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(54) **GAS EXTRACTION DEVICE AND GAS EXTRACTION METHOD FOR REFRIGERATOR**

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(57) **ABSTRACT**

A gas extraction device installed in a refrigerator removes uncondensed gases that exist in the refrigerator. The gas extraction device includes a gas extraction tank used to circulate a refrigerant put in an evaporator, a circulation pipe for circulation between the gas extraction tank and the evaporator, a gas extraction pump which feeds the refrigerant in the evaporator to the gas extraction tank, a shutoff valve configured to shut off a flow of the refrigerant from the gas extraction tank to the evaporator, a gas extractor which extracts the uncondensed gas in the refrigerator into the gas extraction tank, and an auxiliary tank which receives an inflow of the refrigerant filling up the gas extraction tank, and overflowing therefrom.

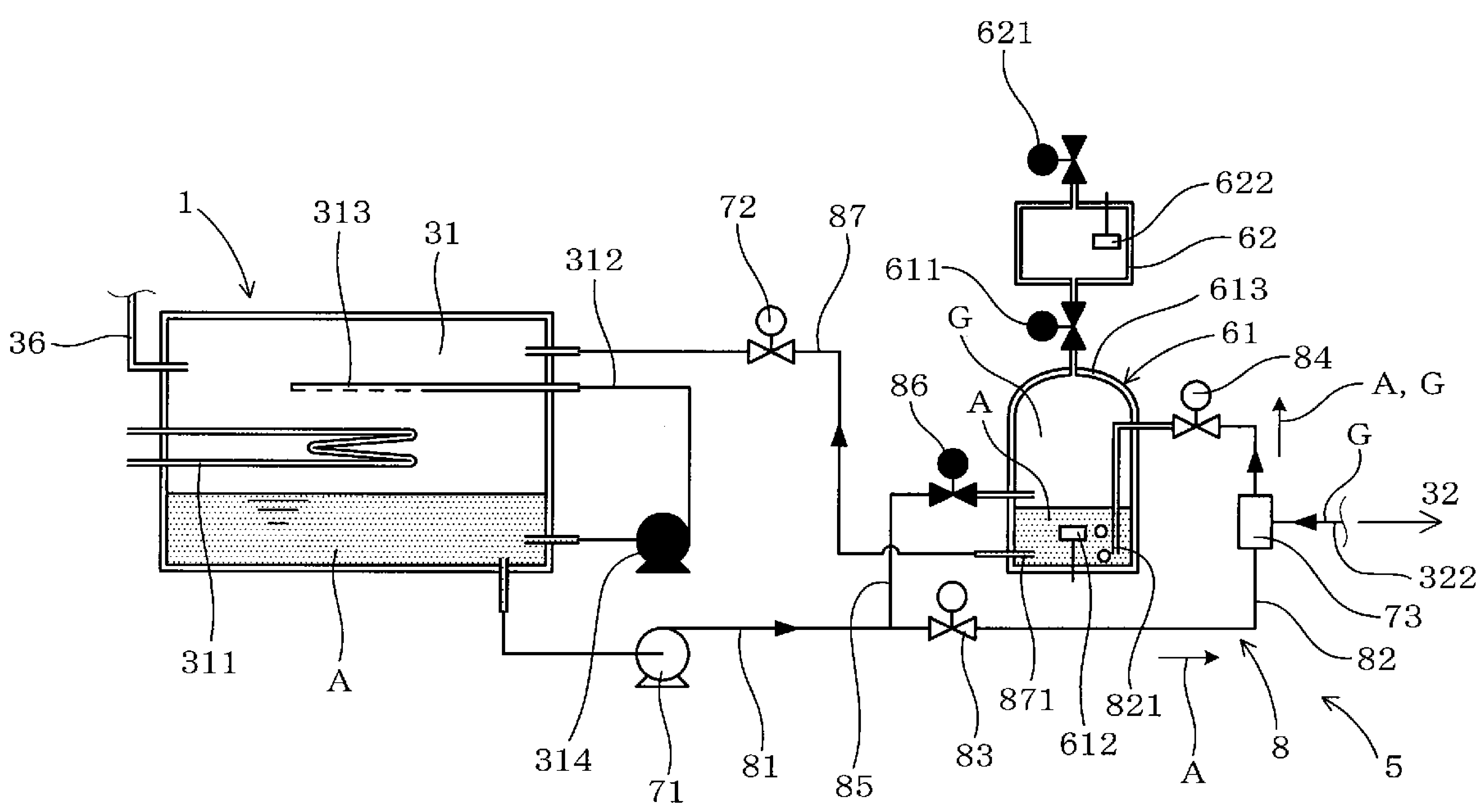
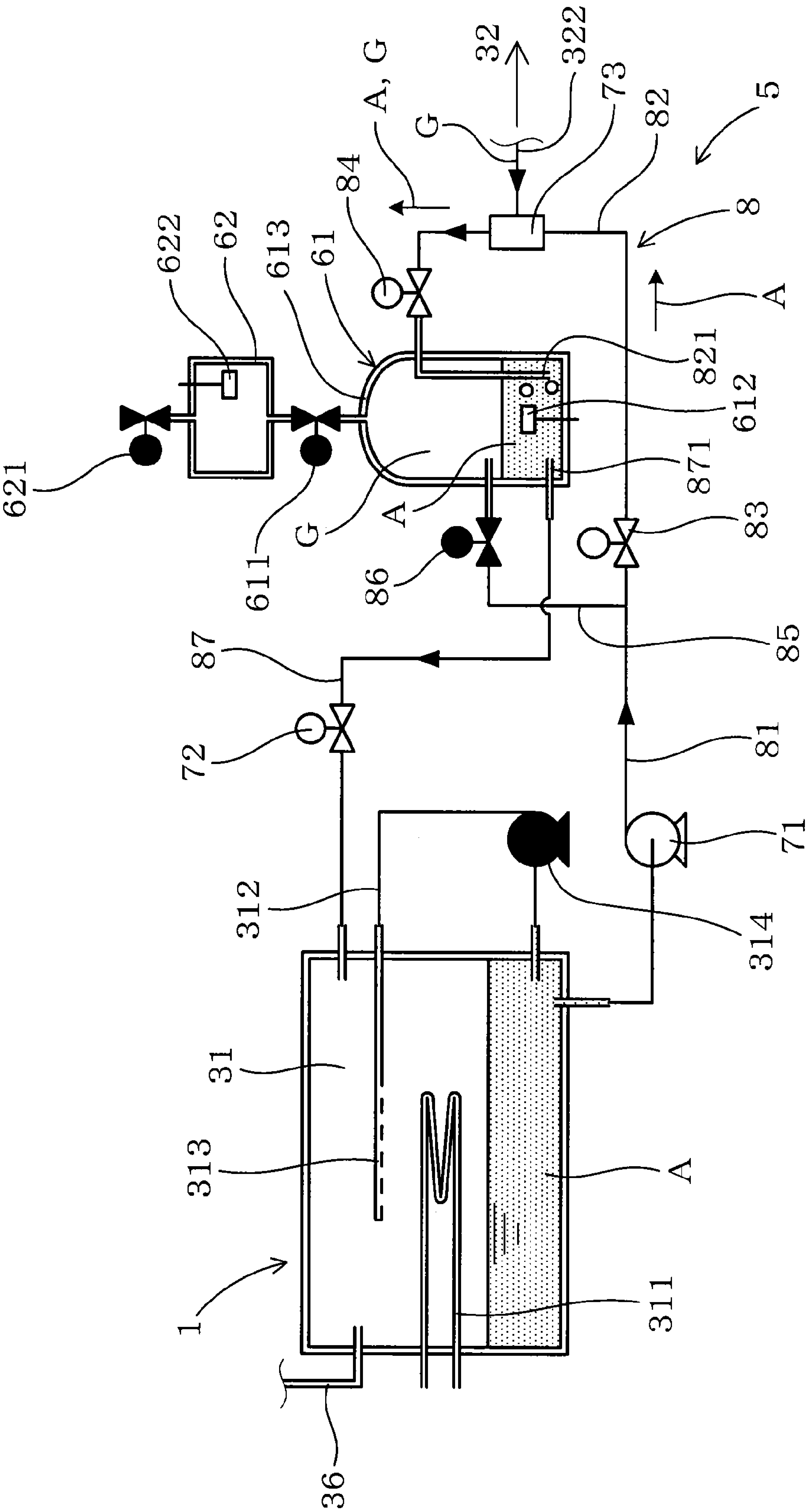


FIG. 1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36
31
311
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FIG. 2

