



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**29.04.2015 Bulletin 2015/18**

(51) Int Cl.:  
**F25B 25/00 (2006.01) F25B 41/00 (2006.01)**

(21) Application number: **14189852.8**

(22) Date of filing: **22.10.2014**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**

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(30) Priority: **22.10.2013 JP 2013218991**  
**22.10.2013 JP 2013218990**

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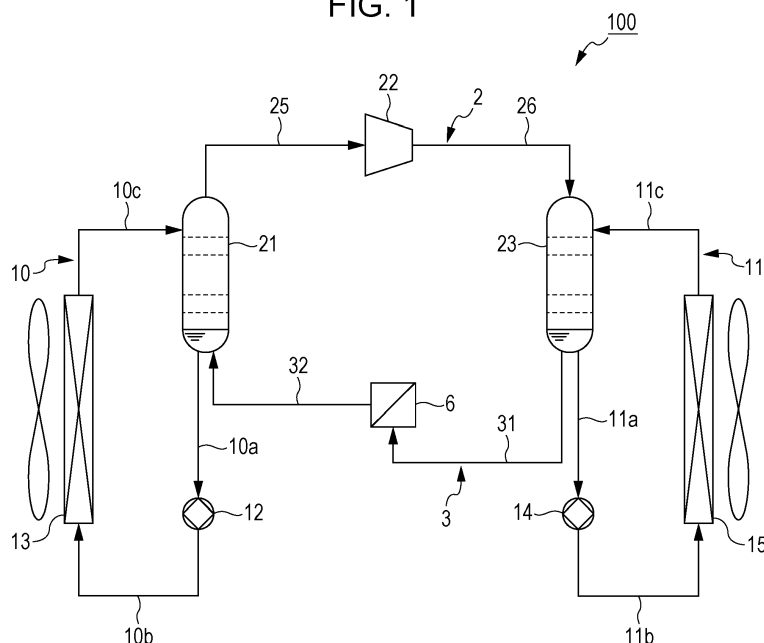
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(54) **Refrigeration-cycle equipment**

(57) There is provided refrigeration-cycle equipment in which a mixture of a refrigerant component and an additive is employed as a refrigerant. The refrigeration-cycle equipment includes an evaporator, a condenser, a vapor passage, and a return passage. The return pas-

sage guides refrigerant liquid from the condenser to the evaporator. The return passage is provided with a separating mechanism that separates the additive from the refrigerant component.

**FIG. 1**



## Description

### BACKGROUND

#### 1. Technical Field

**[0001]** The present disclosure relates to refrigeration-cycle equipment.

#### 2. Description of the Related Art

**[0002]** In known refrigeration-cycle equipment, halogenated hydrocarbons such as Freon and alternative Freon have been widely used as refrigerants. However, such a refrigerant leads to problems such as ozone layer depletion and global warming. Hence, refrigeration-cycle equipment employing water as a refrigerant that has very little damage to the global environment has been proposed.

**[0003]** In Japanese Unexamined Patent Application Publication No. 2008-122012 (Fig. 1), a cooling-only air conditioner is disclosed as such refrigeration-cycle equipment. The air conditioner disclosed by Japanese Unexamined Patent Application Publication No. 2008-122012 achieves a reduction in the damage to the environment on the basis of using a natural refrigerant. The amount of latent heat of water is larger than those of known refrigerants. Therefore, the air conditioner disclosed by Japanese Unexamined Patent Application Publication No. 2008-122012 provides, at a low mass flow rate, a capacity that is equivalent to those of other known air conditioners. That is, as a cooling-only air conditioner, refrigeration-cycle equipment employing water as a refrigerant achieves a high coefficient of performance (COP).

### SUMMARY

**[0004]** In such known refrigeration-cycle equipment, however, the ratio of an additive to the refrigerant in each of an evaporator and a condenser might not be adjusted to a desirable value for smooth operation of the refrigeration-cycle equipment.

**[0005]** In view of the above, the present disclosure provides refrigeration-cycle equipment in which the ratio of an additive to a refrigerant is adjusted to a desirable value for smooth operation of the refrigeration-cycle equipment.

**[0006]** According to the present disclosure, there is provided refrigeration-cycle equipment in which a mixture of a refrigerant component and an additive is employed as a refrigerant. The refrigeration-cycle equipment includes an evaporator that stores refrigerant liquid, evaporates the refrigerant liquid, and generates refrigerant vapor; a condenser that condenses the refrigerant vapor and generates refrigerant liquid; a compressor provided between the evaporator and the condenser and that compresses the refrigerant vapor; a vapor passage

that connects the evaporator and the condenser to each other through the compressor and guides the refrigerant vapor from the evaporator to the condenser; a return passage that guides the refrigerant liquid from the condenser to the evaporator; and a separating mechanism provided in the return passage and that separates the additive from the refrigerant liquid supplied from the condenser to the evaporator.

**[0007]** According to the present disclosure, the ratio of the additive to the refrigerant in each of the evaporator and the condenser can be adjusted to a desirable value for smooth operation of the refrigeration-cycle equipment.

### BRIEF DESCRIPTION OF THE DRAWINGS

#### **[0008]**

Fig. 1 is a diagram of refrigeration-cycle equipment according to a first embodiment;

Fig. 2 is a diagram of refrigeration-cycle equipment according to a second embodiment;

Fig. 3A is a diagram of refrigeration-cycle equipment according to a third embodiment;

Fig. 3B is a diagram of refrigeration-cycle equipment according to a modified example of the third embodiment;

Fig. 4 is a diagram of refrigeration-cycle equipment according to a fourth embodiment;

Fig. 5 is a diagram of refrigeration-cycle equipment according to a fifth embodiment;

Fig. 6 is a diagram of refrigeration-cycle equipment according to a sixth embodiment;

Fig. 7 is a diagram of refrigeration-cycle equipment according to a seventh embodiment;

Fig. 8 is a diagram of refrigeration-cycle equipment according to an eighth embodiment;

Fig. 9 is a diagram of refrigeration-cycle equipment according to a ninth embodiment;

Fig. 10A is a diagram of refrigeration-cycle equipment according to a tenth embodiment;

Fig. 10B is a diagram of refrigeration-cycle equipment according to a modified example of the tenth embodiment;

Fig. 11A is a diagram of refrigeration-cycle equipment according to an eleventh embodiment;

Fig. 11B is a diagram of refrigeration-cycle equipment according to a modified example of the eleventh embodiment;

Fig. 12A is a diagram of refrigeration-cycle equipment according to a twelfth embodiment;

Fig. 12B is a diagram of refrigeration-cycle equipment according to a modified example of the twelfth embodiment;

Fig. 13 is a diagram of refrigeration-cycle equipment according to a thirteenth embodiment;

Fig. 14 is a diagram of refrigeration-cycle equipment according to a fourteenth embodiment;

Fig. 15 is a diagram of refrigeration-cycle equipment according to a fifteenth embodiment;

Fig. 16A is a graph illustrating a saturated-vapor-pressure curve  $C_{REF}$  in a case where the saturated vapor pressure of refrigerant liquid stored in an evaporator is equal to the saturated vapor pressure of refrigerant liquid stored in a condenser;

Fig. 16B is a graph illustrating a saturated-vapor-pressure curve  $C_{CON}$  and a saturated-vapor-pressure curve  $C_{EVA}$  in a case where the saturated vapor pressure of the refrigerant liquid stored in the condenser and being at a specific temperature is lower than the saturated vapor pressure of the refrigerant liquid stored in the evaporator and being at the specific temperature; and

Fig. 17 is a diagram of refrigeration-cycle equipment according to a sixteenth embodiment.

## DETAILED DESCRIPTION

### Knowledge as Grounds for Present Disclosure

**[0009]** Refrigerant employed in refrigeration-cycle equipment often contains an additive as well as a refrigerant component. For example, in the case of the refrigeration-cycle equipment disclosed by Japanese Unexamined Patent Application Publication No. 2008-122012, a mixture of water (a refrigerant component) and an additive that prevents the water from being frozen may be employed as a refrigerant. However, the saturated vapor pressure of a solution of such an additive and the saturated vapor pressure of the refrigerant component may be significantly different from each other. Because of the difference in saturated vapor pressure, the ratio of the additive to the refrigerant may gradually change to a value that is not desirable for smooth operation in some portions (such as an evaporator and a condenser) of the refrigeration-cycle equipment.

**[0010]** If water is employed as the refrigerant as in the refrigeration-cycle equipment (an air conditioner) disclosed by Japanese Unexamined Patent Application Publication No. 2008-122012, the refrigerant is frozen under an operating condition that the temperature of the refrigerant needs to be lowered to a temperature below zero. Therefore, the refrigeration-cycle equipment cannot perform an air-heating operation when the outdoor temperature is low. Moreover, if an object to be cooled has a temperature below zero, the refrigeration-cycle equipment cannot be used as a refrigerator.

**[0011]** If a mixture of antifreeze and water is employed as the refrigerant, the refrigeration-cycle equipment is operable at a low temperature. Typical antifreeze, such as an ethylene glycol solution or a potassium acetate solution, has a lower saturated vapor pressure than water. Therefore, if a mixture of antifreeze and water is employed as the refrigerant, water evaporates first in the evaporator and occupies a large portion of the resulting refrigerant vapor. Consequently, as the operating time increases, the concentration of the antifreeze (precisely, the concentration of ethylene glycol or the concentration of potassium acetate) in refrigerant liquid stored in the evaporator increases while the concentration of the antifreeze in refrigerant liquid stored in the condenser decreases. If the operation of the refrigeration-cycle equipment is stopped in such a state, the refrigerant liquid in the condenser may be frozen, damaging the condenser and other components such as pipes.

**[0012]** To address such a problem, the following measure may be taken. Specifically, the operation (an air-heating operation, for example) of the refrigeration-cycle equipment is temporarily stopped at an increase in the concentration of the antifreeze in the evaporator or at a reduction in the concentration of the antifreeze in the condenser, and a portion of the refrigerant liquid stored in the evaporator and a portion of the refrigerant liquid stored in the condenser are then exchanged. Thus, the concentration of the antifreeze in the refrigerant liquid stored in the evaporator and the concentration of the antifreeze in the refrigerant liquid stored in the condenser can be initialized. However, such a method causes a significant heat loss because of the exchanging of the two portions of the refrigerant liquid. After the exchanging of the two portions of the refrigerant liquid, it takes a long time before the operation can be restarted. Therefore, the system efficiency of the refrigeration-cycle equipment is reduced.

**[0013]** In view of the above, the present inventors have reached the invention having the following aspects.

**[0014]** According to a first aspect of the present disclosure, there is provided refrigeration-cycle equipment in which a mixture of a refrigerant component and an additive is employed as a refrigerant. The refrigeration-cycle equipment includes an evaporator that stores refrigerant liquid, evaporates the refrigerant liquid, and generates refrigerant vapor; a condenser that condenses the refrigerant vapor and generates refrigerant liquid; a compres-

sor provided between the evaporator and the condenser, the compressor compressing the refrigerant vapor; a vapor passage that connects the evaporator and the condenser to each other through the compressor and guides the refrigerant vapor from the evaporator to the condenser; a return passage that guides the refrigerant liquid from the condenser to the evaporator; and a separating mechanism provided in the return passage, the separating mechanism separating the additive from the refrigerant liquid supplied from the condenser to the evaporator.

**[0015]** According to the first aspect, the return passage is provided with the separating mechanism, and the additive is separated from the refrigerant liquid by the separating mechanism. The refrigerant liquid whose additive concentration has been reduced is supplied from the condenser to the evaporator. Consequently, the ratio of the additive to the refrigerant (the refrigerant liquid) in each of the evaporator and the condenser can be adjusted to a desirable value for smooth operation of the refrigeration-cycle equipment. Specifically, the occurrence of concentration of the additive in the evaporator and the occurrence of dilution of the additive in the condenser can be suppressed. Moreover, while a rated or nearly rated operation of the refrigeration-cycle equipment is continued, the concentration of the additive in each of the evaporator and the condenser can be adjusted. Hence, the refrigeration-cycle equipment according to the first aspect can perform stable operation for a long time and can provide superior system efficiency.

**[0016]** Note that the amount of additive supplied from the evaporator through the vapor passage to the condenser may exceed the amount of additive supplied from the condenser through the return passage to the evaporator. In that case, it may be necessary to exchange a portion of the refrigerant liquid stored in the evaporator and a portion of the refrigerant liquid stored in the condenser. However, the separating mechanism can prevent the additive in the condenser from returning to the evaporator. Therefore, the refrigeration-cycle equipment can assuredly continue to operate without the exchange of the portions of the refrigerant liquid for longer time than in a case where the return passage has no separating mechanism. Hence, according to the first aspect, the system efficiency of the refrigeration-cycle equipment can be assuredly improved.

**[0017]** According to a second aspect, for example, the separating mechanism of the refrigeration-cycle equipment according to the first aspect is a filtering device employing a total filtering method. The filtering device employing a total filtering method is superior in separating the additive from the refrigerant liquid.

**[0018]** According to a third aspect, for example, the refrigeration-cycle equipment according to the first or second aspect further includes a flow rate adjustment mechanism for adjusting flow rate of the refrigerant liquid provided in the return passage. With the flow rate adjustment mechanism, the flow rate of the refrigerant liquid in the return passage can be adjusted according to need.

**[0019]** According to a fourth aspect, for example, the refrigeration-cycle equipment according to any one of the first to third aspects further includes a bypass passage that bypasses the separating mechanism and guides the refrigerant liquid from the condenser to the evaporator, and a flow rate adjustment mechanism that adjusts an amount of refrigerant liquid supplied from the condenser through the separating mechanism to the evaporator and an amount of refrigerant liquid supplied from the condenser through the bypass passage to the evaporator. With the bypass passage and the flow rate adjustment mechanism, if, for example, the additive is excessively concentrated in the condenser, a portion of the refrigerant liquid having a higher additive concentration than permeated liquid, which is refrigerant liquid that has permeated through the separating mechanism, can be supplied to the evaporator.

**[0020]** According to a fifth aspect, for example, the refrigeration-cycle equipment according to any one of the first to fourth aspects further includes an adjustment passage that has a valve and that guides the refrigerant liquid from the evaporator to the condenser. Even if the flow rate and the additive concentration of the refrigerant liquid in the return passage are different from the flow rate and the additive concentration of the refrigerant vapor in the vapor passage, the refrigeration-cycle equipment can continue to perform a steady operation by using the adjustment passage.

**[0021]** According to a sixth aspect, for example, the refrigeration-cycle equipment according to any one of the first to fifth aspects further includes a pump provided in the return passage. The pump generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the return passage.

**[0022]** According to a seventh aspect, for example, the separating mechanism of the refrigeration-cycle equipment according to the first aspect is a filtering device employing a cross flow method. The return passage includes (a1) an upstream portion that guides the refrigerant liquid to be treated by the separating mechanism from the condenser to the separating mechanism, (a2) a first downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism to the evaporator, and (a3) a second downstream portion that guides the refrigerant liquid whose additive concentration has been increased from the separating mechanism to the condenser. The filtering device employing a cross flow method has a lower probability of causing clogging of a filter unit than a filtering device employing a total filtering method, and can therefore provide stable performance and high reliability for a long time.

**[0023]** According to an eighth aspect, for example, the refrigeration-cycle equipment according to the seventh aspect further includes a flow rate adjustment mechanism provided in the return passage. With the flow rate adjustment mechanism, the flow rate of the refrigerant liquid in the return passage can be adjusted according

to need.

**[0024]** According to a ninth aspect, for example, the refrigeration-cycle equipment according to the seventh or eighth aspect further includes a bypass passage that bypasses the separating mechanism and that guides the refrigerant liquid from the condenser to the evaporator, and a flow rate adjustment mechanism that adjusts an amount of refrigerant liquid supplied from the condenser through the separating mechanism to the evaporator and an amount of refrigerant liquid supplied from the condenser through the bypass passage to the evaporator. According to the ninth aspect, the refrigerant liquid can be directly supplied from the condenser to the evaporator.

**[0025]** According to a tenth aspect, for example, the refrigeration-cycle equipment according to any one of the seventh to ninth aspects further includes an adjustment passage that has a valve and that guides the refrigerant liquid from the evaporator to the condenser. With the adjustment passage, the balance in the movement of the refrigerant component and the balance in the movement of the additive can each be made close to zero.

**[0026]** According to an eleventh aspect, for example, the refrigeration-cycle equipment according to the second aspect further includes an adjustment passage that guides the refrigerant liquid from the evaporator through the separating mechanism to the condenser. The return passage includes an upstream portion that guides the refrigerant liquid to be treated by the separating mechanism from the condenser to the separating mechanism, and a downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism to the evaporator. The adjustment passage includes an upstream portion that guides the refrigerant liquid to be treated by the separating mechanism from the evaporator to the separating mechanism, and a downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism to the condenser. The refrigeration-cycle equipment further includes a first three-way valve that selectively connects one of the upstream portion of the return passage and the upstream portion of the adjustment passage to an inlet of the separating mechanism, and a second three-way valve that selectively connects one of the downstream portion of the return passage and the downstream portion of the adjustment passage to an outlet of the separating mechanism. According to the eleventh aspect, the refrigerant liquid can be moved not only from the condenser to the evaporator but also from the evaporator to the condenser.

**[0027]** According to a twelfth aspect, for example, the refrigeration-cycle equipment according to the eleventh aspect further includes a bypass passage that bypasses the separating mechanism and that guides the refrigerant liquid from the evaporator to the condenser, and a flow rate adjustment mechanism that adjusts an amount of refrigerant liquid supplied from the evaporator through

the separating mechanism to the condenser and an amount of refrigerant liquid supplied from the evaporator through the bypass passage to the condenser. According to the twelfth aspect, the refrigerant liquid that is not treated by the separating mechanism can be supplied from the evaporator through the bypass passage to the condenser.

**[0028]** According to a thirteenth aspect, for example, the refrigeration-cycle equipment according to the seventh aspect further includes an adjustment passage that guides the refrigerant liquid from the evaporator through the separating mechanism to the condenser. The adjustment passage includes (b1) an upstream portion that guides the refrigerant liquid to be treated by the separating mechanism from the evaporator to the separating mechanism, (b2) a first downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism to the condenser, and (b3) a second downstream portion that guides the refrigerant liquid whose additive concentration has been increased from the separating mechanism to the evaporator. The refrigeration-cycle equipment further includes (c1) a first three-way valve that selectively connects one of the upstream portion of the return passage and the upstream portion of the adjustment passage to an inlet of the separating mechanism, (c2) a second three-way valve that selectively connects one of the first downstream portion of the return passage and the first downstream portion of the adjustment passage to a permeated liquid outlet of the separating mechanism, and (c3) a third three-way valve that selectively connects one of the second downstream portion of the return passage and the second downstream portion of the adjustment passage to a concentrated liquid outlet of the separating mechanism. According to the thirteenth aspect, the refrigerant liquid can be moved not only from the condenser to the evaporator but also from the evaporator to the condenser.

