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Min et al.

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(45) Date of Patent: Aug. 12, 2025

(54) **REFRIGERATOR AND METHOD FOR CONTROLLING THE SAME**

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(73) Assignee: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 162 days.

(21) Appl. No.: **18/230,961**

(22) Filed: **Aug. 7, 2023**

(65) **Prior Publication Data**

US 2024/0125525 A1 Apr. 18, 2024

Related U.S. Application Data

(63) Continuation of application No. PCT/KR2023/010670, filed on Jul. 24, 2023.

(30) **Foreign Application Priority Data**

Oct. 12, 2022 (KR) 10-2022-0130972

(51) **Int. Cl.**
F25D 21/04 (2006.01)
F25B 5/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F25B 41/20*** (2021.01); ***F25B 5/02*** (2013.01); ***F25B 41/37*** (2021.01); ***F25D 21/04*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC .. F25B 5/02; F25B 41/20; F25B 41/37; F25D 11/22; F25D 21/04
See application file for complete search history.

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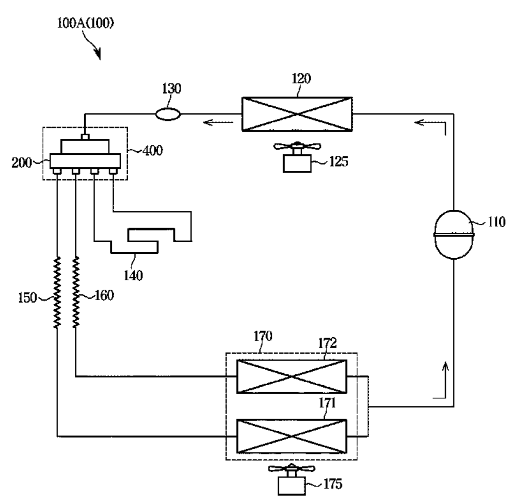
Primary Examiner — Jonathan Bradford
(74) *Attorney, Agent, or Firm* — STAAS & HALSEY LLP

(57) **ABSTRACT**

A refrigerator includes: a compressor; a condenser; a hot pipe; at least one capillary tube; at least one evaporator; a valve device including: an input port connected to the condenser; a first port connected to one end of the hot pipe; a second port connected to an other end; and at least one output port connected to the at least one capillary tube; and a controller configured to: control the valve device to operate in the first mode by connecting one of the first port and the second port to the input port and connecting an other one to the output port; control the valve device to operate in the second mode, by closing one of the first port and the second port and connecting an other one to the output port; and control the valve device to operate in the third mode, by closing all the first port and the second port.

15 Claims, 35 Drawing Sheets



(51) **Int. Cl.**

F25B 41/20	(2021.01)
F25B 41/37	(2021.01)
F25D 11/02	(2006.01)

(52) **U.S. Cl.**

CPC *F25B 2500/24* (2013.01); *F25B 2500/26* (2013.01); *F25B 2600/0253* (2013.01); *F25B 2600/2511* (2013.01); *F25B 2700/02* (2013.01); *F25B 2700/2106* (2013.01); *F25D 11/022* (2013.01); *F25D 2700/14* (2013.01)

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FIG. 1

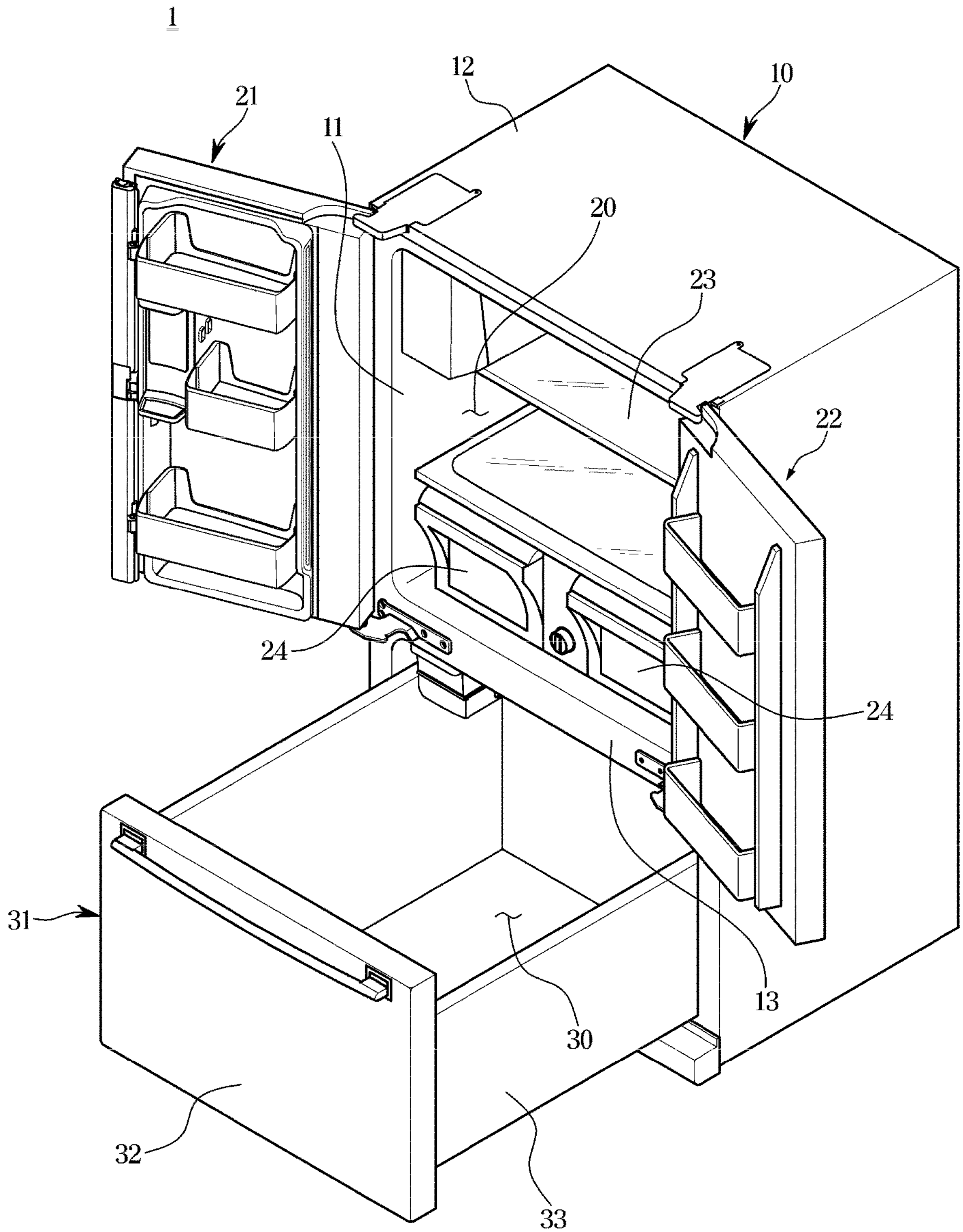


FIG. 2

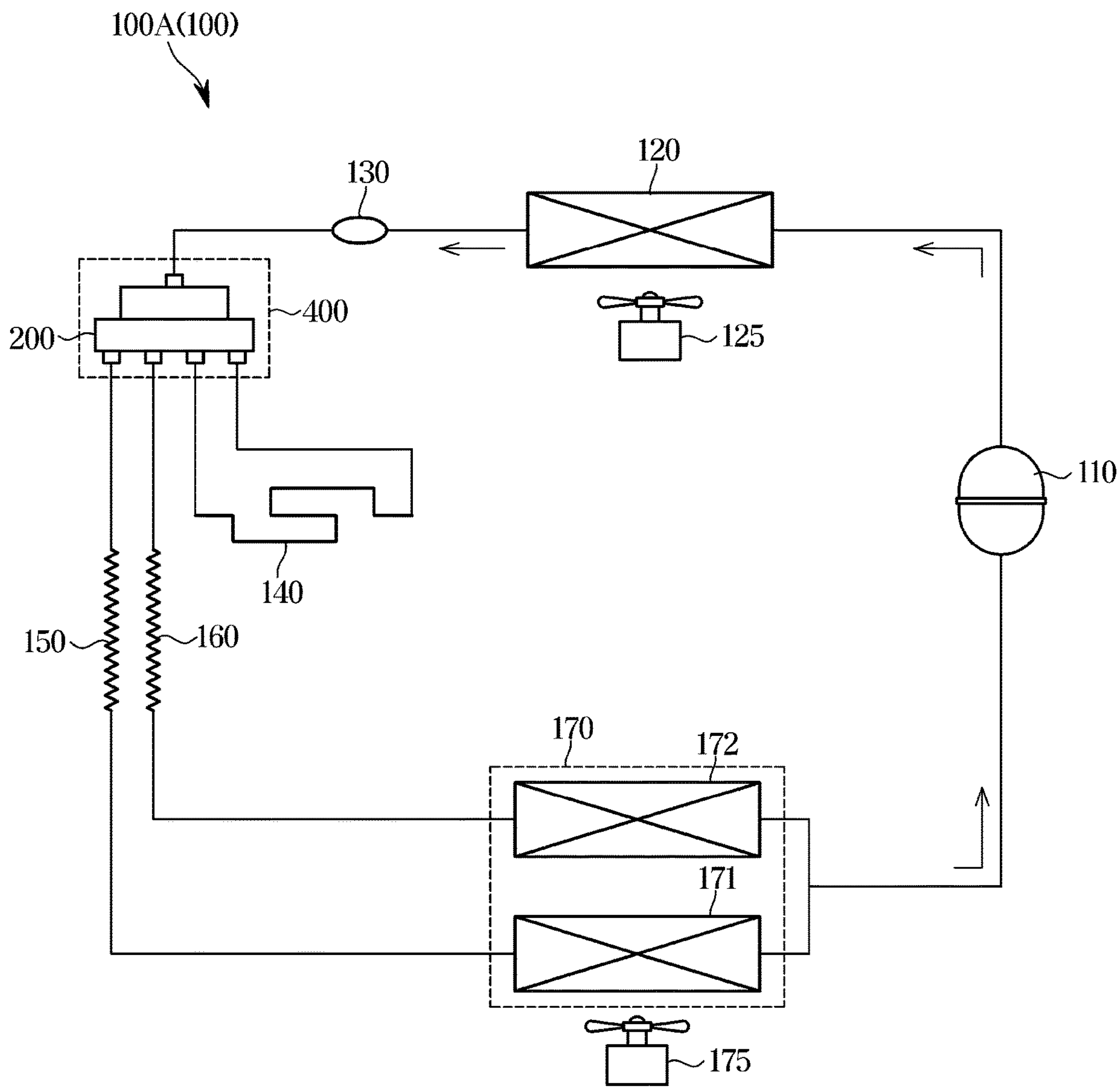


FIG. 3

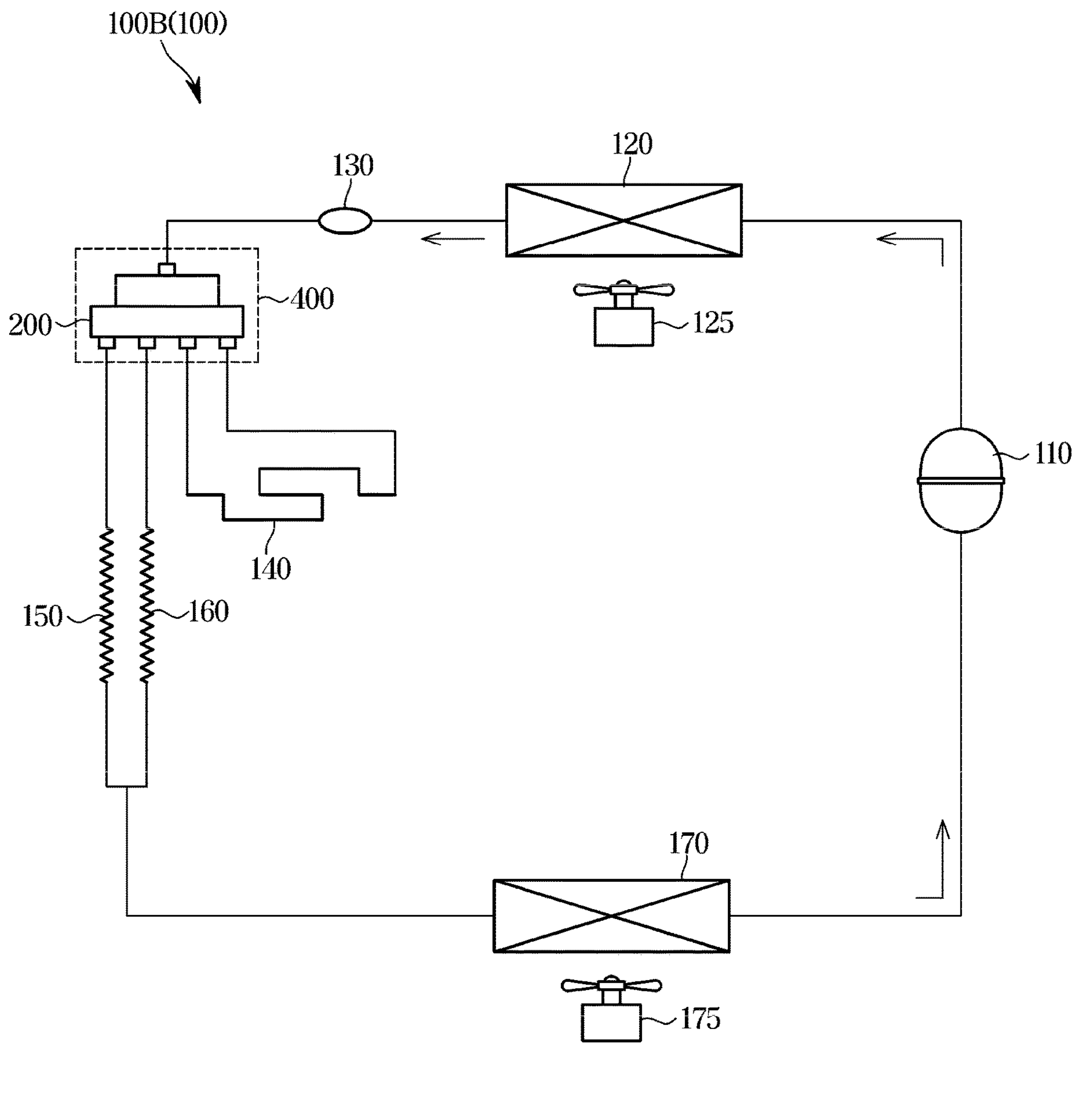


FIG. 4

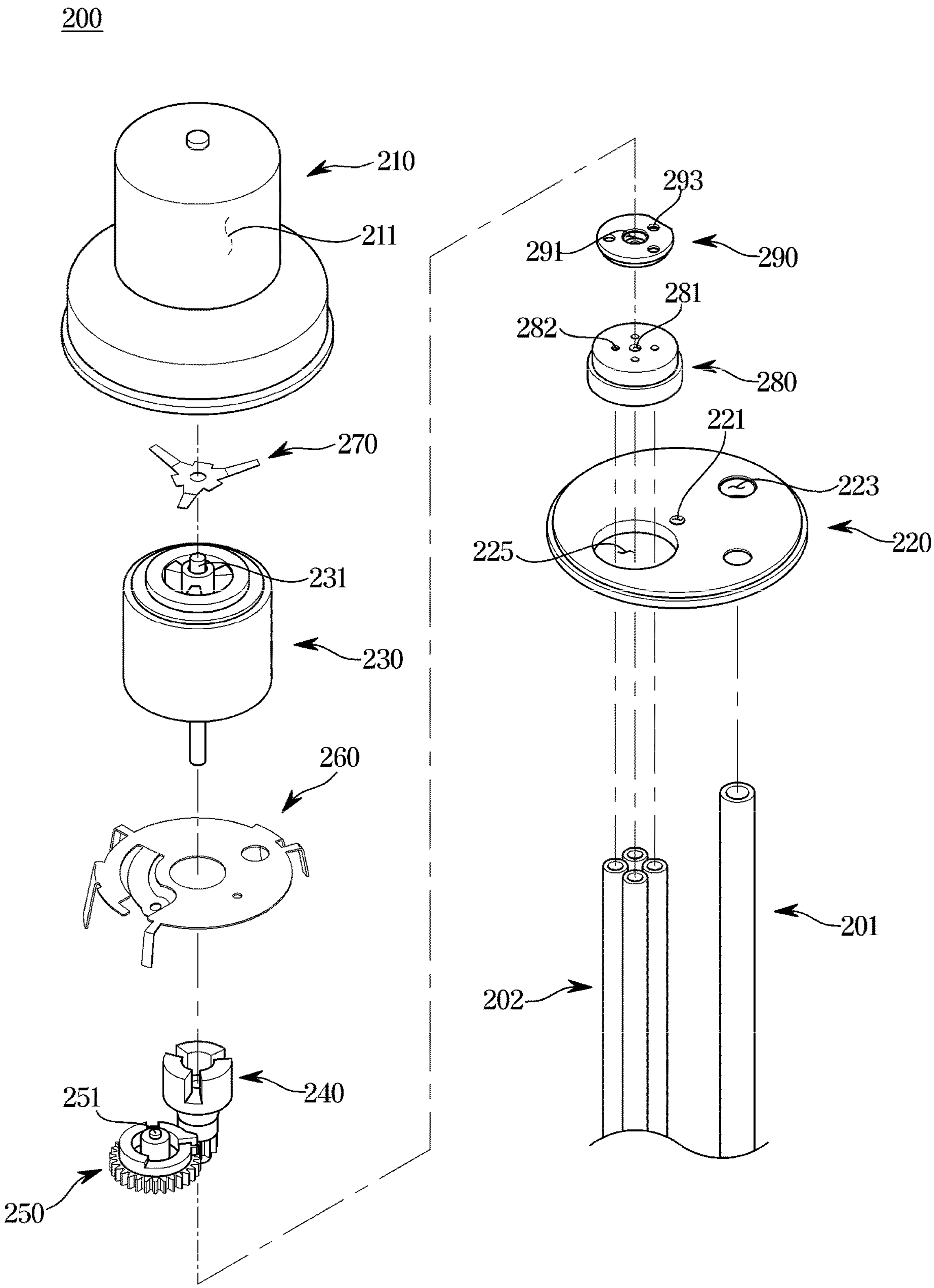

200
210
211
270
231
230
260
240
251
250
293
291
290
281
282
280
221
223
225
220
201
202