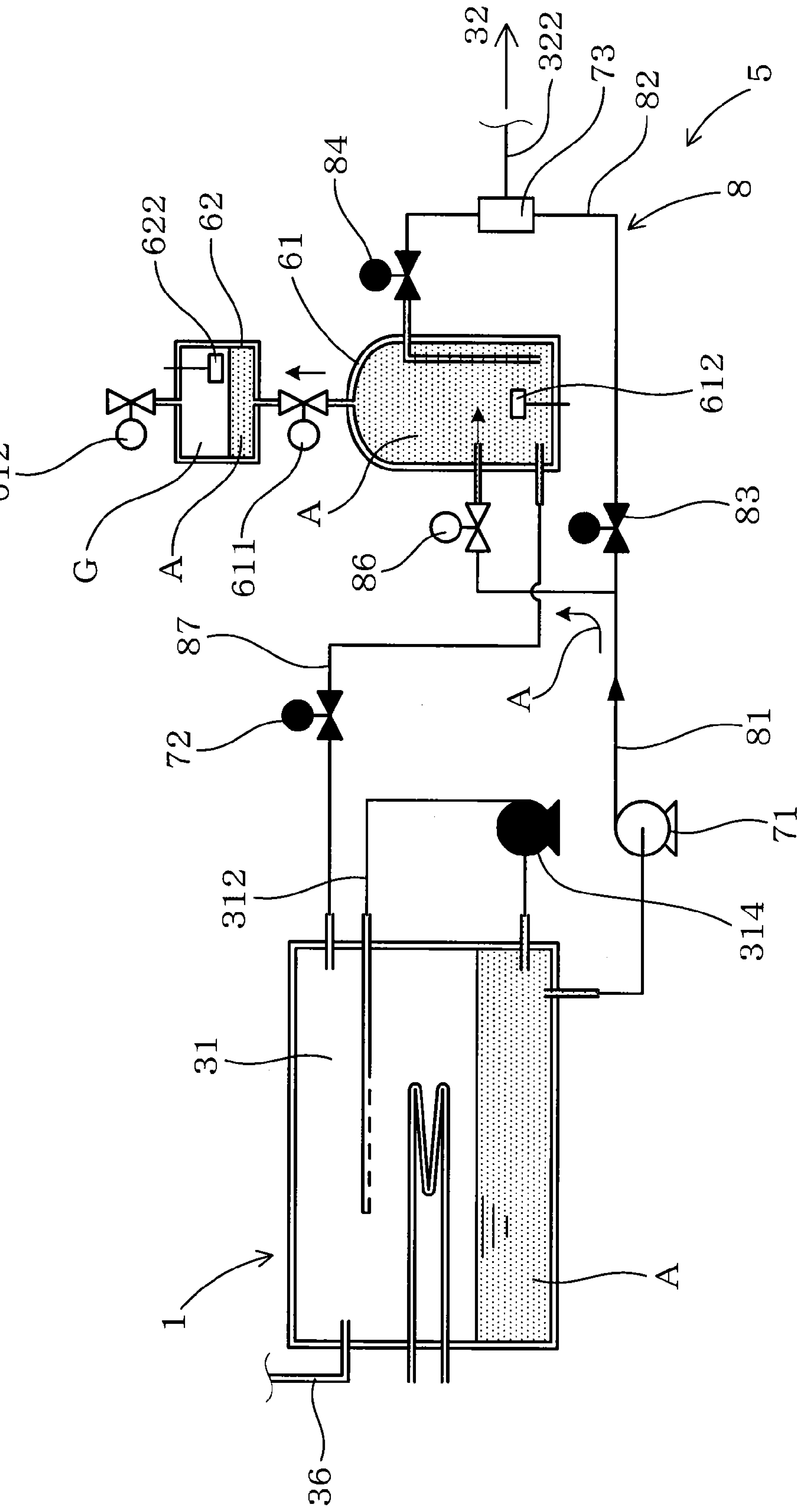
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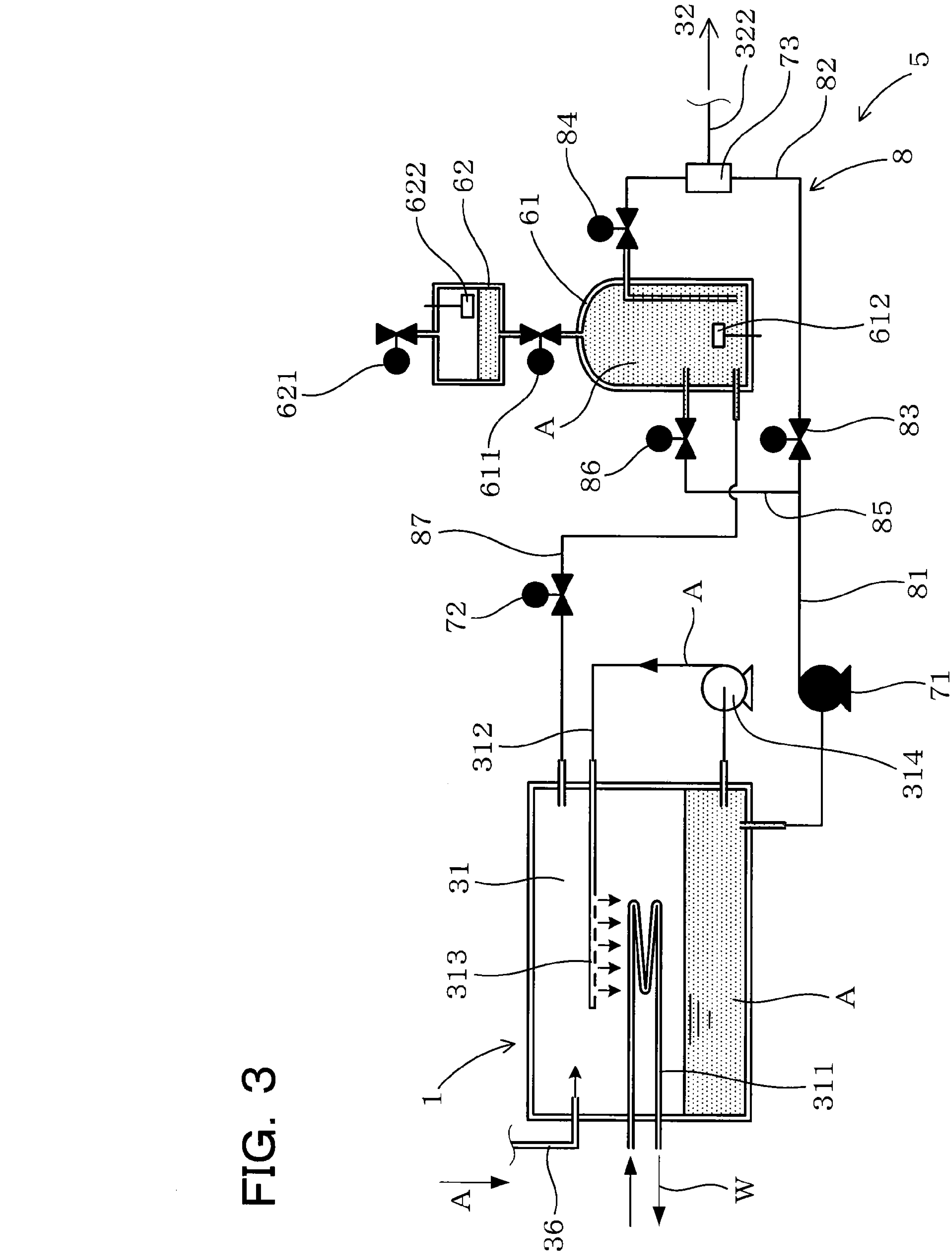
FIG. 3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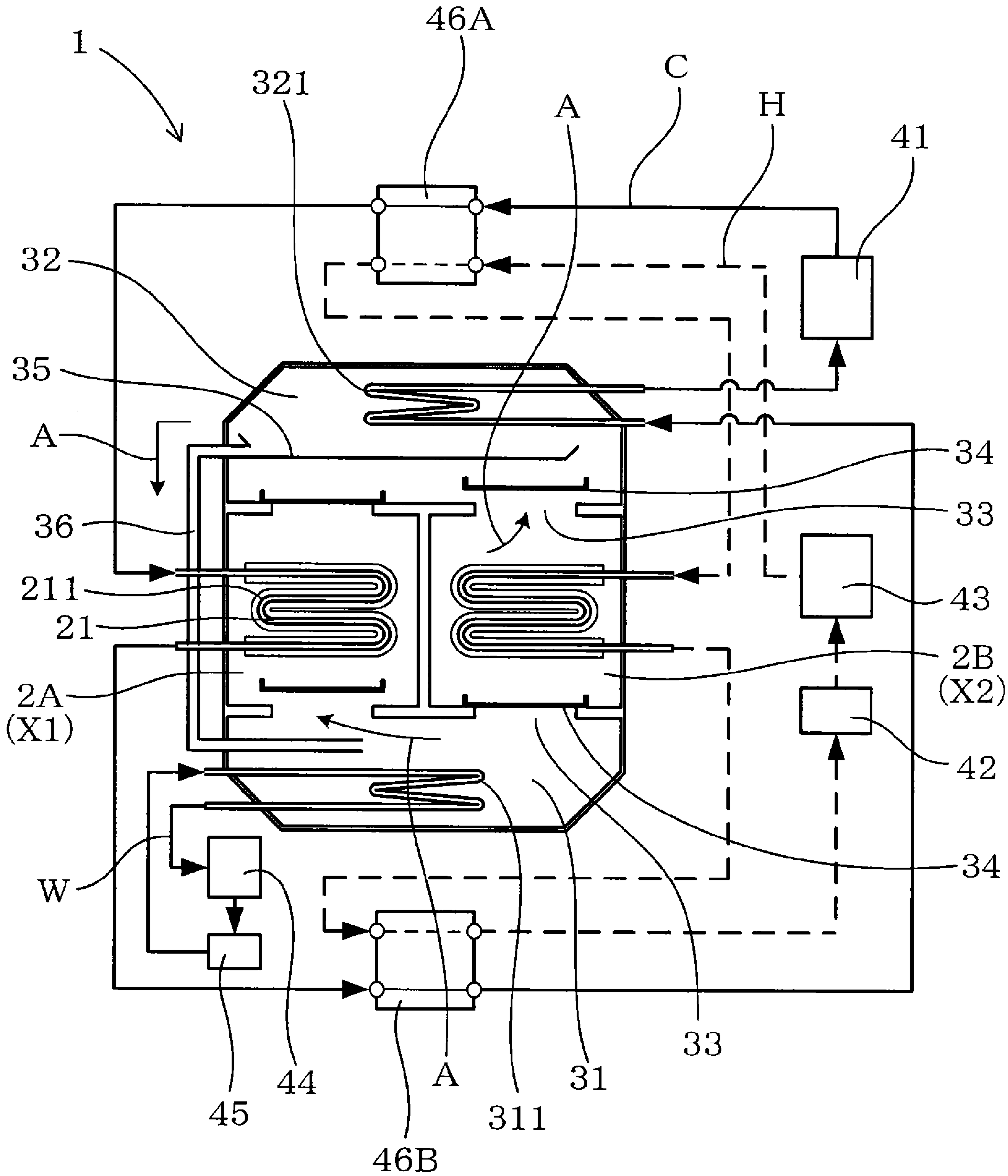
W