**[0029]** According to a fourteenth aspect, for example, the refrigeration-cycle equipment according to the thirteenth aspect further includes a bypass passage that bypasses the separating mechanism and that guides the refrigerant liquid from the evaporator to the condenser, and a flow rate adjustment mechanism that adjusts an amount of refrigerant liquid supplied from the evaporator through the separating mechanism to the condenser and an amount of refrigerant liquid supplied from the evaporator through the bypass passage to the condenser. According to the fourteenth aspect, the refrigerant liquid that is not treated by the separating mechanism can be supplied from the evaporator through the bypass passage to the condenser.

**[0030]** According to a fifteenth aspect, for example, the refrigeration-cycle equipment according to any one of the first to sixth aspects further includes an adjustment passage that guides the refrigerant liquid from the evaporator to the condenser, and a second separating mechanism provided in the adjustment passage and that separates

the additive from the refrigerant liquid supplied from the evaporator to the condenser. The second separating mechanism is a filtering device employing a total filtering method. The adjustment passage allows the refrigerant liquid whose additive concentration has been reduced to be supplied from the evaporator to the condenser.

**[0031]** According to a sixteenth aspect, for example, the refrigeration-cycle equipment according to the fifteenth aspect further includes a flow rate adjustment mechanism provided in the adjustment passage. With the flow rate adjustment mechanism, the flow rate of the refrigerant liquid in the adjustment passage can be adjusted according to need.

**[0032]** According to a seventeenth aspect, for example, the refrigeration-cycle equipment according to the fifteenth or sixteenth aspect further includes a bypass passage that bypasses the second separating mechanism and that guides the refrigerant liquid from the evaporator to the condenser, and a flow rate adjustment mechanism that adjusts an amount of refrigerant liquid supplied from the evaporator through the second separating mechanism to the condenser and an amount of refrigerant liquid supplied from the evaporator through the bypass passage to the condenser. According to the seventeenth aspect, the refrigerant liquid that is not treated by the second separating mechanism can be supplied from the evaporator through the bypass passage to the condenser.

**[0033]** According to an eighteenth aspect, for example, the refrigeration-cycle equipment according to any one of the seventh to ninth aspects further includes an adjustment passage that guides the refrigerant liquid from the evaporator to the condenser, and a second separating mechanism provided in the adjustment passage and that separates the additive from the refrigerant liquid supplied from the evaporator to the condenser. The second separating mechanism is a filtering device employing a cross flow method. The adjustment passage includes (d1) an upstream portion that guides the refrigerant liquid to be treated by the second separating mechanism from the evaporator to the second separating mechanism, (d2) a first downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the second separating mechanism to the condenser, and (d3) a second downstream portion that guides the refrigerant liquid whose additive concentration has been increased from the second separating mechanism to the evaporator. According to the eighteenth aspect, the balance in the amount of a substance that moves between the evaporator and the condenser can be adjusted by exchanging portions of permeated liquid, which is refrigerant liquid that has permeated through the second separating mechanism.

**[0034]** According to a nineteenth aspect, for example, the refrigeration-cycle equipment according to the eighteenth aspect further includes a flow rate adjustment mechanism provided in the adjustment passage. With the flow rate adjustment mechanism, the flow rate of the

refrigerant liquid in the adjustment passage can be adjusted according to need.

**[0035]** According to a twentieth aspect, for example, the refrigeration-cycle equipment according to the eighteenth or nineteenth aspect further includes a bypass passage that bypasses the second separating mechanism and that guides the refrigerant liquid from the evaporator to the condenser, and a flow rate adjustment mechanism that adjusts an amount of refrigerant liquid supplied from the evaporator through the second separating mechanism to the condenser and an amount of refrigerant liquid supplied from the evaporator through the bypass passage to the condenser. According to the twentieth aspect, the refrigerant liquid that is not treated by the second separating mechanism can be supplied from the evaporator through the bypass passage to the condenser.

**[0036]** According to a twenty-first aspect, for example, the refrigeration-cycle equipment according to any one of the first to twentieth aspects further includes a heat-absorbing circulation passage including a first heat exchanger and allowing a heat medium to circulate between the evaporator and the first heat exchanger. With a function of the heat-absorbing circulation passage, the refrigerant liquid stored in the evaporator can be heated efficiently.

**[0037]** According to a twenty-second aspect, for example, the heat medium that circulates through the heat-absorbing circulation passage of the refrigeration-cycle equipment according to the twenty-first aspect is the refrigerant liquid stored in the evaporator. According to the twenty-second aspect, the evaporator and the heat-absorbing circulation passage each have a simpler configuration than in a case where another heat medium circulates through the heat-absorbing circulation passage.

**[0038]** According to a twenty-third aspect, for example, the refrigeration-cycle equipment according to any one of the fifth, tenth, eleventh, thirteenth, fifteenth, and eighteenth aspects further includes a heat-absorbing circulation passage including a first heat exchanger and a pump provided between an outlet of the evaporator and an inlet of the first heat exchanger, the heat-absorbing circulation passage allowing a heat medium to circulate between the evaporator and the first heat exchanger. The adjustment passage branches off from the heat-absorbing circulation passage between an outlet of the pump and the inlet of the first heat exchanger. According to the twenty-third aspect, the number of pumps can be reduced. Hence, the cost and the total size of the refrigeration-cycle equipment can be reduced.

**[0039]** According to a twenty-fourth aspect, for example, the refrigeration-cycle equipment according to any one of the first to twenty-third aspects further includes a heat-dissipating circulation passage including a second heat exchanger and allowing a heat medium to circulate between the condenser and the second heat exchanger. With a function of the heat-dissipating circulation passage, the refrigerant liquid stored in the condenser can be cooled efficiently.

**[0040]** According to a twenty-fifth aspect, for example, the condenser of the refrigeration-cycle equipment according to the twenty-fourth aspect stores the refrigerant liquid generated by condensing the refrigerant vapor. The heat medium that circulates through the heat-dissipating circulation passage is the refrigerant liquid stored in the condenser. According to the twenty-fifth aspect, the condenser and the heat-dissipating circulation passage each have a simpler configuration than in a case where another heat medium circulates through the heat-dissipating circulation passage.

**[0041]** According to a twenty-sixth aspect, for example, the refrigeration-cycle equipment according to any one of the first to twenty-fifth aspects further includes a heat-dissipating circulation passage having a second heat exchanger and a pump provided between an outlet of the condenser and an inlet of the second heat exchanger, the heat-dissipating circulation passage allowing a heat medium to circulate between the condenser and the second heat exchanger. The return passage branches off from the heat-dissipating circulation passage between an outlet of the pump and the inlet of the second heat exchanger. According to the twenty-sixth aspect, the number of pumps can be reduced. Hence, the cost and the total size of the refrigeration-cycle equipment can be reduced.

**[0042]** According to a twenty-seventh aspect, for example, the additive employed in the refrigeration-cycle equipment according to any one of the first to twenty-sixth aspects is a substance that is mixed with the refrigerant component, and a solidifying temperature of the mixture is below a solidifying temperature of the refrigerant component. According to the twenty-seventh aspect, when the outdoor temperature is low, the refrigeration-cycle equipment can be used as an air conditioner (specifically, as a heater). Furthermore, under a condition that an object to be cooled has a temperature below zero, the refrigeration-cycle equipment can be used as a refrigerator.

**[0043]** According to a twenty-eighth aspect, for example, the additive employed in the refrigeration-cycle equipment according to any one of the first to twenty-seventh aspects is a substance that is mixed with the refrigerant component, and a saturated vapor pressure of the mixture at a specific temperature is below a saturated vapor pressure of the refrigerant component at the specific temperature. According to the twenty-eighth aspect, the amount of work that is required of the compressor can be reduced. Thus, the efficiency of the refrigeration-cycle equipment is improved.

**[0044]** According to a twenty-ninth aspect, for example, the refrigerant component employed in the refrigeration-cycle equipment according to any one of the first to twenty-eighth aspects is a substance whose saturated vapor pressure at room temperature is a negative pressure.

**[0045]** According to a thirtieth aspect, for example, in the refrigeration-cycle equipment according to any one

of the first to twenty-ninth aspects, a saturated vapor pressure P1 of the refrigerant liquid stored in the evaporator and being at a specific temperature is higher than a saturated vapor pressure P2 of the refrigerant liquid stored in the condenser and being at the specific temperature. According to the thirtieth aspect, with a reduction in the amount of work required of the compressor, the efficiency of the refrigeration-cycle equipment is improved.

**[0046]** Embodiments of the present disclosure will now be described with reference to the accompanying drawings. The present disclosure is not limited to the following embodiments.

#### 15 First Embodiment

**[0047]** As illustrated in Fig. 1, refrigeration-cycle equipment 100 according to a first embodiment includes an evaporator 21, a vapor passage 2, a condenser 23, and a return passage 3. Refrigerant vapor generated in the evaporator 21 is supplied to the condenser 23 through the vapor passage 2. The vapor passage 2 is provided with a compressor 22. The refrigerant vapor is compressed by the compressor 22. Refrigerant liquid resulting from the compressed refrigerant vapor condensed in the condenser 23 is supplied to the evaporator 21 through the return passage 3. The return passage 3 is provided with a separating mechanism 6.

**[0048]** The evaporator 21, the vapor passage 2, the condenser 23, and the return passage 3 are filled with a refrigerant containing, as a chief component, a substance whose saturated vapor pressure at room temperature ( $20^{\circ}\text{C} \pm 15^{\circ}\text{C}$  according to JIS Z8703 of Japanese Industrial Standards) is a negative pressure (a pressure, as an absolute pressure, lower than the atmospheric pressure). Examples of such a refrigerant include a refrigerant containing water, alcohol, or ether as a chief component. In the refrigeration-cycle equipment 100 that is in operation, the pressure in the refrigeration-cycle equipment 100 is lower than the atmospheric pressure. The pressure at the inlet of the compressor 22 falls within a range of, for example, 0.5 to 5 kPaA. The pressure at the outlet of the compressor 22 falls within a range of, for example, 5 to 15 kPaA. The term "chief component" refers to a component that dominates the largest proportion of the refrigerant by mass ratio.

**[0049]** The refrigerant is a mixture of a refrigerant component and an additive. The additive is typically a substance that is mixed with the refrigerant component such that the solidifying temperature of the mixture becomes lower than the solidifying temperature of the refrigerant component. Employing such a mixture as the refrigerant produces the following benefits. Specifically, when the outdoor temperature is low, the refrigeration-cycle equipment 100 can be used as an air conditioner (specifically, as a heater). Furthermore, under a condition that an object to be cooled has a temperature below zero, the refrigeration-cycle equipment 100 can be used as a refrig-

erator. Examples of the additive for preventing the freezing of the refrigerant include polyvalent alcohols such as ethylene glycol and propylene glycol, and inorganic salts such as potassium acetate. Other examples of the additive include preservative agents, rust-preventive agents, and so forth. The additive is contained in the refrigerant by, for example, 10 to 40% by mass.

**[0050]** The additive may be a substance that is mixed with the refrigerant component such that the saturated vapor pressure of the mixture at a specific temperature becomes lower than the saturated vapor pressure of the refrigerant component at the specific temperature. Such a function is produced by any of the polyvalent alcohols and inorganic salts mentioned above, as well as lithium bromide, which is used as an absorbent in an absorption refrigerator. If such an additive is contained in the refrigerant liquid stored in the condenser 23, refrigerant liquid at a required temperature (40°C, for example) is generated in the condenser 23 at a lower pressure than in a case where the refrigerant liquid stored in the condenser 23 contains only a refrigerant component. That is, the pressure (back pressure) at the outlet of the compressor 22 can be reduced. Consequently, the amount of work required of the compressor 22 can be reduced, whereby the efficiency of the refrigeration-cycle equipment 100 is improved.

**[0051]** The mixture as the refrigerant contains, for example, only one kind of additive having the above-described function. In such a case, the additive concentration of the refrigerant liquid stored in the condenser 23 is easily adjustable. If the saturated vapor pressure of the refrigerant liquid stored in the condenser 23 is appropriately adjustable, the mixture as the refrigerant may contain different kinds of additives each having the above-described function.

**[0052]** The term "specific temperature" referred to herein is a temperature within a range that the refrigerant may reach while the refrigeration-cycle equipment 100 is in operation. Such a temperature range is, for example, -20 to 50°C.

**[0053]** The refrigeration-cycle equipment 100 further includes a heat-absorbing circulation passage 10 and a heat-dissipating circulation passage 11.

**[0054]** The heat-absorbing circulation passage 10 includes a pump 12, a first heat exchanger 13, and passages (pipes) 10a to 10c. Two ends of the heat-absorbing circulation passage 10 are each connected to the evaporator 21. Specifically, one end of the passage 10a is connected to a lower portion (a portion below the surface of the refrigerant liquid) of the evaporator 21, and the other end of the passage 10a is connected to the inlet of the pump 12. One end of the passage 10b is connected to the outlet of the pump 12, and the other end of the passage 10b is connected to the inlet of the first heat exchanger 13. One end of the passage 10c is connected to the outlet of the first heat exchanger 13, and the other end of the passage 10c is connected to a middle portion of the evaporator 21. The pump 12 is provided at a po-

sition where the height from the inlet of the pump 12 to the surface of the refrigerant liquid stored in the evaporator 21 is larger than a required suction head (required net positive suction head

**[0055]** (NPSH)). The heat-absorbing circulation passage 10 allows a heat medium to circulate between the evaporator 21 and the first heat exchanger 13. In the first embodiment, the heat medium that circulates through the heat-absorbing circulation passage 10 is the refrigerant liquid stored in the evaporator 21. With such a function of the heat-absorbing circulation passage 10, the refrigerant liquid stored in the evaporator 21 is heated efficiently. Furthermore, since the refrigerant liquid stored in the evaporator 21 circulates through the heat-absorbing circulation passage 10, the evaporator 21 and the heat-absorbing circulation passage 10 each have a simpler configuration than in a case where another heat medium circulates through the heat-absorbing circulation passage 10.

**[0056]** The first heat exchanger 13 may be a known heat exchanger such as a fin-tube heat exchanger or a shell-tube heat exchanger. For example, in a case where the refrigeration-cycle equipment 100 is an air conditioner that cools an indoor space, the first heat exchanger 13 is provided in the indoor space, whereby indoor air is cooled by using the refrigerant liquid.

**[0057]** The heat-dissipating circulation passage 11 includes a pump 14, a second heat exchanger 15, and passages (pipes) 11a to 11c. Two ends of the heat-dissipating circulation passage 11 are each connected to the condenser 23. Specifically, one end of the passage 11a is connected to a lower portion (a portion below the surface of the refrigerant liquid) of the condenser 23, and the other end of the passage 11a is connected to the inlet of the pump 14. One end of the passage 11b is connected to the outlet of the pump 14, and the other end of the passage 11b is connected to the inlet of the second heat exchanger 15. One end of the passage 11c is connected to the outlet of the second heat exchanger 15, and the other end of the passage 11c is connected to a middle portion of the condenser 23. The pump 14 is provided at a position where the height from the inlet of the pump 14 to the surface of the refrigerant liquid stored in the condenser 23 is larger than a required suction head (required NPSH). The heat-dissipating circulation passage 11 allows a heat medium to circulate between the condenser 23 and the second heat exchanger 15. In the first embodiment, the heat medium that circulates through the heat-dissipating circulation passage 11 is the refrigerant liquid stored in the condenser 23. With such a function of the heat-dissipating circulation passage 11, the refrigerant liquid stored in the condenser 23 is cooled efficiently. Furthermore, since the refrigerant liquid stored in the condenser 23 circulates through the heat-dissipating circulation passage 11, the condenser 23 and the heat-dissipating circulation passage 11 each have a simpler configuration than in a case where another heat medium circulates through the heat-dissipating circulation pas-

sage 11.

**[0058]** The second heat exchanger 15 may be a known heat exchanger such as a fin-tube heat exchanger or a shell-tube heat exchanger. For example, in a case where the refrigeration-cycle equipment 100 is an air conditioner that cools an indoor space, the second heat exchanger 15 is provided in an outdoor space, whereby outdoor air is heated by using the refrigerant liquid.

**[0059]** The evaporator 21 includes, for example, a heat-insulating, pressure-resistant container. The evaporator 21 stores the refrigerant liquid and evaporates the refrigerant therein. That is, the refrigerant liquid that has been heated by absorbing heat from the outer environment boils in the evaporator 21. In the first embodiment, the refrigerant liquid stored in the evaporator 21 directly comes into contact with the refrigerant liquid that circulates through the heat-absorbing circulation passage 10. That is, a portion of the refrigerant liquid stored in the evaporator 21 is heated in the first heat exchanger 13 and is used for heating another portion of the refrigerant liquid that is in a saturated state.

**[0060]** As described above, the additive contained in the refrigerant may be a substance that is mixed with the refrigerant component such that the saturated vapor pressure of the mixture (the refrigerant) at a specific temperature becomes lower than the saturated vapor pressure of the refrigerant component at the specific temperature. In such a case, a large portion of the refrigerant vapor generated in the evaporator 21 is occupied by the refrigerant component. Although it depends on the kind of the additive, the ratio of the refrigerant component to the refrigerant vapor is, for example, 99.8% by mass or higher. Note that the refrigerant vapor may contain only the refrigerant component, except air that is inevitably contained.

**[0061]** The heat-absorbing circulation passage 10 and the evaporator 21 may be configured such that the refrigerant liquid stored in the evaporator 21 is not mixed with the heat medium circulating through the heat-absorbing circulation passage 10. For example, in a case where the evaporator 21 includes a heat exchanging mechanism such as a shell-tube heat exchanger, the refrigerant liquid stored in the evaporator 21 can be heated and evaporated by using the heat medium circulating through the heat-absorbing circulation passage 10. In such a configuration, the first heat exchanger 13 heats the heat medium that is used for heating the refrigerant liquid stored in the evaporator 21. Such a configuration is advantageous in that the total length of passages forming a vacuum system can be reduced. Additionally, a heat source may be provided to the evaporator 21.

**[0062]** The vapor passage 2 guides the refrigerant vapor from the evaporator 21 to the condenser 23. The vapor passage 2 includes an upstream portion 25 and a downstream portion 26. The upstream portion 25 connects an upper portion of the evaporator 21 to the inlet of the compressor 22. The downstream portion 26 connects the outlet of the compressor 22 to an upper portion

of the condenser 23. The compressor 22 may be a centrifugal compressor or a capacity compressor. The compressor 22 takes the refrigerant vapor from the evaporator 21 through the upstream portion 25 and compresses the refrigerant vapor adiabatically. The refrigerant vapor thus compressed is supplied to the condenser 23 through the downstream portion 26.