FIG. 5

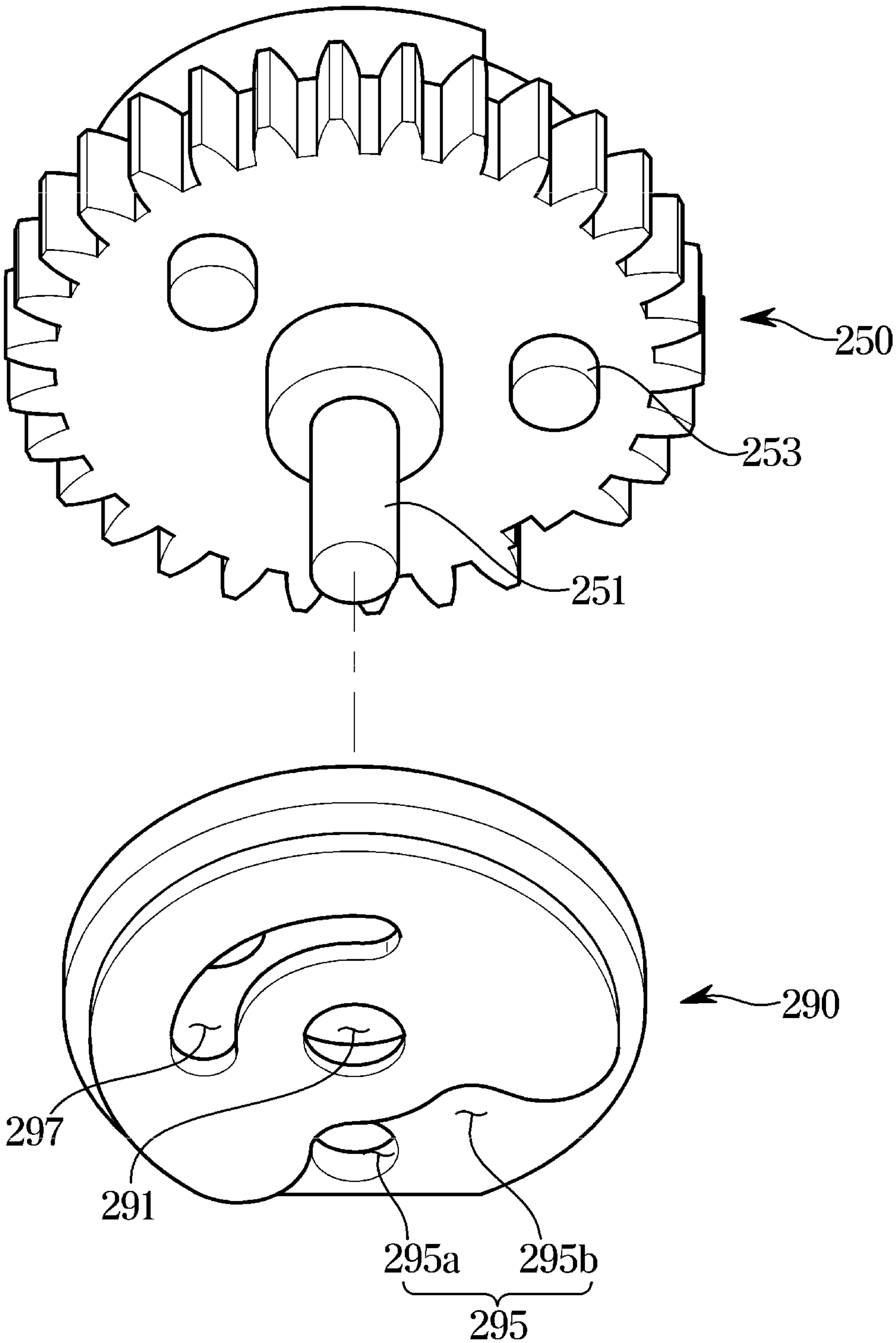


FIG. 6

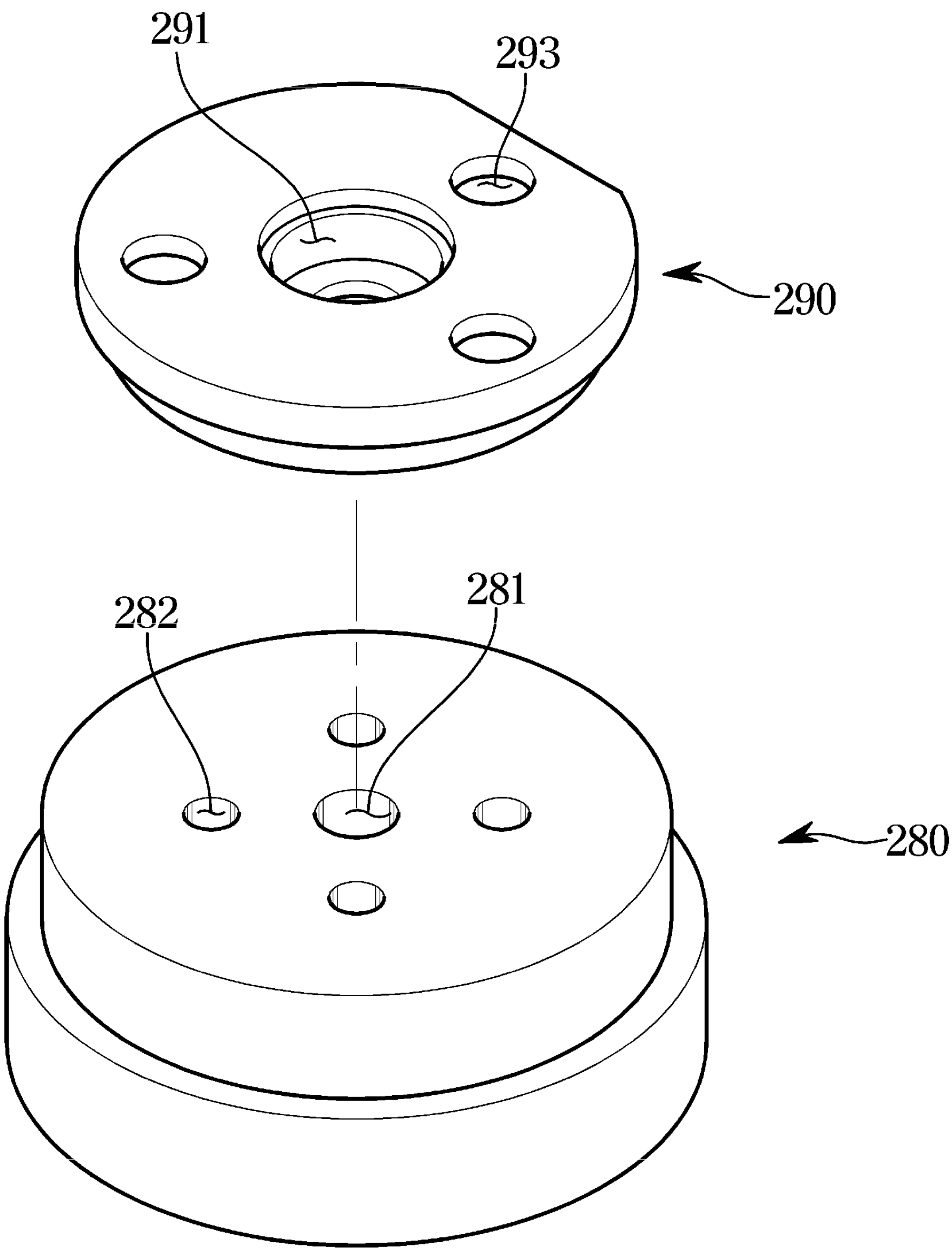


FIG. 7

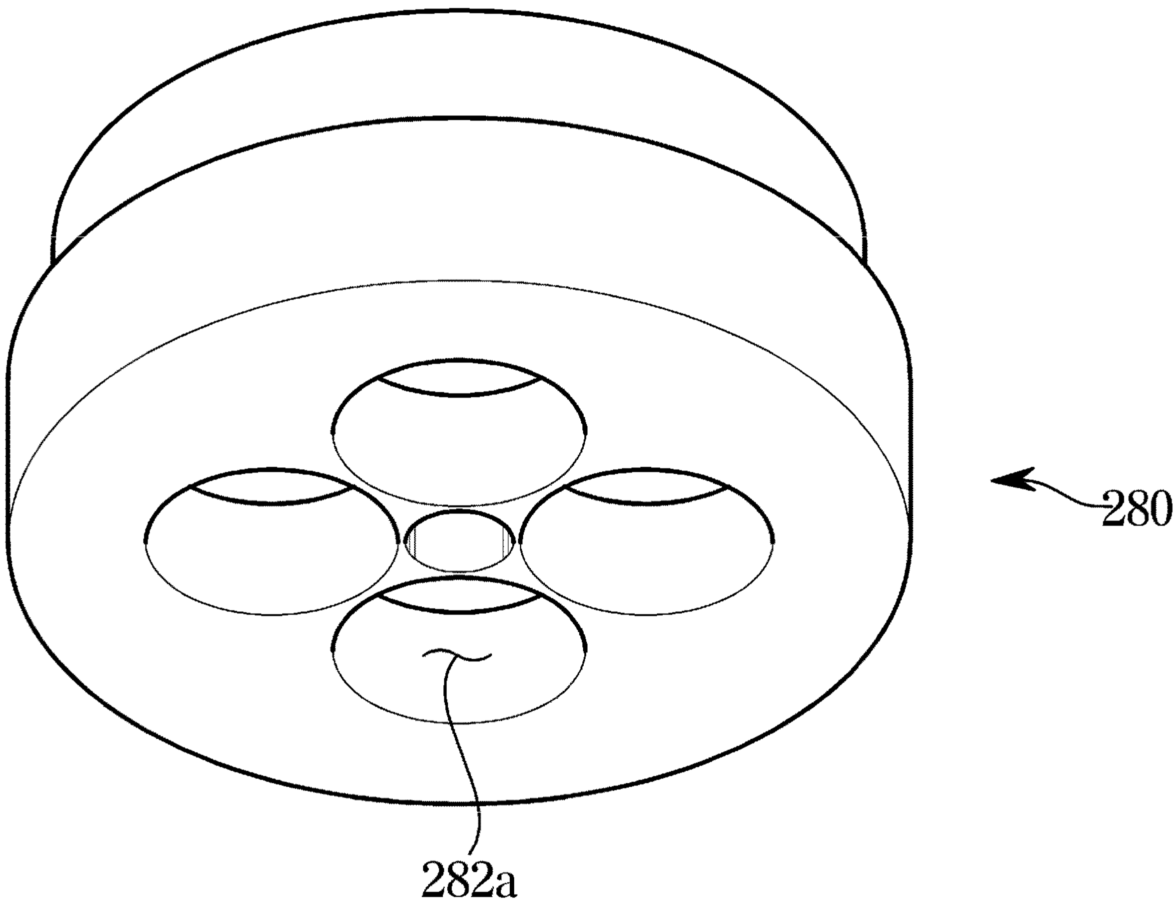


FIG. 8

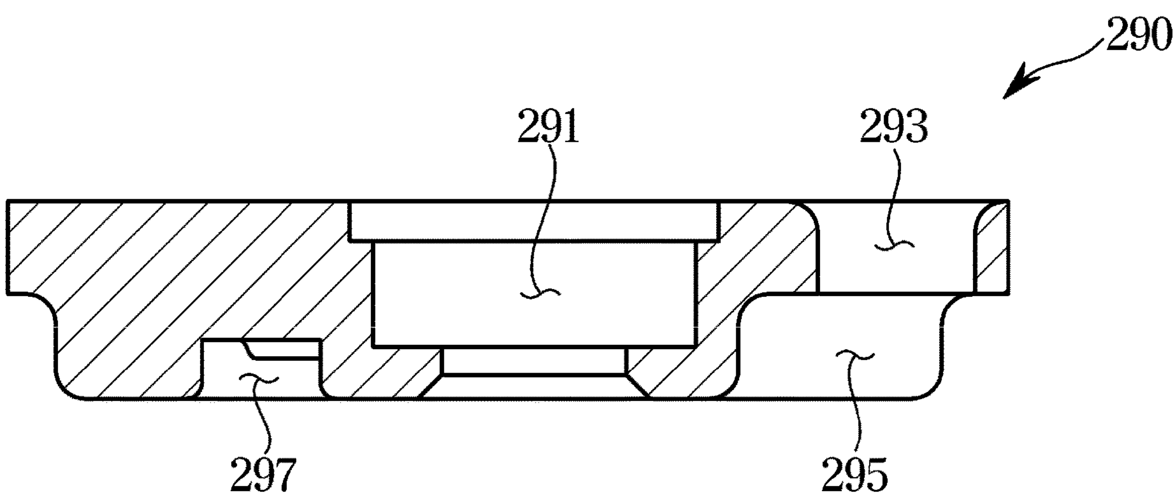


FIG. 9

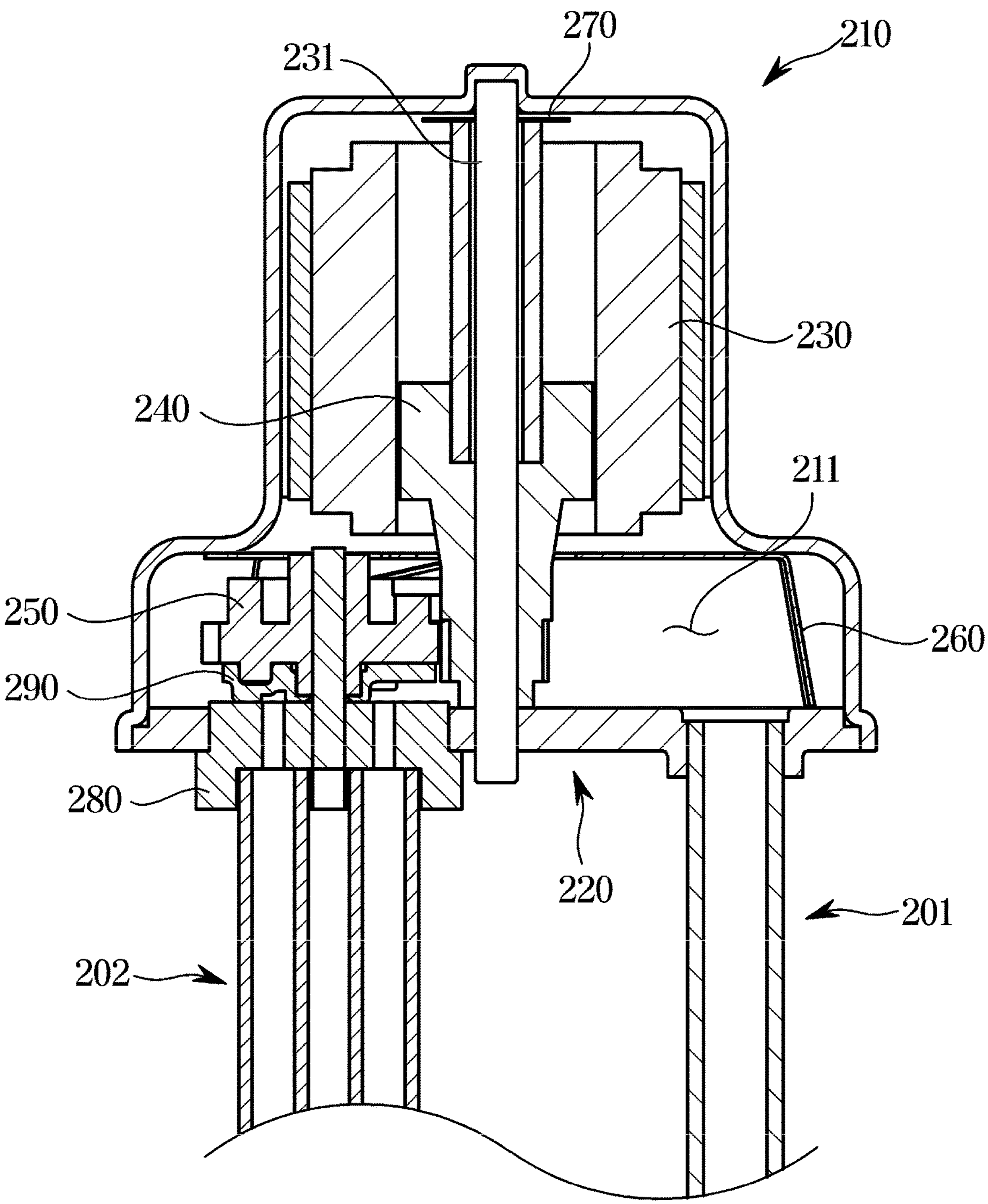
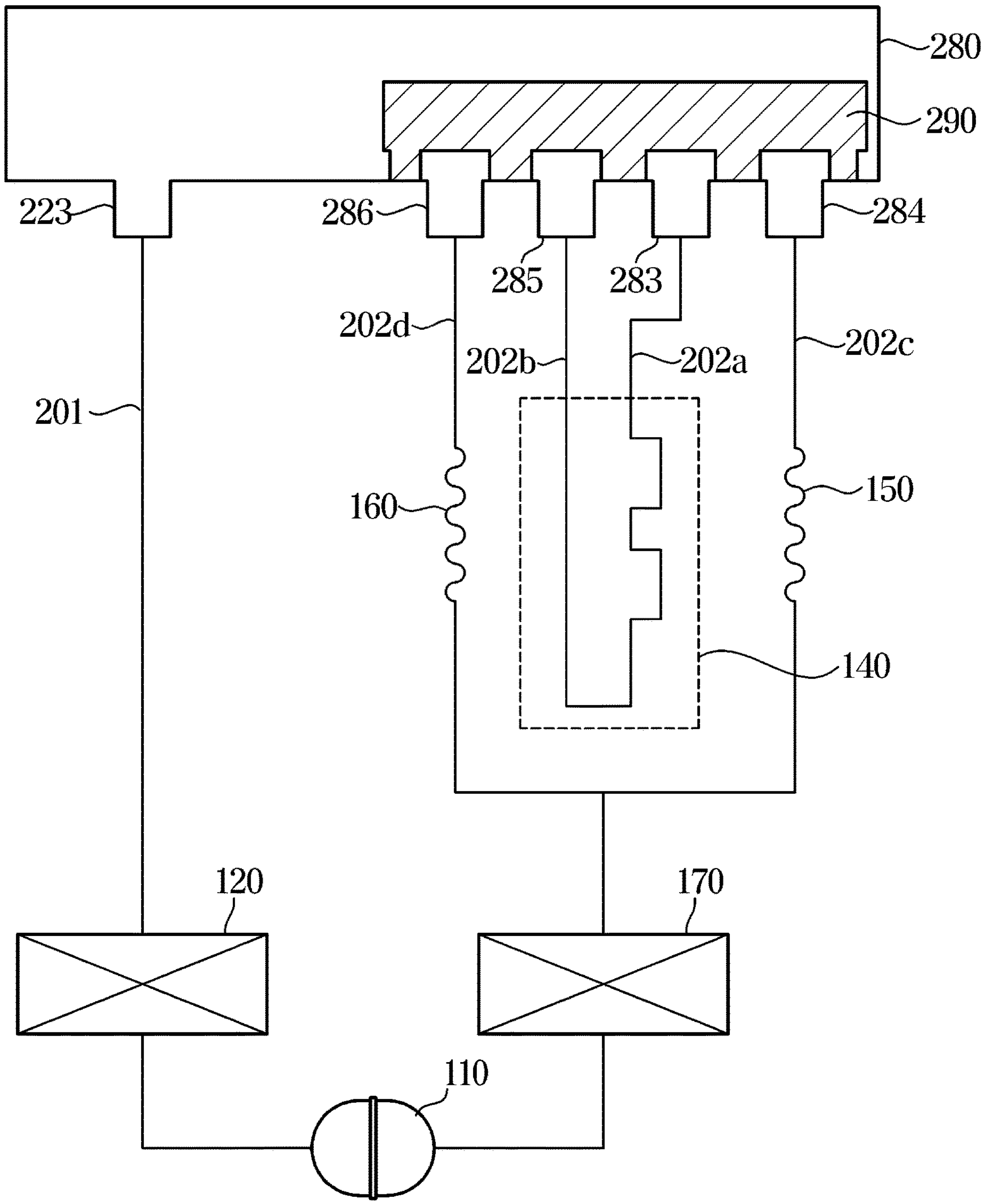


FIG. 10



280
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223
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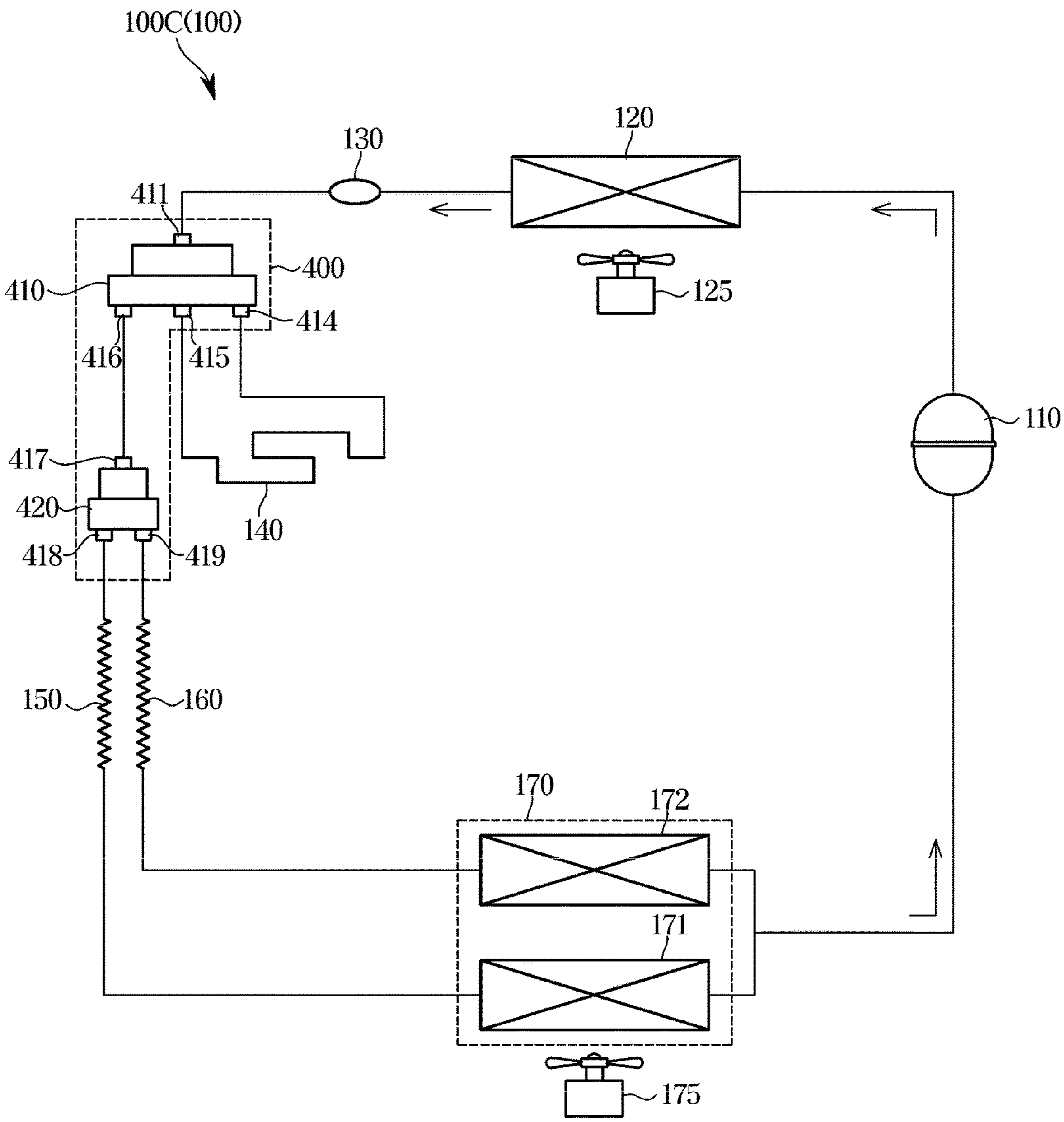
170
110

FIG. 11



100C(100)
130
120
411
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172
171
175