FIG. 4


1
46A
321
A
C
H
41
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34
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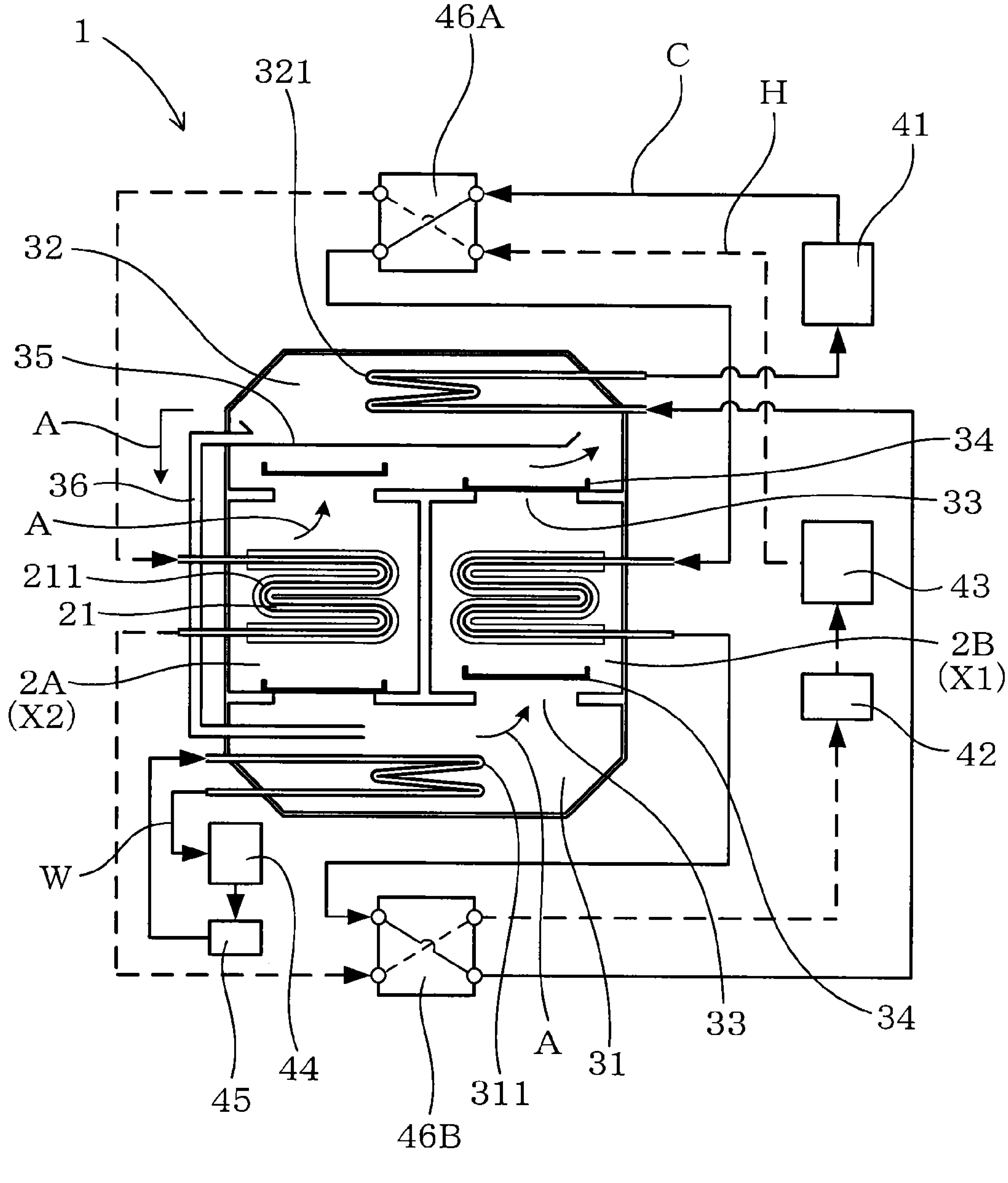
36
211
21
43
2B
(X2)
2A
(X1)
42
34
W
33
45
44
A
31
311
46B

FIG. 5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34

FIG. 6

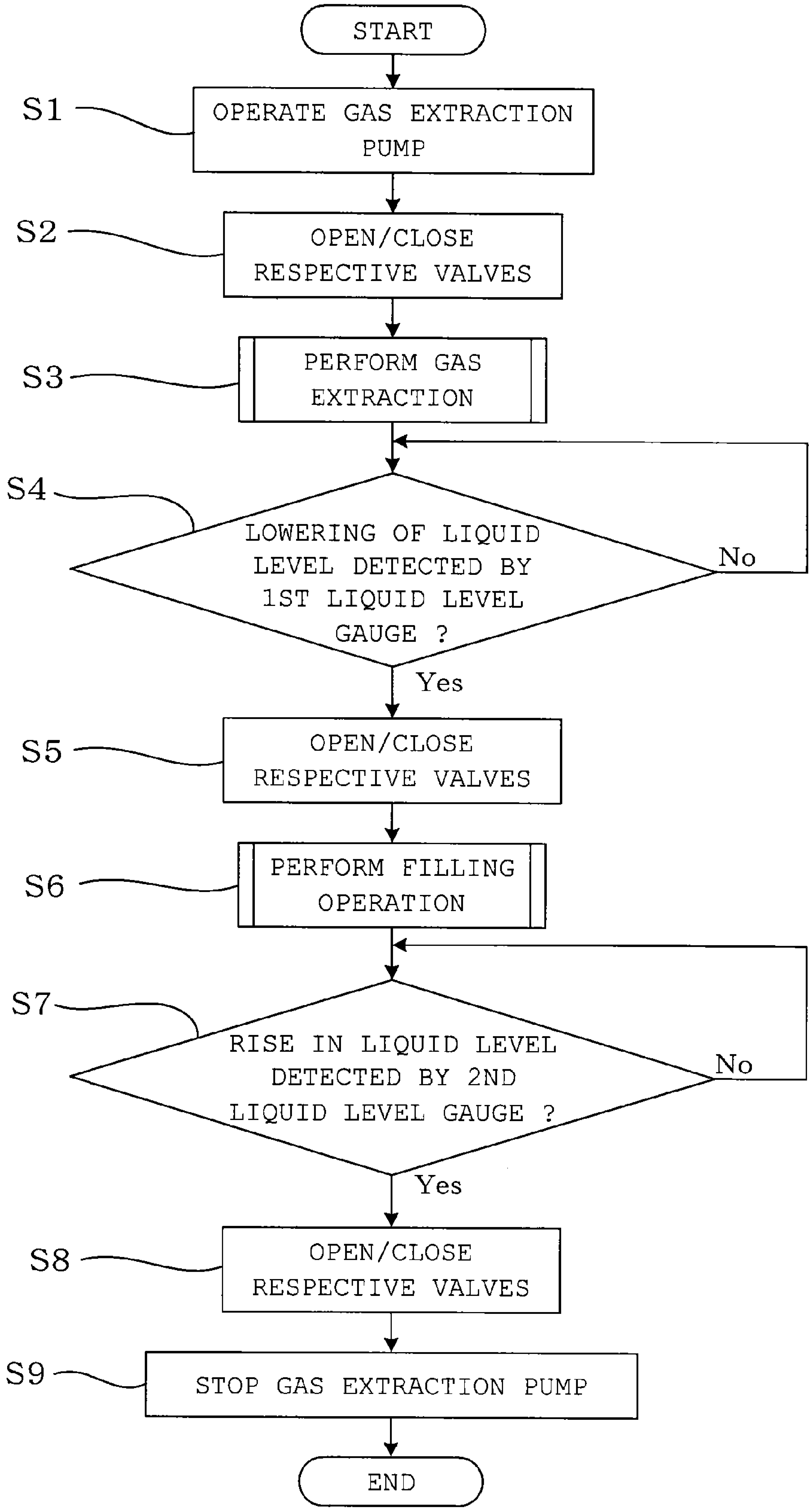
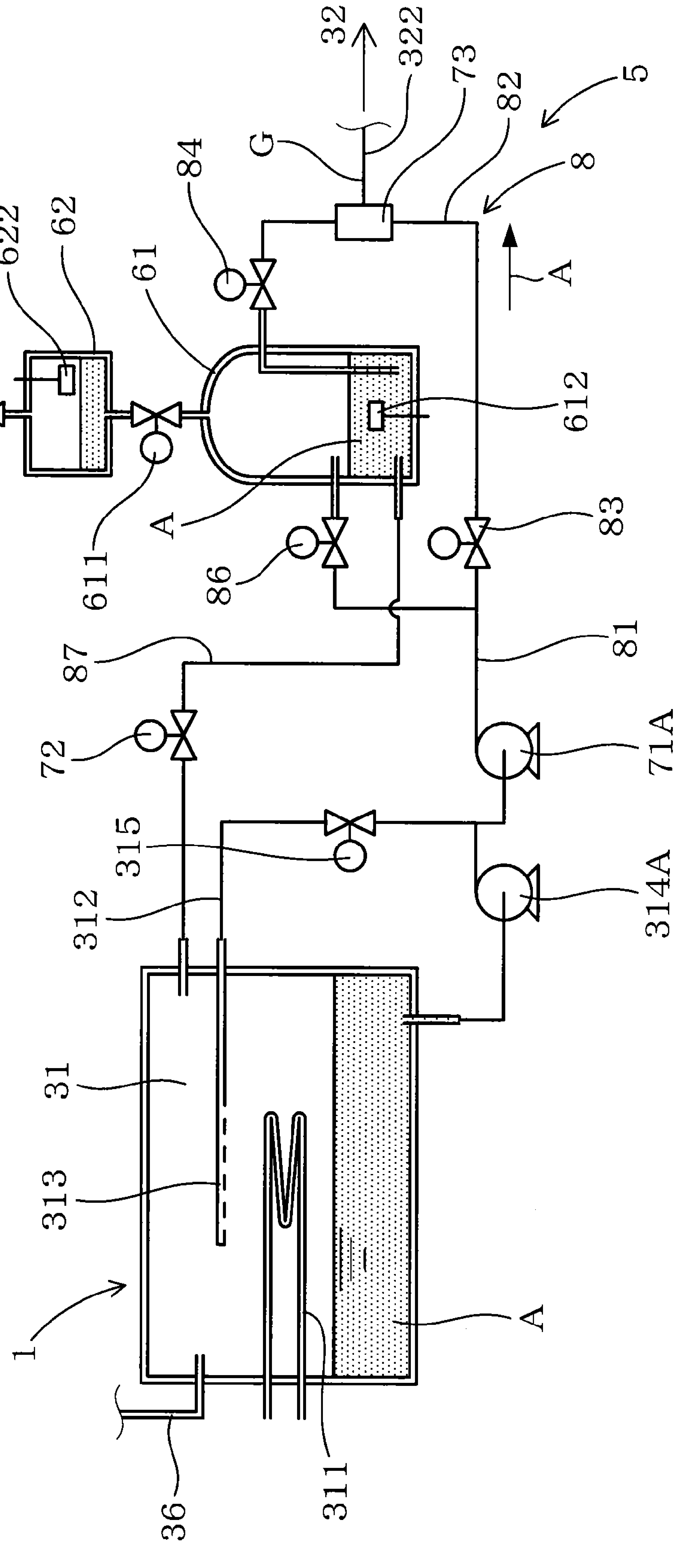