**[0063]** The vapor passage 2 may be provided with a plurality of compressors. In such a case, an intercooler may be provided between a low-pressure-side compressor and a high-pressure-side compressor. The intercooler cools the refrigerant vapor that has been compressed by the low-pressure-side compressor. Thus, the performance and the reliability of the high-pressure-side compressor can be improved. The fluid used for cooling the refrigerant vapor in the intercooler may be the refrigerant flowing through a specific portion (the heat-dissipating circulation passage 11, for example) of the refrigeration-cycle equipment 100 or a heat medium (air or water, for example) supplied from the outside of the refrigeration-cycle equipment 100, or a combination of the two. Moreover, a plurality of intercoolers may be provided to the vapor passage 2. For example, if the n number (where n is an integer of 3 or larger) of compressors are provided in the vapor passage 2, the (n-1) number of intercoolers can be provided in the vapor passage 2.

**[0064]** The condenser 23 includes, for example, a heat-insulating, pressure-resistant container. The condenser 23 condenses the refrigerant vapor and stores refrigerant liquid obtained through the condensation of the refrigerant vapor. In the first embodiment, refrigerant vapor that is in a superheated state is condensed by directly coming into contact with the refrigerant liquid that has been cooled by dissipating its heat to the outer environment. The refrigerant liquid stored in the condenser 23 directly comes into contact with the refrigerant liquid circulating through the heat-dissipating circulation passage 11. That is, a portion of the refrigerant liquid stored in the condenser 23 is cooled in the second heat exchanger 15 and is used for cooling the superheated refrigerant vapor.

**[0065]** The heat-dissipating circulation passage 11 and the condenser 23 may be configured such that the refrigerant liquid stored in the condenser 23 is not mixed with the heat medium circulating through the heat-dissipating circulation passage 11. For example, in a case where the condenser 23 includes a heat exchanging mechanism such as a shell-tube heat exchanger, the refrigerant vapor can be cooled and condensed by using the heat medium circulating through the heat-dissipating circulation passage 11. In such a case, the second heat exchanger 15 cools the heat medium that is used for cooling the refrigerant vapor. Such a configuration is advantageous in that the total length of passages forming a vacuum system can be reduced. Additionally, a heat absorbing source may be provided to the condenser 23.

**[0066]** In the first embodiment, the evaporator 21 and the condenser 23 are each a direct-contact heat ex-

changer. Therefore, the sizes of the evaporator 21 and the condenser 23 are easy to be reduced. On the other hand, in a case where a heat medium that is different from the refrigerant circulates through the heat-absorbing circulation passage 10 (or the heat-dissipating circulation passage 11), the NPSH required of the pump 12 (or the pump 14) is reduced. Therefore, the height of the refrigeration-cycle equipment 100 can be reduced.

**[0067]** The return passage 3 guides the refrigerant liquid from the condenser 23 to the evaporator 21. The return passage 3 includes an upstream portion 31 and a downstream portion 32. The upstream portion 31 connects the lower portion of the condenser 23 to the inlet of the separating mechanism 6. The downstream portion 32 connects the outlet of the separating mechanism 6 to the lower portion of the evaporator 21. That is, the upstream end of the return passage 3 is connected to the lower portion of the condenser 23, and the downstream end of the return passage 3 is connected to the lower portion of the evaporator 21. Thus, the refrigerant in a liquid phase is allowed to move from the condenser 23 to the evaporator 21. The separating mechanism 6 has a function of separating the additive from the refrigerant liquid that is supplied from the condenser 23 to the evaporator 21. In other words, the separating mechanism 6 separates the refrigerant component and the additive from each other, thereby preventing the additive in the condenser 23 from moving to the evaporator 21 together with the refrigerant component.

**[0068]** The mass flow rate of the refrigerant vapor in the vapor passage 2 is equal to, for example, the mass flow rate of the refrigerant liquid in the return passage 3. The mass flow rate of the refrigerant component in the vapor passage 2 is equal to, for example, the mass flow rate of the refrigerant component in the downstream portion 32 of the return passage 3. In such a configuration, the additive concentration of the refrigerant liquid stored in the evaporator 21 is maintained to be constant, and the additive concentration of the refrigerant liquid stored in the condenser 23 is also maintained to be constant. The additive concentration of the refrigerant liquid having permeated through the separating mechanism 6 is satisfactorily lower than the additive concentration of the refrigerant liquid stored in the condenser 23. The refrigerant liquid having permeated through the separating mechanism 6 contains the refrigerant component and a small amount of additive. Although it depends on the performance of the separating mechanism 6, the additive concentration of the refrigerant liquid having permeated through the separating mechanism 6 may be higher than the additive concentration of the refrigerant vapor flowing in the vapor passage 2. The refrigerant liquid having permeated through the separating mechanism 6 may contain only the refrigerant component.

**[0069]** In the first embodiment, the separating mechanism 6 is a filtering device employing a total filtering method. The refrigerant liquid having permeated through the separating mechanism 6 (hereinafter also referred to as

permeated liquid) is supplied to the evaporator 21. The filtering device employing a total filtering method is superior in separating additives from refrigerant liquid. Furthermore, the filtering device employing a total filtering method is advantageous in that the size can be reduced, the cost is relatively low, cleaning is basically not necessary, and so forth. Since the refrigerant employed in the refrigeration-cycle equipment 100 does not contain an insoluble substance, the filtering device employing a total filtering method is particularly suitable as the separating mechanism 6. Specifically, the filtering device employing a total filtering method includes a semi-permeable membrane. With the filtering device including a semi-permeable membrane, additives can be separated from refrigerant liquid by utilizing the difference between the pressures at the inlet and at the outlet of the filtering device. Examples of the semi-permeable membrane include a reverse osmosis membrane (RO membrane). The configuration of the separating mechanism 6 is not particularly limited as long as the additive can be separated from the refrigerant liquid by utilizing the difference between the pressures at the inlet and at the outlet of the separating mechanism 6.

**[0070]** It is not necessary that the downstream end of the return passage 3 be directly connected to the evaporator 21. As long as there is a satisfactory difference between the pressures at the inlet and at the outlet of the separating mechanism 6, the downstream end of the return passage 3 may be connected to a secondary loop (the heat-absorbing circulation passage 10 in the first embodiment) connected to the evaporator 21. However, it is desirable that the downstream end of the return passage 3 be connected to the evaporator 21 or a portion of the secondary loop where the pressure is lowest. In such a configuration, the driving pressure that is necessary for causing the refrigerant liquid to flow through the return passage 3 can be reduced, and the efficiency of the refrigeration-cycle equipment 100 is improved. From such a viewpoint, it is desirable that the downstream end of the return passage 3 be connected to the evaporator 21. In addition, to prevent the refrigerant liquid flowing into the evaporator 21 through the return passage 3 from significantly affecting the suction of the pump 12, it is desirable that the upstream end of the heat-absorbing circulation passage 10 and the downstream end of the return passage 3 be at an appropriate distance from each other.

**[0071]** In the first embodiment, the return passage 3 is provided with no pumps. In such a configuration, the refrigerant liquid in the condenser 23 is returned to the evaporator 21 through the separating mechanism 6 by the following two driving pressures. One is a driving pressure attributed to the difference between the saturated vapor pressure of the refrigerant liquid stored in the evaporator 21 and the saturated vapor pressure of the refrigerant liquid stored in the condenser 23. The other is a driving pressure attributed to the difference between the surface level of the refrigerant liquid stored in the evaporator 21 and the surface level of the refrigerant liquid

stored in the condenser 23 (the difference in refrigerant liquid head). Omitting pumps reduces the cost.

**[0072]** A saturated vapor pressure  $P_2$  of the refrigerant liquid stored in the condenser 23 and being at a specific temperature is lower than a saturated vapor pressure  $P_1$  of the refrigerant liquid stored in the evaporator 21 and being at the specific temperature. That is, supposing that a temperature  $T_1$  of the refrigerant liquid stored in the evaporator 21 is equal to a temperature  $T_2$  of the refrigerant liquid stored in the condenser 23, a relationship of (saturated vapor pressure  $P_1$ ) > (saturated vapor pressure  $P_2$ ) holds. If this relationship holds, the power (compressing work) of the compressor 22 that is required for generating refrigerant liquid that is at a predetermined temperature (40°C, for example) in the condenser 23 can be reduced. That is, the efficiency of the refrigeration-cycle equipment 100 can be improved. Reasons for such a logic will now be described in detail.

**[0073]** For example, to satisfactorily utilize the performance of the refrigeration-cycle equipment 100 in a cooling use, the temperature of the refrigerant liquid stored in the condenser 23 needs to be higher than the temperature on the outside. The temperature of the refrigerant liquid generated in the condenser 23 depends on the pressure of the refrigerant vapor supplied to the condenser 23 and the saturated vapor pressure of the refrigerant liquid stored in the condenser 23.

**[0074]** Here is a first case in which the saturated vapor pressure of refrigerant liquid stored in an evaporator is equal to the saturated vapor pressure of refrigerant liquid stored in a condenser. In the first case, as illustrated in Fig. 16A, not only the temperature and the pressure in the evaporator but also the temperature and the pressure in the condenser change along a single saturated-vapor-pressure curve  $C_{REF}$ . Therefore, for example, to generate a refrigerant liquid at 40°C in the condenser from a refrigerant liquid at 10°C stored in the evaporator, the pressure of the refrigerant vapor generated in the evaporator needs to be raised from  $P_A$  (1.7 kPa, for example) to at least  $P_C$  (9 kPa, for example).

**[0075]** Here is a second case in which the saturated vapor pressure of the refrigerant liquid stored in the condenser 23 and being at a specific temperature is lower than the saturated vapor pressure of the refrigerant liquid stored in the evaporator 21 and being at the specific temperature. In the second case, as illustrated in Fig. 16B, the temperature and the pressure in the evaporator 21 change along a saturated-vapor-pressure curve  $C_{EVA}$ , whereas the temperature and the pressure in the condenser 23 change along a saturated-vapor-pressure curve  $C_{CON}$ . Supposing that the saturated-vapor-pressure curve  $C_{EVA}$  conforms to the saturated-vapor-pressure curve  $C_{REF}$  illustrated in Fig. 16A, a refrigerant liquid at 40°C can be generated in the condenser 23 from a refrigerant at 10°C in the evaporator 21 by raising the pressure of the refrigerant vapor generated in the evaporator 21 from  $P_A$  to  $P_B$  (7 kPa, for example). That is, the amount of work corresponding to a pressure difference

( $P_C - P_E$ ) can be saved.

**[0076]** In the first embodiment, the above-described relationship of (saturated vapor pressure  $P_1$ ) > (saturated vapor pressure  $P_2$ ) is maintained by adjusting the composition of the refrigerant liquid stored in the condenser 23. The composition of the refrigerant liquid is closely related to the saturated vapor pressure of the refrigerant liquid. Therefore, the saturated vapor pressure can be changed relatively easily by adjusting the composition of the refrigerant liquid.

**[0077]** More specifically, the composition of the refrigerant liquid stored in the condenser 23 is adjusted such that an additive concentration  $C_2$  (in % by mass) of the refrigerant liquid stored in the condenser 23 exceeds an additive concentration  $C_1$  (in % by mass) of the refrigerant liquid stored in the evaporator 21. By adjusting the additive concentration, the saturated vapor pressure of the refrigerant liquid stored in the condenser 23 can be changed relatively easily. In the first embodiment, the refrigeration-cycle equipment 100 includes the separating mechanism 6 as means for adjusting the additive concentration.

**[0078]** Suppose that the additive concentration of the refrigerant liquid stored in the evaporator 21 is  $\alpha\%$  by mass, and the additive concentration of the refrigerant vapor flowing in the vapor passage 2 is  $\beta\%$  by mass. When the saturated vapor pressure of a mixture of the additive and the refrigerant component is below the saturated vapor pressure of the refrigerant component, the saturated vapor pressure of a solution (an aqueous solution, for example) of the additive is also below the saturated vapor pressure of the refrigerant component, in general. Hence, in general, the value represented by  $\alpha$  is larger than the value represented by  $\beta$ . When the refrigerant liquid evaporates in the evaporator 21, the refrigerant component having a high saturated vapor pressure easily evaporates. Therefore, the refrigerant component occupies the entirety or a large portion of the refrigerant vapor. Note that, in a case where only the refrigerant component is stored in the evaporator 21, a relationship of  $\alpha = \beta = 0$  holds.

**[0079]** The refrigerant vapor generated in the evaporator 21 is compressed by the compressor 22, thereby turning into superheated vapor. The superheated vapor flows into the condenser 23. The condenser 23 stores the refrigerant liquid containing the refrigerant component and the additive. Letting the additive concentration of the refrigerant liquid be  $\gamma\%$  by mass, the value represented by  $\gamma$  is larger than the value represented by  $\alpha$  and the value represented by  $\beta$ . In general, the higher the concentration of a solute component having a low saturated vapor pressure, the lower the saturated vapor pressure of a mixture containing the solute component. Hence, when the additive concentration in the condenser 23 ( $\gamma\%$  by mass) is higher than the additive concentration in the evaporator 21 ( $\alpha\%$  by mass), the range of reduction in the saturated vapor pressure in the condenser 23 exceeds the range of reduction in the saturated vapor pres-

sure in the evaporator 21. Consequently, the pressure ratio between the evaporator 21 and the condenser 23, i.e., the compression ratio and the amount of work that are required of the compressor 22, can be reduced. Thus, the system efficiency of the refrigeration-cycle equipment 100 is improved. The larger the difference between the additive concentration in the condenser 23 ( $\gamma\%$  by mass) and the additive concentration in the evaporator 21 ( $\alpha\%$  by mass), the higher the superiority of the refrigeration-cycle equipment 100.

**[0080]** Letting the saturated vapor pressure of the refrigerant component at a specific temperature be  $P$ , and the saturated vapor pressure of the refrigerant that is in a specific portion of the refrigeration-cycle equipment 100 and is at the specific temperature be  $P_n$ , the specific portion that maximizes a value  $(P - P_n)$  is the condenser 23 in the first embodiment. Here, the pressure ratio between the evaporator 21 and the condenser 23 can be made satisfactorily small.

**[0081]** The magnitude of the difference between the saturated vapor pressure  $P_1$  and the saturated vapor pressure  $P_2$  is not particularly limited. The magnitude of the difference between the additive concentration  $C_2$  and the additive concentration  $C_1$  is not particularly limited, either. As long as the relationship of (saturated vapor pressure  $P_1$ ) > (saturated vapor pressure  $P_2$ ) or (additive concentration  $C_2$ ) > (additive concentration  $C_1$ ) holds, the amount of work required of the compressor 22 can be assuredly made smaller than in a case where (saturated vapor pressure  $P_1$ ) = (saturated vapor pressure  $P_2$ ) or (additive concentration  $C_2$ ) = (additive concentration  $C_1$ ).

**[0082]** If the mass flow rates of the refrigerant vapor and the refrigerant component in the vapor passage 2 are equal to the mass flow rates of the refrigerant liquid and the refrigerant component in the return passage 3, the additive concentration in the evaporator 21 and the additive concentration in the condenser 23 are maintained to be constant. However, the mass flow rates of the refrigerant vapor and the refrigerant component in the vapor passage 2 are not necessarily equal to the mass flow rates of the refrigerant liquid and the refrigerant component in the return passage 3. For example, the additive concentration of the refrigerant liquid having permeated through the separating mechanism 6 and being supplied to the evaporator 21 may exceed the additive concentration of the refrigerant vapor flowing in the vapor passage 2. In such a case, the additive inevitably concentrates in the evaporator 21. Therefore, as to be described below, a portion of the refrigerant liquid stored in the evaporator 21 and a portion of the refrigerant liquid stored in the condenser 23 may be exchanged regularly or continuously. Even if the refrigeration-cycle equipment 100 is configured such that the portions of the refrigerant liquid are exchanged, the separating mechanism 6 functions such that the variation in the additive concentration in each of the evaporator 21 and the condenser 23 can be reduced. Hence, the amount of refrigerant liquid to be

exchanged can be made smaller than in the known refrigeration-cycle equipment that does not include the separating mechanism 6. That is, since the heat loss accompanying the exchange of the portions of the refrigerant liquid can be reduced, the system efficiency of the refrigeration-cycle equipment 100 is assuredly improved.

**[0083]** Pieces of refrigeration-cycle equipment according to other embodiments will now be described. The description of the refrigeration-cycle equipment 100 according to the first embodiment illustrated in Fig. 1 is also applicable to the following embodiments, unless they technically contradict the first embodiment. Moreover, details of any of the following embodiments are applicable to the pieces of refrigeration-cycle equipment according to other embodiments, as well as to the refrigeration-cycle equipment 100 illustrated in Fig. 1, unless they technically contradict one another. In some of the drawings illustrating the following embodiments, the heat-absorbing circulation passage 10 and the heat-dissipating circulation passage 11 are omitted.

## Second Embodiment

**[0084]** Refrigeration-cycle equipment 102 illustrated in Fig. 2 includes a flow rate adjustment mechanism 81 provided in the return passage 3, in addition to the elements included in the refrigeration-cycle equipment 100 according to the first embodiment. In Fig. 2, the flow rate adjustment mechanism 81 is provided in the downstream portion 32 of the return passage 3. The flow rate adjustment mechanism 81 may alternatively be provided in the upstream portion 31. Examples of the flow rate adjustment mechanism 81 include a check valve, a sluice valve, and a flow rate control valve. With the flow rate adjustment mechanism 81, the flow rate of the refrigerant liquid in the return passage 3 can be adjusted according to need. Furthermore, while the refrigeration-cycle equipment 102 is not in operation, since there are differences in saturated vapor pressure and in refrigerant liquid head between the evaporator 21 and the condenser 23, the refrigerant liquid can be prevented from excessively flowing from the condenser 23 into the evaporator 21. The flow rate of the refrigerant liquid in the return passage 3 may be adjusted when the refrigeration-cycle equipment 102 is performing a rated operation or a transient operation. The flow rate adjustment mechanism 81 may be controlled such that the refrigerant liquid is intermittently supplied from the condenser 23 to the evaporator 21.

**[0085]** As is obvious from the second embodiment, changing the flow rate between 0 and 1 by using a device such as a sluice valve is included in the adjustment of the flow rate in this specification.

## Third Embodiment

**[0086]** Refrigeration-cycle equipment 104 illustrated in Fig. 3A includes a bypass passage 34 and a flow rate adjustment mechanism 85 in addition to the elements

included in the refrigeration-cycle equipment 100 according to the first embodiment or the refrigeration-cycle equipment 102 according to the second embodiment. The bypass passage 34 guides the refrigerant liquid from the condenser 23 to the evaporator 21 and bypasses the separating mechanism 6. The flow rate adjustment mechanism 85 adjusts the amount of refrigerant liquid supplied from the condenser 23 through the separating mechanism 6 to the evaporator 21 and the amount of refrigerant liquid supplied from the condenser 23 through the bypass passage 34 to the evaporator 21. With the bypass passage 34 and the flow rate adjustment mechanism 85 if, for example, the additive excessively concentrates in the condenser 23, the refrigerant liquid having a higher additive concentration than the permeated liquid can be supplied to the evaporator 21. Furthermore, if the refrigerant liquid needs to be supplied quickly from the condenser 23 to the evaporator 21, the bypass passage 34 can be used.

