resistance may not be necessary.

[0019] Fig. 8 shows an example of another structure configured to be employed in the system of Fig. 3, in which a heat exchanging tube 51 having a double-pipe structure is used for heat exchanging between the liquid portion of the refrigerant flowing into second pressure reducing mechanism 5 from separator 4 and the refrigerant which flows from evaporator 6. In heat exchanging tube 51, in order to efficiently perform the heat exchange between the liquid refrigerant portion flowing into second pressure reducing mechanism 5 from separator 4 and the refrigerant which flows from evaporator 6, both flows may be set as a counter flow or a parallel flow.

[0020] The vapor compression refrigerating system according to the present invention may be particularly suitable for an air conditioning system of a vehicle, such as an air conditioning system which uses carbon dioxide as a refrigerant.

Claims

1. A vapor compression refrigerating system comprising:

    a compressor configured to compress a refrigerant;
    a radiator connected to the compressor via a first tube, wherein the radiator is configured to receive the refrigerant from the compressor and to radiate the refrigerant;
    a first pressure reducing mechanism connected to the radiator via a second tube, wherein the first pressure reducing mechanism is configured to receive the refrigerant from the radiator and to reduce a pressure of the refrigerant;
    a separator connected to the first pressure reducing mechanism via a third tube and the compressor via a fourth tube, wherein the separator is configured to receive the refrigerant from the first pressure reducing mechanism, and the separator comprises:

        an oil separator which is configured to separate an oil from the refrigerant; and
        a liquid and gas separator formed integral with the oil separator, wherein the liquid and gas separator is configured to separate a liquid portion and a gas portion from the refrigerant, and the separator is further configured to transmit the oil and the gas portion

to the compressor via the fourth tube;

a second pressure reducing mechanism connected to the separator via a fifth tube, wherein the second pressure reducing mechanism is configured to receive the liquid portion from the separator and to reduce a pressure of the liquid portion; and
an evaporator connected to the second pressure reducing mechanism via a sixth tube and operationally coupled to the compressor via at least a seventh tube, wherein the evaporator is configured to receive the liquid portion from the second pressure reducing mechanism and to evaporate the liquid portion.

2. The vapor compression refrigerating system of claim 1, wherein the evaporator is connected to the compressor via the separator, and the evaporator is configured to receive the liquid portion from the second pressure reducing mechanism and to evaporate the liquid portion into an evaporated portion and to transmit the evaporated portion to the separator, wherein the system further comprises means for exchanging heat between the liquid portion and evaporated portion.

3. The vapor compression refrigerating system of claim 1, wherein the oil separator comprises at least one of a centrifugal oil separator and a collision oil separator.

4. The vapor compression refrigerating system of claim 1, wherein the first pressure reducing mechanism is configured to control a pressure of the refrigerant at an exit side of the first pressure reducing mechanism to be less than or equal to a critical pressure.

5. The vapor compression refrigerating system of claim 1, wherein at least one of the first pressure reducing mechanism and the second pressure reducing mechanism comprises a mechanical expansion valve which changes a degree of expansion in response to at least one of a temperature and a pressure of the refrigerant.

6. The vapor compression refrigerating system of claim 1, wherein at least one of the first pressure reducing mechanism and the second pressure reducing mechanism comprises an electronic expansion valve which changes an opening degree of a valve by an electric signal in response to at least one of a temperature and a pressure of the refrigerant.

7. The vapor compression refrigerating system of claim 1, wherein the refrigerant comprises carbon dioxide.

8. An air conditioning system comprising a vapor compression refrigerating system, wherein the vapor compression refrigerating system comprises:

a compressor configured to compress a refrigerant;
a radiator connected to the compressor via a first tube, wherein the radiator is configured to receive the refrigerant from the compressor and to radiate the refrigerant;
a first pressure reducing mechanism connected to the radiator via a second tube, wherein the first pressure reducing mechanism is configured to receive the refrigerant from the radiator and to reduce a pressure of the refrigerant;
a separator connected to the first pressure reducing mechanism via a third tube and the compressor via a fourth tube, wherein the separator is configured to receive the refrigerant from the first pressure reducing mechanism, and the separator comprises:

an oil separator which is configured to separate an oil from the refrigerant; and
a liquid and gas separator formed integral with the oil separator, wherein the liquid and gas separator is configured to separate a liquid portion and a gas portion from the refrigerant, and the separator is further configured to transmit the oil and the gas portion to the compressor via the fourth tube;

a second pressure reducing mechanism connected to the separator via a fifth tube, wherein the second pressure reducing mechanism is configured to receive the liquid portion from the separator and to reduce a pressure of the liquid portion; and
an evaporator connected to the second pressure reducing mechanism via a sixth tube and operationally coupled to the compressor via at least a seventh tube, wherein the evaporator is configured to receive the liquid portion from the second pressure reducing mechanism and to evaporate the liquid portion.