FIG. 12

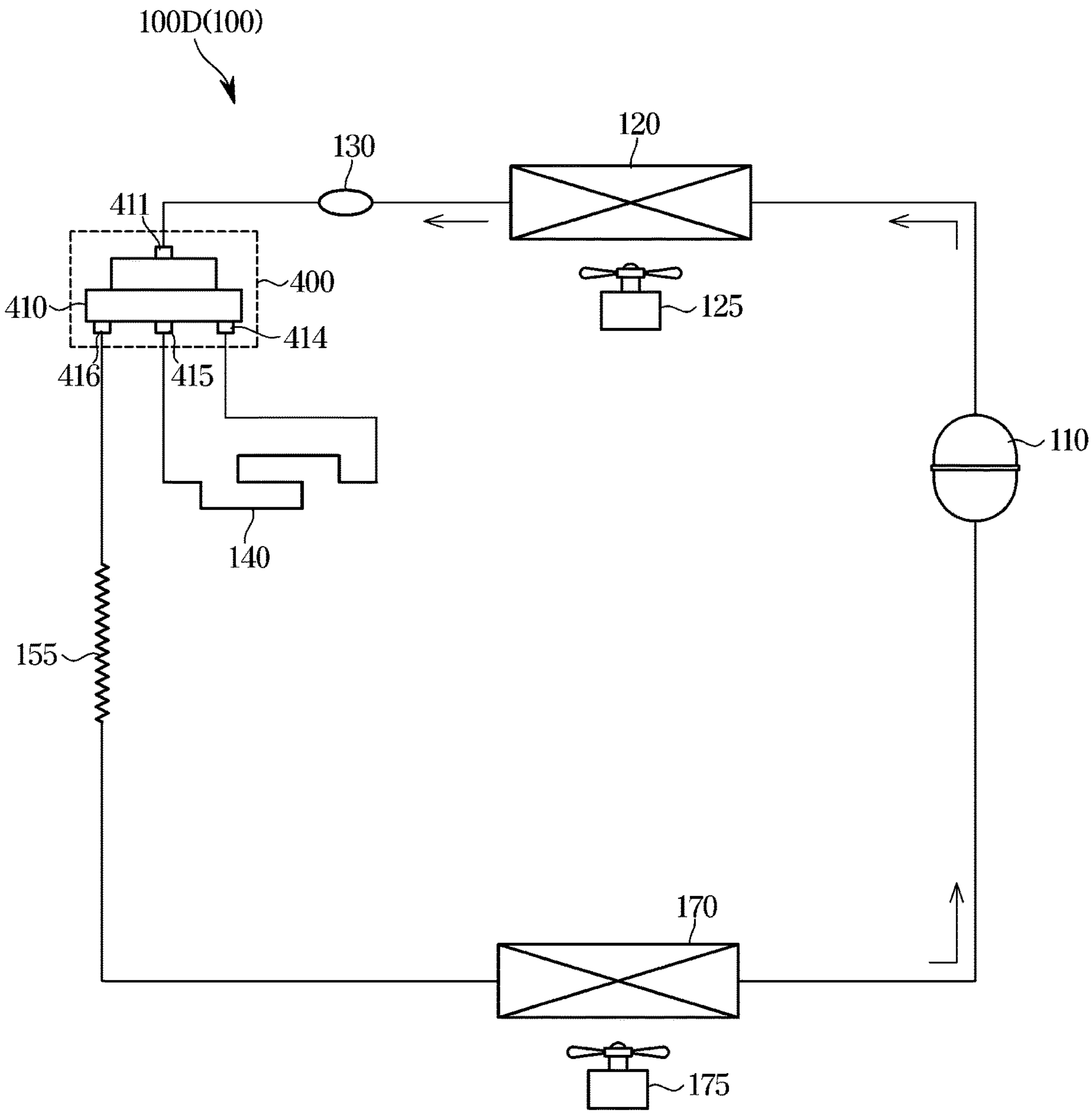
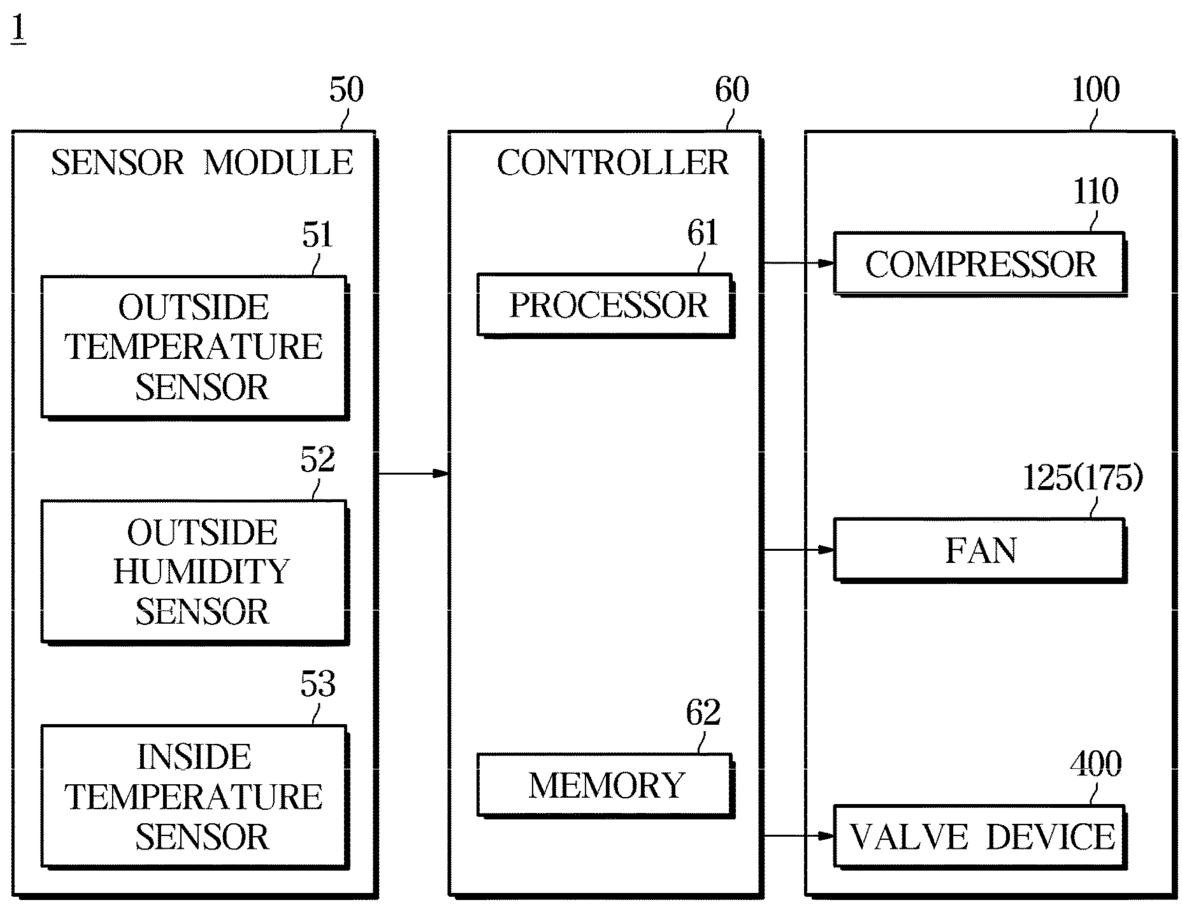


FIG. 13



1
50
SENSOR MODULE
51
OUTSIDE TEMPERATURE SENSOR
52
OUTSIDE HUMIDITY SENSOR
53
INSIDE TEMPERATURE SENSOR
60
CONTROLLER
61
PROCESSOR
62
MEMORY
100
110
COMPRESSOR
125(175)
FAN
400
VALVE DEVICE

FIG. 14

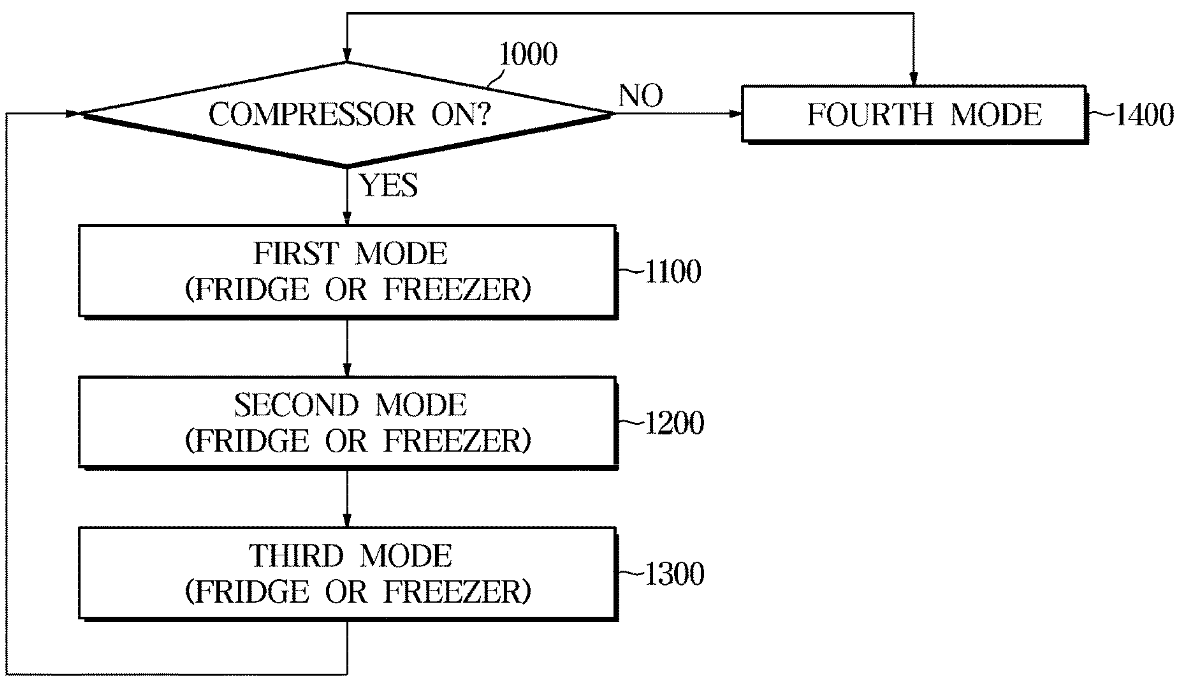

1000
COMPRESSOR ON?
NO
FOURTH MODE
1400
YES
FIRST MODE
(FRIDGE OR FREEZER)
1100
SECOND MODE
(FRIDGE OR FREEZER)
1200
THIRD MODE
(FRIDGE OR FREEZER)
1300

FIG. 15

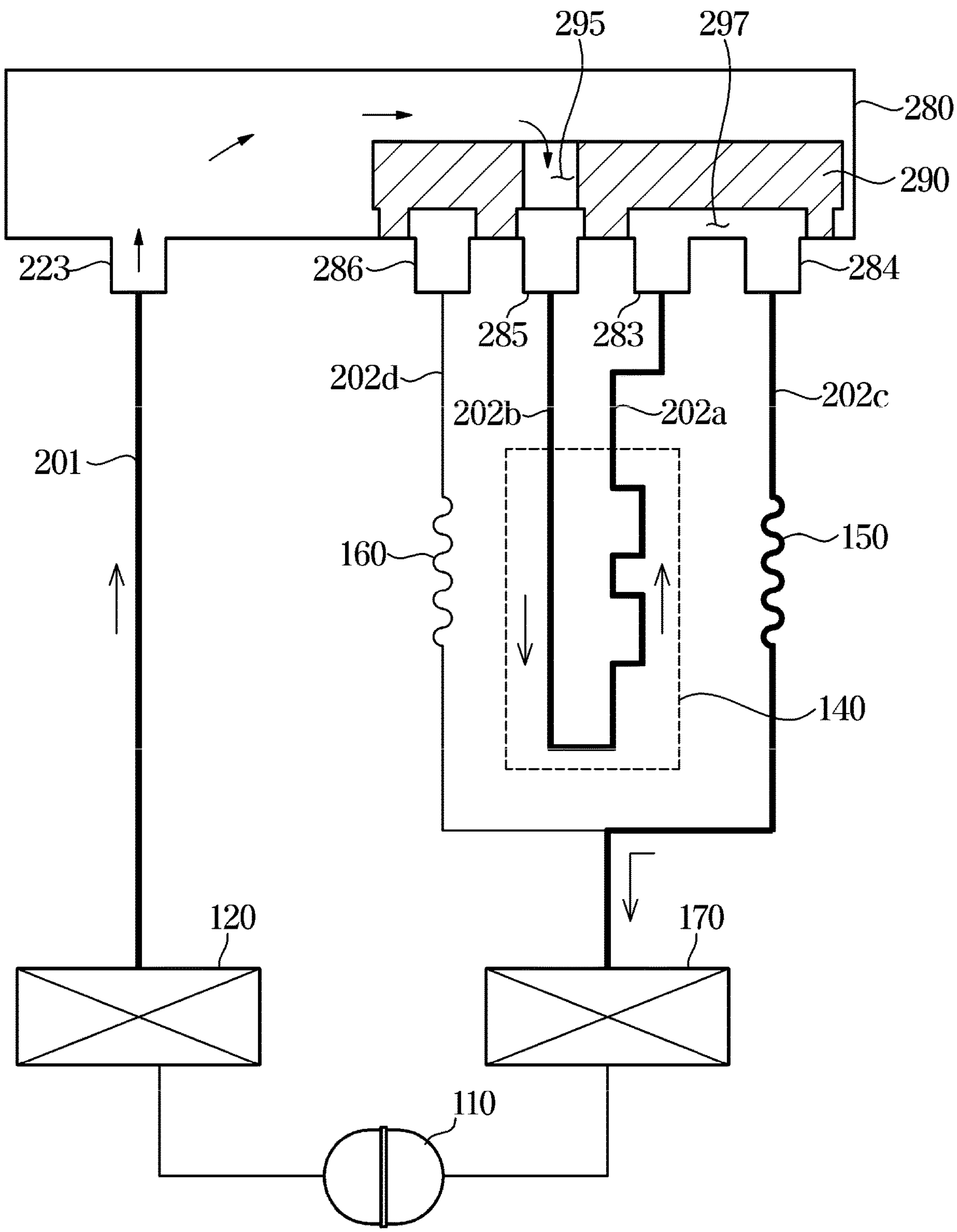

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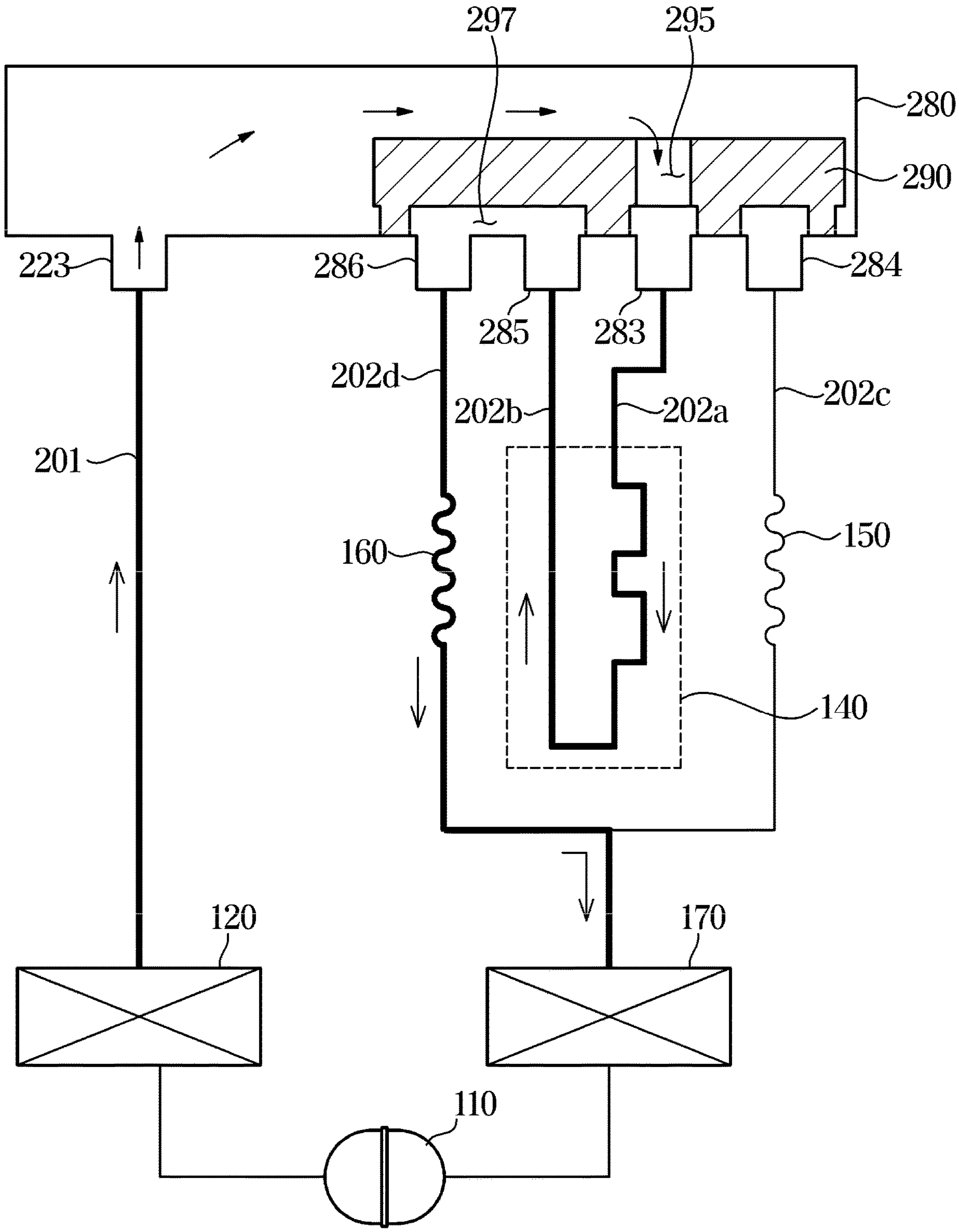
FIG. 16


297
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170
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FIG. 17

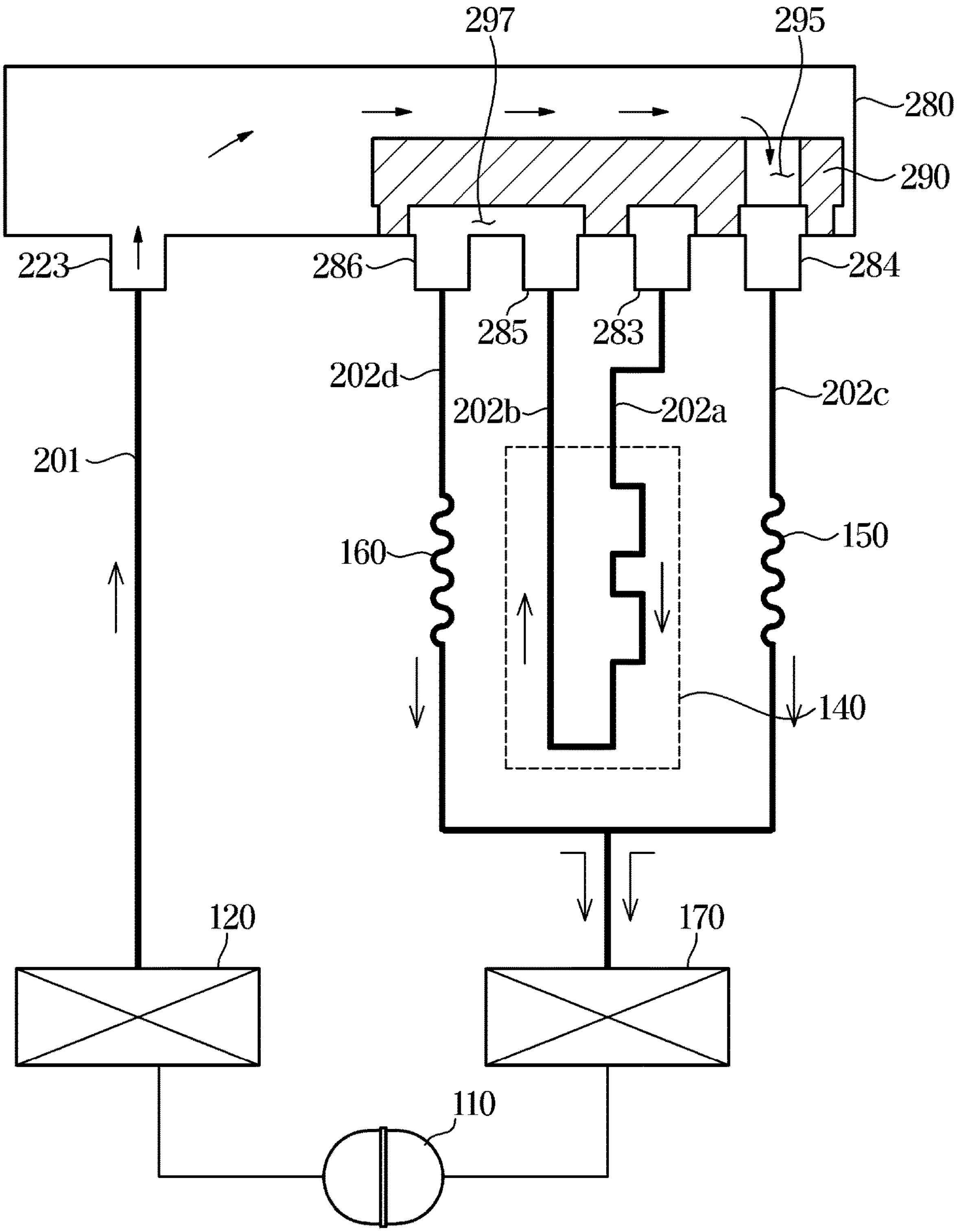
297
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FIG. 18

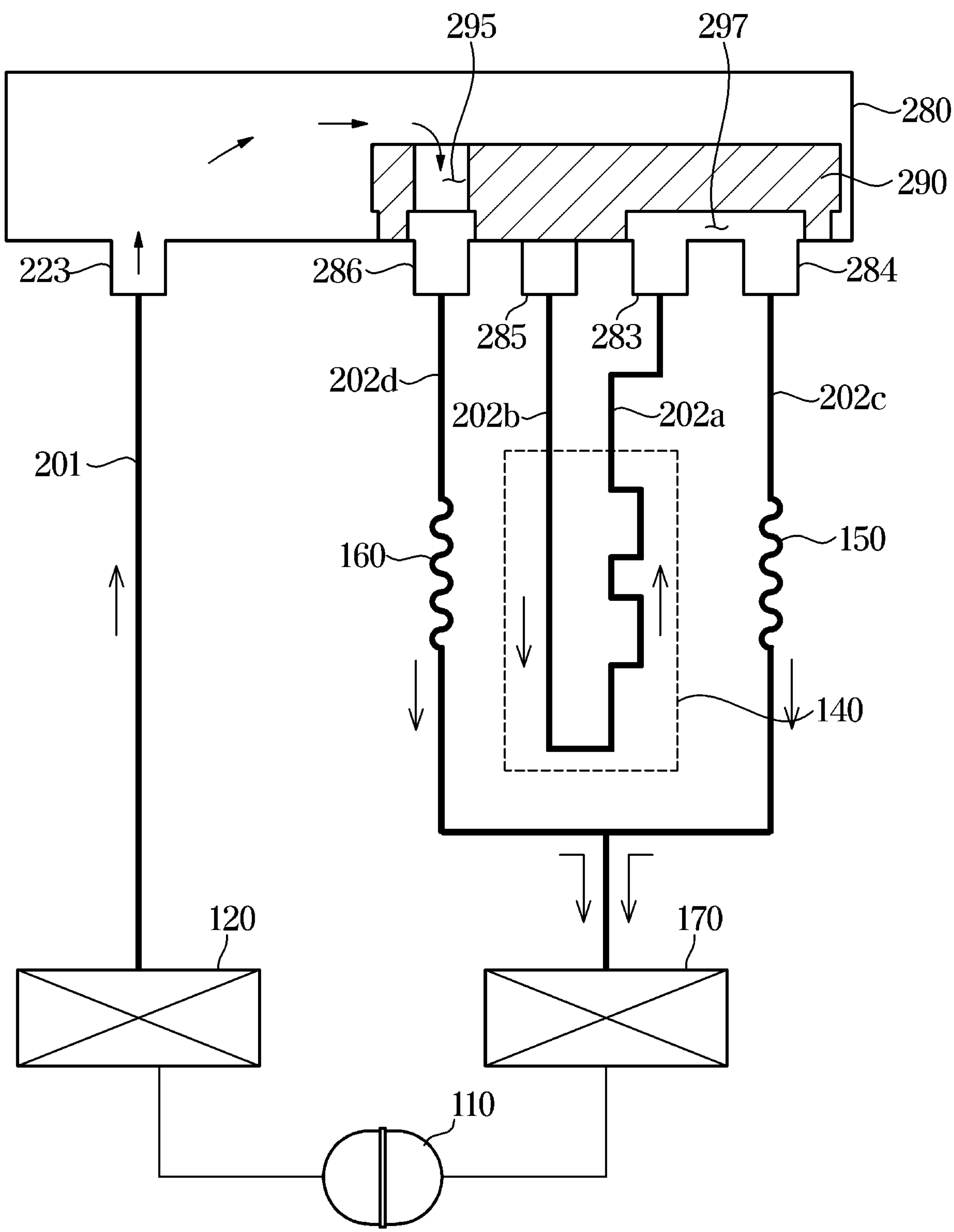

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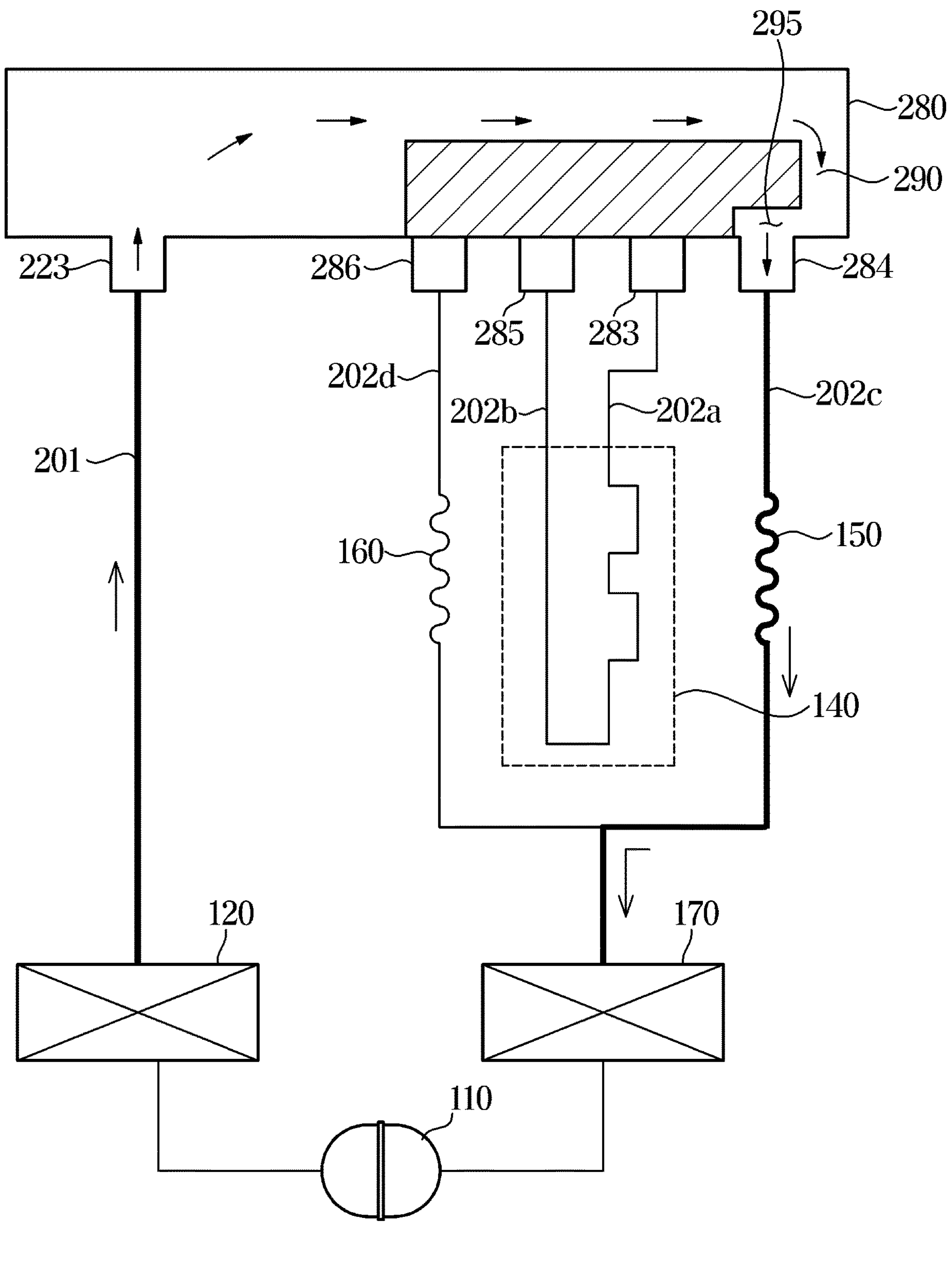
FIG. 19