**[0087]** The bypass passage 34 branches off from the upstream portion 31 of the return passage 3 and merges with the downstream portion 32 of the return passage 3. Alternatively, the upstream end of the bypass passage 34 may be directly connected to the condenser 23, and the downstream end of the bypass passage 34 may be directly connected to the evaporator 21. In the third embodiment, the flow rate adjustment mechanism 85 is a three-way valve that is capable of switching its state between a first state and a second state. In the first state, the refrigerant liquid is supplied from the condenser 23 through the separating mechanism 6 to the evaporator 21. In the second state, the refrigerant liquid is supplied from the condenser 23 through the bypass passage 34 to the evaporator 21. The three-way valve as the flow rate adjustment mechanism 85 is provided at the position where the bypass passage 34 branches off from the upstream portion 31 of the return passage 3. The three-way valve as the flow rate adjustment mechanism 85 may alternatively be provided at the position where the bypass passage 34 merges with the downstream portion 32 of the return passage 3.

**[0088]** As illustrated in Fig. 3B, the flow rate adjustment mechanism 85 may include a first valve 82 provided in the return passage 3 and a second valve 83 provided in the bypass passage 34. In the case where the bypass passage 34 branches off from the return passage 3 and merges with the return passage 3, the first valve 82 can be provided in the return passage 3 between the branching position and the merging position. The first valve 82 and the second valve 83 may each be a sluice valve or a flow rate control valve.

#### Fourth Embodiment

**[0089]** Refrigeration-cycle equipment 106 illustrated in Fig. 4 includes an adjustment passage 9 in addition to the elements included in any one of the pieces of refrigeration-cycle equipment 100, 102, and 104 according to

the first, second, and third embodiments. The adjustment passage 9 guides the refrigerant liquid from the evaporator 21 to the condenser 23. The adjustment passage 9 is provided with a pump 52 and a valve 91. The valve 91 is, for example, a sluice valve. Even if the flow rate and the additive concentration of the refrigerant liquid (the permeated liquid) in the return passage 3 are different from those of the refrigerant vapor in the vapor passage 2, the refrigeration-cycle equipment 106 can continue to perform a steady operation by using the adjustment passage 9.

**[0090]** For example, suppose that the additive concentration of the permeated liquid flowing in the return passage 3 is larger than the additive concentration of the refrigerant vapor flowing in the vapor passage 2. Specifically, suppose that the refrigerant vapor flowing in the vapor passage 2 contains water (the refrigerant component) and ethylene glycol (the additive) by 99.9% and by 0.1%, respectively, while the permeated liquid flowing in the return passage 3 contains water and ethylene glycol by 99% and by 1%, respectively. If the mass flow rate of the refrigerant vapor is equal to the mass flow rate of the permeated liquid, the amount of water that moves from the evaporator 21 to the condenser 23 per unit time is larger than the amount of water that moves from the condenser 23 to the evaporator 21 per unit time. If the refrigeration-cycle equipment 106 continues to operate in such a state, the concentration of ethylene glycol in the evaporator 21 increases, whereas the concentration of ethylene glycol in the condenser 23 decreases. To avoid such a variation in the concentration of ethylene glycol, the amount of water that moves per unit time needs to be equalized between that in the vapor passage 2 and that in the return passage 3. That is, the flow rate adjustment mechanism 81 (see Fig. 2) and other devices are controlled such that the mass flow rate of the permeated liquid slightly exceeds the mass flow rate of the refrigerant vapor. Consequently, the amount of water in the evaporator 21 and the amount of water in the condenser 23 are each maintained to be constant. However, the amount of ethylene glycol that moves from the condenser 23 to the evaporator 21 per unit time still exceeds the amount of ethylene glycol that moves from the evaporator 21 to the condenser 23 per unit time. Hence, the amount of refrigerant liquid in the evaporator 21 gradually increases, whereas the amount of refrigerant liquid in the condenser 23 gradually decreases.

**[0091]** To address such a problem, the adjustment passage 9 is used, and the refrigerant liquid is regularly or continuously supplied from the evaporator 21 to the condenser 23. Thus, the balance in the movement of water and the balance in the movement of ethylene glycol each substantially become even (the balance becomes close to zero), and the amount of refrigerant liquid in the evaporator 21 and the amount of refrigerant liquid in the condenser 23 are each maintained to be constant. Consequently, the refrigeration-cycle equipment 106 can continue to perform a steady operation.

## Fifth Embodiment

**[0092]** Refrigeration-cycle equipment 108 illustrated in Fig. 5 includes a pump 51 provided in the return passage 3, in addition to the elements included in any one of the pieces of refrigeration-cycle equipment 100 to 106 according to the first to fourth embodiments. Specifically, the pump 51 is provided in the upstream portion 31 of the return passage 3. In addition to the differences in saturated vapor pressure and in refrigerant liquid head between the evaporator 21 and the condenser 23 that are produced as described above, the pump 51 generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the return passage 3. According to the fifth embodiment, a high driving pressure can be applied to the refrigerant liquid. Therefore, the size of the separating mechanism 6 can be reduced. Furthermore, the permeability of the separating mechanism 6 (the purity of the refrigerant component contained in the permeated liquid) can be improved. Furthermore, since a supply source for the driving pressure is provided in addition to the differences in saturated vapor pressure and in refrigerant liquid head, the flow rate of the permeated liquid in the return passage 3 can be adjusted relatively freely. For example, even if any conditions for operating the refrigeration-cycle equipment 108 change, the change in the flow rate of the permeated liquid in the return passage 3 can be reduced.

## Sixth Embodiment

**[0093]** In refrigeration-cycle equipment 110 illustrated in Fig. 6, the separating mechanism 6 is a filtering device employing a cross flow method. The filtering device employing a cross flow method may be a filtering device employing a semi-permeable membrane, as with the filtering device employing a total filtering method. In general, the filtering device employing a cross flow method has a lower probability of causing clogging of a filter unit than the filtering device employing a total filtering method, and can therefore provide stable performance and high reliability for a long time.

**[0094]** In the sixth embodiment, the return passage 3 includes the upstream portion 31, a first downstream portion 32, and a second downstream portion 33. The upstream portion 31 guides the refrigerant liquid (the original liquid) to be treated by the separating mechanism 6 from the condenser 23 to the separating mechanism 6. The first downstream portion 32 guides the refrigerant liquid (the permeated liquid) whose additive concentration has been reduced from the separating mechanism 6 to the evaporator 21. The second downstream portion 33 guides (returns) the refrigerant liquid (the concentrated liquid) whose additive concentration has been increased from the separating mechanism 6 to the condenser 23.

**[0095]** The refrigerant liquid to be treated flows from the condenser 23 through the upstream portion 31 into

the separating mechanism 6. The permeated liquid is discharged from a permeated liquid outlet of the separating mechanism 6 and flows through the first downstream portion 32 into the evaporator 21. The concentrated liquid is discharged from a concentrated liquid outlet of the separating mechanism 6 and flows through the second downstream portion 33 into the condenser 23. The upstream portion 31 is provided with the pump 51. In addition to the differences in saturated vapor pressure and in refrigerant liquid head between the evaporator 21 and the condenser 23, the pump 51 produces a driving pressure that is necessary for causing the refrigerant liquid to flow through the return passage 3.

## Seventh Embodiment

**[0096]** Refrigeration-cycle equipment 112 illustrated in Fig. 7 includes the flow rate adjustment mechanism 81 provided in the return passage 3, in addition to the elements included in the refrigeration-cycle equipment 110 according to the sixth embodiment. The flow rate adjustment mechanism 81 is provided in the first downstream portion 32 of the return passage 3. Alternatively, the flow rate adjustment mechanism 81 may be provided in at least one of the upstream portion 31, the first downstream portion 32, and the second downstream portion 33. Examples of the flow rate adjustment mechanism 81 include a check valve, a sluice valve, and a flow rate control valve. According to the seventh embodiment, as in the case of the refrigeration-cycle equipment 102 according to the second embodiment, the flow rate of the refrigerant liquid in the return passage 3 can be adjusted.

## Eighth Embodiment

**[0097]** Refrigeration-cycle equipment 114 illustrated in Fig. 8 includes the bypass passage 34 and the flow rate adjustment mechanism 85 in addition to the elements included in the refrigeration-cycle equipment 110 according to the sixth embodiment or in the refrigeration-cycle equipment 112 according to the seventh embodiment. The bypass passage 34 guides the refrigerant liquid from the condenser 23 to the evaporator 21 and bypasses the separating mechanism 6. The flow rate adjustment mechanism 85 adjusts the amount of refrigerant liquid supplied from the condenser 23 through the separating mechanism 6 to the evaporator 21 and the amount of refrigerant liquid supplied from the condenser 23 through the bypass passage 34 to the evaporator 21. According to the eighth embodiment, as in the case of the refrigeration-cycle equipment 104 according to the third embodiment, the refrigerant liquid can be supplied directly from the condenser 23 to the evaporator 21. Furthermore, the additive concentration in the condenser 23 can be reduced while the additive concentration in the evaporator 21 can be increased.

**[0098]** The bypass passage 34 branches off from the upstream portion 31 of the return passage 3 and merges

with the first downstream portion 32 of the return passage 3. Alternatively, the upstream end of the bypass passage 34 may be directly connected to the condenser 23, and the downstream end of the bypass passage 34 may be directly connected to the evaporator 21. In the eighth embodiment, the flow rate adjustment mechanism 85 is a three-way valve that is capable of switching its state between a first state and a second state. In the first state, the refrigerant liquid is supplied from the condenser 23 through the separating mechanism 6 to the evaporator 21. In the second state, the refrigerant liquid is supplied from the condenser 23 through the bypass passage 34 to the evaporator 21. The three-way valve as the flow rate adjustment mechanism 85 is provided at the position where the bypass passage 34 branches off from the upstream portion 31 of the return passage 3. The three-way valve as the flow rate adjustment mechanism 85 may alternatively be provided at the position where the bypass passage 34 merges with the first downstream portion 32 of the return passage 3.

**[0099]** As described above with reference to Fig. 3B, the flow rate adjustment mechanism 85 may be replaced with a combination of the first valve 82 provided in the return passage 3 and the second valve 83 provided in the bypass passage 34. In the case where the bypass passage 34 branches off from the return passage 3 and merges with the return passage 3, the first valve 82 can be provided in the return passage 3 between the branching position and the merging position. The first valve 82 and the second valve 83 may each be a sluice valve or a flow rate control valve.

#### Ninth Embodiment

**[0100]** Refrigeration-cycle equipment 116 illustrated in Fig. 9 includes the adjustment passage 9 in addition to the elements included in any one of the pieces of refrigeration-cycle equipment 110, 112, and 114 according to the sixth, seventh, and eighth embodiments. The adjustment passage 9 guides the refrigerant liquid from the evaporator 21 to the condenser 23. The adjustment passage 9 is provided with the pump 52 and the valve 91. The valve 91 is, for example, a sluice valve. As described in the fourth embodiment, with the adjustment passage 9, the balance in the movement of the refrigerant component and the balance in the movement of the additive can each be made close to zero. Hence, the refrigeration-cycle equipment 116 can continue to perform a steady operation for a long time.

#### Tenth Embodiment

**[0101]** Refrigeration-cycle equipment 118 illustrated in Fig. 10A includes an adjustment passage 4 in addition to the elements included in any one of the pieces of refrigeration-cycle equipment 100 to 108 according to the first to fifth embodiments. The adjustment passage 4 guides the refrigerant liquid from the evaporator 21

through the separating mechanism 6 to the condenser 23. In the tenth embodiment, the separating mechanism 6 is a filtering device employing a total filtering method.

**[0102]** The return passage 3 includes the upstream portion 31 and the downstream portion 32. The upstream portion 31 guides the refrigerant liquid (the original liquid) to be treated by the separating mechanism 6 from the condenser 23 to the separating mechanism 6. The downstream portion 32 guides the refrigerant liquid (the permeated liquid) whose additive concentration has been reduced from the separating mechanism 6 to the evaporator 21. The adjustment passage 4 includes an upstream portion 41 and a downstream portion 42. The upstream portion 41 guides the refrigerant liquid (the original liquid) to be treated by the separating mechanism 6 from the evaporator 21 to the separating mechanism 6. The upstream portion 41 is provided with the pump 52. The pump 52 generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the adjustment passage 4. The downstream portion 42 guides the refrigerant liquid (the permeated liquid) whose additive concentration has been reduced from the separating mechanism 6 to the condenser 23.

**[0103]** The refrigeration-cycle equipment 118 further includes a first three-way valve 64 and a second three-way valve 65. The first three-way valve 64 selectively connects one of the upstream portion 31 of the return passage 3 and the upstream portion 41 of the adjustment passage 4 to the inlet of the separating mechanism 6. The second three-way valve 65 selectively connects one of the downstream portion 32 of the return passage 3 and the downstream portion 42 of the adjustment passage 4 to the outlet of the separating mechanism 6. That is, the first three-way valve 64 and the second three-way valve 65 enable the switching between a state where the refrigerant liquid is allowed to flow through the return passage 3 and a state where the refrigerant liquid is allowed to flow through the adjustment passage 4. The outlet of the first three-way valve 64 and the inlet of the separating mechanism 6 are connected to each other with a passage 61. The outlet of the separating mechanism 6 and the inlet of the second three-way valve 65 are connected to each other with a passage 62.

**[0104]** According to the tenth embodiment, the refrigerant liquid is allowed to move not only from the condenser 23 to the evaporator 21 but also from the evaporator 21 to the condenser 23. For example, if the outdoor temperature has suddenly dropped while the refrigeration-cycle equipment 118 as an air conditioner is performing an air-heating operation, the additive concentration of the refrigerant liquid stored in the evaporator 21 needs to be increased quickly. In such a case, if the refrigerant liquid is made to flow from the evaporator 21 through the adjustment passage 4 into the condenser 23, the separating mechanism 6 functions in such a manner as to increase the additive concentration in the evaporator 21. Thus, the refrigerant liquid stored in the evaporator 21 is prevented from being frozen.

**[0105]** As illustrated in Fig. 10B, the refrigeration-cycle equipment 118 may further include a bypass passage 44 and a flow rate adjustment mechanism 86. The bypass passage 44 guides the refrigerant liquid from the evaporator 21 to the condenser 23 and bypasses the separating mechanism 6. The flow rate adjustment mechanism 86 adjusts the amount of refrigerant liquid supplied from the evaporator 21 through the separating mechanism 6 to the condenser 23 and the amount of refrigerant liquid supplied from the evaporator 21 through the bypass passage 44 to the condenser 23.

**[0106]** The bypass passage 44 branches off from the upstream portion 41 of the adjustment passage 4 and merges with the downstream portion 42 of the adjustment passage 4. Alternatively, the upstream end of the bypass passage 44 may be directly connected to the evaporator 21, and the downstream end of the bypass passage 44 may be directly connected to the condenser 23. In the tenth embodiment, the flow rate adjustment mechanism 86 is a three-way valve that is capable of switching its state between a first state and a second state. In the first state, the refrigerant liquid is supplied from the evaporator 21 through the separating mechanism 6 to the condenser 23. In the second state, the refrigerant liquid is supplied from the evaporator 21 through the bypass passage 44 to the condenser 23. The three-way valve as the flow rate adjustment mechanism 86 is provided at the position where the bypass passage 44 branches off from the upstream portion 41 of the adjustment passage 4. The three-way valve as the flow rate adjustment mechanism 86 may alternatively be provided at the position where the bypass passage 44 merges with the downstream portion 42 of the adjustment passage 4.

**[0107]** As described above with reference to Fig. 3B, the flow rate adjustment mechanism 86 may be replaced with the first valve 82 provided in the adjustment passage 4 and the second valve 83 provided in the bypass passage 44. In the case where the bypass passage 44 branches off from the adjustment passage 4 and merges with the adjustment passage 4, the first valve 82 can be provided between the branching position and the merging position, more specifically, at a position of the adjustment passage 4 between the branching position and the first three-way valve 64 (or between the second three-way valve 65 and the merging position). The first valve 82 and the second valve 83 may each be a sluice valve or a flow rate control valve.

**[0108]** According to the modified example illustrated in Fig. 10B, while the refrigerant liquid whose additive concentration has been reduced is supplied from the condenser 23 through the return passage 3 to the evaporator 21, the refrigerant that is not treated by the separating mechanism 6 can be supplied from the evaporator 21 through the bypass passage 44 to the condenser 23. The refrigeration-cycle equipment 118 may further include the bypass passage 34 and the flow rate adjustment mechanism 85 (not illustrated in Fig. 10B) described above with reference to Fig. 8. In that case, while the

refrigerant liquid whose additive concentration has been reduced is supplied from the evaporator 21 through the adjustment passage 4 to the condenser 23, the refrigerant liquid that is not treated by the separating mechanism 6 can be supplied from the condenser 23 through the bypass passage 34 to the evaporator 21. Thus, as described in the fourth embodiment, the balance in the movement of the refrigerant component and the balance in the movement of the additive can be relatively easily made even. Consequently, the refrigeration-cycle equipment 118 can continue to perform a steady operation for a long time.

#### Eleventh Embodiment

**[0109]** Refrigeration-cycle equipment 120 illustrated in Fig. 11A includes the adjustment passage 4 in addition to the elements included in any one of the pieces of refrigeration-cycle equipment 110 to 116 according to the sixth to ninth embodiments. The adjustment passage 4 guides the refrigerant liquid from the evaporator 21 through the separating mechanism 6 to the condenser 23. In the eleventh embodiment, the separating mechanism 6 is a filtering device employing a cross flow method.

**[0110]** The return passage 3 includes the upstream portion 31, the first downstream portion 32, and the second downstream portion 33, the functions of which have been described in the sixth embodiment. The adjustment passage 4 includes the upstream portion 41, a first downstream portion 42, and a second downstream portion 43. The upstream portion 41 guides the refrigerant liquid (the original liquid) to be treated by the separating mechanism 6 from the evaporator 21 to the separating mechanism 6. The upstream portions 31 and 41 are provided with the pumps 51 and 52, respectively. The pump 51 generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the return passage 3. The pump 52 generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the adjustment passage 4. The first downstream portion 42 guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism 6 to the condenser 23. The second downstream portion 43 guides (returns) the refrigerant liquid whose additive concentration has been increased from the separating mechanism 6 to the evaporator 21.