9. A vehicle comprising an air conditioning system, wherein the air conditioning system comprises a vapor compression refrigerating system, and the vapor compression refrigerating system comprises:

a compressor configured to compress a refrigerant;
a radiator connected to the compressor via a first tube, wherein the radiator is configured to receive the refrigerant from the compressor and to radiate the refrigerant;
a first pressure reducing mechanism connected to the radiator via a second tube, wherein the

first pressure reducing mechanism is configured to receive the refrigerant from the radiator and to reduce a pressure of the refrigerant;
a separator connected to the first pressure reducing mechanism via a third tube and the compressor via a fourth tube, wherein the separator is configured to receive the refrigerant from the first pressure reducing mechanism, and the separator comprises:

an oil separator which is configured to separate an oil from the refrigerant; and
a liquid and gas separator formed integral with the oil separator, wherein the liquid and gas separator is configured to separate a liquid portion and a gas portion from the refrigerant, and the separator is further configured to transmit the oil and the gas portion to the compressor via the fourth tube;

a second pressure reducing mechanism connected to the separator via a fifth tube, wherein the second pressure reducing mechanism is configured to receive the liquid portion from the separator and to reduce a pressure of the liquid portion; and
an evaporator connected to the second pressure reducing mechanism via a sixth tube and operationally coupled to the compressor via at least a seventh tube, wherein the evaporator is configured to receive the liquid portion from the second pressure reducing mechanism and to evaporate the liquid portion.

FIG. 1

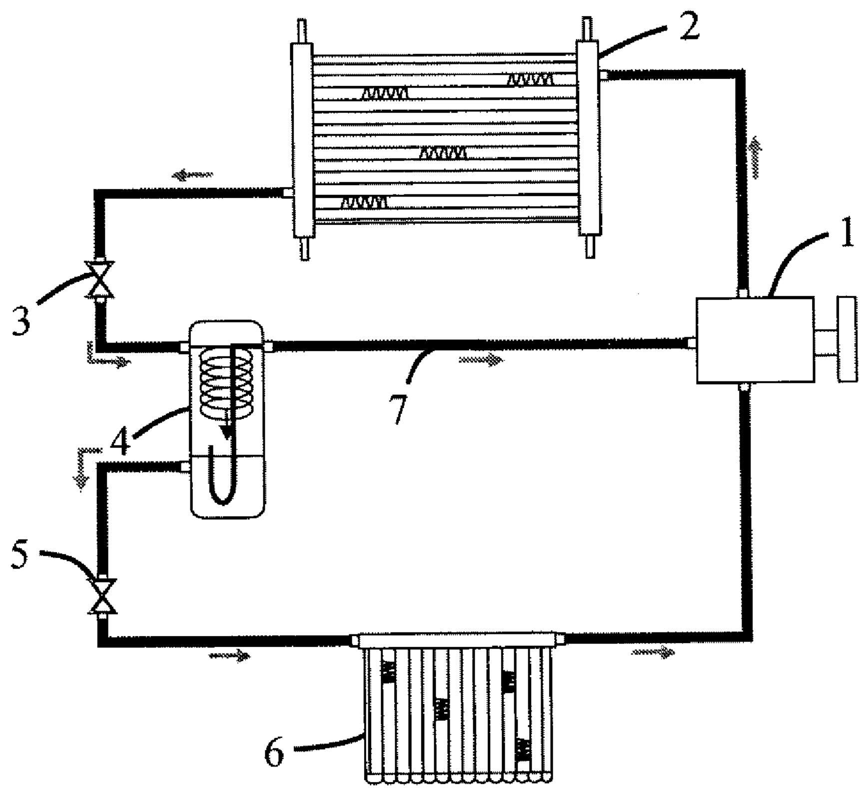
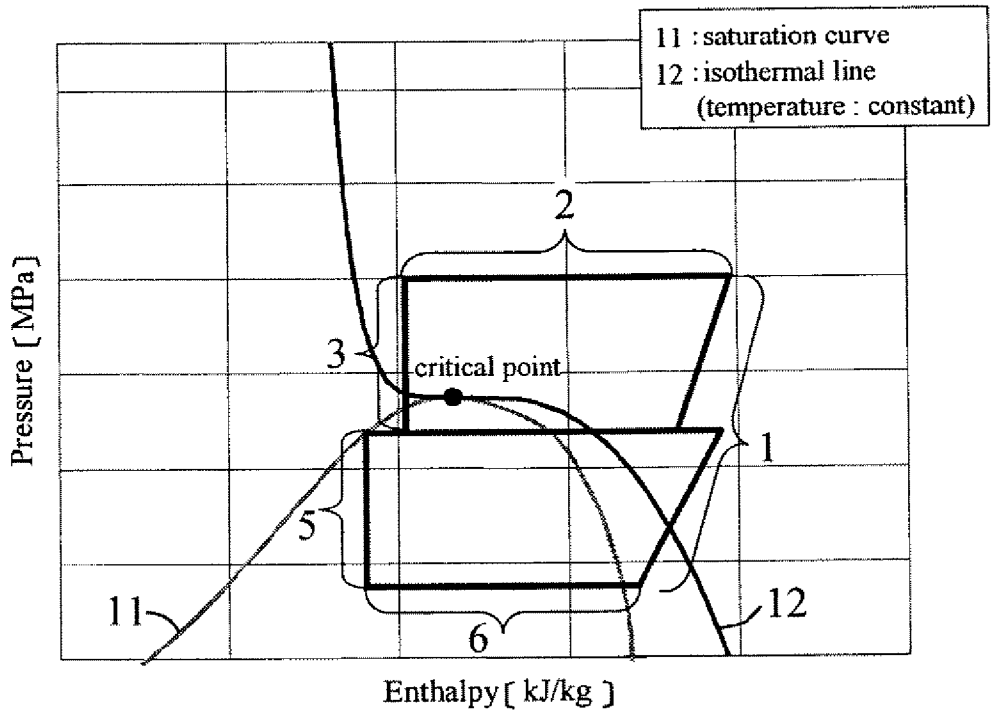