START
S1
OPERATE GAS EXTRACTION PUMP
S2
OPEN/CLOSE RESPECTIVE VALVES
S3
PERFORM GAS EXTRACTION
S4
LOWERING OF LIQUID LEVEL DETECTED BY 1ST LIQUID LEVEL GAUGE ?
No
Yes
S5
OPEN/CLOSE RESPECTIVE VALVES
S6
PERFORM FILLING OPERATION
S7
RISE IN LIQUID LEVEL DETECTED BY 2ND LIQUID LEVEL GAUGE ?
No
Yes
S8
OPEN/CLOSE RESPECTIVE VALVES
S9
STOP GAS EXTRACTION PUMP
END

FIG. 7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GAS EXTRACTION DEVICE AND GAS EXTRACTION METHOD FOR REFRIGERATOR

FIELD OF THE INVENTION

[0001] The present invention relates to a gas extraction device and a gas extraction method for removing uncondensed gases that exist in a refrigerator.

BACKGROUND OF THE INVENTION

[0002] In conventional refrigerators, for example, adsorption type refrigerators and absorption type refrigerators, a refrigerant is put in a container such as a vacuumized evaporator and the condenser, and heat of evaporation generated when evaporating the refrigerant in the evaporator is used to produce cold water. The containers of these refrigerators are injected with the refrigerant and then vacuumized before shipment.

[0003] Over a long-term use of such a refrigerator, traces of air infiltrating through sealed sections of the container or pipes, or hydrogen associated with internal corrosion is generated, and air and hydrogen, which are uncondensed gases, are accumulated in the container. These uncondensed gases that reside in the container, adversely interfere with evaporation and condensation of the refrigerant, resulting in deterioration of the refrigerator performance. To avoid that, variously designed gas extraction devices have been used to draw and discharge these uncondensed gases from the container.

[0004] The Patent document 1 discloses an absorption type refrigerator including a gas extraction device which evacuates air from inside of the absorption type refrigerator, a gas extraction tank used for storage of the gasses extracted by the gas extraction device, and a palladium cell for discharging the gasses stored in the gas extraction tank out of the refrigerator. In the absorption type refrigerator, the air-impermeable palladium cell having a hydrogen-permeability at certain temperatures is used to discharge the hydrogen out of the refrigerator.

[0005] It is disclosed in the Patent document 2 that when an absorbing solution, such as a lithium bromide solution, is supplied from an absorber to a regenerator by a solution pump, the uncondensed gases in the absorber are drawn into a liquid-vapor separator to be discharged by a down-flow gas extraction device.

PRIOR ART DOCUMENT

Patent Document

[0006] Patent document 1: JP-A Publication No. 2002-295929

[0007] Patent document 2: JP-A Publication No. 05-264132

SUMMARY OF THE INVENTION

Problems to be Solved by the Invention

[0008] According to the disclosures of the Patent documents 1 and 2, the uncondensed gases in vapor phase and the solution in liquid phase are separated from each other simply by liquid-vapor separation in the liquid-vapor separator or gas extraction tank. Therefore, a device resistant to atmospheric pressure, such as a water ejector or a vacuum pump, is additionally necessary after the liquid-vapor separation to discharge the uncondensed gases remaining in the liquid-vapor separator or the gas extraction tank, such as air, into atmosphere.

[0009] The present invention was accomplished to solve these conventional technical problems. The present invention provides a gas extraction device and a gas extraction method for refrigerator configured to prevent uncondensed gases, such as air and hydrogen, from accumulating in a gas extraction tank and further adapted to prevent the uncondensed gases and outside air from flowing into a refrigerator.

Means for Solving Problems

[0010] An aspect of the present invention provides a gas extraction device for a refrigerator, which is installed in the refrigerator configured to produce cold water using heat of evaporation generated when evaporating a refrigerant put in a vacuumized evaporator, the gas extraction device for removing an uncondensed gas that exists in the refrigerator including:

[0011] a gas extraction tank for circulating the refrigerant in the evaporator;

[0012] a circulation pipe for circulation between the gas extraction tank and the evaporator;

[0013] a gas extraction pump installed in the circulation pipe to feed the refrigerant in the evaporator to the gas extraction tank;

[0014] a shutoff valve installed in the circulation pipe so as to shut off a flow of the refrigerant from the gas extraction tank to the evaporator;

[0015] a gas extractor for extracting the uncondensed gas in the refrigerator into the gas extraction tank using the refrigerant supplied from the evaporator to the gas extraction tank; and

[0016] an auxiliary tank connected to an upper section of the gas extraction tank and receives an inflow of the refrigerant filling up the gas extraction tank, and overflowing therefrom.

[0017] Another aspect of the present invention provides a gas extraction method for a refrigerator using the above-configured gas extraction device for the refrigerator, the method including:

[0018] gas extraction step of opening the shutoff valve accompanied with an operation of the gas extraction pump, circulating the refrigerant in the evaporator to the gas extraction tank, and drawing the uncondensed gas in the refrigerator into the gas extraction tank using the gas extractor; and

[0019] discharging step of closing the shutoff valve accompanied with the operation of the gas extraction pump, filling up the gas extraction tank with the refrigerant put in the evaporator so as to be overflowed into the auxiliary tank, and discharging the uncondensed gases drawn and stored in the gas extraction tank into the auxiliary tank.

Effect of the Invention

[0020] The gas extraction device for refrigerator employs the gas extraction pump and the gas extractor so that the refrigerant in the evaporator is supplied to the gas extraction tank by the gas extraction pump, and the uncondensed gases in the refrigerator are extracted into the gas extraction tank. After the uncondensed gases are extracted into the gas extraction tank, the shutoff valve is closed and the gas extraction pump is operated. Then, the refrigerant supplied to the gas extraction tank by the gas extraction pump fills up the gas extraction tank and then overflows into the auxiliary tank.

[0021] Accordingly, all the uncondensed gases extracted into the gas extraction tank, such as air and hydrogen, are fully discharged into the auxiliary tank. Finally, the uncondensed gases are finally discharged from the auxiliary tank out of the refrigerator into atmosphere.

[0022] Thus, the gas extraction device prevents the uncondensed gases from residing in the gas extraction tank.

[0023] Therefore, it is unnecessary to additionally provide a device, such as a water ejector or a vacuum pump, to discharge the uncondensed gases remaining in the vacuumized gas extraction tank (at an internal pressure lower than atmospheric pressure) into atmosphere. Further, the gas extraction tank filled with the refrigerant leaves no space for the uncondensed gases. This eliminates the possibility of backflow of the uncondensed gases and outside air into the refrigerator when the uncondensed gases are extracted by the gas extraction pump and the gas extractor.

[0024] The gas extraction device for refrigerator prevents the uncondensed gases, such as air and hydrogen, from remaining in the gas extraction tank and further prevents the uncondensed gases and outside air from flowing back into the refrigerator.

[0025] The gas extraction method for refrigerator, by performing the gas extraction step and the discharging step, prevents the uncondensed gases, such as air and hydrogen, from remaining in the gas extraction tank and further prevent the uncondensed gases from flowing back into the refrigerator.

BRIEF DESCRIPTION OF DRAWINGS

[0026] FIG. **1** is an illustration of a gas extraction device that performs a gas extracting operation (gas extraction step) according to an embodiment of the present invention.

[0027] FIG. **2** is an illustration of a gas extraction device that performs a filling operation (filling step) according to the embodiment.

[0028] FIG. **3** is an illustration of a gas extraction device according to the embodiment when operating a refrigerator.