295
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286
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202d
202b
202a
202c
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160
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120
170
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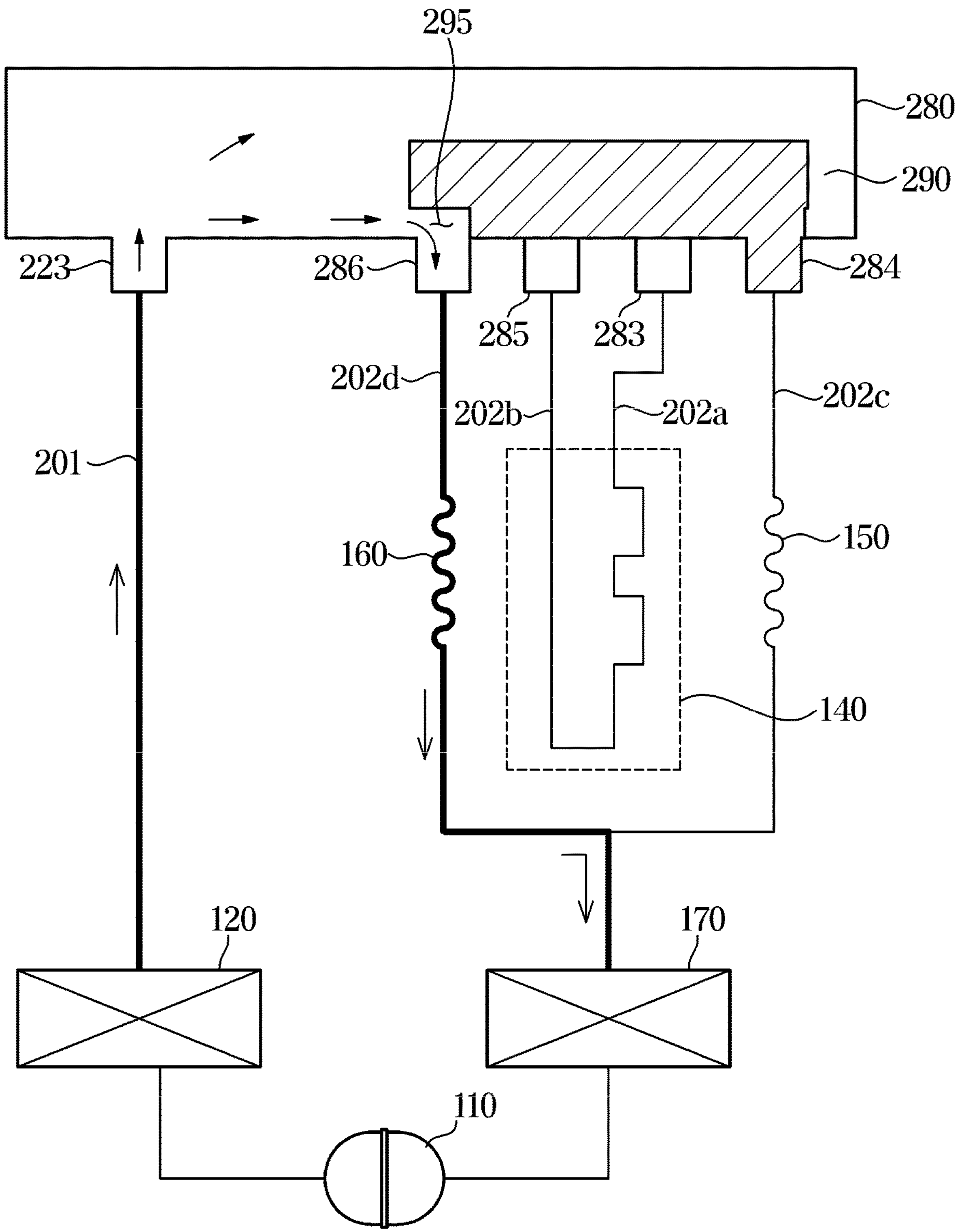
FIG. 20


295
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285
283
202d
202b
202a
202c
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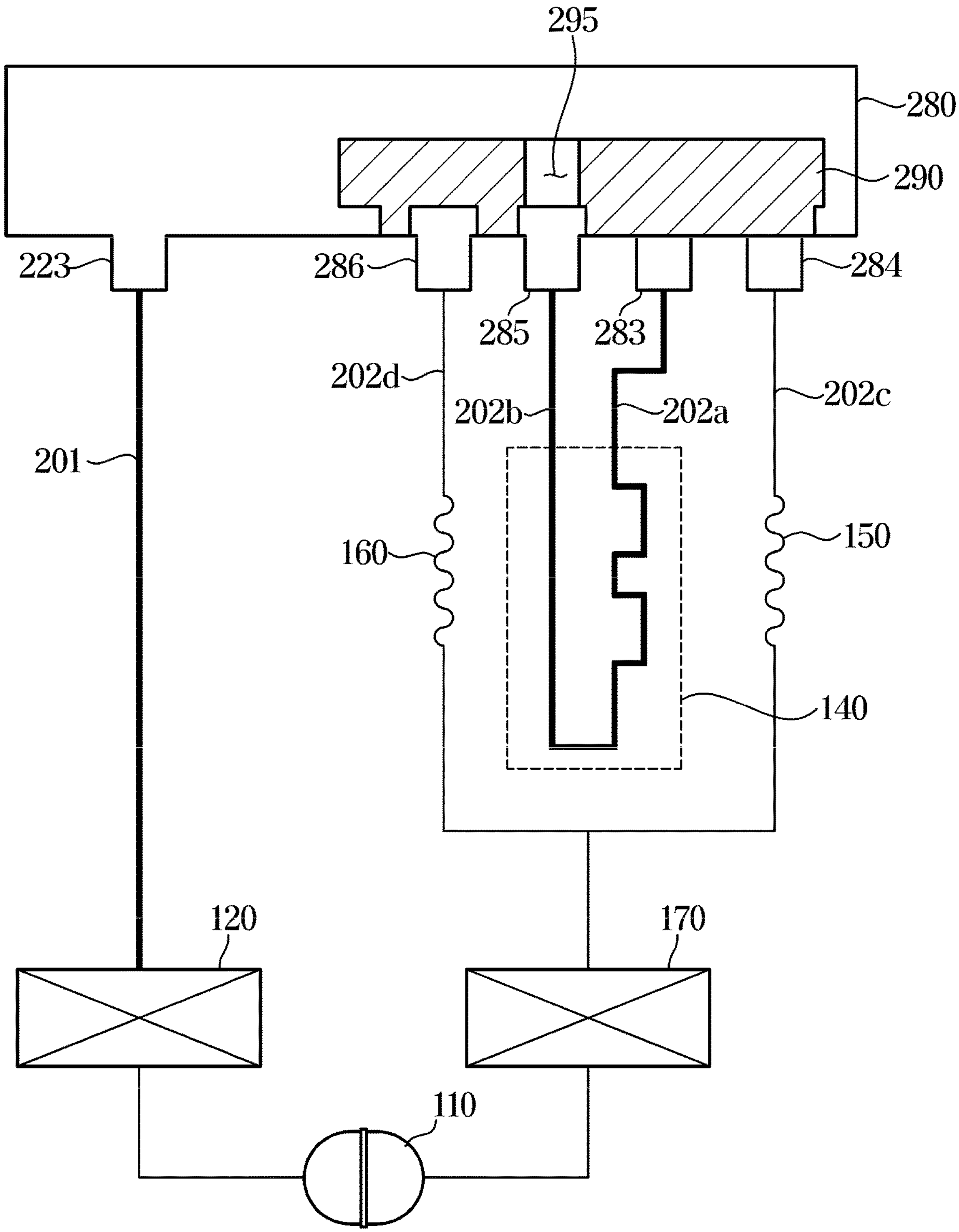
FIG. 21


295
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285
283
202d
202b
202a
202c
201
160
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140
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170
110