2
1
3
7
4
5
6

FIG. 2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12 : isothermal line
(temperature : constant)
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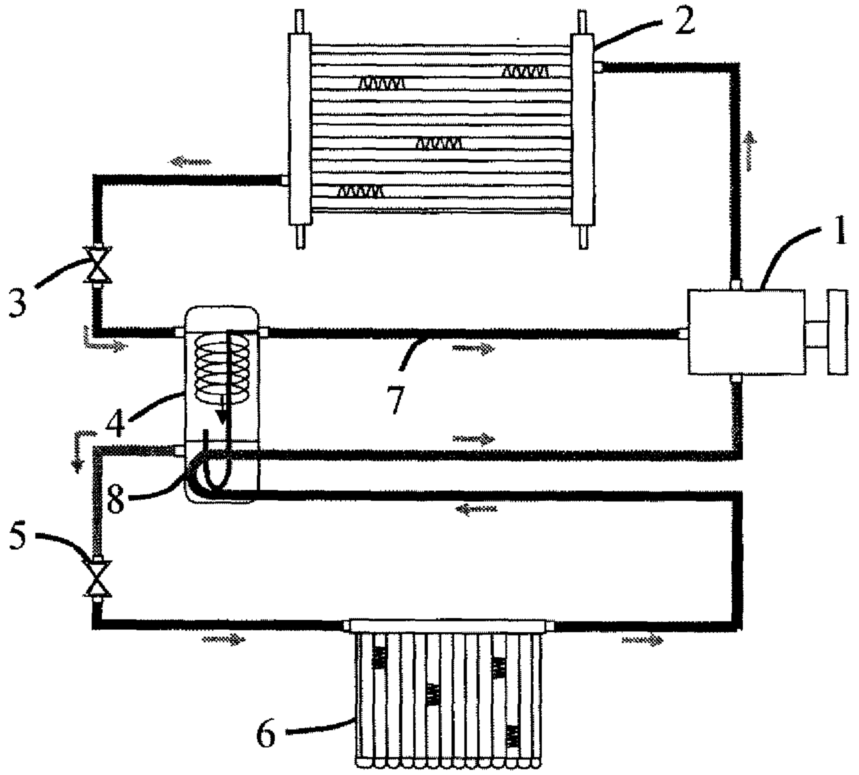
3
critical point
1
5
11
6
12
Pressure [MPa]
Enthalpy [kJ/kg]