[0029] FIG. **4** is an illustration of a refrigerator according to the embodiment, which is operated using a first adsorbing/desorbing device functioning as an adsorbing device and a second adsorbing/desorbing device functioning as a desorbing device.

[0030] FIG. **5** is an illustration of a refrigerator according to the embodiment, which is operated using a first adsorbing/desorbing device functioning as the desorbing device and a second adsorbing/desorbing device functioning as the adsorbing device.

[0031] FIG. **6** is a flowchart illustrating a gas extraction method for refrigerator according to the embodiment.

[0032] FIG. **7** is an illustration of another gas extraction device according to the embodiment.

MODES FOR CARRYING OUT THE INVENTION

[0033] Preferred mode of the gas extraction device and the gas extraction method for refrigerator as above will be described below.

[0034] The refrigerator may be formed as an adsorption type refrigerator in which refrigerant vapor is repeatedly adsorbed to and desorbed from a solid adsorbent by an adsorbing device and a desorbing device to circulate the refrigerant between an evaporator and a condenser, so that cold water is produced in an evaporator pipe provided in the evaporator so as to penetrate therethrough. The refrigerator may be an absorption type refrigerator in which a refrigerant is circulated between a condenser and an evaporator by the use of an absorbing solution which absorbs refrigerant vapor, so that cold water is produced in an evaporator pipe provided in the evaporator so as to penetrate therethrough.

[0035] The gas extractor may be an ejector configured to draw in gas using a liquid flow. The gas extractor is allowed to extract the uncondensed gases from the refrigerator at a portion where the uncondensed gases are most likely to accumulate. The condenser of the adsorption type refrigerator may be subjected to the gas extraction, and the absorber device of the absorption type refrigerator may be subjected to the gas extraction, for example.

[0036] Preferably, the gas extraction tank includes a first liquid level gauge which outputs a water-level signal when a liquid level of the refrigerant in the gas extraction tank becomes the same as or lower than a predefined height;

[0037] the auxiliary tank includes a second liquid level gauge which outputs a water-level signal when a liquid level of the refrigerant in the auxiliary tank becomes the same as or higher than a predefined height; and

[0038] a controller of the gas extraction device is configured to perform a gas extraction operation by opening the shutoff valve, and continuously operating the gas extraction pump until reception of the water-level signal output from the first liquid level gauge, and a filling operation by closing the shutoff valve, and continuously operating the gas extraction pump until reception of the water-level signal output from the second liquid level gauge.

[0039] In this case, the use of the first liquid level gauge enables proper management of a duration of the gas extraction performed by the gas extraction pump, and the use of the second liquid level gauge enables proper discharge of the uncondensed gases from the gas extraction tank into the auxiliary tank, and easy prevention of the refrigerant overflow from the auxiliary tank.

[0040] The duration of the gas extraction performed by the gas extraction pump may be set to a length of time suitably determined without using the first liquid level gauge.

[0041] Preferably, the circulation pipe includes a feed pipe connected to a lower section of the evaporator and equipped with the gas extraction pump, and a return pipe connected to a lower section of the gas extraction tank and equipped with the shutoff valve; and

[0042] end portions of the feed pipe and the return pipe that are open to the gas extraction tank are positioned lower than the height of the liquid level of the refrigerant, which is established upon output of the water-level signal from the first liquid level gauge.

[0043] This may prevent the uncondensed gases extracted into the gas extraction tank from accidentally flowing into the return pipe and being mixed therein. This may further prevent the uncondensed gases extracted into the gas extraction tank from accidentally flowing back into the feed pipe.

[0044] Preferably, a first tank valve is provided between the gas extraction tank and the auxiliary tank;

[0045] a second tank valve is provided above the auxiliary tank; and

[0046] the controller is configured to close the first tank valve when performing the gas extraction operation, open the first tank valve and the second tank valve when performing the filling operation, and close the first tank valve when receiving the water-level signal output from the second liquid level gauge.

[0047] In this case, upon the gas extraction, the first tank valve is closed so as to prevent outside air from being mixed into the gas extraction tank by way of the auxiliary tank. After the filling operation, the first tank valve is closed so as to prevent the uncondensed gases, such as air and hydrogen, from being mixed into the gas extraction tank again by way of the auxiliary tank.

[0048] Preferably, an upper section of the gas extraction tank has a shape with a horizontal sectional area that becomes smaller toward an upward direction; and

[0049] the auxiliary tank is connected to a portion at the upper section of the gas extraction tank, which has a minimum horizontal sectional area.

[0050] This may prevent a part of the uncondensed gases constituting a vapor phase component in the gas extraction tank from remaining in corners at the upper section of the gas extraction tank when the refrigerant filled in the gas extraction tank overflows into the auxiliary tank. As a result, all the uncondensed gases in the gas extraction tank are fully discharged into the auxiliary tank.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0051] Hereinafter, an embodiment of a gas extraction device for a refrigerator is described in detail referring to the accompanied drawings.

[0052] As illustrated in FIGS. **1** to **3**, a gas extraction device **5** for a refrigerator **1** according to the embodiment is installed in the refrigerator **1** that produces a cold water W by using heat of evaporation generated upon evaporation of a refrigerant A put in a vacuumized evaporator **31**.

[0053] The gas extraction device **5** is provided with a gas extraction tank **61**, a circulation pipe **8**, a gas extraction pump **71**, a shutoff valve **72**, a gas extractor **73**, and an auxiliary tank **62**.

[0054] The gas extraction tank **61** has a container shape and is used to circulate the refrigerant A in the evaporator **31**. The circulation pipe **8** is connected to the gas extraction tank **61** and the evaporator **31** for circulation therebetween. The gas extraction pump **71** is installed in the circulation pipe **8** and used to feed the refrigerant A from the evaporator **31** to the gas extraction tank **61**. The shutoff valve **72** is installed in the circulation pipe **8** and capable of blocking a flow of the refrigerant A from the gas extraction tank **61** to the evaporator **31**. The gas extractor **73** extracts the uncondensed gases G in the refrigerator **1** into the gas extraction tank **61** using the refrigerant A supplied from the evaporator **31** to the gas extraction tank **61**. The auxiliary tank **62** is connected to an upper section of the gas extraction tank **61** to cause the refrigerant A that is filled and overflows from the gas extraction tank **61** to inflow.

[0055] The gas extraction device **5** of the refrigerator **1** and a gas extraction method according to the embodiment will be hereinafter described in detail referring to FIGS. **1** to **7**.

[0056] First, the refrigerator **1** according to the embodiment will be described.

[0057] FIGS. **4** and **5** are illustrations of the refrigerator **1**. FIG. **5** illustrates that an adsorbing device X1 and a desorbing device X2 of the refrigerator shown in FIG. **4** are switched.

[0058] As illustrated in these drawings, the refrigerator **1** according to the embodiment is an adsorption type refrigerator **1** in which vapor of the refrigerant A is repeatedly adsorbed to and desorbed from a solid adsorbent **211** by the adsorbing device X**1** and the desorbing device X**2** to circulate the refrigerant A between an evaporator **31** and a condenser **32** so that the cold water W is produced in an evaporator pipe **311** that is inserted into the evaporator **31**.

[0059] The adsorption type refrigerator **1** has a plurality of (two in the embodiment) adsorbing/desorbing devices **2**A and **2**B each having a heat transfer pipe **21** inserted therethrough, a surface of which is applied with the solid adsorbent **211**, the evaporator **31** configured to communicate with the plurality of adsorbing/desorbing devices **2**A and **2**B individually, and the condenser **32** configured to communicate with the plurality of adsorbing/desorbing devices **2**A and **2**B individually.

[0060] The adsorbing/desorbing devices **2**A and **2**B, the evaporator **31**, and the condenser **32** are configured to allow circulation of the refrigerant A (may be called refrigerant vapor A). The internal spaces of the adsorbing/desorbing devices **2**A and **2**B, the evaporator **31**, and the condenser **32** are vacuumized to allow easy evaporation of the refrigerant A. The evaporator **31** has an internal pressure equal to about $1/100$ of atmospheric pressure, and the condenser **32** has an internal pressure equal to about $1/20$ of atmospheric pressure. According to the embodiment, the solid adsorbent **211** is silica gel, and the refrigerant A is water.

[0061] There are communication paths **33** for the refrigerant vapor A to pass through between the adsorbing/desorbing devices **2**A and **2**B, and the evaporator **31**, and between the adsorbing/desorbing devices **2**A and **2**B, and the condenser **32**. The communication paths **33** respectively have dampers **34** placed therein, which open and close the communication paths **33** under their own weights and a pressure of the refrigerant vapor A.

[0062] As illustrated in FIGS. **4** and **5**, the heat transfer pipes **21** of the adsorbing/desorbing devices **2**A and **2**B are installed up to the region where two selector valve devices **46**A and **46**B are provided. The selective valve devices **46**A and **46**B switchably select between a cooling water C and a warm water H to be circulated in the respective heat transfer pipes **21**.

[0063] The evaporator pipe **311** is inserted into the evaporator **31** as a passage of the cold water W. The evaporator pipe **311** is connected to a cold water tank **44**. The evaporator pipe **311** is connected to a refrigerating device **45** to be cooled with supplied cold water W. The refrigerating device **45** may be exemplified by an air conditioning system and a refrigerator, for example. The evaporator pipe **311** is arranged to circulate through the evaporator **31**, cold water tank **44**, and refrigerating device **45**.

[0064] A condenser pipe **321** is inserted into the condenser **32** as a passage of the cooling water C. The condenser pipe **321** is connected to a cooling water tank **41**. The cooling water C from the cooling water tank **41** is circulated to the condenser pipe **321** by way of the selector valve device **46**A, heat transfer pipes **21** of the adsorbing/desorbing devices **2**A and **2**B, and the selector valve device **46**B, and then returns to the cooling water tank **41** from the condenser pipe **321**.