**[0111]** The refrigeration-cycle equipment 120 further includes the first three-way valve 64, the second three-way valve 65, and a third three-way valve 66. The first three-way valve 64 selectively connects one of the upstream portion 31 of the return passage 3 and the upstream portion 41 of the adjustment passage 4 to the inlet of the separating mechanism 6. The second three-way valve 65 selectively connects one of the first downstream portion 32 of the return passage 3 and the first downstream portion 42 of the adjustment passage 4 to the permeated liquid outlet of the separating mechanism 6. The third three-way valve 66 selectively connects one

of the second downstream portion 33 of the return passage 3 and the second downstream portion 43 of the adjustment passage 4 to the concentrated liquid outlet of the separating mechanism 6. That is, the three-way valves 64, 65, and 66 enable the switching between a state where the refrigerant liquid is allowed to flow through the return passage 3 and a state where the refrigerant liquid is allowed to flow through the adjustment passage 4. The outlet of the first three-way valve 64 and the inlet of the separating mechanism 6 are connected to each other with the passage 61. The permeated liquid outlet of the separating mechanism 6 and the inlet of the second three-way valve 65 are connected to each other with the passage 62. The concentrated liquid outlet of the separating mechanism 6 and the inlet of the third three-way valve 66 are connected to each other with a passage 63.

**[0112]** According to the eleventh embodiment, as in the tenth embodiment, the refrigerant liquid is allowed to move not only from the condenser 23 to the evaporator 21 but also from the evaporator 21 to the condenser 23. Hence, the eleventh embodiment produces the same effect as the tenth embodiment.

**[0113]** As illustrated in Fig. 11B, the refrigeration-cycle equipment 120 may further include the bypass passage 44 and the flow rate adjustment mechanism 86. The bypass passage 44 guides the refrigerant liquid from the evaporator 21 to the condenser 23 and bypasses the separating mechanism 6. The flow rate adjustment mechanism 86 adjusts the amount of refrigerant liquid supplied from the evaporator 21 through the separating mechanism 6 to the condenser 23 and the amount of refrigerant liquid supplied from the evaporator 21 through the bypass passage 44 to the condenser 23. The configurations of the bypass passage 44 and the flow rate adjustment mechanism 86 have been described above with reference to Fig. 10B. As described above with reference to Fig. 3B, the flow rate adjustment mechanism 86 may be replaced with the first valve 82 provided in the adjustment passage 4 and the second valve 83 provided in the bypass passage 44, which has also been described above with reference to Fig. 10B. The refrigeration-cycle equipment 120 may further include the bypass passage 34 and the flow rate adjustment mechanism 85 (not illustrated in Fig. 11B) described above with reference to Fig. 8.

**[0114]** The only difference between the modified example illustrated in Fig. 10B and the modified example illustrated in Fig. 11B is the type of the separating mechanism 6. Hence, all description regarding the modified example illustrated in Fig. 10B also applies to the modified example illustrated in Fig. 11B.

**[0115]** The pieces of refrigeration-cycle equipment that have been described with reference to Figs. 1 to 11B each includes only one separating mechanism 6. To change the direction of the flow of the refrigerant liquid, at least one three-way valve, for example, is provided. However, the number of separating mechanisms is not

limited to one, as described below.

## Twelfth Embodiment

**[0116]** Refrigeration-cycle equipment 122 illustrated in Fig. 12A includes the adjustment passage 9 and a second separating mechanism 7 in addition to the elements included in any one of the pieces of refrigeration-cycle equipment 100 to 108 according to the first to fifth embodiments. The adjustment passage 9 guides the refrigerant liquid from the evaporator 21 to the condenser 23. The second separating mechanism 7 is provided in the adjustment passage 9. The second separating mechanism 7 has a function of separating the additive from the refrigerant liquid supplied from the evaporator 21 to the condenser 23. In the twelfth embodiment, the second separating mechanism 7 is a filtering device employing a total filtering method, as with the separating mechanism 6 (a first separating mechanism). The refrigerant liquid whose additive concentration has been reduced can be supplied from the evaporator 21 through the adjustment passage 9 to the condenser 23. Although it depends on the performance of the second separating mechanism 7, the refrigerant liquid that has permeated through the second separating mechanism 7 may contain only the refrigerant component.

**[0117]** The adjustment passage 9 guides the refrigerant liquid from the evaporator 21 to the condenser 23. The adjustment passage 9 includes an upstream portion 92 and a downstream portion 93. The upstream portion 92 connects the lower portion of the evaporator 21 to the inlet of the second separating mechanism 7. The downstream portion 93 connects the outlet of the second separating mechanism 7 to the lower portion of the condenser 23. That is, the upstream end of the adjustment passage 9 is connected to the lower portion of the evaporator 21, and the downstream end of the adjustment passage 9 is connected to the lower portion of the condenser 23. Hence, the refrigerant in the liquid phase is allowed to move from the evaporator 21 to the condenser 23.

**[0118]** The return passage 3 is provided with the pump 51 and the flow rate adjustment mechanism 81. Specifically, the pump 51 is provided in the upstream portion 31 of the return passage 3. The flow rate adjustment mechanism 81 is provided in the upstream portion 31 (or the downstream portion 32) of the return passage 3. In addition to the differences in saturated vapor pressure and in refrigerant liquid head between the evaporator 21 and the condenser 23, the pump 51 generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the return passage 3. The adjustment passage 9 is provided with the pump 52 and a flow rate adjustment mechanism 91. Specifically, the pump 52 is provided in the upstream portion 92 of the adjustment passage 9. The flow rate adjustment mechanism 91 is provided in the upstream portion 92 (or the downstream portion 93) of the adjustment passage 9. The pump 52 produces a driving pressure that is necessary for causing

the refrigerant to flow through the adjustment passage 9. The flow rate adjustment mechanisms 81 and 91 are each, for example, a check valve, a sluice valve, or a flow rate control valve. As in the second embodiment, with the flow rate adjustment mechanisms 81 and 91, the flow rates of the refrigerant liquid in the return passage 3 and in the adjustment passage 9 can be adjusted according to need. Therefore, the additive concentrations in the evaporator 21 and in the condenser 23 can be easily stabilized even if the refrigeration-cycle equipment 122 is in unsteady operation. Furthermore, when the refrigeration-cycle equipment 122 is not in operation, the refrigerant liquid is prevented from excessively flow from one of the evaporator 21 and the condenser 23 into the other.

**[0119]** In the twelfth embodiment, the return passage 3 is separate from the adjustment passage 9. Hence, there is no need to provide a mechanism for switching the passage, and the refrigerant liquid is allowed to flow through the return passage 3 and through the adjustment passage 9 simultaneously. The first separating mechanism 6 and the second separating mechanism 7 may each be capable of adjusting the purity of the permeated liquid. In such a configuration, the balance in the amount of the substance that moves between the evaporator 21 and the condenser 23 can be adjusted by exchanging portions of the permeated liquid. While the amounts of portions of the refrigerant liquid that are exchanged between the evaporator 21 and the condenser 23 are reduced, the heat loss can be further reduced.

**[0120]** As illustrated in Fig. 12B, the refrigeration-cycle equipment 122 may further include a bypass passage 95 and a flow rate adjustment mechanism 97. The bypass passage 95 bypasses the second separating mechanism 7 and guides the refrigerant liquid from the evaporator 21 to the condenser 23. The flow rate adjustment mechanism 97 adjusts the amount of refrigerant liquid supplied from the evaporator 21 through the second separating mechanism 7 to the condenser 23 and the amount of refrigerant liquid supplied from the evaporator 21 through the bypass passage 95 to the condenser 23. In this modified example, the flow rate adjustment mechanism 97 includes a first valve 91 provided in the adjustment passage 9 and a second valve 96 provided in the bypass passage 95. The flow rate adjustment mechanism 97 may be a three-way valve provided at a position where the bypass passage 95 branches off from (or merges with) the adjustment passage 9. The description regarding the third embodiment and the modified example thereof (see Figs. 3A and 3B) is also applicable to the bypass passage 95 and the flow rate adjustment mechanism 97.

#### Thirteenth Embodiment

**[0121]** Refrigeration-cycle equipment 124 illustrated in Fig. 13 includes the adjustment passage 4 and the second separating mechanism 7 in addition to the elements

included in any one of the pieces of refrigeration-cycle equipment 110 to 116 according to the sixth to ninth embodiments. The adjustment passage 4 guides the refrigerant liquid from the evaporator 21 to the condenser 23.

5 The second separating mechanism 7 is provided in the adjustment passage 4 and has a function of separating the additive from the refrigerant liquid supplied from the evaporator 21 to the condenser 23. In the thirteenth embodiment, the second separating mechanism 7 is a filtering device employing a cross flow method. The refrigerant liquid whose additive concentration has been reduced is supplied from the evaporator 21 through the adjustment passage 4 to the condenser 23. Although it depends on the performance of the second separating mechanism 7, the refrigerant liquid that has permeated through the second separating mechanism 7 may contain only the refrigerant component.

**[0122]** The return passage 3 includes the upstream portion 31, the first downstream portion 32, and the second downstream portion 33, the functions of which have been described above in the sixth embodiment. The adjustment passage 4 includes the upstream portion 41, the first downstream portion 42, and the second downstream portion 43. The upstream portion 41 guides the refrigerant liquid (the original liquid) to be treated by the second separating mechanism 7 from the evaporator 21 to the second separating mechanism 7. The upstream portions 31 and 41 are provided with the pumps 51 and 52, respectively. The pump 51 generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the return passage 3. The pump 52 generates a driving pressure that is necessary for causing the refrigerant liquid to flow through the adjustment passage 4. The first downstream portion 42 guides the refrigerant liquid whose additive concentration has been reduced from the second separating mechanism 7 to the condenser 23. The second downstream portion 43 guides (returns) the refrigerant liquid whose additive concentration has been increased from the second separating mechanism 7 to the evaporator 21.

**[0123]** The refrigeration-cycle equipment 124 further includes the first three-way valve 64 and the second three-way valve 65. The first three-way valve 64 selectively connects one of the first downstream portion 32 of the return passage 3 and the second downstream portion 43 of the adjustment passage 4 to the evaporator 21. The second three-way valve 65 selectively connects one of the second downstream portion 33 of the return passage 3 and the first downstream portion 42 of the adjustment passage 4 to the condenser 23. That is, the three-way valves 64 and 65 enable the switching between a state where the refrigerant liquid is allowed to flow through the return passage 3 and a state where the refrigerant liquid is allowed to flow through the adjustment passage 4. One of two inlets of the first three-way valve 64 and the permeated liquid outlet of the first separating mechanism 6 are connected to each other with the first downstream portion 32 of the return passage 3. The other

inlet of the first three-way valve 64 and the concentrated liquid outlet of the second separating mechanism 7 are connected to each other with the second downstream portion 43 of the adjustment passage 4. One of two inlets of the second three-way valve 65 and the concentrated liquid outlet of the first separating mechanism 6 are connected to each other with the second downstream portion 33 of the return passage 3. The other inlet of the second three-way valve 65 and the permeated liquid outlet of the second separating mechanism 7 are connected to each other with the first downstream portion 42 of the adjustment passage 4. The outlet of the first three-way valve 64 and the evaporator 21 is connected to each other with a passage 67. The outlet of the second three-way valve 65 and the condenser 23 are connected to each other with a passage 68.

**[0124]** According to the thirteenth embodiment, as in the twelfth embodiment, the balance in the amount of the substance that moves between the evaporator 21 and the condenser 23 can be adjusted by exchanging portions of the permeated liquid. While the amounts of portions of the refrigerant liquid that are exchanged between the evaporator 21 and the condenser 23 are reduced, the heat loss can be further reduced.

**[0125]** As in the twelfth embodiment (see Figs. 12A and 12B), the return passage 3 of the refrigeration-cycle equipment 124 according to the thirteenth embodiment may be provided with the flow rate adjustment mechanism 81, and the adjustment passage 9 may be provided with the flow rate adjustment mechanism 91. Such a configuration produces the same advantageous effects as in the twelfth embodiment.

**[0126]** In addition, as in the twelfth embodiment (see Fig. 12B), the refrigeration-cycle equipment 124 according to the thirteenth embodiment may include the bypass passage 95 and the flow rate adjustment mechanism 97. The configurations and the functions of the bypass passage 95 and the flow rate adjustment mechanism 97 have been described above with reference to Fig. 12B.

#### Fourteenth Embodiment

**[0127]** In refrigeration-cycle equipment 126 according to a fourteenth embodiment illustrated in Fig. 14, a portion of the heat-absorbing circulation passage 10 is shared with the adjustment passage 4. Specifically, in the heat-absorbing circulation passage 10, the pump 12 is provided between the outlet of the evaporator 21 (the outlet is provided in the lower portion of the evaporator 21) and the inlet of the first heat exchanger 13. The adjustment passage 4 branches off from a position (the passage 10b) of the heat-absorbing circulation passage 10 between the outlet of the pump 12 and the inlet of the first heat exchanger 13. The adjustment passage 4 is provided with a flow rate adjustment mechanism 87, which is a sluice valve, a control valve, or the like.

**[0128]** On the other hand, a portion of the heat-dissipating circulation passage 11 is shared with the return

passage 3. Specifically, in the heat-dissipating circulation passage 11, the pump 14 is provided between the outlet of the condenser 23 (the outlet is provided in the lower portion of the condenser 23) and the inlet of the second heat exchanger 15. The return passage 3 branches off from a position (the passage 11b) of the heat-dissipating circulation passage 11 between the outlet of the pump 14 and the inlet of the second heat exchanger 15. The return passage 3 is provided with the flow rate adjustment mechanism 81, which is a sluice valve, a control valve, or the like.

**[0129]** According to the fourteenth embodiment, the number of pumps is reduced. Therefore, the cost and the total size of the refrigeration-cycle equipment 126 can be reduced. The configuration according to the fourteenth embodiment is also applicable to the refrigeration-cycle equipment according to any of the other embodiments that includes the return passage 3 and the adjustment passage 4 (or 9).

#### Fifteenth Embodiment

**[0130]** Refrigeration-cycle equipment 128 according to a fifteenth embodiment illustrated in Fig. 15 includes an ejector 28 in addition to the elements included in any one of the pieces of refrigeration-cycle equipment 100 to 126 according to the first to fourteenth embodiments. The ejector 28 is provided in the vapor passage 2 and on the downstream side with respect to the compressor 22. The vapor passage 2 includes portions 25, 26, and 27. The portion 25 connects the upper portion of the evaporator 21 to the inlet of the compressor 22. The portion 26 connects the outlet of the compressor 22 to the suction port of the ejector 28. The portion 27 connects the outlet of the ejector 28 to the upper portion of the condenser 23 (an extractor 23).

**[0131]** The refrigerant liquid that has flowed out of the second heat exchanger 15 is supplied as a motive fluid to the ejector 28 through the passage 11c. The refrigerant vapor that has been compressed by the compressor 22 is supplied as a suction fluid to the ejector 28 through the portion 26. The ejector 28 generates a high-temperature refrigerant flow from the refrigerant vapor compressed by the compressor 22 and the refrigerant liquid flowed out of the second heat exchanger 15. The high-temperature refrigerant flow may be a single-phase refrigerant liquid. In that case, the ejector 28 has a function of condensing the refrigerant vapor. The high-temperature refrigerant flow may be a two-phase flow composed of refrigerant liquid and refrigerant vapor. The pressure of the refrigerant (refrigerant flow) at the outlet of the ejector 28 is higher than the pressure of the refrigerant vapor at the outlet of the compressor 22. That is, the ejector 28 has a function of increasing the pressure of the refrigerant. When the pressure at the outlet of the ejector 28 is reduced, the pressure (back pressure) at the outlet of the compressor 22 can be further reduced. The extractor 23 receives the refrigerant flow from the ejector 28 and ex-

tracts refrigerant liquid from the refrigerant flow. In the fifteenth embodiment, a combination of the ejector 28 and the extractor 23 forms a condenser (a condensation mechanism). The extractor 23 has the same configuration as, for example, the condenser 23 described above.

#### Sixteenth Embodiment

**[0132]** A sixteenth embodiment will now be described. The first to fifteenth embodiments each concern a case where the refrigeration-cycle equipment includes the separating mechanism. The sixteenth embodiment concerns a case where the refrigeration-cycle equipment does not include the separating mechanism.

**[0133]** Refrigeration-cycle equipment 130 according to the sixteenth embodiment illustrated in Fig. 17 includes the evaporator 21, the vapor passage 2, and the condenser 23. The vapor passage 2 is provided with the compressor 22. The configurations of the foregoing elements have been described above in the first embodiment. Note that the refrigeration-cycle equipment 130 employs an open cycle method in which the refrigerant liquid stored in the condenser 23 is discharged to the outside of the refrigeration-cycle equipment 130, instead of returning the refrigerant liquid to the evaporator 21.

**[0134]** Specifically, the refrigeration-cycle equipment 130 includes a heating passage 17 connected to the condenser 23. More specifically, the upstream end of the heating passage 17 is connected to the lower portion of the condenser 23. The heating passage 17 is provided with the pump 14 and the heat exchanger 15. The pump 14 is provided between the outlet of the condenser 23 and the inlet of the heat exchanger 15. The refrigerant liquid stored in the condenser 23 is supplied to the heat exchanger 15 through the heating passage 17. The heat exchanger 15 is, for example, provided in an indoor space so as to heat indoor air. The refrigerant liquid is cooled by a heat medium, such as the indoor air, in the heat exchanger 15 and is discharged to the outside of the refrigeration-cycle equipment 130. The additive can be collected from the refrigerant liquid thus discharged to the outside.

**[0135]** The evaporator 21 stores refrigerant liquid that contains only the refrigerant component. Alternatively, the evaporator 21 may store refrigerant liquid that contains the refrigerant component and the additive. As the refrigeration-cycle equipment 130 continues to operate, the amount of refrigerant liquid in the evaporator 21 is gradually reduced. Hence, to allow the refrigerant component (water, for example) to be additionally supplied to the refrigeration-cycle equipment 130 from the outside when the amount of the refrigerant component has been reduced by the generation of refrigerant vapor, the evaporator 21 has a supply port from which the refrigerant component can be supplied. In addition to the refrigerant component, the additive (ethylene glycol, for example) may be supplied to the evaporator 21.

**[0136]** The condenser 23 includes a mechanism, such

as a shell-tube heat exchanger, so as to generate refrigerant liquid by cooling the refrigerant vapor. That is, the refrigerant vapor is cooled by a heat medium (such as water) that circulates through a tube, and the resulting refrigerant liquid is stored in a shell. The condenser 23 stores refrigerant liquid containing the refrigerant component and the additive. The refrigerant liquid stored in the condenser 23 is discharged to the outside of the refrigeration-cycle equipment 130 through the heating passage 17. Therefore, as the refrigeration-cycle equipment 130 continues to operate, the additive concentration of the refrigerant liquid stored in the condenser 23 is gradually reduced. Hence, to allow the additive to be additionally supplied to the refrigeration-cycle equipment 130 from the outside, the condenser 23 has a supply port from which the additive can be supplied.