FIG. 22

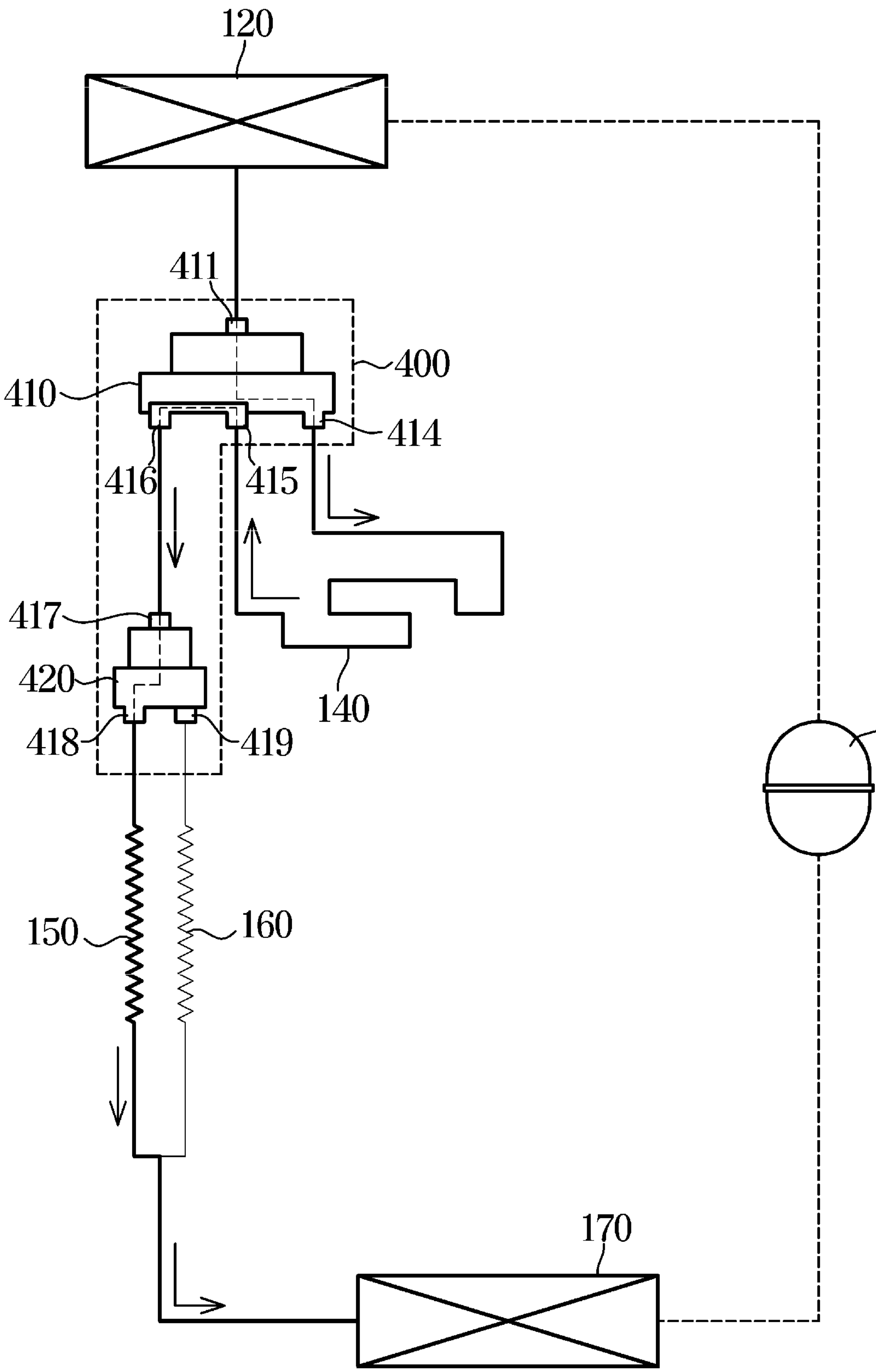


FIG. 23

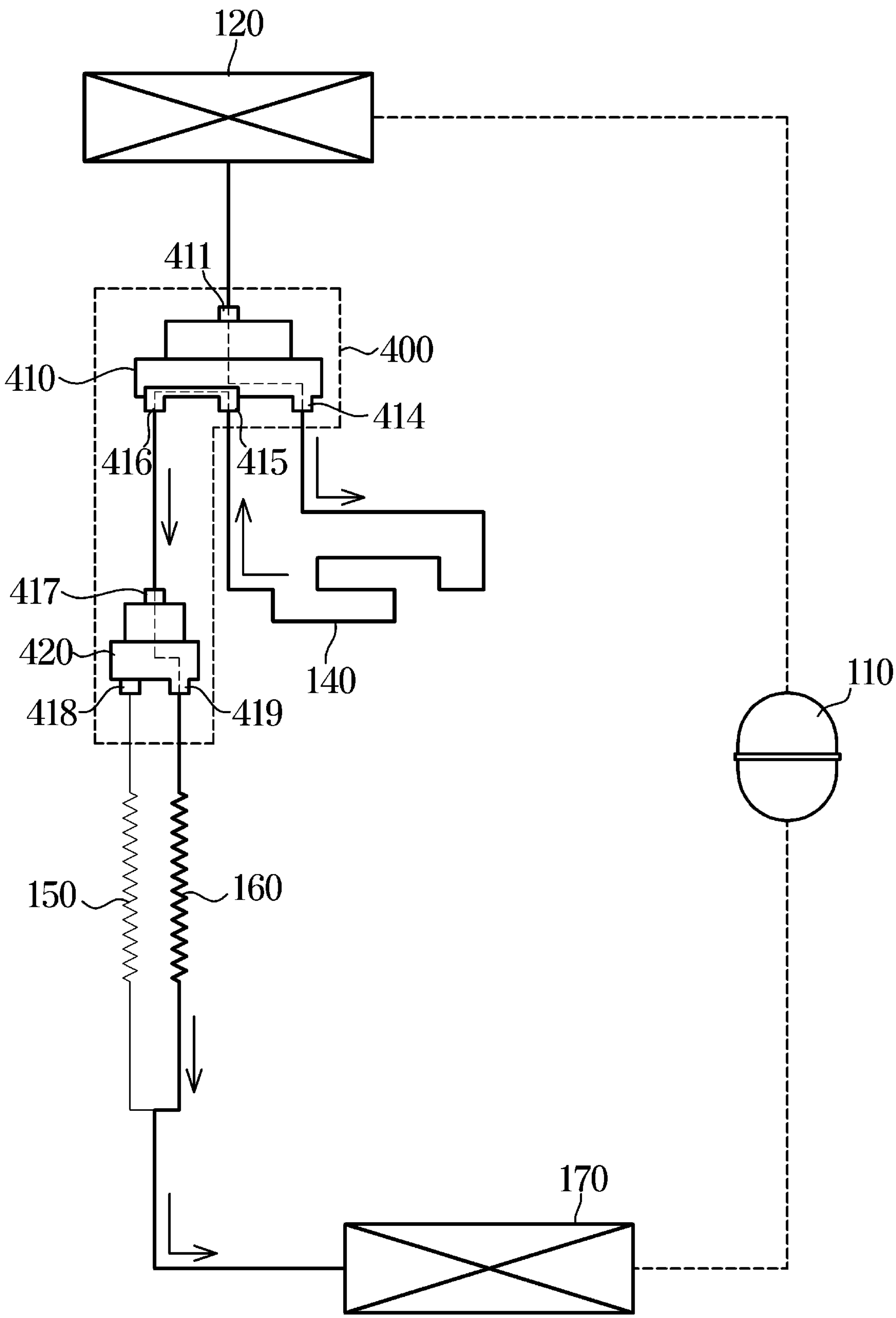


FIG. 24

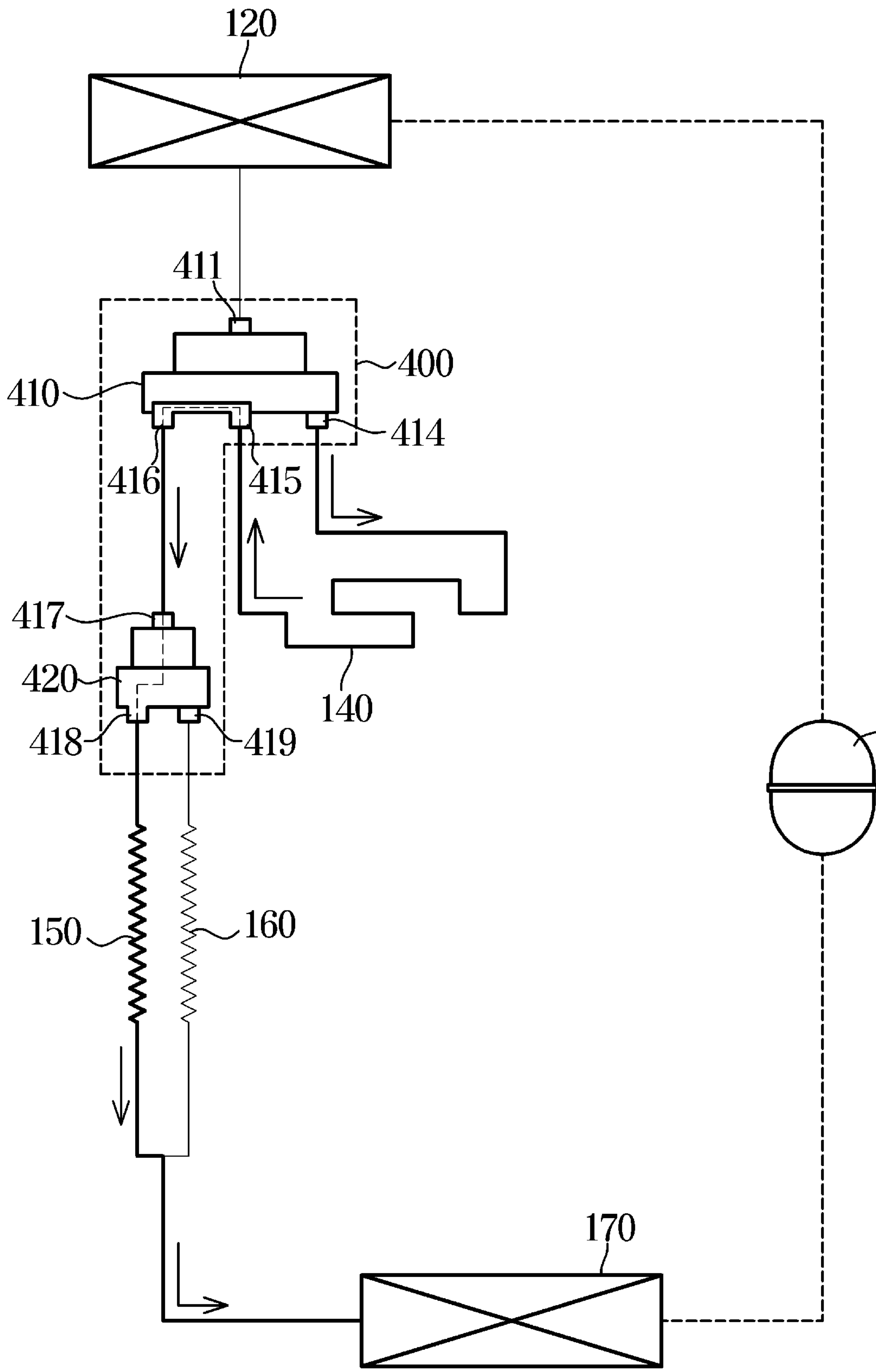


FIG. 25

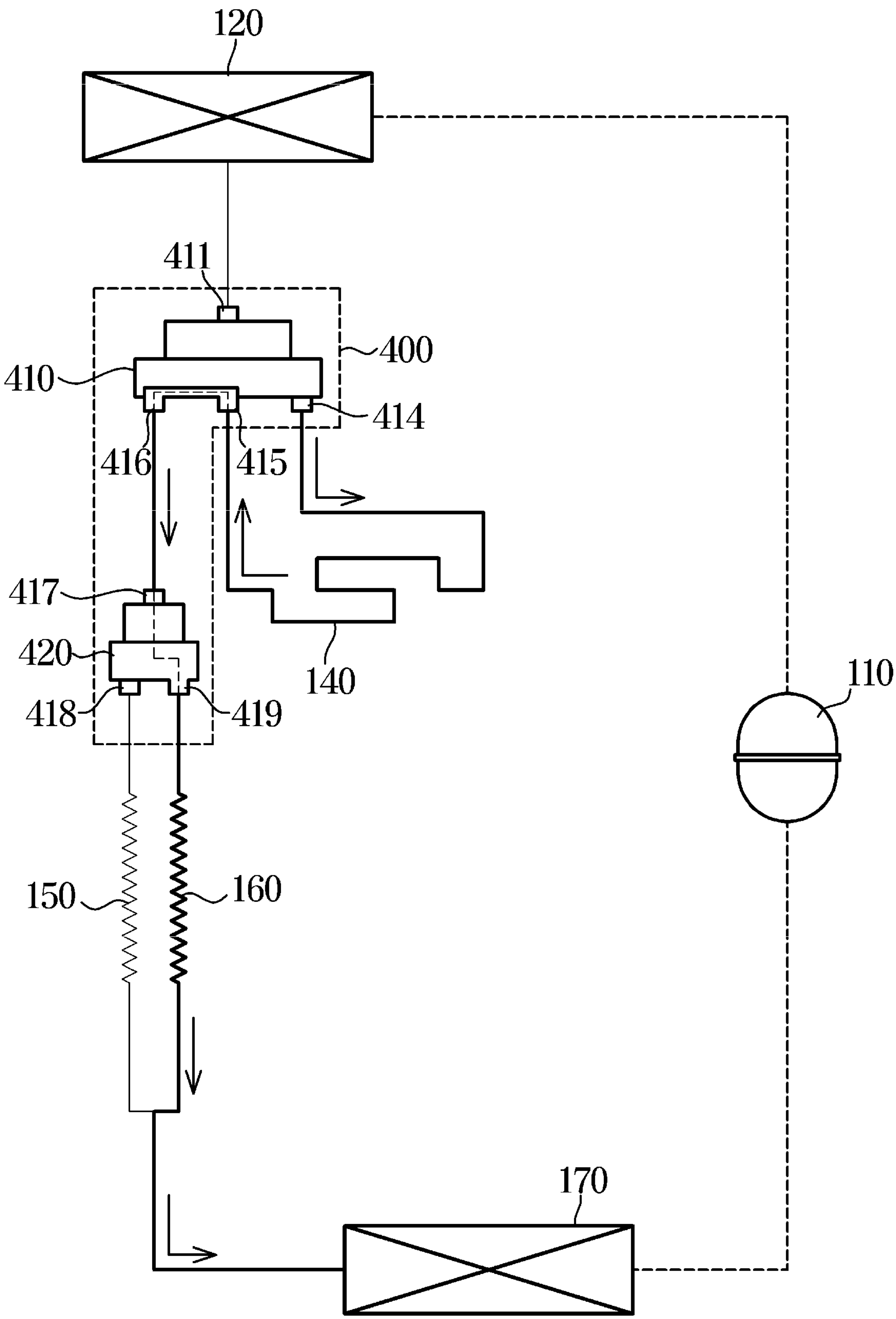


FIG. 26

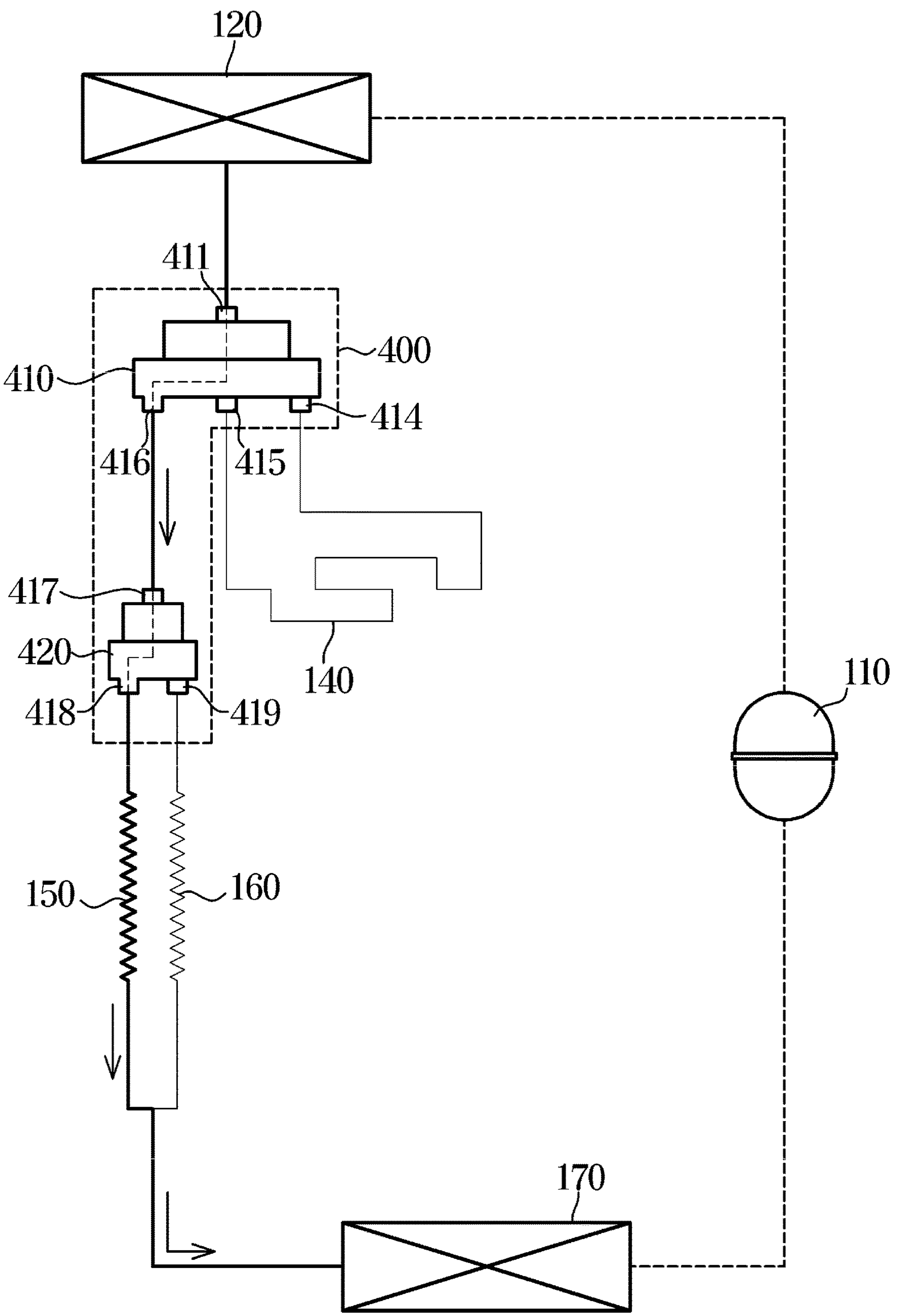


FIG. 27

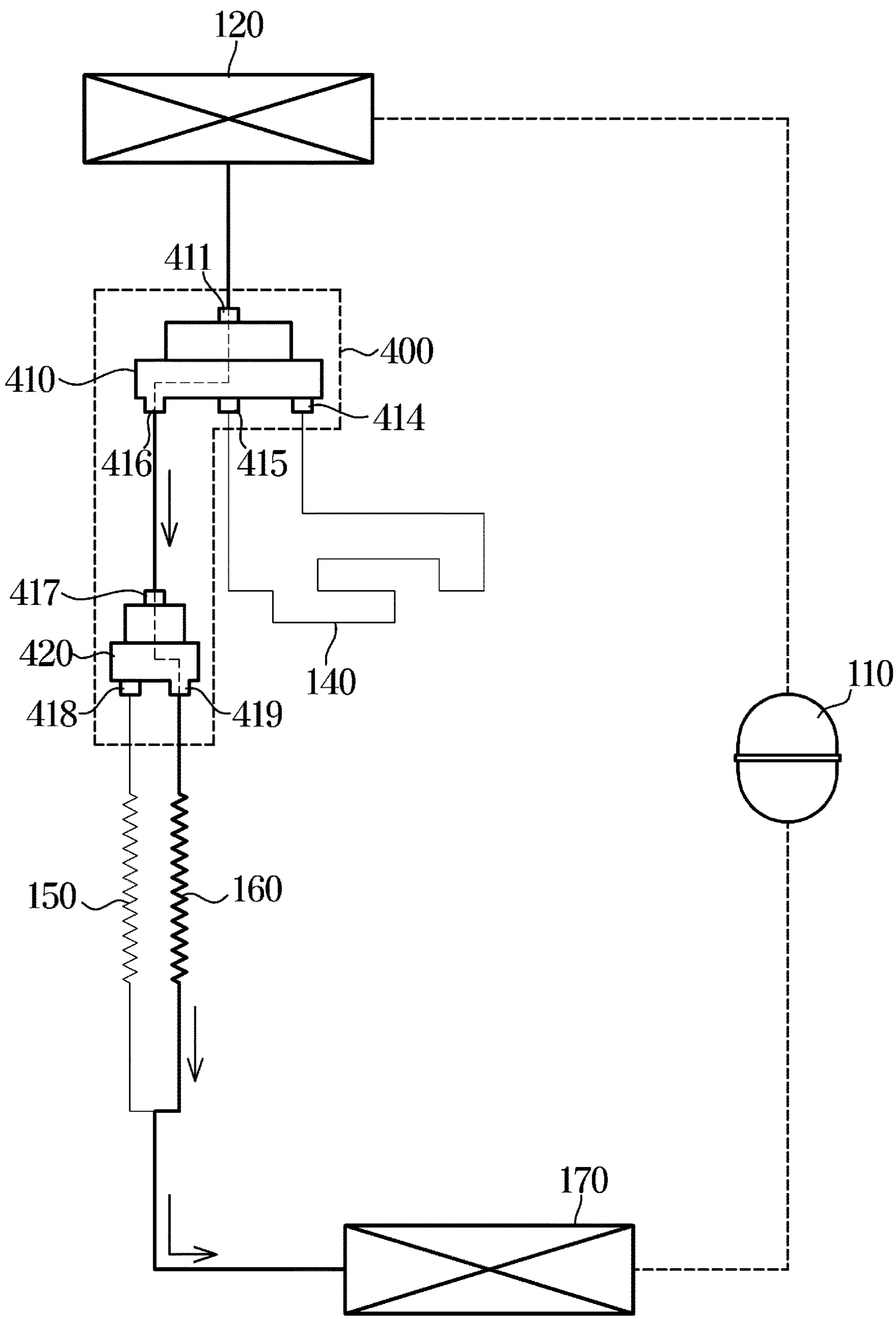


FIG. 28

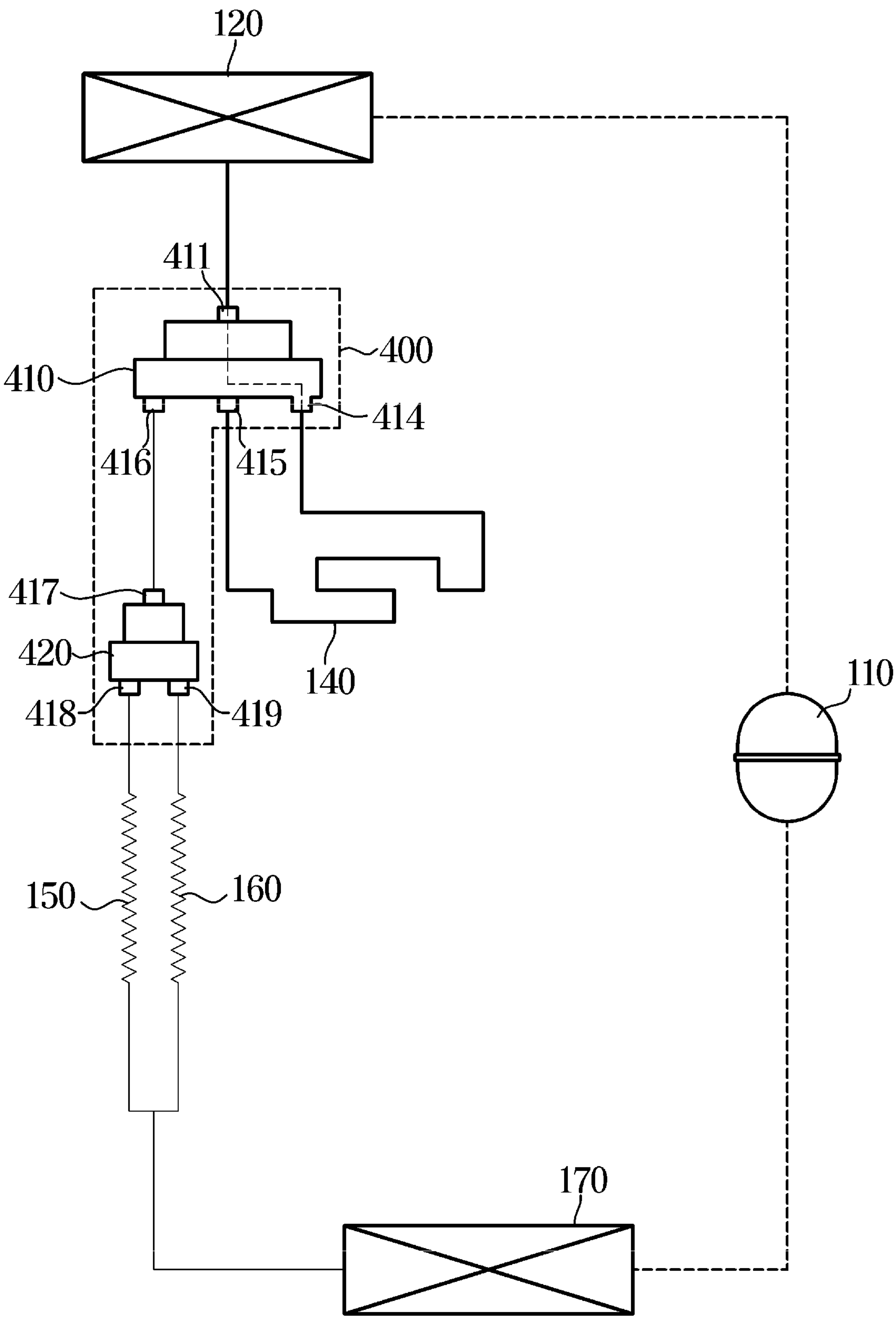


FIG. 29

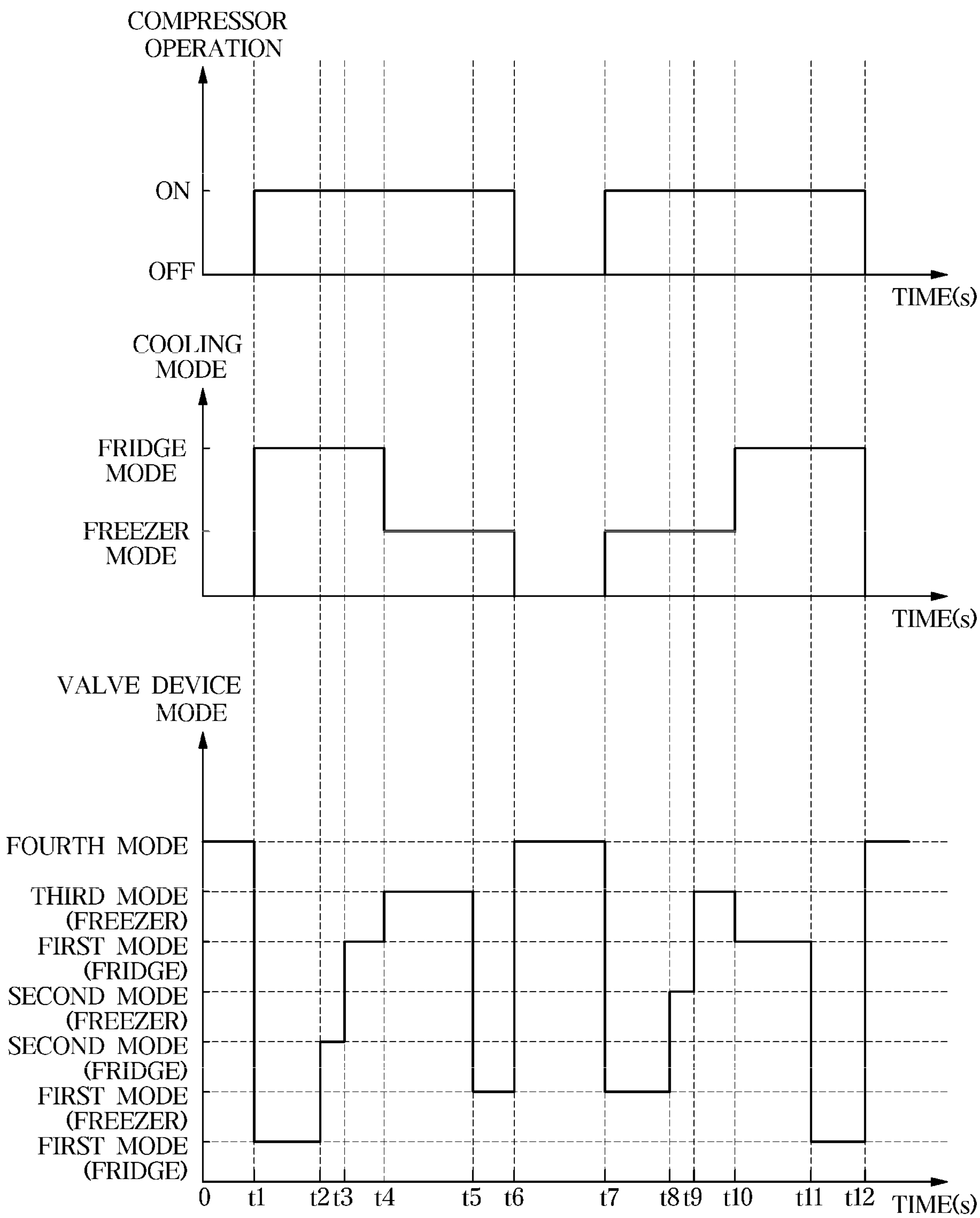

COMPRESSOR OPERATION
ON
OFF
TIME(s)
COOLING MODE
FRIDGE MODE
FREEZER MODE
TIME(s)
VALVE DEVICE MODE
FOURTH MODE
THIRD MODE (FREEZER)
FIRST MODE (FRIDGE)
SECOND MODE (FREEZER)
SECOND MODE (FRIDGE)
FIRST MODE (FREEZER)
FIRST MODE (FRIDGE)
0
t1
t2
t3
t4
t5
t6
t7
t8
t9
t10
t11
t12
TIME(s)