[0065] The condenser **32** has a tray **35** for receiving the refrigerant A (water in the embodiment) condensed and liquefied by the condenser pipe **321**. There is a circulation pipe **36** between the tray **35** and the evaporator **31** to feed the refrigerant A accumulated on the tray **35** to a surface of the evaporator pipe **311** in the evaporator **31**.

[0066] The warm water H supplied to the heat transfer pipes **21** of the adsorbing/desorbing devices **2**A and **2**B is heated by exhaust heat discharged from a heat generator **42** to generate heat. The heat generator **42** may be exemplified by a solar energy assisted system, a gas engine system, a boiler, or a device configured to discharge vapor drain. The warm water H is obtained by the use of exhaust heat discharged from the heat generator **42** and stored in a warm water tank **43**, and then circulated to inlets of the heat transfer pipe **21** of the adsorbing/desorbing devices **2**A and **2**B via the selector valve device **46**A. The warm water H is further circulated from outlets of the heat transfer pipe **21** of the adsorbing/desorbing devices **2**A and **2**B to the heat generator **42** via the selector valve device **46**B.

[0067] The cooling water C is water at 25° C. to 35° C. (about 30° C.), and the warm water H is water heated to 70° C. to 90° C. (about 80° C.). The cold water W in the evaporator pipe **311** in the evaporator **31** is cooled down to 9 to 14° C. (about 11° C.).

[0068] The adsorption type refrigerator **1** is configured to be operated by switching between the adsorbing/desorbing device **2**A (or **2**B) functioning as the adsorbing device X**1** by circulating the cooling water C to the heat transfer pipe **21** and the adsorbing/desorbing device **2**B (or **2**A) functioning as the desorbing device X**2** by circulating the warm water H to the heat transfer pipe **21** at given time intervals to cool the cold water W in the evaporator pipe **311** inserted into the evaporator **31**. The adsorption type refrigerator **1** continuously supplies the produced cold water W from the cold water tank **44** to the refrigerating device **45**.

[0069] The operation of the adsorption type refrigerator **1** will be hereinafter described.

[0070] As illustrated in FIG. **4**, the first adsorbing/desorbing device **2**A functions as the adsorbing device X**1** when the cooling water C is supplied to the heat transfer pipe **21** in the first adsorbing/desorbing device **2**A. The solid adsorbent **211** applied to the surface of the heat transfer pipe **21** in the first adsorbing/desorbing device **2**A is cooled down, and the refrigerant vapor A is adsorbed to the solid adsorbent **211** by adsorption reaction. Then, an internal pressure of the first adsorbing/desorbing device **2**A reduces to a lower pressure level than the internal pressures of the evaporator **31** and the condenser **32**. Affected by the thus generated pressure difference, the damper **34** disposed in the communication path **33** between the first adsorbing/desorbing device **2**A and the evaporator **31** is opened, while the damper **34** disposed in the communication path **33** between the first adsorbing/desorbing device **2**A and the condenser **32** is closed. Then, the refrigerant vapor A in the evaporator **31** flows into the first adsorbing/desorbing device **2**A and removes heat of evaporation from the surface of the evaporator pipe **311** in the evaporator **31**, thus cooling down the cold water W in the evaporator pipe **311**.

[0071] As illustrated in the drawing, when the cooling water C is supplied to the heat transfer pipe **21** in the first adsorbing/desorbing device **2**A, the warm water H is supplied to the heat transfer pipe **21** in the second adsorbing/desorbing device **2**B. The second adsorbing/desorbing device **2**B supplied with the warm water H in the heat transfer pipe **21** functions as the desorbing device X**2**. The solid adsorbent **211** applied to the surface of the heat transfer pipe **21** in the second adsorbing/desorbing device **2**B is heated, and the refrigerant vapor A is thus desorbed from the solid adsorbent **211** by desorption reaction. Then, an internal pressure of the second adsorbing/desorbing device **2**B is elevated to a higher pressure level than the internal pressures of the evaporator **31** and the condenser **32**. Affected by the thus generated pressure difference, the damper **34** disposed in the communication path **33** between the second adsorbing/desorbing device **2**B and the evaporator **31** is closed, while the damper **34** disposed in the communication path **33** between the second adsorbing/desorbing device **2**B and the condenser **32** is opened. Then, the refrigerant vapor A in the second adsorbing/desorbing device **2**B flows into the condenser **32**, and the refrigerant vapor A is condensed by the cooling water C running in the condenser pipe **321** of the condenser **32**. The condensed refrigerant vapor A is circulated into the evaporator **31** through the circulation pipe **36**.

[0072] When an amount of the refrigerant vapor A adsorbed to the solid adsorbent **211** in the first adsorbing/desorbing device **2**A functioning as the adsorbing device X**1** is about to reach a saturation amount, the two selector valve devices **46**A and **46**B are manipulated as illustrated in FIG. **5** to circulate the warm water H to the heat transfer pipe **21** in the first adsorbing/desorbing device **2**A, and circulate the cooling water C to the heat transfer pipe **21** in the second adsorbing/desorbing device **2**B. Then, the function of the first adsorbing/desorbing device **2**A is switched to the desorbing device X**2**, while switching the function of the second adsorbing/desorbing device **2**B to the adsorbing device X**1**. Accordingly, the second adsorbing/desorbing device **2**B functions as the adsorbing device X**1**, and the first adsorbing/desorbing device **2**A functions as the desorbing device X**2** as described above.

[0073] Thereafter, supply of the cooling water C and the warm water H to the heat transfer pipe **21** in the first adsorbing/desorbing device **2**A and the heat transfer pipe **21** in the second adsorbing/desorbing device **2**B is switched in turn at given time intervals. Accordingly, two adsorbing/desorbing devices **2**A and **2**B are switchably used as the adsorbing device X**1** and the desorbing device X**2** in turn at given time intervals, so that the cold water W generated in the evaporator pipe **311** is continuously supplied to the refrigerating device **45** via the cold water tank **44**.

[0074] Next, the gas extraction device **5** will be described.

[0075] FIGS. **1** to **3** illustrate a structure of the gas extraction device **5**. FIG. **1** is an illustration of the gas extraction device performing a gas extracting operation (gas extraction step). FIG. **2** is an illustration of the gas extraction device performing a filling operation (filling step). FIG. **3** is an illustration of the gas extraction device when operating the refrigerator **1**. These drawings illustrate the evaporator **31** alone, while omitting any other devices of the refrigerator **1**. A gas extraction pipe **322**, which will be described later, is connected to inside of the condenser **32** of the refrigerator **1**. In these drawings, the currently active pumps **314** and **71** and opened valves **611**, **621**, **72**, **83**, **84**, and **86** are illustrated in white. Meanwhile, currently inactive pumps **314** and **71**, and the closed valves **611**, **621**, **72**, **83**, **84**, and **86** are illustrated in black.

[0076] As illustrated in FIG. **3**, the liquefied refrigerant A is contained in the evaporator **31**. The evaporator **31** is provided with a refrigerant drip-feed pipe **312** configured to drip the liquefied refrigerant A as a liquid phase component in a lower section, into a vapor phase in an upper section. An upper end portion of the refrigerant drip-feed pipe **312** inserted in the evaporator **31** has a nozzle **313** through which the refrigerant A drips. A lower end portion of the refrigerant drip-feed pipe

312 has a drip-feed pump **314** which suctions the liquefied refrigerant A from the evaporator **31** and drips the suctioned liquefied refrigerant A through the nozzle **313**. The drip-feed pump **314** remains active at all times so far as the refrigerator **1** which continuously produces the cold water W is operating.

[0077] As illustrated in FIGS. **1** and **2**, an upper section **613** of the gas extraction tank **61** according to the embodiment has a shape where a horizontal sectional area is smaller toward upward direction. More specifically, the upper section **613** of the gas extraction tank **61** has a dome shape so that the gas extraction tank **61** becomes the highest at a horizontal center position. The upper section **613** of the gas extraction tank **61** is not necessarily limited to the dome shape but may be formed in a conical shape.

[0078] The auxiliary tank **62** is connected to a horizontal center of the upper section **613** of the gas extraction tank **61** where the horizontal sectional area is reduced to minimum as the highest position.

[0079] The circulation pipe **8** includes a feed pipe **81** connected to a lower section of the evaporator **31** and equipped with the gas extraction pump **71**, and a return pipe **87** connected to a lower section of the gas extraction tank **61** and equipped with the shutoff valve **72**. The feed pipe **81** according to the embodiment is bifurcated at a position downstream of the gas extraction pump **71** and then connected to the gas extraction tank **61**. More specifically, the feed pipe **81** is bifurcated at a position downstream of the gas extraction pump **71** into a gas extraction pipe section **82** connected to the gas extraction tank **61** via the gas extractor **73** and a bypass pipe section **85** directly connected to the gas extraction tank **61** without passing through the gas extractor **73**. The gas extraction pipe section **82** has switching valves **83** and **84** configured to open and close at upstream and downstream sides of the gas extractor **73**. The bypass pipe section **85** has an opening-closing valve **86**.

[0080] A first tank valve **611** configured to open and close is provided between the gas extraction tank **61** and the auxiliary tank **62**, and a second tank valve **621** configured to open and close is provided above the auxiliary tank **62**.