FIG. 3


2
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7
4
8
5
6

FIG. 4

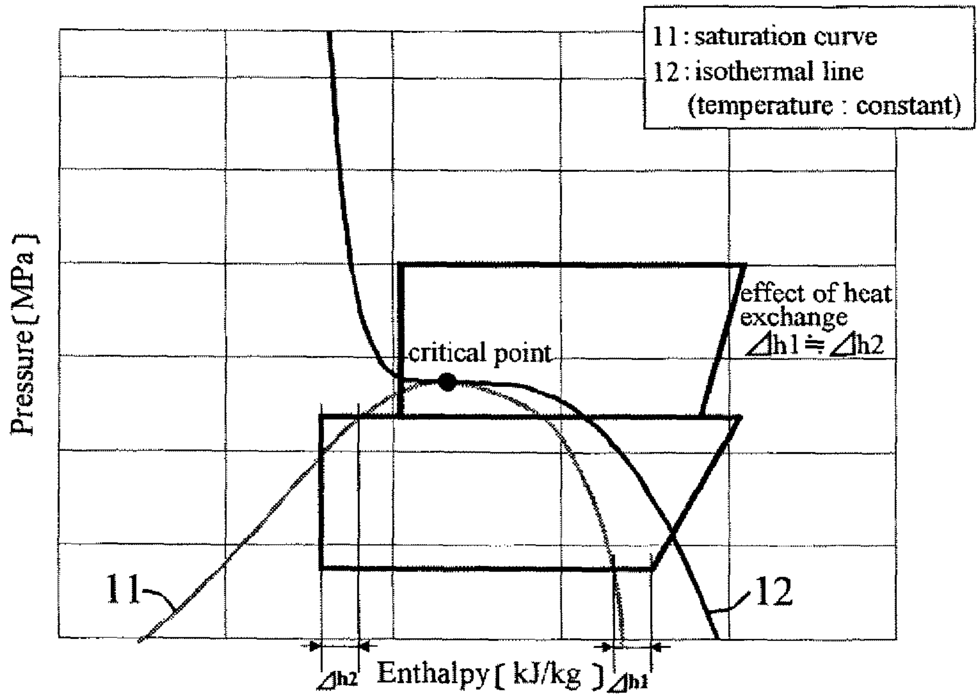

11 : saturation curve
12 : isothermal line
(temperature : constant)
effect of heat exchange
⊿h1≒⊿h2
critical point
Pressure [MPa]
11
12
⊿h2
Enthalpy [kJ/kg]
⊿h1