FIG. 30

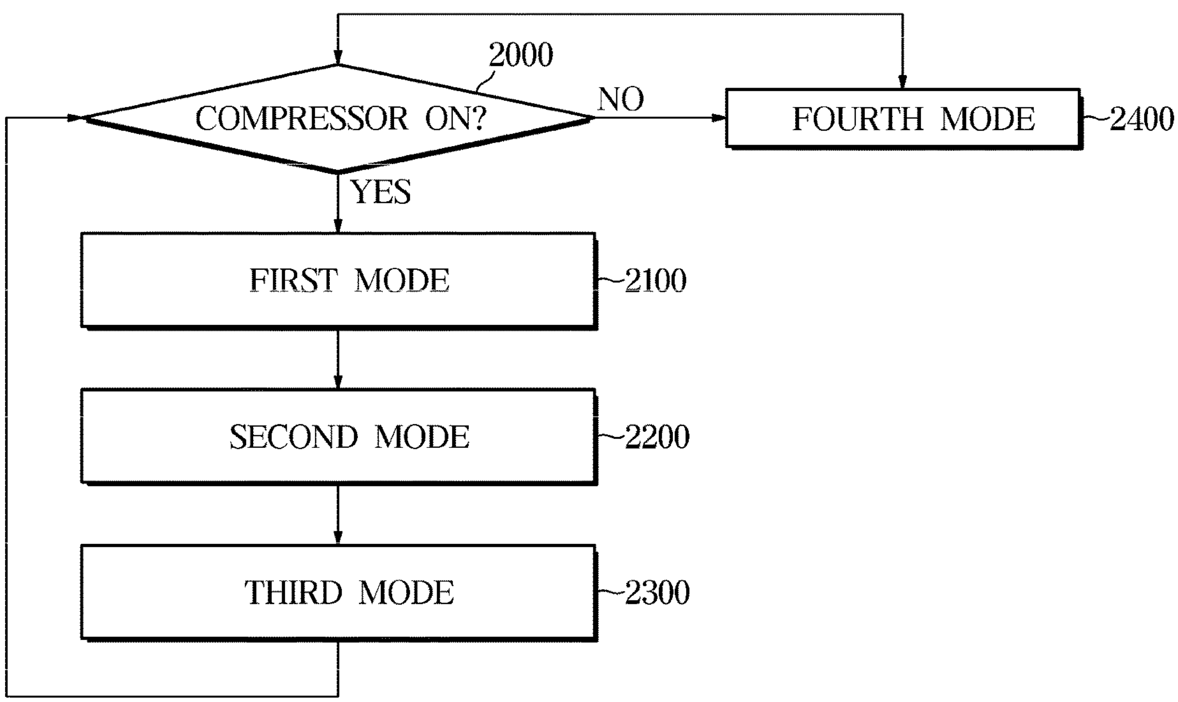

2000
COMPRESSOR ON?
NO
FOURTH MODE
2400
YES
FIRST MODE
2100
SECOND MODE
2200
THIRD MODE
2300

FIG. 31

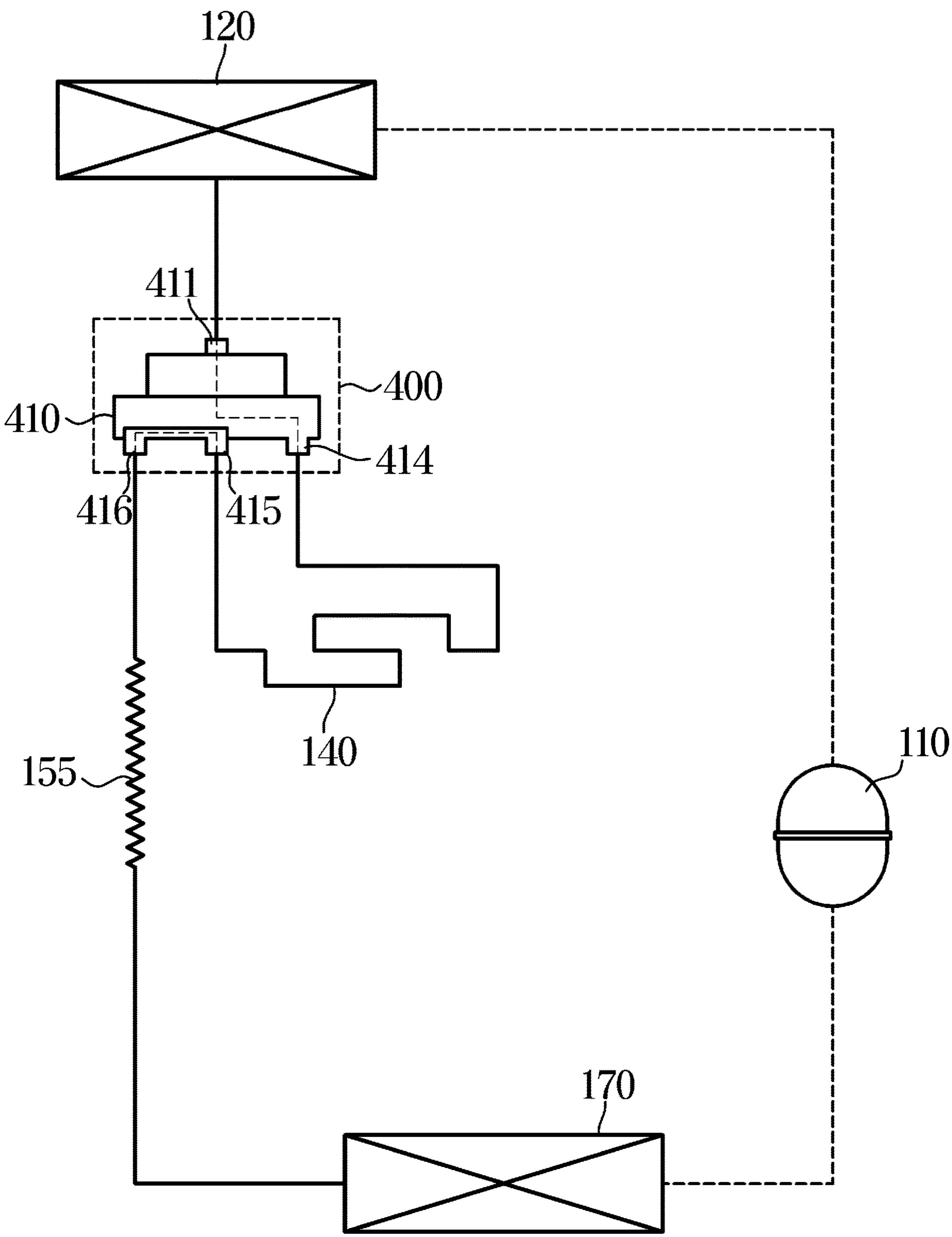


FIG. 32

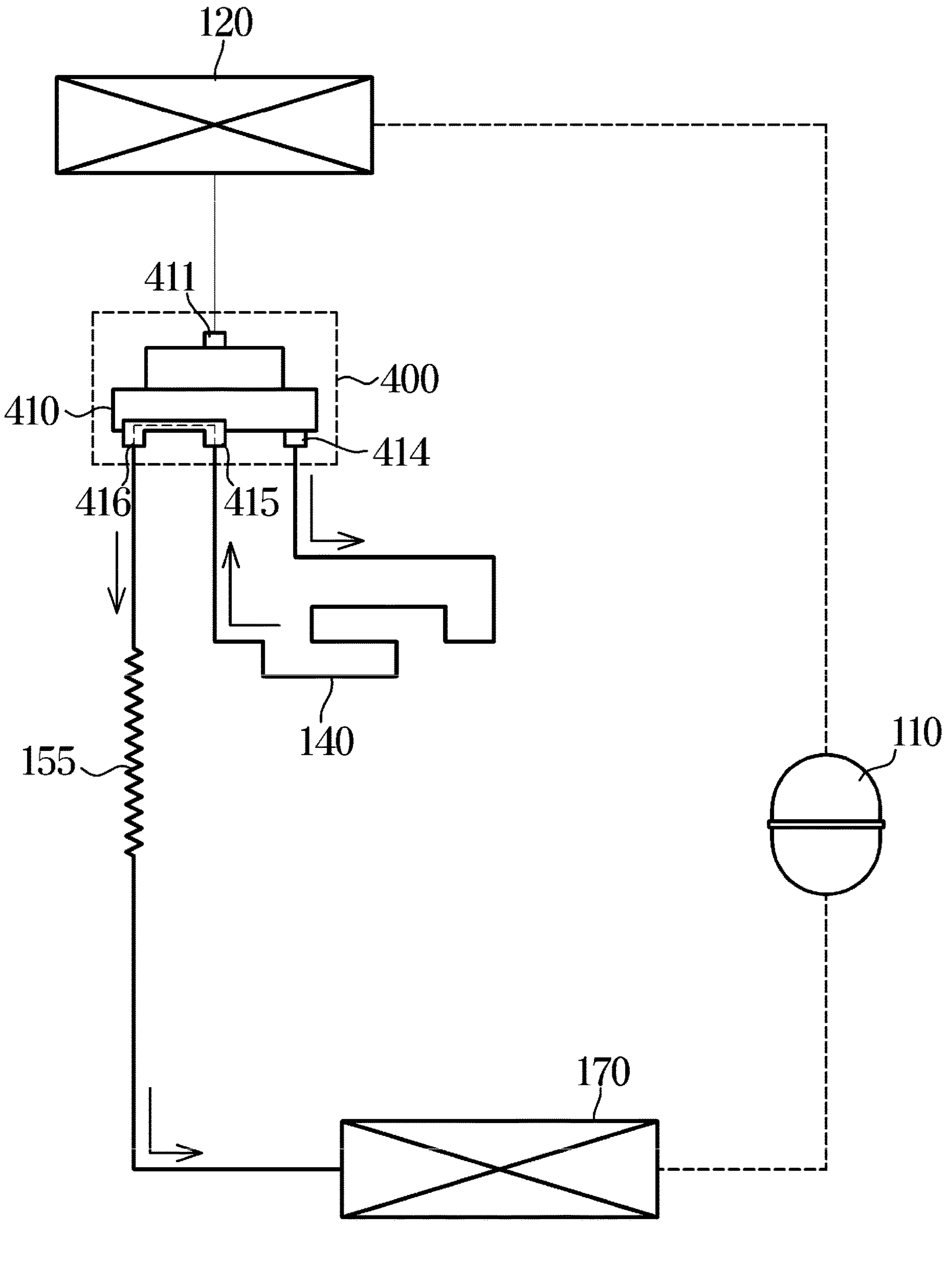


FIG. 33

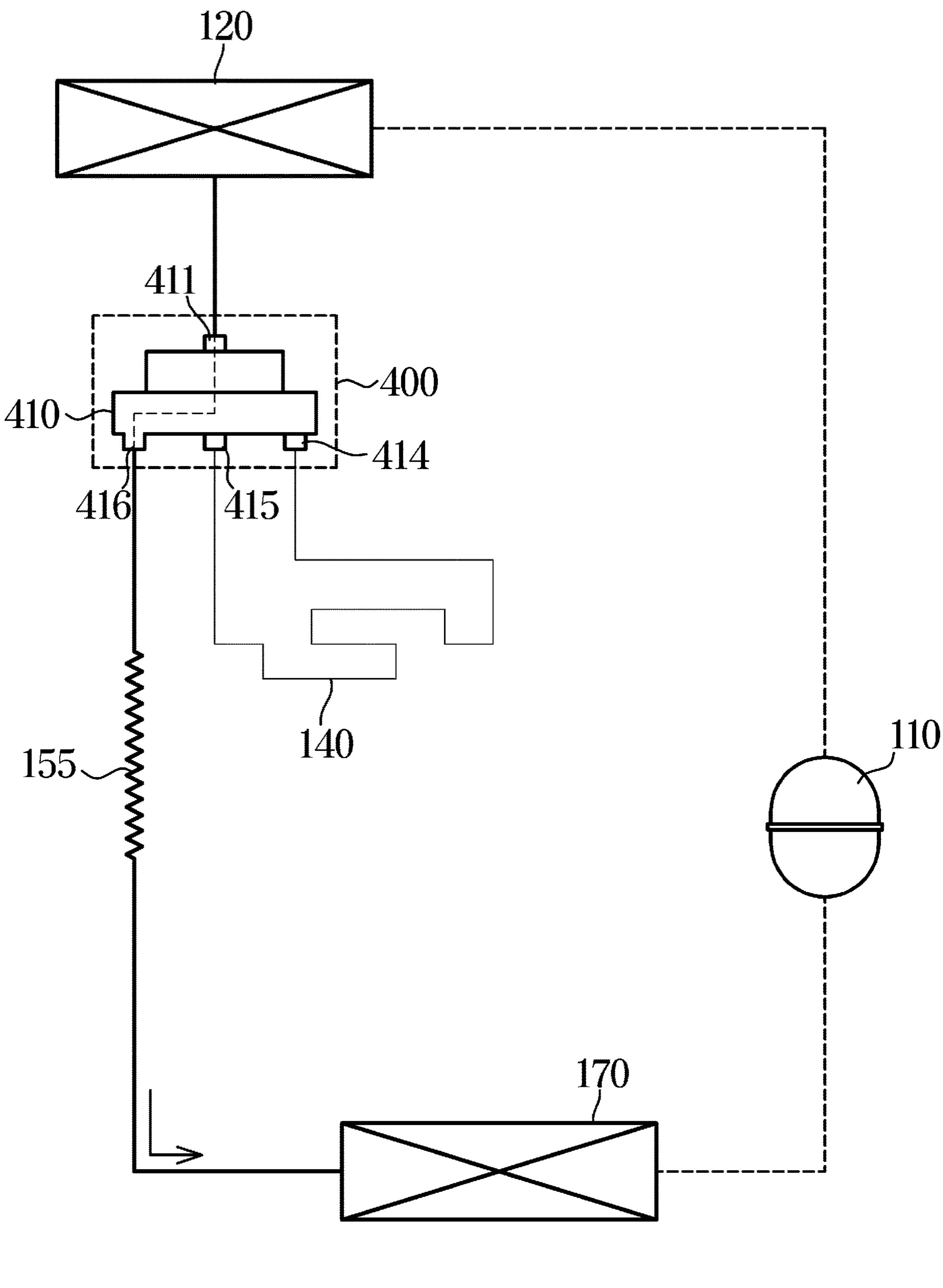


FIG. 34

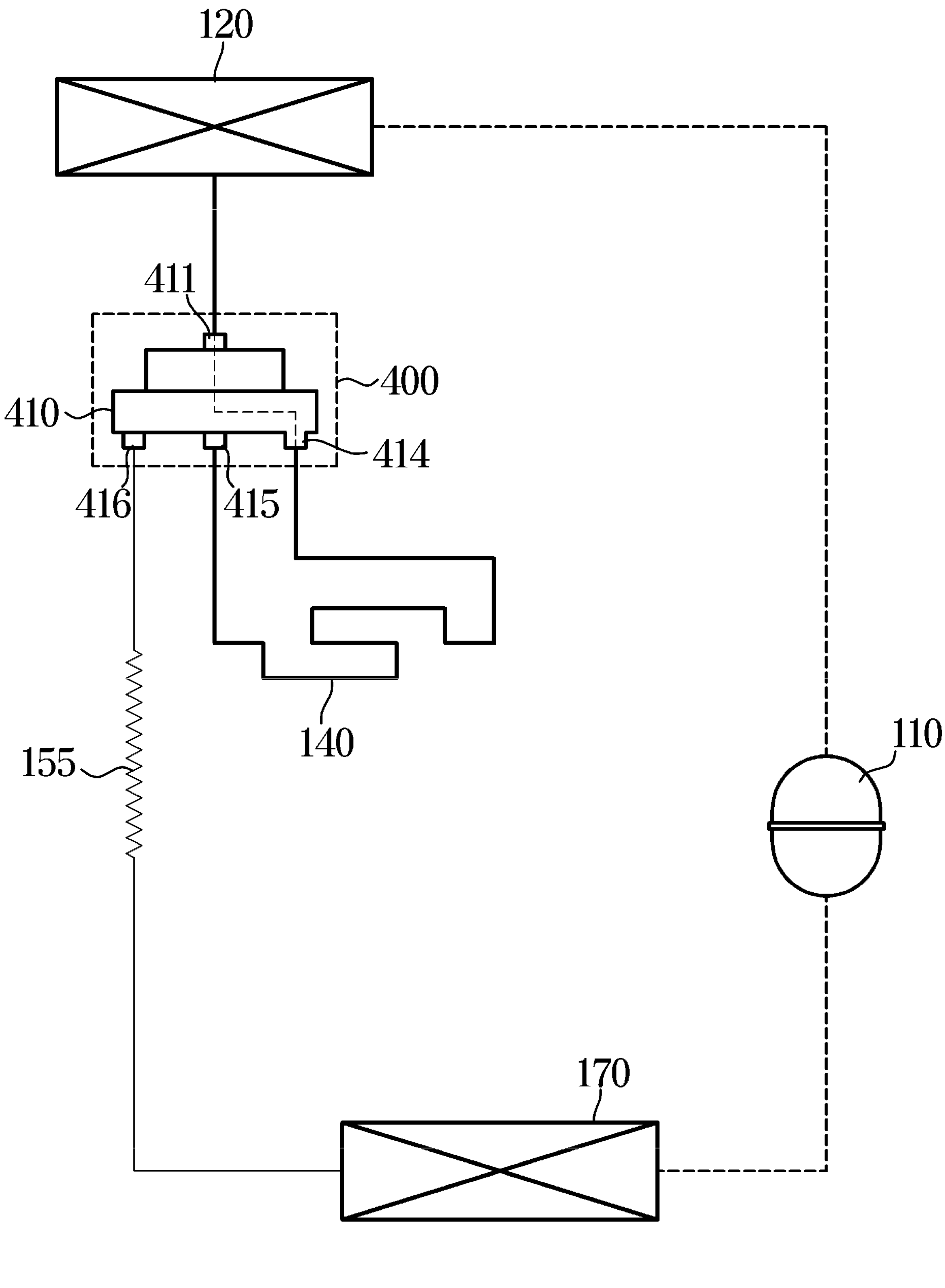
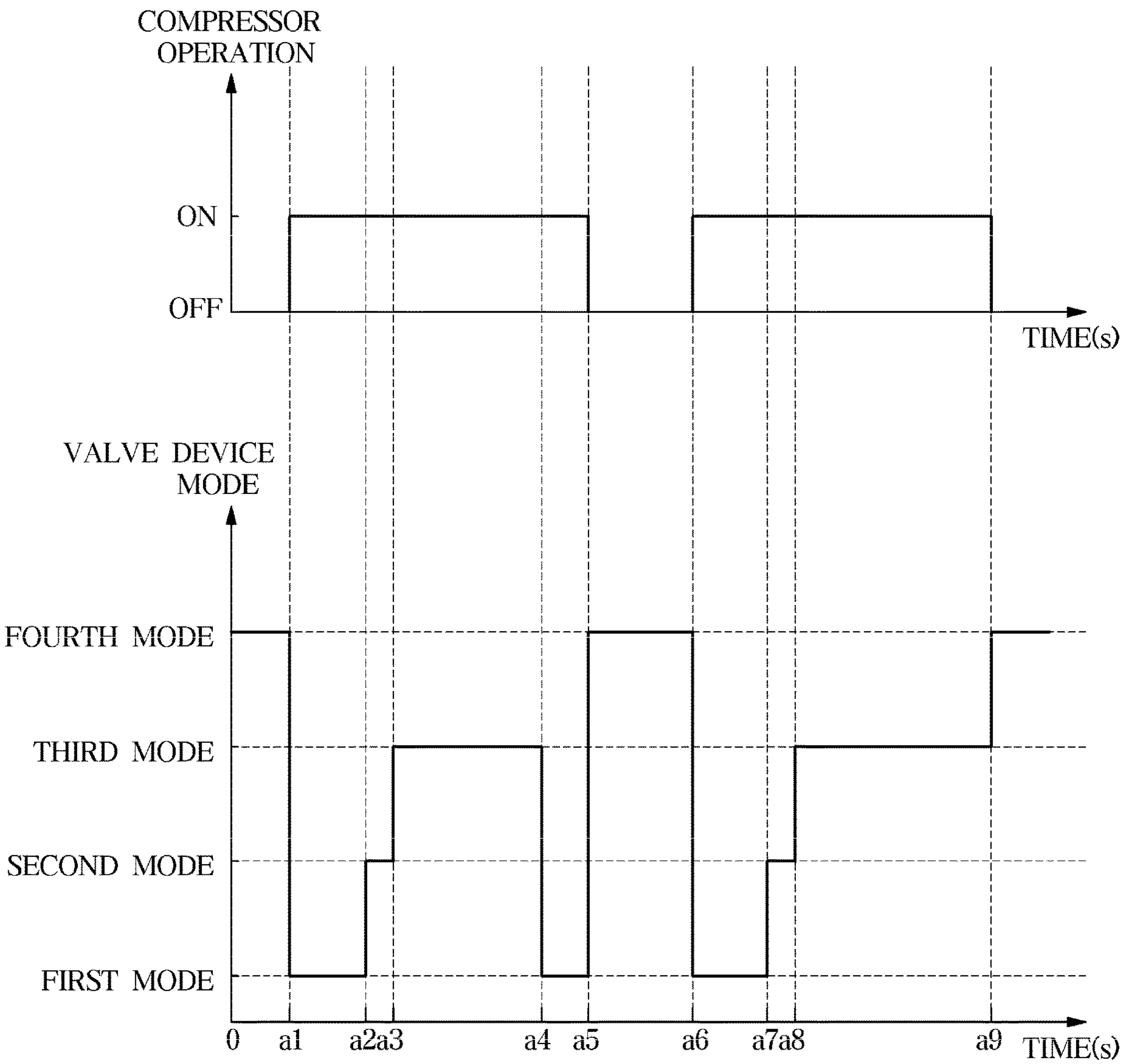


FIG. 35


COMPRESSOR OPERATION
ON
OFF
TIME(s)
VALVE DEVICE MODE
FOURTH MODE
THIRD MODE
SECOND MODE
FIRST MODE
0
a1
a2a3
a4
a5
a6
a7a8
a9
TIME(s)

REFRIGERATOR AND METHOD FOR CONTROLLING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a continuation application, under 35 U.S.C. § 111(a), of international application No. PCT/KR2023/010670, filed on Jul. 24, 2023, which claims priority to Korean Patent Application No. 10-2022-0130972, filed on Oct. 12, 2022, in the Korean Intellectual Property Office, the disclosures of which are incorporated by reference herein in their entireties.

BACKGROUND

1. Field

The disclosure relates to a refrigerator equipped with a cold air supplier and method for controlling the refrigerator.

2. Description of Related Art

A refrigerator employing a common cooling cycle by which a refrigerant is circulated therein is to keep various food items fresh for a long time by supplying cold air into food storage chambers, the cold air generated as the refrigerant in a liquid state absorbs surrounding heat while being evaporated. Of the food storage chambers, a freezer is maintained at a temperature of about minus 20 degrees and a fridge is maintained at a low temperature of about minus 3 degrees.

The refrigerant circulating through the refrigerator in the cooling cycle may have different cooling levels according to the surrounding temperature. For example, when the surrounding temperature is low, the refrigerant is supercooled and concentrated in the condenser, causing shortage of refrigerant on the side of the evaporator.

A way to solve the shortage of refrigerant by increasing the number of revolutions of the compressor to increase pressure in the cooling cycle not only increases noise of the refrigerator but also increases the whole power consumption.

SUMMARY

A refrigerator may comprise a compressor having an inlet and an outlet; a condenser having an inlet and an outlet, the inlet of the condenser connected to the outlet of the compressor; a hot pipe; at least one capillary tube; at least one evaporator connected to the at least one capillary tube and the inlet of the compressor; a valve device including: an input port connected to the outlet of the condenser; a first port connected to one end of the hot pipe; a second port connected to an other end of the hot pipe; and at least one output port connected to the at least one capillary tube; and a controller configured to: control the valve device to operate in a first mode, a second mode, and a third mode during an operation of the compressor, control the valve device to operate in the first mode by connecting one of the first port and the second port to the input port and connecting an other one of the first port and the second port to the output port; control the valve device to operate in the second mode, by closing one of the first port and the second port and connecting an other one of the first port and the second port to the output port; and control the valve device to operate in the third mode, by closing all the first port and the second port.

The controller may be configured to control the valve device to operate in an order of the first mode, the second mode, and the third mode or in an order of the second mode, the third mode, and the first mode.

The refrigerator may further comprise a plurality of sensors to detect outside temperature and outside humidity, and wherein the controller is configured to determine a duration of the first mode based on at least one of the detected outside temperature or the detected outside humidity.

The controller may be configured to control the valve device to close the output port based on the compressor being turned off.

The controller may operate the valve device in the first mode based on the start of operation of the compressor.

The controller may operate the valve device in the second mode based on the start of operation of the compressor.

A refrigerant flowing into the input port may pass through the hot pipe, and is discharged to the at least one evaporator in the first mode, a refrigerant left in the hot pipe is collected to the at least one evaporator in the second mode, and a refrigerant flowing into the input port bypasses the hot pipe, and is discharged to the at least one evaporator in the third mode.

The controller may be configured to control a frequency of the compressor to a first value based on the valve device being operating in the first mode and control the frequency of the compressor to a second value lower than the first value based on the valve device being operating in the third mode.

The controller may be configured to: control the valve device to switch from the first mode to the second mode based on a termination condition of the first mode being satisfied; control the valve device to switch from the second mode to the third mode based on a termination condition of the second mode being satisfied, and control the valve device to switch from the third mode to the first mode based on a termination condition of the third mode being satisfied, during the operation of the compressor.

The controller may be configured to control the valve device to operate in the second mode after an operation in the first mode and before an operation in the third mode.

The controller may be configured to control the valve device to operate in the second mode after an operation in the first mode and before an operation in the third mode.

The at least one capillary tube may comprise a first capillary tube and a second capillary tube; the at least one output port comprises a first output port connected to the first capillary tube and a second output port connected to the second capillary tube; and the controller is configured to control the valve device such that the first port is connected to the first output port and the second port is connected to the input port in the first mode based on the refrigerator being operating in a fridge mode, and control the valve device such that the second port is connected to the second output port and the first port is connected to the input port in the first mode based on the refrigerator being operating in a freezer mode.

The at least one capillary tube comprises a first capillary tube and a second capillary tube; the at least one output port comprises a first output port connected to the first capillary tube and a second output port connected to the second capillary tube; and the controller is configured to: control the valve device such that the first port is closed and the second port is connected to the second output port in the second mode based on the refrigerator being operating in a fridge mode, and control the valve device such that the second port is closed and the first port is connected to the first output port in the second mode based on the refrigerator being operating in a freezer mode.

The controller may be configured to control the valve device such that the input port is connected to the first output port in the second mode based on the refrigerator being operating in the fridge mode, and control the valve device such that the input port is connected to the second output port in the second mode based on the refrigerator being operating in the freezer mode.