[0081] As illustrated in FIGS. **1** and **2**, the gas extraction tank **61** is provided with a first liquid level gauge **612** therein, which outputs a water-level signal when a liquid level of the refrigerant A in the gas extraction tank **61** is equal to or lower than a predefined height. The first liquid level gauge **612** detects an amount of the uncondensed gases G extracted into the gas extraction tank **61** based on the height of the liquid level of the refrigerant A. The first liquid level gauge **612** may be provided at a lower position in the gas extraction tank **61**. Adjustment of the position in height of the first liquid level gauge **612** allows the liquid level of the refrigerant in the gas extraction tank **61** and the amount of the uncondensed gases G to be extracted into the gas extraction tank **61** to be suitably set.

[0082] The auxiliary tank **62** is provided with a second liquid level gauge **622** therein, which outputs a water-level signal when the liquid level of the refrigerant A in the auxiliary tank **62** is equal to or higher than a predetermined height. The second liquid level gauge **622** detects an amount of the refrigerant A flowing into the auxiliary tank **62** based on the height of the liquid level of the refrigerant A. The second liquid level gauge **622** may be provided at a longitudinally intermediate position in the auxiliary tank **62**. Adjustment of the position in height of the second liquid level gauge **622** allows the amount of the refrigerant A flowing into the auxiliary tank **62** to be suitably set.

[0083] An end portion **821** of the gas extraction pipe section **82** and an end portion **871** of the return pipe **87** both open to the gas extraction tank **61** are located lower than the height of the liquid-level of the refrigerant A, which are established upon output of the water-level signal from the first liquid level gauge **612**. The aforementioned structure prevents the uncondensed gases G extracted into the gas extraction tank **61** from accidentally flowing into the return pipe **87** and flowing back to the feed pipe **81**. The gas extraction pipe section **82** is inserted into the gas extraction tank **61** from above and provided to a position lower than the position of the first liquid level gauge **612**.

[0084] As illustrated in FIGS. **1** and **2**, the gas extractor **73** according to the embodiment corresponds to an ejector **73** configured to draw in gas using a liquid flow. The ejector **73** has a gas draw-in passage formed on an outer or inner side of a liquid passage. The liquid passage is connected to an intermediate position of the gas extraction pipe section **82**, and the gas draw-in passage is connected to the inside of the condenser **32** of the refrigerator **1** via the gas extraction pipe **322**.

[0085] The gas extraction pump **71** according to the embodiment has a higher discharge pressure than atmospheric pressure (0.1 MPa) to cause the refrigerant A filled in the gas extraction tank **61** to overflow into the auxiliary tank **62** opened under atmospheric pressure.

[0086] The refrigerator **1** according to the embodiment is controlled by a controller (control computer or control sequencer) to manipulate the two selector valve devices **46**A and **46**B, drip-feed pump **314**, gas extraction pump **71**, shutoff valve **72**, first tank valve **611**, second tank valve **621**, and switching valves **83**, **84**, and **86**. The water-level signals output from the first liquid level gauge **612** and the second liquid level gauge **622** are transmitted to the controller.

[0087] The controller according to the embodiment implements a gas extracting operation in which the shutoff valve **72** is opened and the first tank valve **611** and the second tank valve **621** are closed, and the gas extraction pump **71** is continuously operated until the water-level signal output from the first liquid level gauge **612** is received as illustrated in FIG. **1**, and a filling operation in which the shutoff valve **72** is closed and the first tank valve **611** and the second tank valve **621** are opened, and the gas extraction pump **71** is continuously operated until the water-level signal output from the second liquid level gauge **622** is received as illustrated in FIG. **2**. When the controller receives the water-level signal from the second liquid level gauge **622** during the filling operation, the controller closes the first tank valve **611** and the second tank valve **621**.

[0088] A method for discharging the uncondensed gases G in the refrigerator **1** using the gas extraction device **5** according to the embodiment will be described referring to a flowchart illustrated in FIG. **6**.

[0089] Prior to the discharge of the uncondensed gases G, the refrigerator **1** is operated to produce the cold water W continuously in the evaporator pipe **311** of the evaporator **31**. As illustrated in FIG. **3**, the drip-feed pump **314** of the evaporator **31** is operated, while the gas extraction pump **71** remains inactive. The shutoff valve **72**, and the switching valves **83**, **84**, and **86** are closed.

[0090] After the refrigerator **1** is operated over a given period of time (for example, a few days), the operation of the refrigerator **1** is stopped, and the gas extracting step is performed to extract the uncondensed gases G, such as air and hydrogen, accumulated in the refrigerator **1** as illustrated in FIG. **1**. During the gas extracting operation, the drip-feed pump **314** is kept active, while stopping the operation of the refrigerator **1**. The gas extraction pump **71** is operated with the first tank valve **611**, second tank valve **621**, and switching valve **86** of the bypass pipe section **85** are kept closed (Step S**1** of FIG. **6**, subsequent steps will be recited with symbols alone). Then, the shutoff valve **72** and the switching valves **83** and **84** of the gas extractor **73** are opened (S**2**).

[0091] The refrigerant A is circulated between the evaporator **31** and the gas extraction tank **61**, and the uncondensed gases G in the condenser **32** are drawn into the gas extraction tank **61** using the refrigerant A passing through the gas extractor **73** (S**3**). The gas extracting operation continues until the controller receives the water-level signal from the first liquid level gauge **612** (S**4**). More specifically, when the uncondensed gases G are extracted into the gas extraction tank **61**, the vapor phase component in the gas extraction tank **61** increases. Meanwhile, the refrigerant A as the liquid phase component reduces, thus lowering the liquid level of the refrigerant A. When the liquid level of the refrigerant A in the gas extraction tank **61** is equal to the predefined height, the first liquid level gauge **612** transmits the water-level signal to the controller. Then, the controller switches the step from the ongoing gas extracting operation to the filling operation.

[0092] In the filing step, the controller closes the shutoff valve **72** and the switching valves **83** and **84** of the gas extractor **73**, while opening the first tank valve **611**, second tank valve **621**, and switching valve **86** of the bypass pipe section **85** (S**5**) to continue the operation of the gas extraction pump **71** as illustrated in FIG. **2**.

[0093] The refrigerant A circulated from the evaporator **31** by the gas extraction pump **71** is continuously accumulated in the gas extraction tank **61**. When the gas extraction tank **61** is filled up with the refrigerant A, the refrigerant A starts overflowing into the auxiliary tank **62** (S**6**). Then, the uncondensed gases G and outside air constituting the vapor phase component in the gas extraction tank **61** are forced out by the refrigerant A into the auxiliary tank **62** and then discharged from the auxiliary tank **62** into atmosphere.

[0094] Since the auxiliary tank **62** is released to atmosphere, the refrigerant A in the auxiliary tank **62** drops into the gas extraction tank **61**. The uncondensed gases G and outside air are mixed both in the gas extraction tank **61** and the auxiliary tank **62**.

[0095] When the liquid level of the refrigerant A in the auxiliary tank **62** reaches the predetermined height, the second liquid level gauge **622** in the auxiliary tank **62** transmits the water-level signal to the controller (S**7**). The controller then closes the first tank valve **611** and the second tank valve **621** (S**8**) and stops the operation of the gas extraction pump **71** (S**9**). In this way, the gas extraction device **5** successfully discharges the uncondensed gases G in the refrigerator **1** into atmosphere.

[0096] As illustrated in FIG. **3**, the switching valves **83**, **84**, and **86** are closed and the drip-feed pump **314** is operated while having the gas extraction pump **71** inactive to restart the operation of the refrigerator **1**. After the refrigerator **1** is operated over a given period of time (for example, a few days), the uncondensed gases G are similarly extracted while the refrigerator **1** is stopped.

[0097] The gas extraction tank **61** that contains the uncondensed gases G has an internal pressure higher than that of the evaporator **31**. Under the resultant pressure difference therebetween, the refrigerant A that resides in the return pipe **87** is circulated into the evaporator **31**.

[0098] According to the gas extraction device **5** of the refrigerator **1** and the gas extraction method in the embodiment, the refrigerant A in the evaporator **31** is supplied to the gas extraction tank **61** by the gas extraction pump **71** and the gas extractor **73** so as to extract the uncondensed gases G in the refrigerator **1** into the gas extraction tank **61** using the combination of the gas extraction pump **71** and the gas extractor **73**. After the uncondensed gases G are extracted into the gas extraction tank **61**, the gas extraction pump **71** is continuously operated by closing the shutoff valve **72**. The refrigerant A discharged into the gas extraction tank **61** by the gas extraction pump **71** fills up the gas extraction tank **61** and starts overflowing into the auxiliary tank **62**.

[0099] In this way, the gas extraction device **5** successfully discharges all the uncondensed gases G extracted into the gas extraction tank **61**, such as air and hydrogen, into the auxiliary tank **62** and then discharges the uncondensed gases G from the auxiliary tank **62** into atmosphere.

[0100] This makes it possible to prevent the uncondensed gases G from residing in the gas extraction tank **61**. Therefore, it is unnecessary to additionally provide a device, such as a water ejector and a vacuum pump, to discharge the uncondensed gases G remaining in the vacuumized gas extraction tank **61** (at an internal pressure lower than atmospheric pressure) into atmosphere. Further, the gas extraction tank **61** is filled up with the refrigerant A to prevent the uncondensed gasses G from remaining in the gas extraction tank **61**. This may prevent backflow of the uncondensed gases G and outside air into the refrigerator **1** when extracting the uncondensed gases G are extracted by the gas extraction pump **71** and the gas extractor **73**.

[0101] The gas extraction device **5** of the refrigerator **1** and the gas extraction method according to the embodiment may prevent the uncondensed gases G, such as air and hydrogen, from remaining in the gas extraction tank **61** and further prevent the uncondensed gases G and outside air from flowing back into the refrigerator **1**.