**[0137]** According to the sixteenth embodiment, the additive concentration of the refrigerant liquid stored in the evaporator 21 can be reduced to zero. By adjusting the amount of additive to be supplied to the condenser 23, the additive concentration of the refrigerant liquid stored in the condenser 23 can be changed relatively freely. That is, in each of the evaporator 21 and the condenser 23, the ratio of the amount of additive to the amount of refrigerant liquid can be adjusted to a value desirable for a smooth operation of the refrigeration-cycle equipment 130. Consequently, the saturated vapor pressure P2 of the refrigerant liquid stored in the condenser 23 and being at a specific temperature can be maintained at a pressure lower than the saturated vapor pressure P1 of the refrigerant liquid stored in the evaporator 21 and being at the specific temperature.

**[0138]** Refrigeration-cycle equipment according to another aspect of the present disclosure includes an evaporator that stores refrigerant liquid and evaporates the refrigerant liquid, a compressor that compresses refrigerant vapor flowing from the evaporator, and a condenser that condenses the refrigerant vapor having been compressed by the compressor and stores the refrigerant liquid generated by condensing the refrigerant vapor. A saturated vapor pressure P1 of the refrigerant liquid stored in the evaporator and being at a specific temperature is higher than a saturated vapor pressure P2 of the refrigerant liquid stored in the condenser and being at the specific temperature.

**[0139]** According to this aspect, the efficiency of the refrigeration-cycle equipment is improved by reducing the amount of work that is required of the compressor.

**[0140]** The refrigeration-cycle equipment disclosed in this specification is particularly useful as an air conditioner such as a home-use air conditioner or an industrial-use air conditioner. The refrigeration-cycle equipment disclosed in this specification is not limited to an air conditioner and may be any other equipment such as a chiller or a heat storage. An object to be heated by the first heat exchanger 13 and an object to be cooled by the second heat exchanger 15 may each be a gas other than air, or liquid.

**Claims**

1. Refrigeration-cycle equipment in which a mixture of a refrigerant component and an additive is employed as a refrigerant, the refrigeration-cycle equipment comprising:
  - an evaporator that stores refrigerant liquid, evaporates the refrigerant liquid, and generates refrigerant vapor;
  - a condenser that condenses the refrigerant vapor and generates refrigerant liquid;
  - a compressor provided between the evaporator and the condenser, the compressor compressing the refrigerant vapor;
  - a vapor passage that connects the evaporator and the condenser to each other through the compressor and guides the refrigerant vapor from the evaporator to the condenser;
  - a return passage that guides the refrigerant liquid from the condenser to the evaporator; and
  - a separating mechanism provided in the return passage, the separating mechanism separating the additive from the refrigerant liquid supplied from the condenser to the evaporator.
2. The refrigeration-cycle equipment according to Claim 1, wherein the separating mechanism is a filtering device employing a total filtering method.
3. The refrigeration-cycle equipment according to Claim 1 or 2, further comprising a flow rate adjustment mechanism for adjusting flow rate of the refrigerant liquid provided in the return passage.
4. The refrigeration-cycle equipment according to any one of Claims 1 to 3, further comprising a pump provided in the return passage.
5. The refrigeration-cycle equipment according to Claim 1, wherein the separating mechanism is a filtering device employing a cross flow method, and wherein the return passage includes
  - (a1) an upstream portion that guides the refrigerant liquid to be treated by the separating mechanism from the condenser to the separating mechanism;
  - (a2) a first downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism to the evaporator; and
  - (a3) a second downstream portion that guides the refrigerant liquid whose additive concentration has been increased from the separating mechanism to the condenser.
6. The refrigeration-cycle equipment according to Claim 5, further comprising a flow rate adjustment mechanism for adjusting flow rate of the refrigerant liquid provided in the return passage.
7. The refrigeration-cycle equipment according to Claim 5 or 6, further comprising:
  - a bypass passage that bypasses the separating mechanism and guides the refrigerant liquid from the condenser to the evaporator; and
  - a flow rate adjustment mechanism that adjusts an amount of refrigerant liquid supplied from the condenser through the separating mechanism to the evaporator and an amount of refrigerant liquid supplied from the condenser through the bypass passage to the evaporator.
8. The refrigeration-cycle equipment according to any one of Claims 5 to 7, further comprising an adjustment passage that has a valve and guides the refrigerant liquid from the evaporator to the condenser.
9. The refrigeration-cycle equipment according to Claim 2, further comprising:
  - an adjustment passage that guides the refrigerant liquid from the evaporator through the separating mechanism to the condenser, wherein the return passage includes
    - an upstream portion that guides the refrigerant liquid to be treated by the separating mechanism from the condenser to the separating mechanism; and
    - a downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism to the evaporator,
  - wherein the adjustment passage includes
    - an upstream portion that guides the refrigerant liquid to be treated by the separating mechanism from the evaporator to the separating mechanism; and
    - a downstream portion that guides the refrigerant liquid whose additive concentration has been reduced from the separating mechanism to the condenser, and
  - wherein the refrigeration-cycle equipment further includes
    - a first three-way valve that selectively connects one of the upstream portion of the return passage and the upstream portion of the adjustment passage to an inlet of the

separating mechanism; and  
 a second three-way valve that selectively  
 connects one of the downstream portion of  
 the return passage and the downstream  
 portion of the adjustment passage to an out-  
 let of the separating mechanism.

10. The refrigeration-cycle equipment according to  
 Claim 9, further comprising:

a bypass passage that bypasses the separating  
 mechanism and guides the refrigerant liquid  
 from the evaporator to the condenser; and  
 a flow rate adjustment mechanism that adjusts  
 an amount of refrigerant liquid supplied from the  
 evaporator through the separating mechanism  
 to the condenser and an amount of refrigerant  
 liquid supplied from the evaporator through the  
 bypass passage to the condenser.

11. The refrigeration-cycle equipment according to  
 Claim 5, further comprising:

an adjustment passage that guides the refriger-  
 ant liquid from the evaporator through the sep-  
 arating mechanism to the condenser,  
 wherein the adjustment passage includes

- (b1) an upstream portion that guides the re-  
 frigerant liquid to be treated by the separat-  
 ing mechanism from the evaporator to the  
 separating mechanism;
- (b2) a first downstream portion that guides  
 the refrigerant liquid whose additive con-  
 centration has been reduced from the sep-  
 arating mechanism to the condenser; and
- (b3) a second downstream portion that  
 guides the refrigerant liquid whose additive  
 concentration has been increased from the  
 separating mechanism to the evaporator,

wherein the refrigeration-cycle equipment fur-  
 ther includes

- (c1) a first three-way valve that selectively  
 connects one of the upstream portion of the  
 return passage and the upstream portion of  
 the adjustment passage to an inlet of the  
 separating mechanism;
- (c2) a second three-way valve that selec-  
 tively connects one of the first downstream  
 portion of the return passage and the first  
 downstream portion of the adjustment pas-  
 sage to a permeated liquid outlet of the sep-  
 arating mechanism; and
- (c3) a third three-way valve that selectively  
 connects one of the second downstream

portion of the return passage and the sec-  
 ond downstream portion of the adjustment  
 passage to a concentrated liquid outlet of  
 the separating mechanism.

12. The refrigeration-cycle equipment according to  
 Claim 11, further comprising:

a bypass passage that bypasses the separating  
 mechanism and guides the refrigerant liquid  
 from the evaporator to the condenser; and  
 a flow rate adjustment mechanism that adjusts  
 an amount of refrigerant liquid supplied from the  
 evaporator through the separating mechanism  
 to the condenser and an amount of refrigerant  
 liquid supplied from the evaporator through the  
 bypass passage to the condenser.

13. The refrigeration-cycle equipment according to any  
 one of Claims 1 to 12,  
 wherein the additive is a substance that is mixed with  
 the refrigerant component, and  
 wherein a saturated vapor pressure of the mixture  
 at a specific temperature is below a saturated vapor  
 pressure of the refrigerant component at the specific  
 temperature.

14. The refrigeration-cycle equipment according to any  
 one of Claims 1 to 13, wherein the refrigerant com-  
 ponent is a substance whose saturated vapor pres-  
 sure at room temperature is a negative pressure.

15. The refrigeration-cycle equipment according to any  
 one of Claims 1 to 14, wherein a saturated vapor  
 pressure P1 of the refrigerant liquid stored in the  
 evaporator and being at a specific temperature is  
 higher than a saturated vapor pressure P2 of the  
 refrigerant liquid stored in the condenser and being  
 at the specific temperature.