FIG. 5A

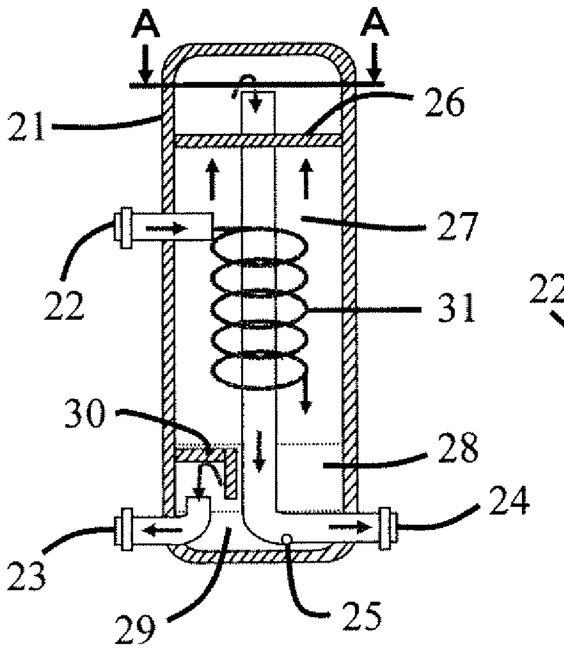


FIG. 5B

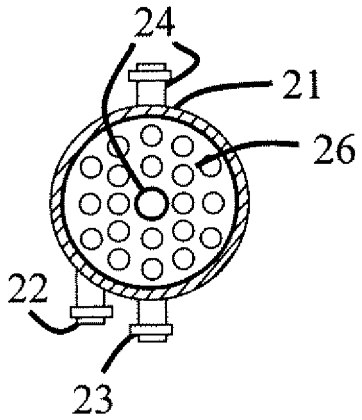


FIG. 6A

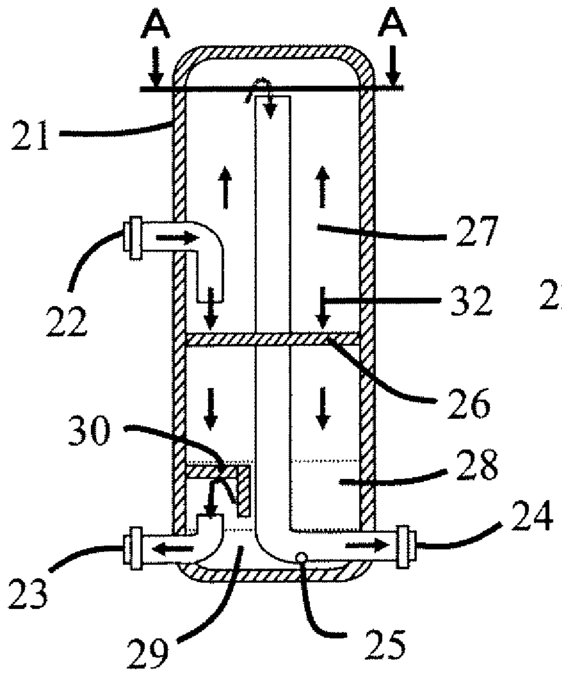


FIG. 6B

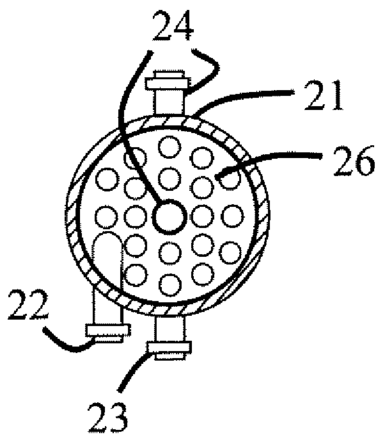


FIG. 7A

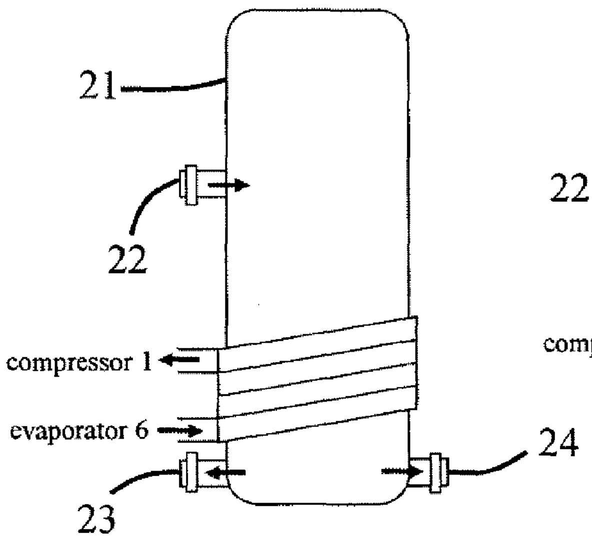


FIG. 7B

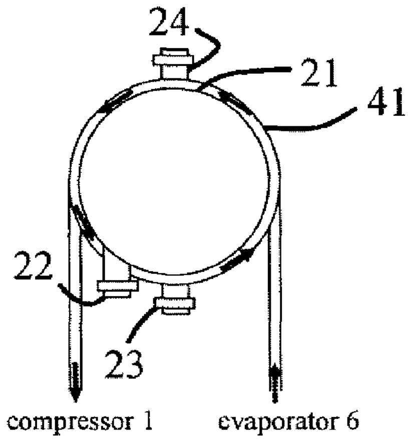


FIG. 7C

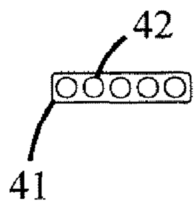
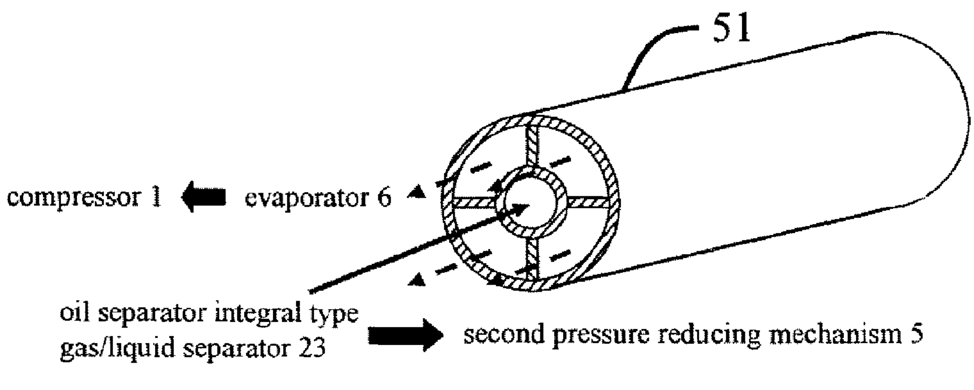


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

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