At least one capillary tube may comprise a first capillary tube and a second capillary tube; the at least one output port comprises a first output port connected to the first capillary tube and a second output port connected to the second capillary tube; and the controller is configured to: control the valve device such that the input port is connected to the first output port in the third mode based on the refrigerator being operating in a fridge mode; and control the valve device such that the input port is connected to the second output port in the third mode based on the refrigerator being operating in a freezer mode.

A method of controlling a refrigerator may include a valve device including an input port connected to a condenser, a first port connected to one end of a hot pipe, a second port connected to an other end of the hot pipe, and at least one output port connected to at least one capillary tube, the method comprising: controlling the valve device to operate in a first mode, a second mode and a third mode during an operation of a compressor; controlling the valve device to operate in the first mode to connect one of the first port and the second port to the input port and connect an other one of the first port and the second port to the output port; controlling the valve device to operate in the second mode to close one of the first port and the second port and connect an other one of the first port and the second port to the output port; and controlling the valve device to operate in the third mode to close all the first port and the second port.

The controlling of the valve device to operate in the first mode, the second mode, and the third mode during an operation of the compressor may comprise controlling the valve device to operate in an order of the first mode, the second mode and the third mode or in an order of the second mode, the third mode and the first mode.

The method may further include determining duration of the first mode based on at least one of outside temperature or outside humidity.

The method may further include controlling the valve device to close the output port based on the compressor being off.

The method may further include operating the valve device in the first mode based on the start of operation of the compressor.

The method may further include operating the valve device in the second mode based on the start of operation of the compressor.

The method may further include controlling frequency of the compressor to a first value based on the valve device operating in the first mode and controlling the frequency of the compressor to a second value lower than the first value based on the valve device operating in the third mode.

The method may further include switching the valve device from the first mode to the second mode based on a termination condition of the first mode satisfied, switching the valve device from the second mode to the third mode based on a termination condition of the second mode satisfied, and switching the valve device from the third mode to the first mode based on a termination condition of the third mode satisfied, during operation of the compressor.

The controlling of the valve device such that one of the first port and the second port is connected to the input port and the other is connected to the output port in the first mode may include controlling the valve device such that the first port is connected to the first output port and the second port is connected to the input port in the first mode based on the refrigerator operating in a fridge mode, and controlling the valve device such that the second port is connected to the second output port and the first port is connected to the input port in the first mode based on the refrigerator operating in a freezer mode.

The controlling of the valve device such that one of the first port and the second port is closed and the other is connected to the output port in the second mode may include controlling the valve device such that the first port is closed and the second port is connected to the second output port in the second mode based on the refrigerator operating in a fridge mode, and controlling the valve device such that the second port is closed and the first port is connected to the first output port in the second mode based on the refrigerator operating in a freezer mode.

The controlling of the valve device such that one of the first port and the second port is closed and the other is connected to the output port may include controlling the valve device such that the input port is connected to the first output port in the second mode based on the refrigerator operating in a fridge mode, and controlling the valve device such that the input port is connected to the second output port in the second mode based on the refrigerator operating in a freezer mode.

The method may further include controlling the valve device such that the input port is connected to the first output port in the third mode based on the refrigerator operating in a fridge mode, and control the valve device such that the input port is connected to the second output port in the third mode based on the refrigerator operating in a freezer mode.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a refrigerator, according to an embodiment.

FIG. **2** illustrates an example of a cold air supplier including a valve device, according to an embodiment.

FIG. **3** illustrates another example of a cold air supplier including a valve device, according to an embodiment.

FIG. **4** is an exploded perspective view of a valve device, according to an embodiment.

FIG. **5** illustrates a pad gear and a pad of a valve device being coupled to each other, according to an embodiment.

FIG. **6** illustrates a pad of a valve device arranged on the top of a boss, according to an embodiment.

FIG. **7** illustrates a bottom surface of a boss of a valve device, according to an embodiment.

FIG. **8** is a cross-sectional view of a pad of a valve device, according to an embodiment.

FIG. **9** is a side cross-sectional view of a valve device, according to an embodiment.

FIG. **10** is a schematic view for describing a flow of refrigerant through a valve device, according to an embodiment.

FIG. **11** illustrates an example of a cold air supplier including a valve device, according to an embodiment.

FIG. **12** illustrates an example of a cold air supplier including a valve device, according to an embodiment.

FIG. **13** is a block diagram illustrating a configuration of a refrigerator, according to an embodiment.

FIG. **14** is a flowchart illustrating an example of a method of controlling a refrigerator, according to an embodiment.

FIG. **15** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in a fridge mode, according to an embodiment.

FIG. **16** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in a freezer mode, according to an embodiment.

FIG. **17** illustrates flows of a refrigerant through a valve device operating in a second mode when a refrigerator operates in a fridge mode, according to an embodiment.

FIG. **18** illustrates flows of a refrigerant through a valve device operating in a second mode when a refrigerator operates in a freezer mode, according to an embodiment.

FIG. **19** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a fridge mode, according to an embodiment.

FIG. **20** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a freezer mode, according to an embodiment.

FIG. **21** illustrates flows of a refrigerant through a valve device operating in a fourth mode.

FIG. **22** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in a fridge mode, according to an embodiment.

FIG. **23** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in a freezer mode, according to an embodiment.

FIG. **24** illustrates flows of a refrigerant through a valve device operating in a second mode when a refrigerator operates in a fridge mode, according to an embodiment.

FIG. **25** illustrates flows of a refrigerant through a valve device operating in a second mode when a refrigerator operates in a freezer mode, according to an embodiment.

FIG. **26** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a fridge mode, according to an embodiment.

FIG. **27** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a freezer mode, according to an embodiment.

FIG. **28** illustrates flows of a refrigerant through a valve device operating in a fourth mode.

FIG. **29** illustrates an example of a method of controlling a refrigerator over time, according to an embodiment.

FIG. **30** is a flowchart illustrating an example of a method of controlling a refrigerator, according to an embodiment.

FIG. **31** illustrates flows of a refrigerant through a valve device operating in a first mode.

FIG. **32** illustrates flows of a refrigerant through a valve device operating in a second mode.

FIG. **33** illustrates flows of a refrigerant through a valve device operating in a third mode.

FIG. **34** illustrates flows of a refrigerant through a valve device operating in a fourth mode.

FIG. **35** illustrates an example of a method of controlling a refrigerator over time, according to an embodiment.

DETAILED DESCRIPTION

Embodiments and features as described and illustrated in the disclosure are merely examples, and there may be various modifications replacing the embodiments and drawings at the time of filing this application.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the disclosure.

For example, the singular forms "a", "an" and "the" as herein used are intended to include the plural forms as well, unless the context clearly indicates otherwise.

The terms "comprises" and/or "comprising," when used in this specification, represent the presence of stated features, integers, steps, operations, elements, components or combinations thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, or combinations thereof.

The term including an ordinal number such as "first", "second", or the like is used to distinguish one component from another and does not restrict the former component.

Furthermore, the terms, such as "— part", "— block", "— member", "— module", etc., may refer to a unit of handling at least one function or operation. For example, the terms may refer to at least one process handled by hardware such as a field-programmable gate array (FPGA)/application specific integrated circuit (ASIC), etc., software stored in a memory, or at least one processor.

An embodiment of the disclosure will now be described in detail with reference to accompanying drawings. Throughout the drawings, like reference numerals or symbols refer to like parts or components.

The working principle and embodiments of the disclosure will now be described with reference to accompanying drawings.

The disclosure provides a refrigerator and method for controlling the refrigerator capable of preventing shortage of refrigerant on the side of an evaporator.

The disclosure also provides a refrigerator and method for controlling the refrigerator capable of collecting refrigerant left in a hot pipe.

The disclosure provides a refrigerator and method for controlling the refrigerator capable of increasing energy efficiency by minimizing a thermal load with the hot pipe.

Technological objectives of the disclosure are not limited to what are mentioned above, and throughout the specification, it will be clearly appreciated by those of ordinary skill in the art that there may be other technological objectives unmentioned.

According to the disclosure, a refrigerator may have increased energy efficiency.

According to the disclosure, a shortage of refrigerant in an evaporator may be prevented.

The effects according to the disclosure are not limited thereto, and throughout the specification it will be clearly appreciated by those of ordinary skill in the art that there may be other effects unmentioned.

FIG. **1** is a perspective view of a refrigerator, according to an embodiment.

Referring to FIG. **1**, a refrigerator **1** may include a main body **10**, at least one storeroom **20** and **30** formed in the main body **10**, and at least one door **21**, **22**, and **31** arranged to open or close the at least one storeroom **20** and **30**.

The main body **10** may include an inner case **11** that defines the storerooms **20** and **30**, an outer case **12** coupled onto the outer side of the inner case **11**, and insulation (not shown) arranged between the inner case **11** and the outer case **12**.

The inner case **11** may be formed of a plastic substance through injection molding, and the outer case **12** may be formed of a metal substance. For the insulation, urethane foam insulation may be used, and when required, used with vacuum insulation.

After the inner case **11** and the outer case **12** are coupled with each other, the urethane foam insulation may be formed by filling foamed urethane obtained by mixing urethane and a foam agent in between the inner case **11** and the outer case **12**. The foamed urethane is strongly adhesive, thus reinforcing coupling power between the inner case **11** and the outer case **12**, and may have sufficient strength after foaming is complete.

The main body **10** may include a middle wall **13** that makes vertical division into the storerooms **20** and **30**. The middle wall **13** may separate the fridge **20** from the freezer **30**.

How to divide the storerooms **20** and **30** is not, however, limited to what is shown in FIG. **1**, but may be implemented in various known ways.

The storerooms **20** and **30** may include the fridge **20** formed in the upper portion of the main body **10** and the freezer **30** formed in the lower portion of the main body **10**. In other words, the freezer **30** may be placed under the fridge **20**.

The fridge **20** may be maintained at temperatures of about 0 to 5 degrees Celsius to keep foods refrigerated. The freezer **30** may be maintained at temperatures of about minus 30 to 0 degree Celsius to keep foods frozen.

Shelves **23** for food items to be put thereon and containers **24** for storing food items may be provided in the fridge **20**.

The fridge **20** and the freezer **30** may each have an open front to put in and take out foods. The open front of the fridge **20** may be opened or closed by a pair of fridge doors **21** and **22** coupled with the main body **10**. The fridge doors **21** and **22** may be rotationally coupled with the main body **10**. The open front of the freezer **30** may be opened or closed by a freezer door **31** that may slide against the main body **10**. The freezer door **31** may be shaped like a box with an open top side and may include a front plate **32** defining an exterior and a drawer **33** coupled to the rear side of the front plate **32**.

The shape of the freezer door **31** is not, however, limited thereto, and it is obvious that the freezer door **31** may have a shape that is rotationally coupled with the main body **10** like the fridge doors **21** and **22**.

Gaskets (not shown) may be arranged on rear edges of the fridge doors **21** and **22** to seal up the space between the fridge doors **21** and **22** and the main body **10** to contain cold air of the fridge **20** when the fridge doors **21** and **22** are closed.

The refrigerator **1** may also include a cold air supplier **100** for supplying cold air into the storeroom. The cold air supplier **100** will be described in detail later.

In the meantime, the shape of the refrigerator **1** may not be limited to what is described above, but may have various forms, such as a top-mounted freezer (TMF) refrigerator with the freezer formed in the upper portion of the main body **10** and the fridge formed in the lower portion of the main body **10** or a side-by-side (SBS) refrigerator.

Moreover, it is obvious that any type of refrigerator **1** may be used as long as it receives cold air from the cold air supplier **100**.

FIG. **2** illustrates a cold air supplier including a valve device, according to an embodiment. FIG. **3** illustrates another example of a cold air supplier including a valve device, according to an embodiment.

Referring to FIGS. **2** and **3**, the cold air supplier **100** (see **100**A in FIG. **2**, **100**B in FIG. **3**, **100**C in FIGS. **11** and **100**D in FIG. **12**) may include a compressor **110** and a condenser **120**.

The compressor **110** may be provided to compress a refrigerant provided to circulate through the cold air supplier **100** to high-temperature and high-pressure gas.

The condenser **120** may be provided to condense the refrigerant compressed by the compressor **110**. Specifically, the condenser **120** may be connected to an outlet of the compressor **110** for radiating heat from the high-temperature high-pressure gaseous refrigerant compressed by the compressor **110** to make a phase change to a room temperature liquid.

The cold air supplier **100** may further include a dryer **130**. The dryer **130** may remove moisture contained in the refrigerant.

The working refrigerant flowing through the cold air supplier **100** may include HC based isobutane (R600a), propane (R290), HFC-based R134a, or HFO-based R1234yf. The type of the refrigerant is not, however, limited thereto, but any refrigerant that attains a target temperature through heat exchange with surroundings may be used.

An outlet of the condenser **120** may be connected to the valve device **400** directly or via the dryer **130**.

The cold air supplier **100** may include a hot pipe **140**.

The hot pipe **140** may be arranged where the main body **10** of the refrigerator **1** meets the doors **21**, **22** and **31** and installed around the main body **10** to prevent condensation of water vapor.

The hot pipe **140** may be a pipe installed to prevent dew formation caused in a gasket portion of the doors **21**, **22** and **31**, which is vulnerable to the temperature in the refrigerator **1**. When the hot refrigerant flows in the hot pipe **140**, it may prevent the problem of dew formation around the doors **21**, **22** and **31**.

Both ends of the hot pipe **140** may be connected to the valve device **400**.

The cold air supplier **100** may include at least one capillary tube **150** and **160**.

For example, the cold air supplier **100** may include the first capillary tube **150** and the second capillary tube **160**.

The first and second capillary tubes **150** and **160** may be provided to have different diameters and lengths. Specifically, the second capillary tube **160** may be provided to be longer than the first capillary tube **150**.

The refrigerant may expand and be decompressed while flowing through the at least one capillary tube **150** and **160**.

For example, the refrigerant may expand and be decompressed while flowing through the first capillary tube **150** or the second capillary tube **160**.

One end of the at least one capillary tube **150** and **160** may be connected to the valve device **400** and the other end may be connected to at least one evaporator **170**.

The cold air supplier **100** may include the at least one evaporator **170**.

For example, the cold air supplier **100**A may include a first evaporator **171** connected to the first capillary tube **150** and a second evaporator **172** connected to the second capillary tube **160**.

In various embodiments, the first evaporator **171** may be arranged in the fridge **20** and the second evaporator **172** may be arranged in the freezer **30**. The first evaporator **171** may supply cold air into the fridge **20** and the second evaporator **172** may supply cold air into the freezer **30**.

Locations of the first and second evaporators **171** and **172** are not, however, limited thereto, and both the first and second evaporators **171** and **172** may be arranged in the fridge **20**. In the case that both the first and second evaporators **171** and **172** are arranged in the fridge **20**, the refrigerator **1** may lower the temperature in the freezer **30** by using the cold air subsidence phenomenon.

In an embodiment, the refrigerator **1** may operate in a fridge mode or a freezer mode.

For example, the refrigerator **1** may operate in the fridge mode or the freezer mode based on the temperature in the storeroom **20** or **30**.

In an embodiment, when the refrigerator **1** operates in the fridge mode, the refrigerant may flow to the first evaporator **171**. When the refrigerator **1** operates in the freezer mode, the refrigerant may flow to the second evaporator **172**.

In another example, the cold air supplier **100**B may include a single evaporator **170** connected to the first and second capillary tubes **150** and **160**.

In various embodiments, the evaporator **170** may be arranged in the fridge **20** or the freezer **30**.

In an embodiment, when the refrigerator **1** operates in the fridge mode, the refrigerant may flow to the evaporator **170** through the first capillary tube **150**. When the refrigerator **1** operates in the freezer mode, the refrigerant may flow to the evaporator **170** through the second capillary tube **160**.

The cold air supplier **100** may include a heat radiation fan **125** and an air blow fan **175**.

The heat radiation fan **125** may be arranged near the condenser **120**. The air blow fan **175** may be arranged near the evaporator **170**. The heat radiation fan **125** may be provided to increase heat radiation efficiency of the condenser **120**. The air blow fan **175** may be provided to increase evaporation efficiency of the evaporator **170**.

The cold air supplier **100** may include the valve device **400**.

The valve device **400** may include a plurality of ports connected to the respective components of the cold air supplier **100**.

In an embodiment, the valve device **400** may include an input port connected to the outlet of the condenser **120**, a first port connected to an end of the hot pipe **140**, a second port connected to the other end of the hot pipe **140**, and at least one output port connected to the at least one capillary tube **150** and **160**.

In various embodiments, the valve device **400** may include a 5-way valve device **200**. That is, the cold air supplier **100**A or **100**B may include the 5-way valve device **200**.

The 5-way valve device **200** may include an input port **223** connected to the outlet of the condenser **120**, a first port **283** connected to an end of the hot pipe **140**, a second port **285** connected to the other end of the hot pipe **140**, a first output port **284** connected to the first capillary tube **150** and a second output port **286** connected to the second capillary tube **160**.

The structure of the 5-way valve device **200** will be described in connection with FIGS. **4** to **9**.

A closed loop refrigerant circuit may be formed in the refrigerator **1** by connecting the compressor **110**, the condenser **120**, the dryer **130**, the hot pipe **140**, the valve device **400**, the first capillary tube **150**, the second capillary tube **160**, and the evaporator **170** through connection tubes, through which the refrigerant circulates.

The cold air supplier **100** may include the condenser **120** connected to the outlet of the compressor **110**, the valve device **400** connected to the outlet of the condenser **120**, the hot pipe **140** connected to the valve device **400**, at least one capillary tube **150** and **160**, and the at least one evaporator **170** connected to the at least one capillary tube **150** and **160**, and the outlet of the at least one evaporator **170** may be connected to the compressor **110**.

As the compressor **110** operates, the refrigerant may circulate from the compressor **110** to the condenser **120** to the evaporator **170**.

In various embodiments, the cold air supplier **100** may further include additional components and omit a certain component (e.g., the dryer **130**).

Furthermore, as will be described later, the cold air supplier **100** may include the valve device **400** in various embodiments.

An example of the valve device shown in FIGS. **2** and **3**, i.e., the 5-way valve device, will now be described in connection with FIGS. **4** to **9**.

FIG. **4** is an exploded perspective view of a valve device, according to an embodiment. FIG. **5** illustrates a pad gear and a pad of a valve device being coupled to each other, according to an embodiment. FIG. **6** illustrates a pad of a valve device arranged on the top of a boss, according to an embodiment. FIG. **7** illustrates a bottom surface of a boss of a valve device, according to an embodiment. FIG. **8** is a cross-sectional view of a pad of a valve device, according to an embodiment. FIG. **9** is a side cross-sectional view of a valve device, according to an embodiment.

In an embodiment, the valve device **400** may include the 5-way valve device **200**.

Referring to FIGS. **4** to **9**, the 5-way valve device **200** may include a case **210**, a base plate **220** covering an open bottom of the case **210**, a flow-in pipe **201** into which the refrigerant flows, a plurality of flow-in/out pipes **202** through which the refrigerant flows in/out, a boss **280** including a plurality of ports **282** through which the refrigerant flows in/out, and a pad **290** rotationally arranged on the boss **280**.

The case **210** may be provided to have the bottom open and a receiving space **211** formed therein.

A rotor **230** may be arranged in the receiving space **211** in the case **210**. The rotor **230** may include a rotor shaft **231**.

Furthermore, a pinion gear **240** may be arranged in the receiving space **211**. The pinion gear **240** may be coupled to the rotor **230**. The pinion gear **240** may be coupled to the rotor shaft **231** and rotated along with the rotor **230**.

In addition, a pad gear **250** may be arranged in the receiving space **211**. The pad gear **250** may be arranged on a side of the pinion gear **240**. The pad gear **250** may be in gear with the pinion gear **240** and engaged with the pinion gear **240**. Accordingly, when the pinion gear **240** is rotated by the rotor **230**, the pad gear **250** may be rotated by the pinion gear **240**. The pad gear **250** may include a pad valve device shaft **251** corresponding to a rotation axis. The pad valve device shaft **251** may be coupled to the pad **290** so that the pad **290** may be rotated along with the pad gear **250**. The pad gear **250** may include a pad coupling projection **253** coupled to the pad **290**. The pad coupling projection **253** may be provided in the plural. The pad coupling projection **253** may be provided on the bottom surface of the pad gear **250**. The pad coupling projection **253** may be coupled to a pad gear coupling hole **293** formed at the top surface of the pad **290**.

In addition, an elastic support spring **260** may be arranged in the receiving space **211**. The elastic support spring **260** may be fixed to the case **210** in the receiving space **211**. The elastic support spring **260** may be in a plate type. The elastic support spring **260** may elastically support a top center of the pad gear **250**. The pad gear **250** may be rotationally mounted at the elastic support spring **260**.

Furthermore, a rotor support plate spring **270** may be arranged in the receiving space **211**. The rotor support plate spring **270** may be fixed to the case **210** in the receiving space **211**. The rotor support plate spring **270** may elastically support the rotor **230**. The rotor **230** may be rotationally supported on the rotor support late spring **270**.

The base plate **220** may cover the open bottom of the case **210**. The base plate **220** may include a rotor shaft support hole **221** through which the rotor shaft **231** is rotationally supported. The base plate **220** may include the input port **223** coupled to the flow-in pipe **201** to which the refrigerant flows in. The base plate **220** may include a boss hole **225** through which the boss **280** is installed.

The boss **280** may be installed in the boss hole **225** of the base plate **220**. An upper portion of the boss **280** may be arranged in the receiving space **211**. A lower portion of the boss **280** may be arranged outside the receiving space **211**. The boss **280** may include the pad valve device shaft hole **281** to which the pad valve device shaft **251** is rotationally inserted. The boss **280** may include the plurality of ports **282** through which the refrigerant flows in/out. The plurality of ports **282** may be coupled to the plurality of flow-in/out pipes **202** through which the refrigerant flows in/out. There may be four ports **282**. Also, there may be four flow-in/out pipes **202** coupled to the plurality of ports **282**. The boss **280** may include a plurality of insertion holes **282***a* to which the plurality of flow-in/out pipes **202** are inserted. There may be four insertion holes **282***a* to match the number of the plurality of flow-in/out pipes **202**. The plurality of insertion holes **282***a* may be connected to the plurality of ports **282**.

The pad **290** may be rotationally arranged on the top of the boss **280**. The pad **290** may include a pad valve device shaft coupling hole **291** to which the pad valve device shaft **251** is coupled. The pad **290** may include a pad gear coupling hole **293** to which the pad coupling projection **253** of the pad gear **250** is coupled. Accordingly, the pad **290** may be rotated along with the pad gear **250**.