FIG. 1

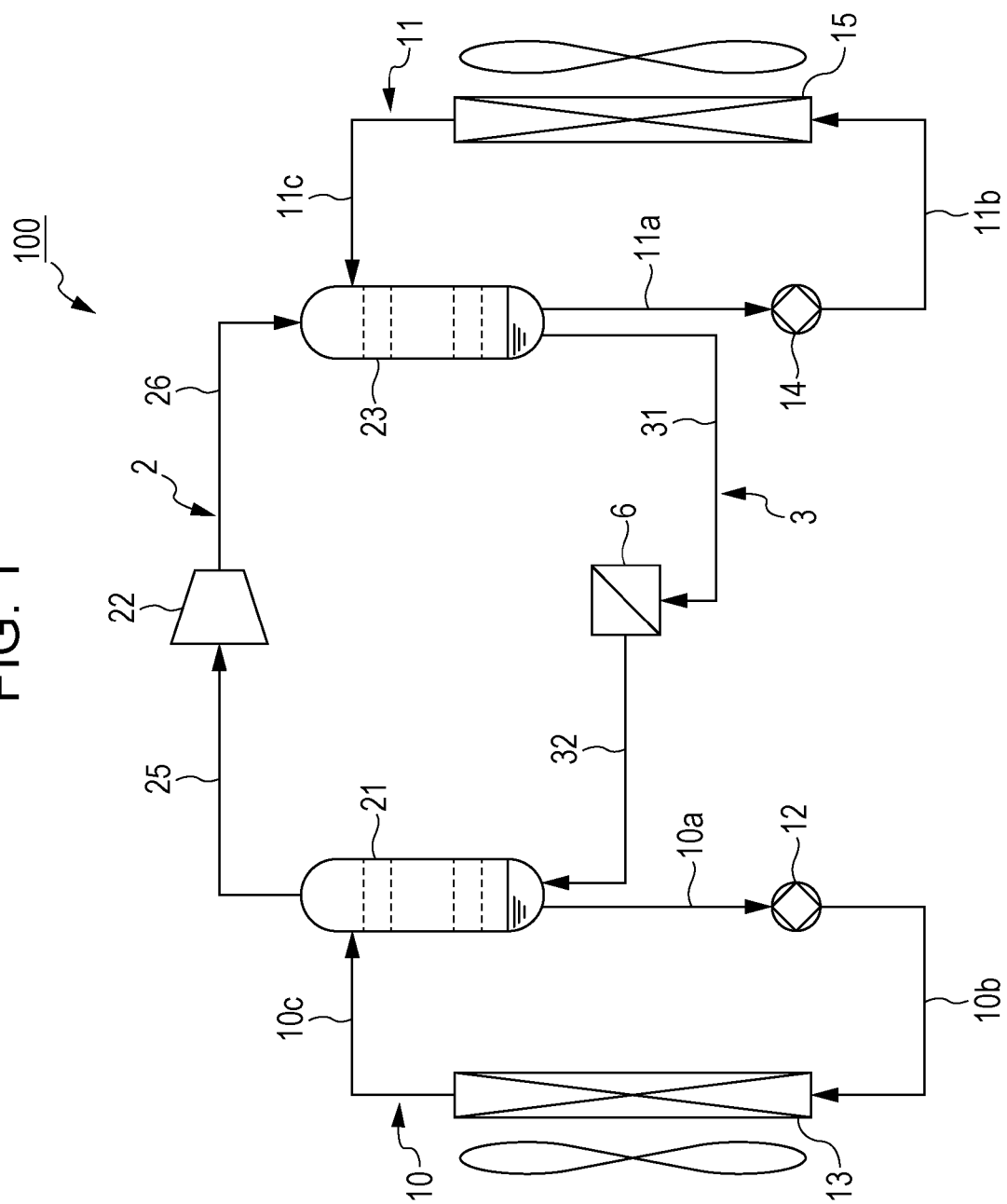


FIG. 2

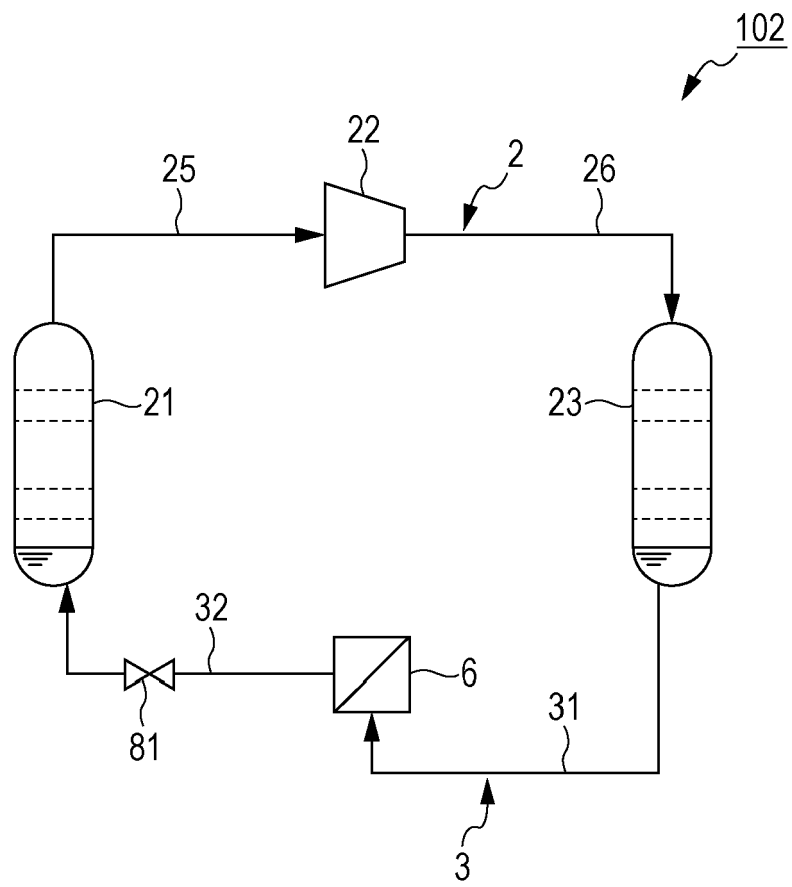


FIG. 3A

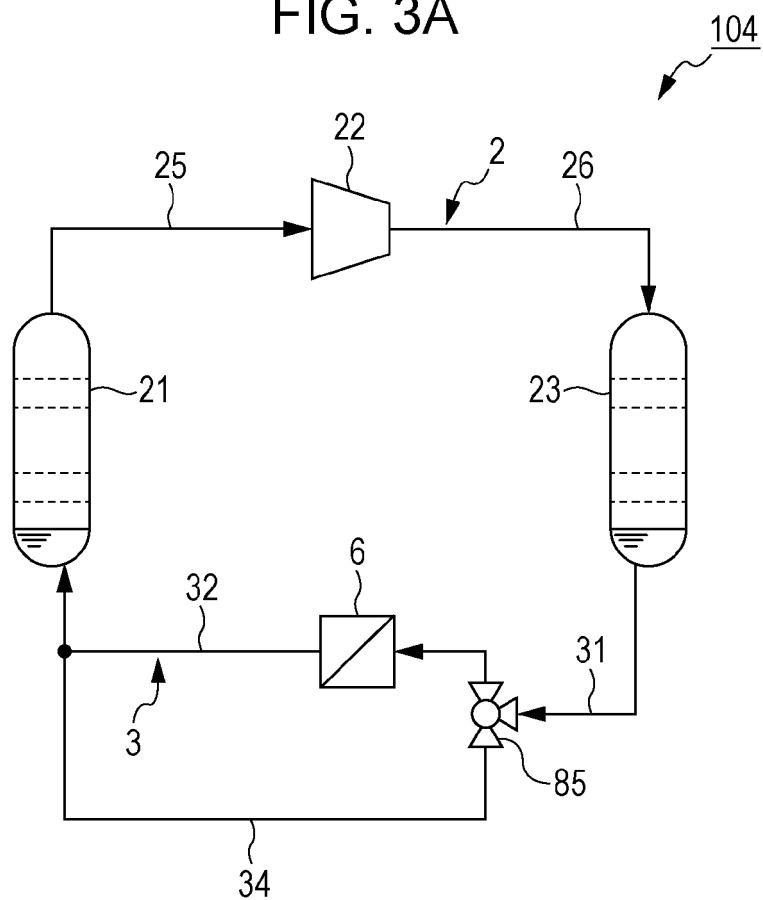


FIG. 3B

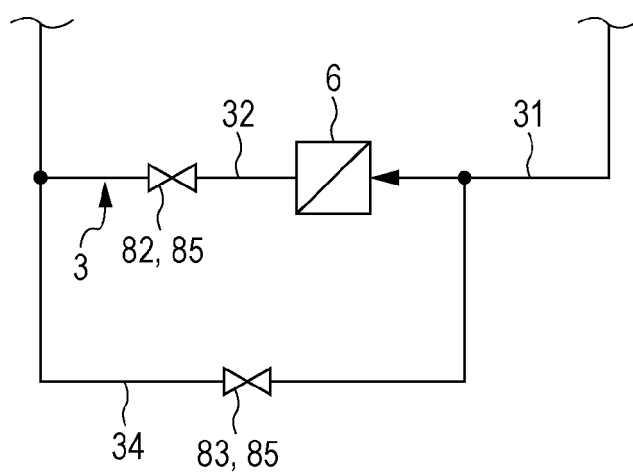


FIG. 4

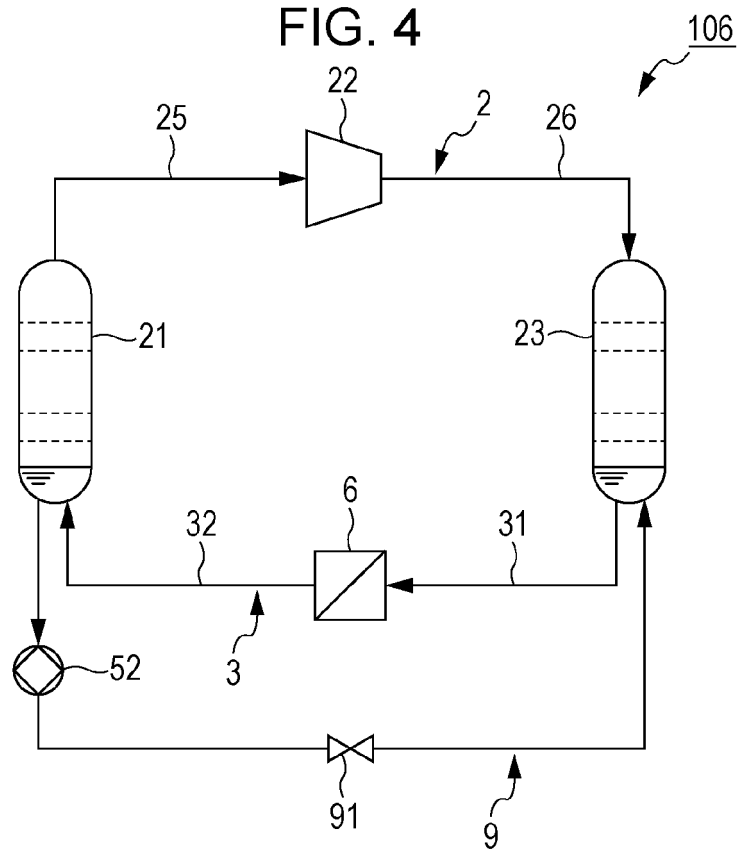


FIG. 5

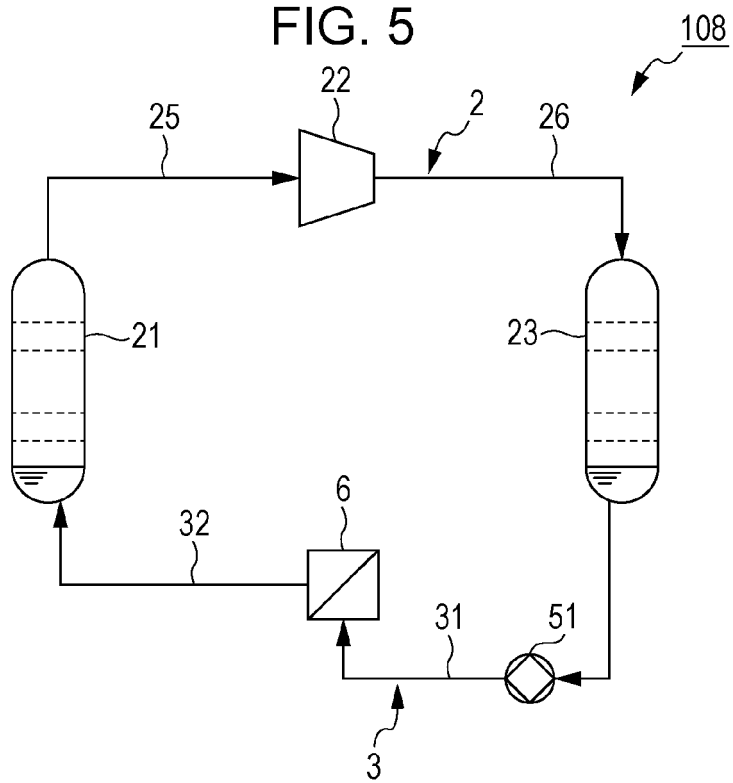


FIG. 6

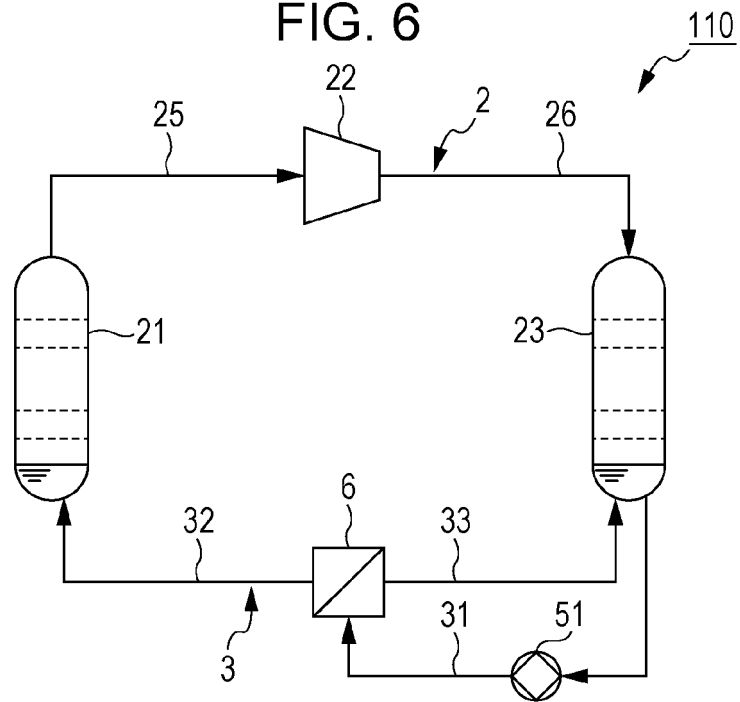


FIG. 7

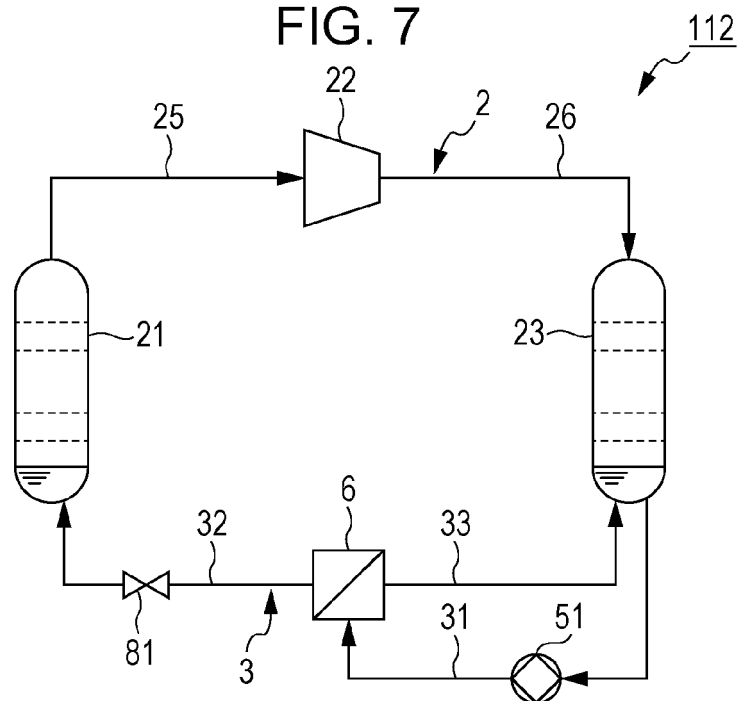


FIG. 8

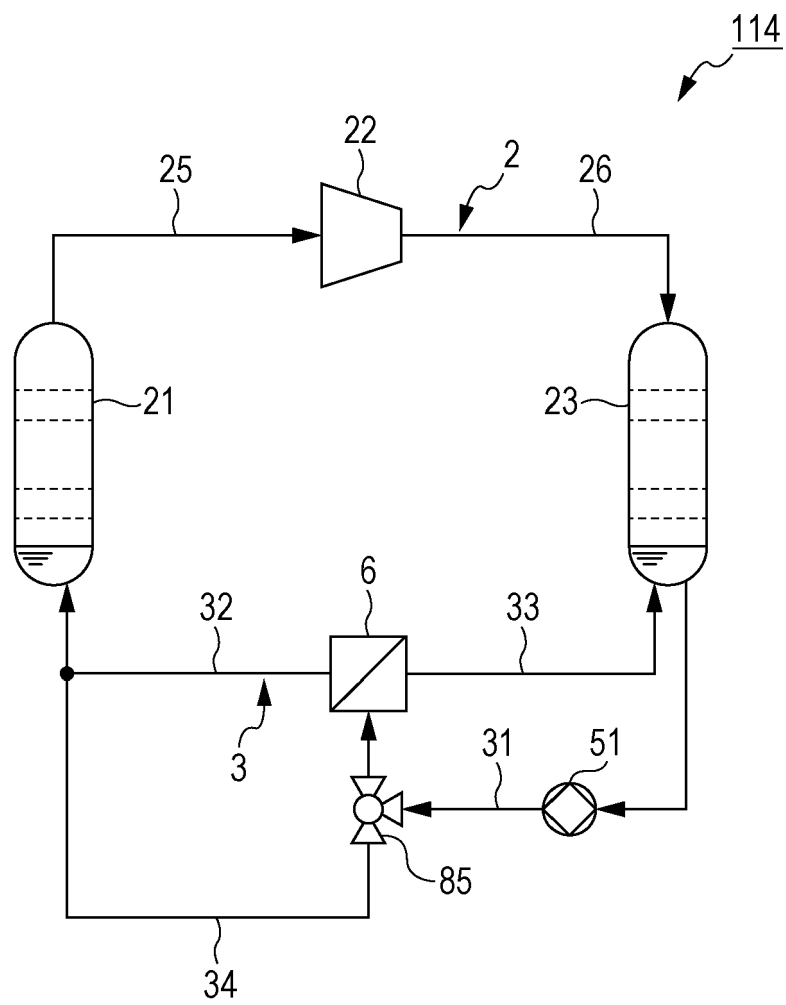


FIG. 9

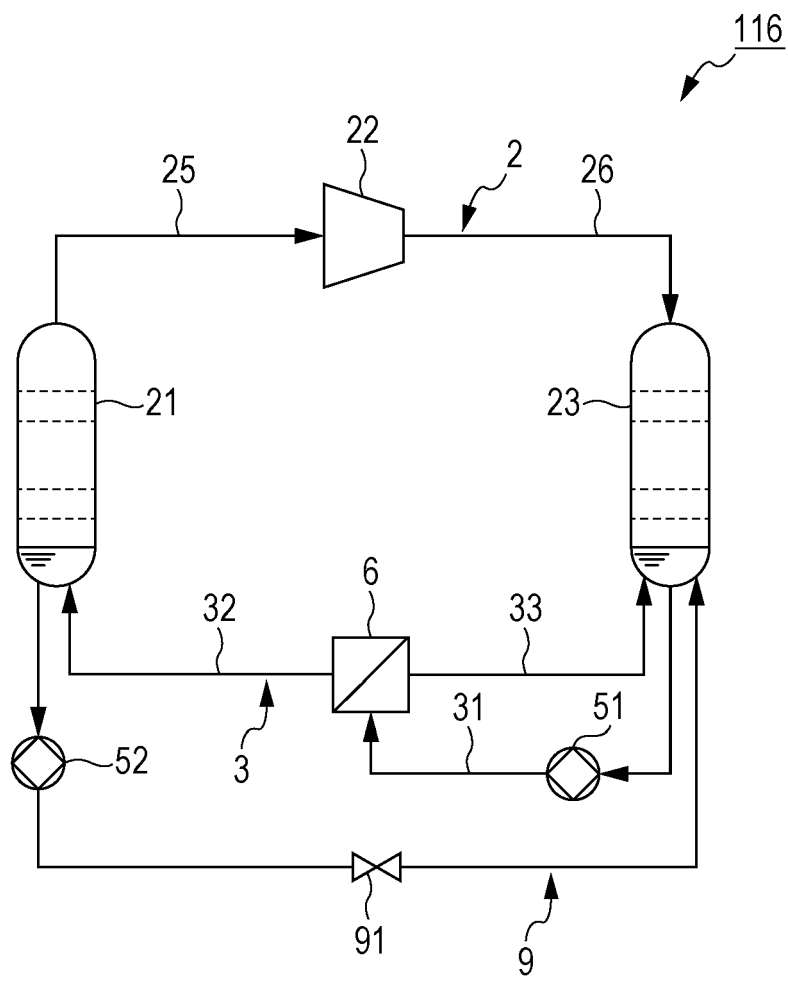


FIG. 10A

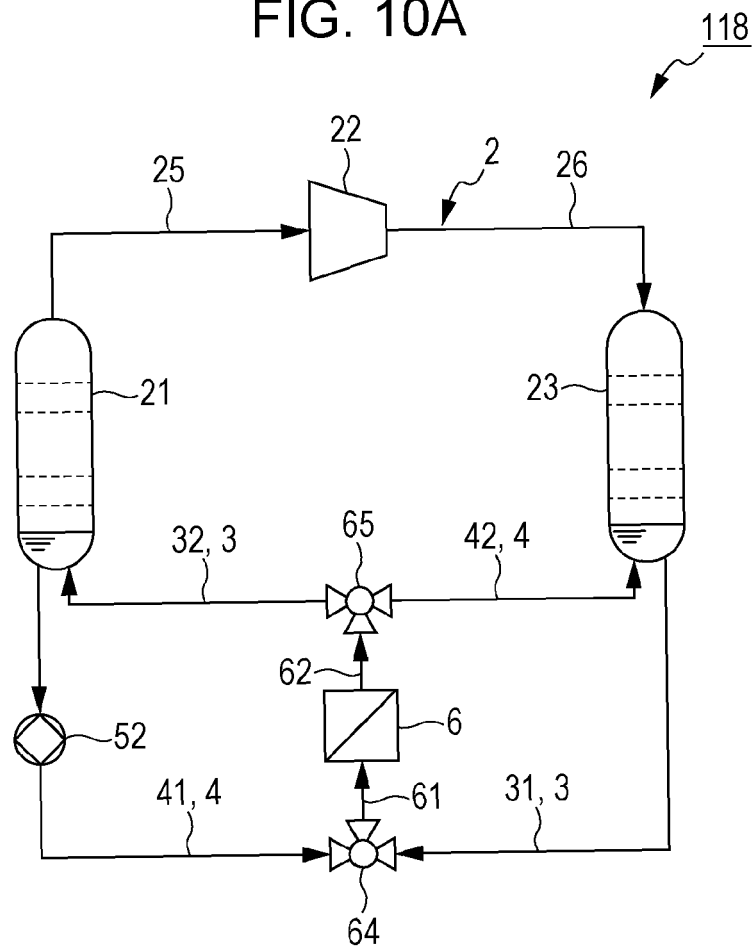


FIG. 10B

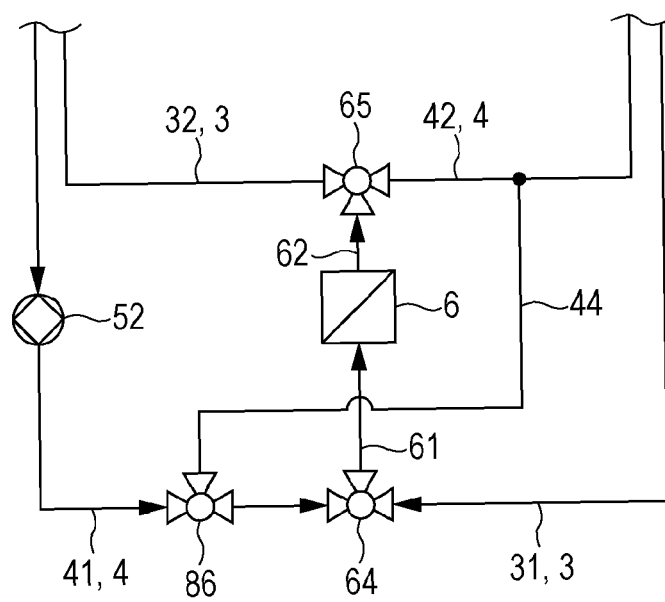


FIG. 11A

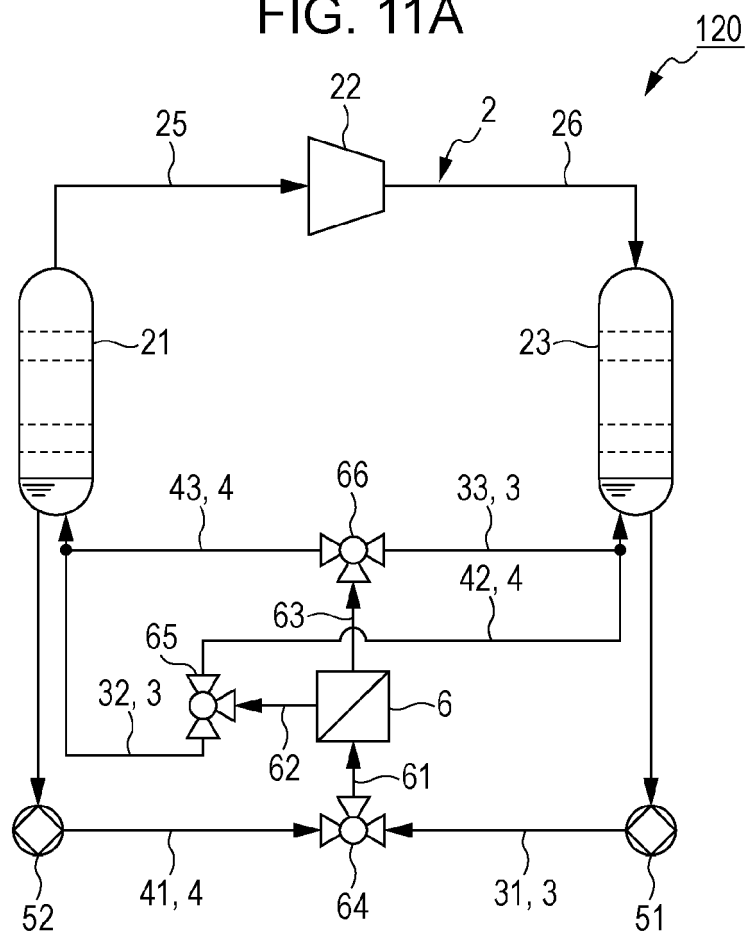


FIG. 11B

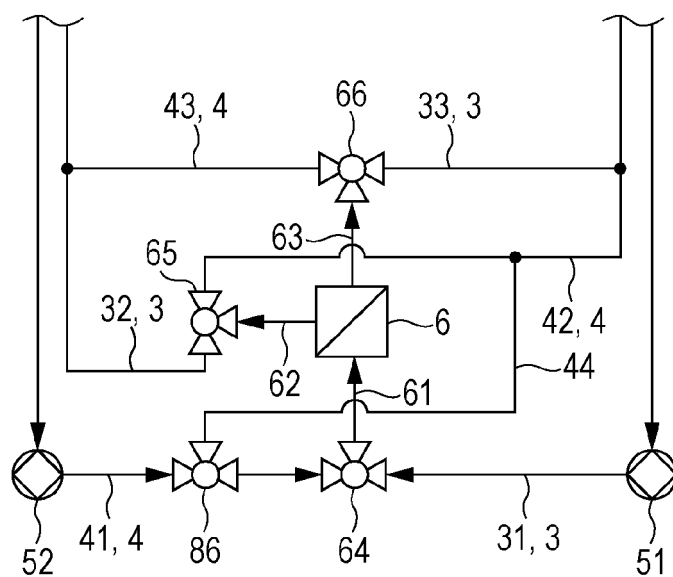


FIG. 12A

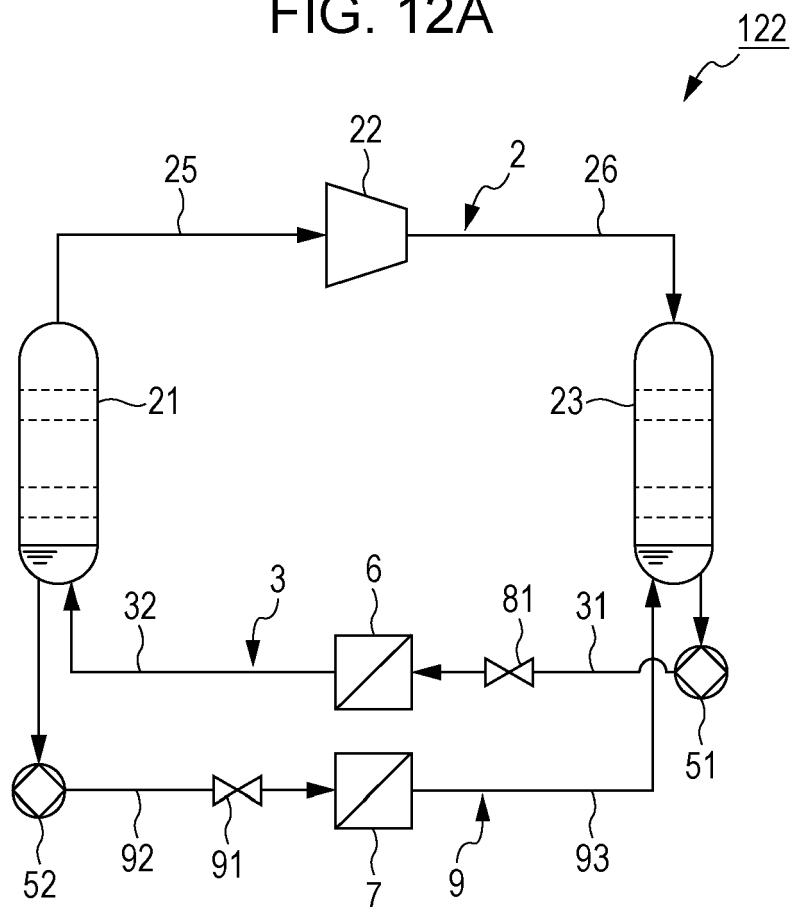


FIG. 12B

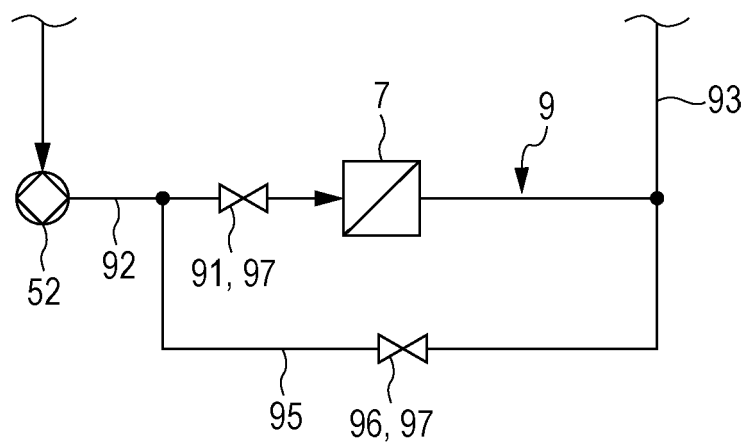


FIG. 13

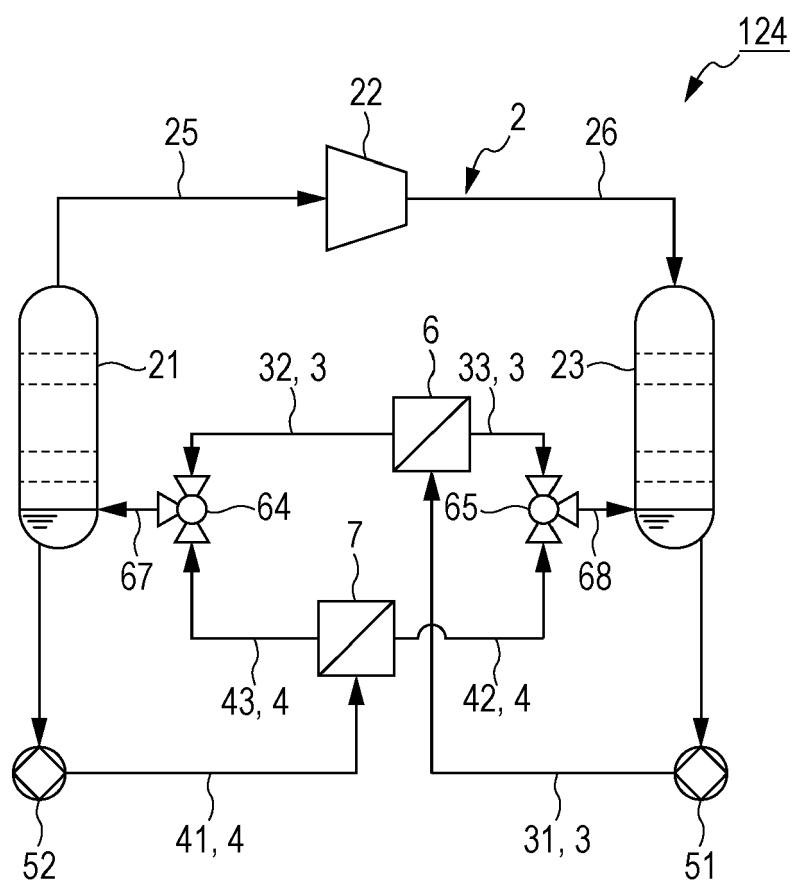


FIG. 14

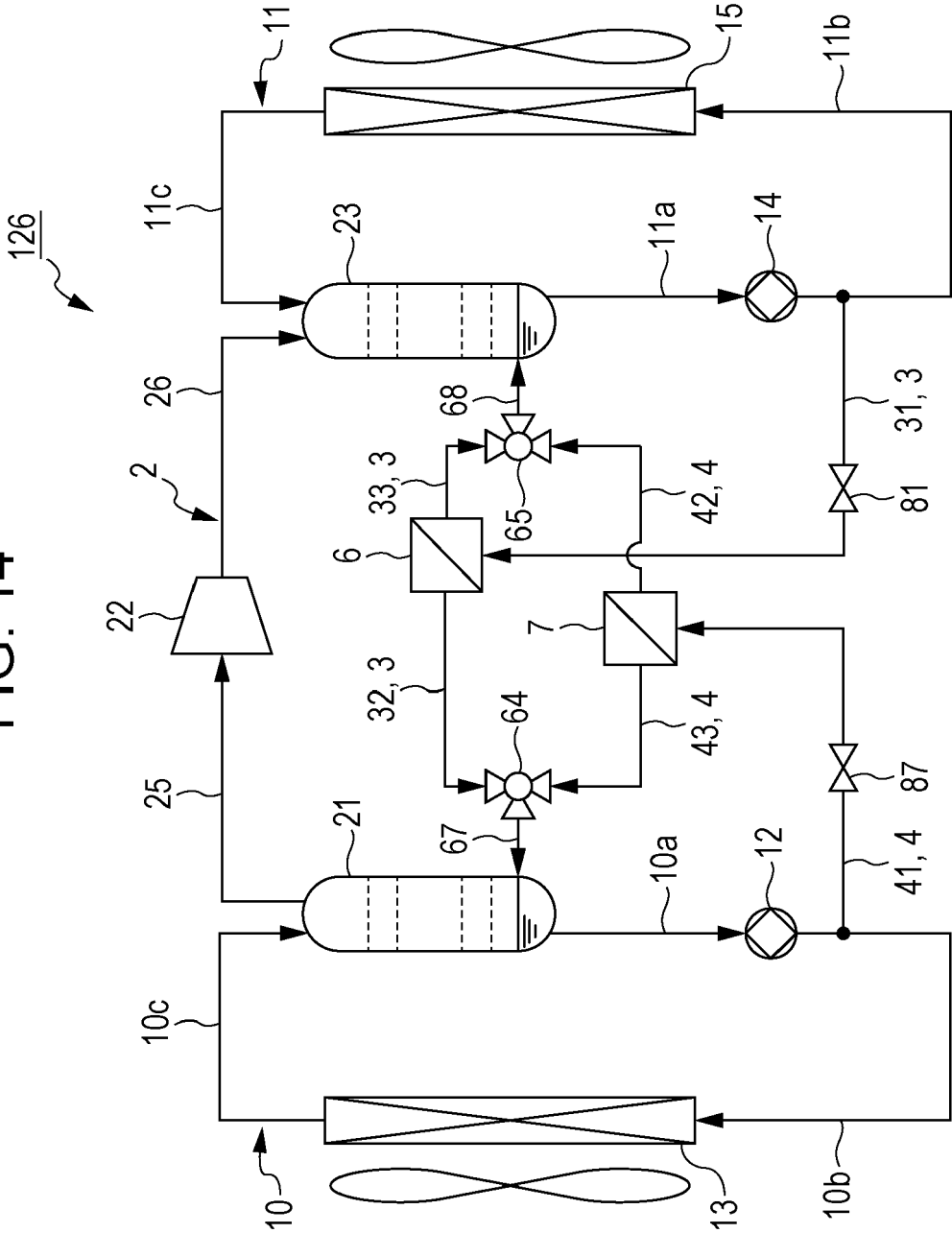


FIG. 15

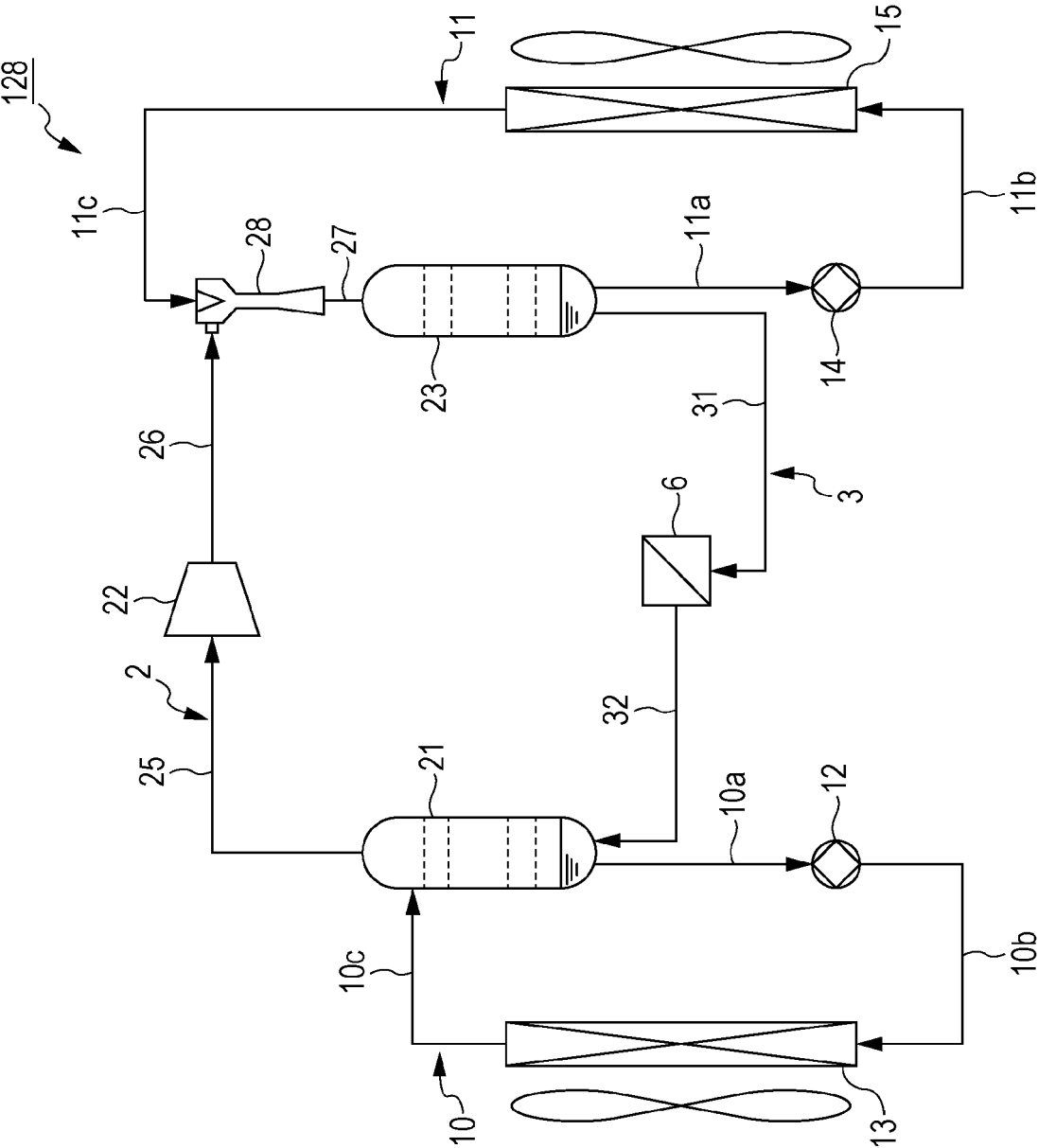


FIG. 16A

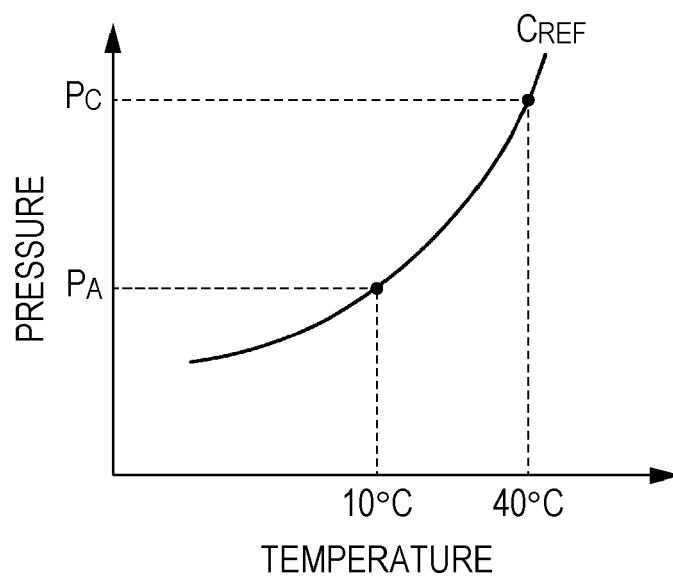


FIG. 16B

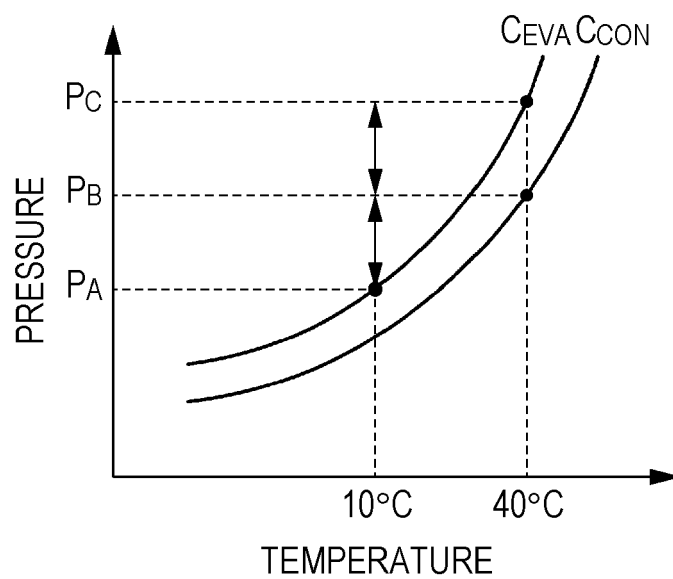
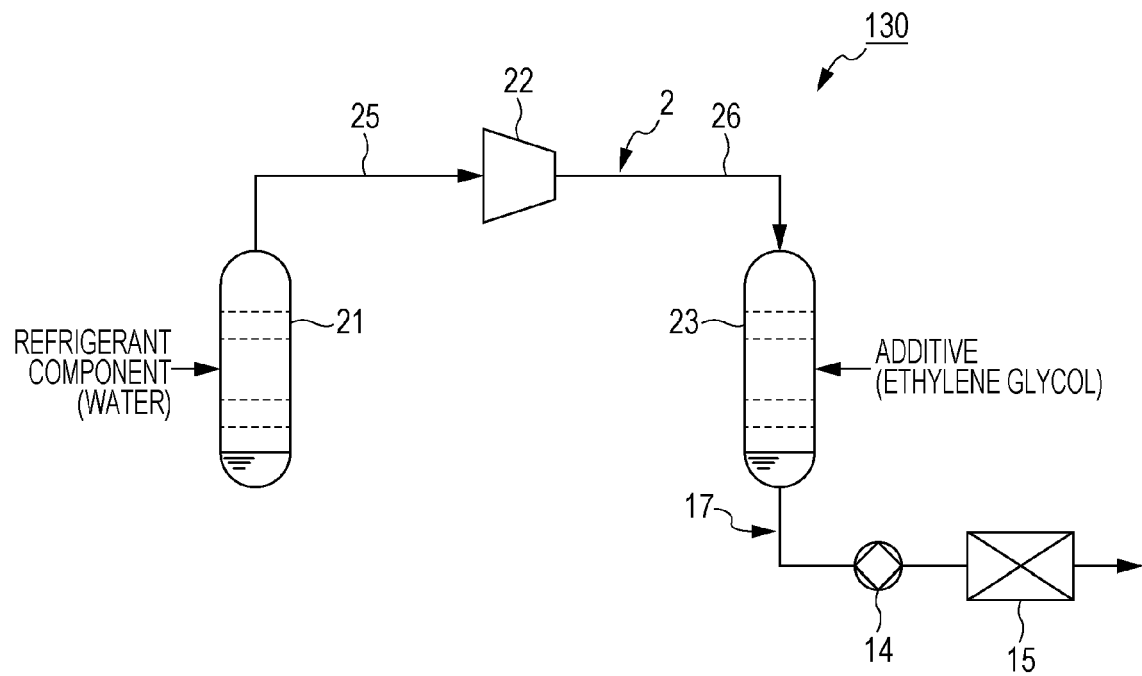


FIG. 17





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Application Number  
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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                         |                                                      |                                         |
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| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                         |                                                      |                                         |
| Place of search<br>Munich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                         | Date of completion of the search<br>20 February 2015 | Examiner<br>Lucic, Anita                |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                         |                                                      |                                         |

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20-02-2015

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**REFERENCES CITED IN THE DESCRIPTION**

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