[0102] The gas extraction pump **71** and the drip-feed pump **314** according to the embodiment are connected in parallel to the evaporator **31**, and separately operated. As illustrated in FIG. **7**, a drip-feed pump **314**A and a gas extraction pump **71**A are connected in series to the evaporator **31**, the refrigerant drip-feed pipe **312** is connected to the nozzle **313** from the portion between the drip-feed pump **314**A and the gas extraction pump **71**A, and the refrigerant drip-feed pipe **312** is equipped with a switching valve **315**. In this case, the switching valve **315** provided in the refrigerant drip-feed pipe **312** is opened to selectively operate the drip-feed pump **314** alone during the operation of the refrigerator **1**.

[0103] To extract the uncondensed gases G, the switching valve **315** of the refrigerant drip-feed pipe **312** is closed, and the drip-feed pump **314**A and the gas extraction pump **71**A are both operated. Therefore, the refrigerant A in the evaporator **31** is discharged into the gas extraction tank **61** by two pumps, that is, the drip-feed pump **314**A and the gas extraction pump **71**A. In the case where the gas extraction pump **71**A has a discharge pressure equal to or lower than atmospheric pressure (0.1 MPa), a sum of the discharge pressure of the gas extraction pump **71**A and the discharge pressure of the drip-feed pump **314**A may be made higher than the atmospheric pressure.

[0104] Though not illustrated in the drawings, the refrigerator **1** is not necessarily limited to the adsorption type refrigerator **1** but may be an absorption type refrigerator in which an absorbing solution which absorbs the refrigerant vapor A (lithium bromide solution) is used to circulate the refrigerant A between the condenser **32** and the evaporator **31**, so that cold water is produced in the evaporator pipe inserted into the evaporator **31**. The absorption type refrigerator uses an absorber device containing the absorbing solution which absorbs the refrigerant vapor A evaporated from the evaporator **31** and a regenerator device which receives the absorbing solution including the refrigerant A from the absorber device and separates the refrigerant A from the absorbing solution by heating. The refrigerant vapor A in the regenerator device flows into the condenser **32**. The refrigerant vapor A is cooled down in the condenser **32** and then drops into the evaporator **31** to be used as the refrigerant A in the evaporator **31**.

[0105] In the absorption type refrigerator, a similar gas extraction device **5** can be installed to work with the evaporator **31**. The gas draw-in passage of the gas extractor (ejector) **73** may be connected to the absorber device where the uncondensed gases G are most likely to accumulate. The structure of the gas extraction device **5** of the absorption type refrigerator is similar to that of the gas extraction device of the adsorption type refrigerator **1** and provides a similar operational effect.

1. A gas extraction device for a refrigerator, which is installed in the refrigerator configured to produce cold water using heat of evaporation generated when evaporating a refrigerant put in a vacuumized evaporator, the gas extraction device for removing an uncondensed gas that exists in the refrigerator comprising:

a gas extraction tank for circulating the refrigerant in the evaporator;

a circulation pipe for circulation between the gas extraction tank and the evaporator;

a gas extraction pump installed in the circulation pipe to feed the refrigerant in the evaporator to the gas extraction tank;

a shutoff valve installed in the circulation pipe so as to shut off a flow of the refrigerant from the gas extraction tank to the evaporator;

a gas extractor for extracting the uncondensed gas in the refrigerator into the gas extraction tank using the refrigerant supplied from the evaporator to the gas extraction tank; and

an auxiliary tank connected to an upper section of the gas extraction tank and receives an inflow of the refrigerant filling up the gas extraction tank, and overflowing therefrom.

2. The gas extraction device for a refrigerator according to claim **1**, wherein:

the gas extraction tank includes a first liquid level gauge which outputs a water-level signal when a liquid level of the refrigerant in the gas extraction tank becomes the same as or lower than a predefined height;

the auxiliary tank includes a second liquid level gauge which outputs a water-level signal when a liquid level of the refrigerant in the auxiliary tank becomes the same as or higher than a predefined height; and

a controller is provided, which is configured to perform a gas extraction operation by opening the shutoff valve, and continuously operating the gas extraction pump until reception of the water-level signal output from the first liquid level gauge, and a filling operation by closing the shutoff valve, and continuously operating the gas extraction pump until reception of the water-level signal output from the second liquid level gauge.

3. The gas extraction device for a refrigerator according to claim **2**, wherein:

the circulation pipe includes a feed pipe connected to a lower section of the evaporator and equipped with the gas extraction pump, and a return pipe connected to a lower section of the gas extraction tank and equipped with the shutoff valve; and

end portions of the feed pipe and the return pipe that are open to the gas extraction tank are positioned lower than the height of the liquid level of the refrigerant, which is established upon output of the water-level signal from the first liquid level gauge.

4. The gas extraction device for a refrigerator according to claim **2**, wherein:

a first tank valve is provided between the gas extraction tank and the auxiliary tank;

a second tank valve is provided above the auxiliary tank; and

the controller is configured to close the first tank valve when performing the gas extraction operation, open the first tank valve and the second tank valve when performing the filling operation, and close the first tank valve when receiving the water-level signal output from the second liquid level gauge.

5. The gas extraction device for a refrigerator according to claim **1**, wherein:

an upper section of the gas extraction tank has a shape with a horizontal sectional area that becomes smaller toward an upward direction; and

the auxiliary tank is connected to a portion at the upper section of the gas extraction tank, which has a minimum horizontal sectional area.

6. A gas extraction method for a refrigerator, which uses the gas extraction device for a refrigerator according to claim **1**, the method comprising:

gas extraction step of opening the shutoff valve accompanied with an operation of the gas extraction pump, circulating the refrigerant in the evaporator to the gas extraction tank, and drawing the uncondensed gas in the refrigerator into the gas extraction tank using the gas extractor; and

discharging step of closing the shutoff valve accompanied with the operation of the gas extraction pump, filling up the gas extraction tank with the refrigerant put in the evaporator so as to be overflowed into the auxiliary tank, and discharging the uncondensed gases drawn and stored in the gas extraction tank into the auxiliary tank.

7. The gas extraction device for a refrigerator according to claim **3**, wherein:

a first tank valve is provided between the gas extraction tank and the auxiliary tank;

a second tank valve is provided above the auxiliary tank; and

the controller is configured to close the first tank valve when performing the gas extraction operation, open the first tank valve and the second tank valve when performing the filling operation, and close the first tank valve when receiving the water-level signal output from the second liquid level gauge.

8. The gas extraction device for a refrigerator according to claim **2**, wherein:

an upper section of the gas extraction tank has a shape with a horizontal sectional area that becomes smaller toward an upward direction; and

the auxiliary tank is connected to a portion at the upper section of the gas extraction tank, which has a minimum horizontal sectional area.

9. The gas extraction device for a refrigerator according to claim **3**, wherein:

an upper section of the gas extraction tank has a shape with a horizontal sectional area that becomes smaller toward an upward direction; and

the auxiliary tank is connected to a portion at the upper section of the gas extraction tank, which has a minimum horizontal sectional area.

10. The gas extraction device for a refrigerator according to claim **4**, wherein:

an upper section of the gas extraction tank has a shape with a horizontal sectional area that becomes smaller toward an upward direction; and

the auxiliary tank is connected to a portion at the upper section of the gas extraction tank, which has a minimum horizontal sectional area.

11. A gas extraction method for a refrigerator, which uses the gas extraction device for a refrigerator according to claim **2**, the method comprising:

gas extraction step of opening the shutoff valve accompanied with an operation of the gas extraction pump, circulating the refrigerant in the evaporator to the gas extraction tank, and drawing the uncondensed gas in the refrigerator into the gas extraction tank using the gas extractor; and

discharging step of closing the shutoff valve accompanied with the operation of the gas extraction pump, filling up the gas extraction tank with the refrigerant put in the evaporator so as to be overflowed into the auxiliary tank, and discharging the uncondensed gases drawn and stored in the gas extraction tank into the auxiliary tank.

12. A gas extraction method for a refrigerator, which uses the gas extraction device for a refrigerator according to claim **3**, the method comprising:

gas extraction step of opening the shutoff valve accompanied with an operation of the gas extraction pump, circulating the refrigerant in the evaporator to the gas extraction tank, and drawing the uncondensed gas in the refrigerator into the gas extraction tank using the gas extractor; and

discharging step of closing the shutoff valve accompanied with the operation of the gas extraction pump, filling up the gas extraction tank with the refrigerant put in the evaporator so as to be overflowed into the auxiliary tank, and discharging the uncondensed gases drawn and stored in the gas extraction tank into the auxiliary tank.

13. A gas extraction method for a refrigerator, which uses the gas extraction device for a refrigerator according to claim **4**, the method comprising:

gas extraction step of opening the shutoff valve accompanied with an operation of the gas extraction pump, circulating the refrigerant in the evaporator to the gas extraction tank, and drawing the uncondensed gas in the refrigerator into the gas extraction tank using the gas extractor; and

discharging step of closing the shutoff valve accompanied with the operation of the gas extraction pump, filling up the gas extraction tank with the refrigerant put in the evaporator so as to be overflowed into the auxiliary tank, and discharging the uncondensed gases drawn and stored in the gas extraction tank into the auxiliary tank.

14. A gas extraction method for a refrigerator, which uses the gas extraction device for a refrigerator according to claim **5**, the method comprising:

gas extraction step of opening the shutoff valve accompanied with an operation of the gas extraction pump, circulating the refrigerant in the evaporator to the gas extraction tank, and drawing the uncondensed gas in the refrigerator into the gas extraction tank using the gas extractor; and

discharging step of closing the shutoff valve accompanied with the operation of the gas extraction pump, filling up the gas extraction tank with the refrigerant put in the evaporator so as to be overflowed into the auxiliary tank, and discharging the uncondensed gases drawn and stored in the gas extraction tank into the auxiliary tank.

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