The pad **290** may include an open cavity **295** that selectively opens one of the plurality of ports **282** formed at the boss **280**. The open cavity **295** may be formed in a lower portion of the pad **290**. The open cavity **295** may have the form of a groove sunken upward from the bottom surface of the pad **290**. The open cavity **295** may be formed to extend to an edge of the pad **290** in a radial direction. The open cavity **295** may have a size of 75 to 80 degrees in a circumferential direction of the pad **290** with respect to the center of the pad **290**. The open cavity **295** may include a first area **295***a* formed on one side of the open cavity **295** and a second area **295***b* formed on the other side of the open cavity **295**. The first area **295***a* may be located near the leftmost end of the pad **290** when the pad **290** is viewed from above (see FIG. **8**). The second area **295***b* may be located near the rightmost end of the pad **290** when the pad **290** is viewed from above. The second area **295***b* may be at a location rotated 45 degrees from the first area **295***a* with respect to the center of the pad **290**. The open cavity **295** may have an enough size to selectively open one of the plurality of ports **282** in the first area **295***a* or the second area **295***b*. The open cavity **295** may have a size that is unable to open two of the plurality of ports **282** at a time. In other words, one of the plurality of ports **282** may be opened in the first area **295***a* or opened in the second area **295***b*. The pad **290** may be rotated along with the pad gear **250** to selectively open one of the plurality of ports **282** formed at the boss **280**.

The pad **290** may include a connection cavity **297** that selectively connects two of the plurality of ports **282** formed at the boss **280**. The connection cavity **297** may be formed in a lower portion of the pad **290**. The connection cavity **297** may have the form of a groove sunken upward from the bottom surface of the pad **290**. The connection cavity **297** may connect two adjacent ports **282** among the plurality of ports **282**.

The 5-way valve device **200** may further include a stator (not shown). The stator may be provided to enclose a portion in which the rotor **230** is arranged, from outside of the case **210**.

The 5-way valve device **200** may further include a bracket (not shown). The bracket may allow the case **210** to be coupled to the stator. The bracket may allow the 5-way valve device **200** to be fixed to an external device.

FIG. **10** is a schematic view for describing a flow of refrigerant through a valve device, according to an embodiment.

Referring to FIG. **10**, when the valve device **400** is implemented with the 5-way valve device **200**, the valve device **400** may include the input port **223** connected to the outlet of the condenser **120**, the first port **283** connected to an end of the hot pipe **140**, the second port **285** connected to the other end of the hot pipe **140**, the first output port **284** connected to the first capillary tube **150** and the second output port **286** connected to the second capillary tube **160**.

The outlet of the condenser **120** may be connected to the flow-in pipe **201**, which may be connected to the input port **223**.

The plurality of flow-in/out pipes **202** to which the refrigerant flows in or out may include a first pipe **202***a*, a second pipe **202***b*, a third pipe **202***c*, and a fourth pipe **202***d*.

One end of the hot pipe **140** may be connected to the first pipe **202***a*, which may be connected to the first port **283**.

The other end of the hot pipe **140** may be connected to the second pipe **202***b*, which may be connected to the second port **285**.

The first capillary tube **150** may be connected to the third pipe **202***c*, which may be connected to the first output port **284**.

The second capillary tube **160** may be connected to the fourth pipe **202***d*, which may be connected to the second output port **286**.

As described above, the pad **290** may include an open cavity **295** that selectively opens one of the plurality of ports **282**, **283**, **284**, **285** and **286** formed at the boss **280**.

The open cavity **295** may connect the input port to one of the plurality of ports **282**, **283**, **284**, **285** and **286**.

In other words, the refrigerant flowing in through the input port **223** may be delivered to one of the plurality of ports **282**, **283**, **284**, **285** and **286** through the open cavity **295**. As described above, the pad **290** may include the connection cavity **297** that selectively connects two of the plurality of ports **282**, **283**, **284**, **285** and **286** formed at the boss **280**.

The connection cavity **297** may connect two of the plurality of ports **282**, **283**, **284**, **285** and **286**.

As will be described later, the 5-way valve device **200** may connect the input port **223** to one port **283**, **284**, **285** or **286** and connect two ports of the plurality of ports **282**, **283**, **284**, **285** and **286** according to a control signal of the controller **60** (see FIG. **13**).

An example in which the valve device **400** included in the cold air supplier **100** is implemented with the 5-way valve device **200** has thus far been described.

Referring to FIGS. **11** and **12**, a cold air supplier including the valve device **400** will now be described according to various embodiments. Overlapping components use the same reference numerals, and detailed description thereof will not be repeated.

FIG. **11** illustrates an example of a cold air supplier including a valve device, according to an embodiment.

Referring to FIG. **11**, the valve device **400** may include a 4-way valve device **410** and a 3-way valve device **420**.

Unlike the aforementioned cold air supplier **100**A or **100**B, a cold air supplier **100**C in an embodiment may include the 4-way valve device **410** and the 3-way valve device **420**. As the structure of the 5-way valve device **200** was described in connection with FIGS. **4** to **9**, structures of the 4-way valve device **410** and the 3-way valve device **420** will not be described in detail.

The 4-way valve device **410** may include one input port **411** and three output ports **414**, **415** and **416**. The input port **411** of the 4-way valve device **410** may be connected to one of the three output ports **414**, **415** and **416**. Furthermore, two of the three output ports **414**, **415** and **416** of the 4-way valve device **410** may be connected to each other.

The 3-way valve device **420** may include one input port **417** and two output ports **418** and **419**. The input port **417** of the 3-way valve device **420** may be connected to one of the two output ports **418** and **419**.

In an embodiment, when the valve device **400** is implemented with the 4-way valve device **410** and the 3-way valve device **420**, the valve device **400** may include the input port **411** connected to the outlet of the condenser **120**, the first port **414** connected to an end of the hot pipe **140**, the second port **415** connected to the other end of the hot pipe **140**, the first output port **418** connected to the first capillary tube **150** and the second output port **419** connected to the second capillary tube **160**.

As will be described later, the 4-way valve device **410** and the 3-way valve device **420** may connect the input port **411** to one port **414**, **418** or **419** and connect two ports of the plurality of ports **414**, **415**, **418** and **419** according to a control signal of the controller **60** (see FIG. **13**).

Furthermore, although the cold air supplier **100**C is shown as including two evaporators **171** and **172** in FIG. **11**, the cold air supplier **100**C may include a single evaporator **170** as in the cold air supplier **100**B of FIG. **3** in various embodiments.

In other words, the cold air supplier **100**C may include at least one evaporator **170**.

FIG. **12** illustrates a cold air supplier including a valve device, according to an embodiment.

Referring to FIG. **12**, the valve device **400** may include the 4-way valve device **410**.

Unlike the aforementioned cold air supplier **100**A, **100**B or **100**C, the valve device **400** of a cold air supplier **100**D in an embodiment may include only the 4-way valve device **410**.

Furthermore, unlike the aforementioned cold air supplier **100**A, **100**B or **100**C, the cold air supplier **100**D may include a single capillary tube **155**.

The 4-way valve device **410** may include one input port **411** and three output ports **414**, **415** and **416**. The input port **411** of the 4-way valve device **410** may be connected to one of the three output ports **414**, **415** and **416**. Furthermore, two of the three output ports **414**, **415** and **416** of the 4-way valve device **410** may be connected to each other.

In an embodiment, when the valve device **400** is implemented with the 4-way valve device **410**, the valve device **400** may include the input port **411** connected to the outlet of the condenser **120**, the first port **414** connected to an end of the hot pipe **140**, the second port **415** connected to the other end of the hot pipe **140**, and the output port **416** connected to the capillary tube **155**.

As will be described later, the 4-way valve device **410** may connect the input port **411** to one port **414**, **415** or **416** and connect two of the plurality of ports **414**, **415** and **416** according to a control signal of the controller **60** (see FIG. **13**).

The cold air supplier **100**D may include the evaporator **170** connected to the capillary tube **155**.

Various examples of the cold air supplier **100** (**100**A, **100**B, **100**C and **100**D) included in the refrigerator **1** were described above. The examples of the components included in the cold air supplier **100** are not, however, limited thereto, and those of ordinary skill in the art may omit some of the components of the cold air supplier **100** or add certain components to the cold air supplier **100** as required.

FIG. **13** is a block diagram illustrating a configuration of a refrigerator, according to an embodiment.

Referring to FIG. **13**, the refrigerator **1** according to the embodiment may include a sensor module **50**, a controller **60**, and the cold air supplier **100**.

The cold air supplier **100** may include the compressor **110**, the fans **125** and **175**, and the valve device **400**.

In an embodiment, the valve device **400** may include the input port **223** or **411** connected to the outlet of the condenser **120**, the first port **283** or **414** connected to an end of the hot pipe **140**, a second port **285** or **415** connected to the other end of the hot pipe **140**, the at least one output port **284** and **286**, **418** and **419**, or **416** connected to the at least one capillary tube **150** and **160** or **155**.

The compressor **110**, the fans **125** and **175**, and the valve device **400** were already described above, so the description thereof will not be repeated.

The sensor module **50** may include an outside temperature sensor **51**.

The outside temperature sensor **51** may detect air temperature outside the refrigerator **1**, and send the outside temperature information to the controller **60**. For this, the outside temperature sensor **51** may be arranged on the main body **10**.

The sensor module **50** may include an outside humidity sensor **52**.

The outside humidity sensor **52** may detect air humidity outside the refrigerant **1** and send the outside humidity information to the controller **60**. For this, the outside humidity sensor **52** may be arranged on the main body **10**.

The sensor module **50** may include an inside temperature sensor **53**.

The inside temperature sensor **53** may be arranged in at least one storeroom **20** and **30** to detect temperature in the at least one storeroom **20** and **30**. The inside temperature sensor **53** may send the inside temperature information to the controller **60**.

In various embodiments, the inside temperature sensor **53** may include a first inside temperature **53** arranged in the fridge **20** and a second inside temperature sensor **53** arranged in the freezer **30**. The first inside temperature sensor **53** may send temperature information of the fridge **20** to the controller **60**, and the second inside temperature sensor **53** may send temperature information of the freezer **30** to the controller **60**.

In various embodiments, among the components of the sensor module **50**, the outside temperature sensor **51** and/or the outside humidity sensor **52** may be omitted. In various embodiments, the outside temperature sensor **51** and the outside humidity sensor **52** may be implemented with a single sensor. In various embodiments, the sensor module **50** may further include an inside humidity sensor. For example, the inside humidity sensor may be implemented in the inside temperature sensor **53**.

In an embodiment, the controller **60** may estimate outside temperature based on operation information of the compressor **110** and the inside temperature information.

For example, the controller **60** may estimate the outside temperature based on an operation time of the compressor **110** required to reduce the inside temperature by a certain value.

Although not shown, the refrigerator **1** may further include a communication module. Functions of the outside temperature sensor **51** and the outside humidity sensor **52** may be replaced by the communication module.

The communication module may transmit or receive data to or from an external device. For example, the communication module may transmit or receive various data by communicating with a server and/or a user terminal and/or a home appliance.

For this, the communication module may support establishment of a direct (e.g., wired) communication channel or a wireless communication channel between external devices (e.g., a server, a user terminal and/or a home appliance), and communication through the established communication channel According to an embodiment, the communication module may include a wireless communication module (e.g., a cellular communication module, a short-range wireless communication module or a global navigation satellite system (GNSS) communication module) or a wired communication module (e.g., a local area network (LAN) communication module or a power-line communication module). A corresponding one of the communication modules may communicate with an external electronic device over a first network (e.g., a short-range communication network such as bluetooth, wireless-fidelity (Wi-Fi) direct or infrared data association (IrDA)) or a second network (e.g., a remote communication network such as a legacy cellular network, a fifth generation (5G) network, a next generation communication network, the Internet, or a computer network (e.g., a LAN or wide area network (WAN)). These various types of communication modules may be integrated into a single component (e.g., a single chip) or implemented as a plurality of separate components (e.g., a plurality of chips).

The communication module may include a Wi-Fi module, and perform communication with an external server and/or a user terminal and/or a home appliance based on establishment of communication with a home access point (AP).

The communication module may communicate with a home appliance at home to receive outside temperature information and outside humidity information from the home appliance.

For example, the communication module may communicate with an air conditioner at home to receive outside temperature information and outside humidity information from the air conditioner. The controller **60** may include a processor **61** for generating a control signal for an operation of the refrigerator **1**, and a memory **62** for storing a program, an application, instructions and/or data for operation of the refrigerator **1**. The processor **61** and the memory **62** may be implemented with separate semiconductor devices or in a single semiconductor device. The controller **60** may include a plurality of processors **61** and a plurality of memories **62**. The controller **60** may be provided in various positions inside the refrigerator **1**. For example, the controller **60** may be included in a printed circuit board arranged inside a control panel.

The processor **61** may include an operation circuit, a storage circuit, and a control circuit. The processor **61** may include one or multiple chips. Furthermore, the processor **61** may include one or multiple cores.

The memory **62** may store a program for controlling the cold air supplier and data required to control the cold air supplier.

The memory **62** may include a volatile memory, such as a static random access memory (S-RAM) or a dynamic RAM (D-RAM), and a non-volatile memory, such as a read only memory (ROM) or an erasable programmable ROM (EPROM). The memory **62** may include a memory device, or multiple memory devices.

The processor **61** may process data and/or a signal based on the program provided from the memory **62**, and transmit a control signal to each component of the refrigerator **1** based on the processing result. For example, the processor **61** may process information obtained from the sensor module **50** (e.g., outside humidity information, outside temperature information, inside temperature information) and/or operation information of components included in the cold air supplier (e.g., mode information of the valve device **400**, operation information of the compressor **110**).

The components of the cold air supplier **100** (e.g., the compressor **110**, the valve device **400**, and the fans **125** and **175**) may be controlled by the controller **60**.

FIG. **14** is a flowchart illustrating an example of a method of controlling a refrigerator, according to an embodiment.

Referring to FIG. **14**, the controller **60** may operate the compressor **110** based on an operation condition of the compressor **110** being satisfied, in **1000**. The controller **60** may switch the valve device **400** into the fourth mode based on the compressor **110** being off in **1000**, in **1400**.

For example, the controller **60** may operate the compressor **110** based on the temperature of the storeroom **20** or **30** rising above a certain temperature.

In an embodiment, when the cold air supplier **100**A, **100**B or **100**C includes at least two capillary tubes, the controller **60** may control the refrigerator **1** to perform fridge operation or freezer operation.

Accordingly, the refrigerator **1** may operate in a fridge mode or a freezer mode. During operation of the compressor **110** in **1000**, the controller **60** may operate the valve device **400** in a first mode, a second mode and a third mode in **1100**, **1200** and **1300**.

Although it is shown that the controller **60** operates the valve device **400** in an order of the first mode, the second mode and the third mode, the controller **60** may operate the valve device **400** in an order of the first mode, the second mode and the third mode or the second mode, the third mode and the first mode based on the compressor **110** being started to operate.

For example, the controller **60** may operate the valve device **400** in the first mode based on the compressor **110** being started to operate.

Furthermore, the controller **60** may operate the valve device **400** in the second mode based on the compressor **110** being started to operate.

The controller **60** may switch the valve device **400** from the first mode to the second mode based on a termination condition of the first mode satisfied, switch the valve device **400** from the second mode to the third mode based on a termination condition of the second mode satisfied, and switch the valve device **400** from the third mode to the first mode based on a termination condition of the third mode satisfied, during operation of the compressor **110**.

The controller **60** may switch the valve device **400** to a fourth mode based on the compressor **110** being off in **1000** while the valve device **400** is operating in the first, second, or third mode.

The controller **60** may operate the valve device **400** in the first mode during operation of the compressor **110**, in **1100**.

The controller **60** may operate the valve device **400** in the second mode during operation of the compressor **110**, in **1200**.

The controller **60** may operate the valve device **400** in the third mode during operation of the compressor **110**, in **1300**.

When the cold air supplier **100** (**100**A, **100**B or **100**C) includes at least two capillary tubes **150** and **160**, the flow path switching method of the valve device **400** in the first, second and third modes may be different depending on whether the refrigerator **1** operates in the fridge mode or the freezer mode.

Flows of refrigerant in the cold air supplier **100**A or **100**B including the 5-way valve device **200** will now be described with reference to FIGS. **15** to **21**.

FIG. **15** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in the fridge mode, according to an embodiment. FIG. **16** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in the freezer mode, according to an embodiment.

When the valve device **400** operates in the first mode, the refrigerant discharged through the outlet of the condenser **120** may be supplied into the capillary tubes **150** and **160** via the hot pipe **140**.

The controller **60** may control the valve device **400** such that one of the first port **283** and the second port **285** is connected to the input port **223** and the other is connected to the output port **284** or **286**.

Accordingly, the first mode may be defined as a hot pipe-pass mode.

When the refrigerator **1** operates in the fridge mode and the valve device **400** operates in the first mode, the refrigerant discharged through the outlet of the condenser **120** may be supplied into the first capillary tube **150** via the hot pipe **140**.

When the refrigerator **1** operates in the freezer mode and the valve device **400** operates in the first mode, the refrigerant discharged through the outlet of the condenser **120** may be supplied into the second capillary tube **160** via the hot pipe **140**.

Hence, the first mode may be divided into two modes, e.g., fridge-first and freezer-first modes, according to the operation mode of the refrigerator **1**.

Referring to FIG. **15**, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 5-way valve device **200** such that the first port **283** is connected to the first output port **284** and the second port **285** is connected to the input port **223** in the first mode. Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 5-way valve device **200** to close the second output port **286** in the first mode.

In the fridge-first mode, the refrigerant discharged from the condenser **120** and flowing into the input port **223** may flow into the second port **285** through the open cavity **295**, the refrigerant flowing into the second port **285** may pass through the hot pipe **140** and flow into the first port **283**, the refrigerant flowing into the first port **283** may flow into the first output port **284** through the connection cavity **297**, and the refrigerant flowing into the first output port **284** may be delivered into the first capillary tube **150** through the third pipe **202***c*.

Referring to FIG. **16**, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 5-way valve device **200** such that the second port **285** is connected to the second output port **286** and the first port **283** is connected to the input port **223** in the first mode. Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 5-way valve device **200** to close the first output port **284** in the first mode.

In the freezer-first mode, the refrigerant discharged from the condenser **120** and flowing into the input port **223** may flow into the first port **283** through the open cavity **295**, the refrigerant flowing into the first port **283** may pass through the hot pipe **140** and flow into the second port **285**, the refrigerant flowing into the second port **285** may flow into the second output port **286** through the connection cavity **297**, and the refrigerant flowing into the first output port **286** may be delivered into the second capillary tube **160** through the fourth pipe **202***d*.

In various embodiments, when the operation mode of the refrigerator **1** is switched to the freezer mode from the fridge mode while the valve device **400** is operating in the fridge-first mode, the controller **60** may switch the valve device **400** operating in the fridge-first mode to the freezer-first mode.

In the disclosure, the refrigerator **1** may have the refrigerant having passed through the hot pipe **140** supplied to the different capillary tube **150** or **160** depending on the operation mode of the refrigerator **1**.

FIG. **17** illustrates flows of a refrigerant through the valve device **400** operating in a second mode when a refrigerator operates in a fridge mode, according to an embodiment. FIG. **18** illustrates flows of a refrigerant through a valve device operating in a second mode when a refrigerator operates in a freezer mode, according to an embodiment.

When the valve device **400** operates in the second mode, the refrigerant left in the hot pipe **140** may be collected through the capillary tube **150** or **160**.

The controller **60** may control the valve device **400** such that one of the first port **283** and the second port **285** is closed and the other is connected to the output port **284** or **286**.

Accordingly, the second mode may be defined as a refrigerant collection mode.

In an embodiment, when the refrigerator **1** operates in the fridge mode and the valve device **400** operates in the second mode, the refrigerant left in the hot pipe **140** may be collected to the evaporator **170** through the second capillary tube **160**.

In various embodiments, when the refrigerator **1** operates in the fridge mode and the valve device **400** operates in the second mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the first capillary tube **150**.

When the refrigerator **1** operates in the freezer mode and the valve device **400** operates in the second mode, the refrigerant left in the hot pipe **140** may be collected to the evaporator **170** through the first capillary tube **150**.

In various embodiments, when the refrigerator **1** operates in the freezer mode and the valve device **400** operates in the second mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the second capillary tube **160**.

Hence, the second mode may be divided into two modes, e.g., fridge-second and freezer-second modes, according to the operation mode of the refrigerator **1**.

Referring to FIG. **17**, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 5-way valve device **200** such that the first port **283** is closed and the second port **285** is connected to the second output port **286** in the second mode. Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 5-way valve device **200** to connect the input port **223** to the first output port **284** in the second mode.

As the compressor **110** operates, the refrigerant is moved in a direction from the evaporator **170** to the compressor **110**.

In the fridge-second mode, as the first port **283** is closed, the refrigerant left in the hot pipe **140** may not move toward the first port **283**. In the meantime, as the second port **285** is connected to the second output port **286** through the connection cavity **297**, the refrigerant left in the hot pipe **140** is discharged toward the second output port **286** through the connection cavity **297**.

As the refrigerant left in the hot pipe **140** is discharged toward the second output port **286**, the refrigerant left in the hot pipe **140** is collected to the evaporator **170** through the second capillary tube **160**.

According to the disclosure, as the refrigerant left in the hot pipe **140** is collected to the evaporator **170**, the shortage of refrigerant in the cold air supplier **100** may be prevented.

Furthermore, according to the disclosure, by securing a sufficient amount of refrigerant required for a cooling cycle through the second mode, frequency of the compressor **110** may be lowered, thereby saving energy.

In the meantime, in the fridge-second mode, the refrigerant discharged from the condenser **120** and flowing into the input port **223** may flow into the first output port **284** through the open cavity **295**, and the refrigerant flowing into the first output port **284** may be delivered into the first capillary tube **150** through the third pipe **202***c*.

According to the disclosure, refrigeration performance may be maintained by collecting the refrigerant left in the hot pipe **140** through the second capillary tube and simultaneously, forcing the refrigerant discharged from the condenser **120** to flow into the first capillary tube **150**.

Referring to FIG. **18**, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 5-way valve device **200** such that the second port **285** is closed and the first port **283** is connected to the first output port **284** in the second mode. Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 5-way valve device **200** to connect the input port **223** to the second output port **286** in the second mode.

As the compressor **110** operates, the refrigerant is moved in a direction from the evaporator **170** to the compressor **110**.

In the freezer-second mode, as the second port **285** is closed, the refrigerant left in the hot pipe **140** may not move toward the second port **285**. In the meantime, as the first port **283** is connected to the first output port **284** through the connection cavity **297**, the refrigerant left in the hot pipe **140** is discharged toward the first output port **284** through the connection cavity **297**.

As the refrigerant left in the hot pipe **140** is discharged toward the first output port **284**, the refrigerant left in the hot pipe **140** is collected to the evaporator **170** through the first capillary tube **150**.

According to the disclosure, as the refrigerant left in the hot pipe **140** is collected to the evaporator **170**, the shortage of refrigerant in the cold air supplier **100** may be prevented.

Furthermore, according to the disclosure, by securing a sufficient amount of refrigerant required for a cooling cycle through the second mode, frequency of the compressor **110** may be lowered, thereby saving energy.

In the meantime, in the freezer-second mode, the refrigerant discharged from the condenser **120** and flowing into the input port **223** may flow into the second output port **286** through the open cavity **295**, and the refrigerant flowing into the second output port **286** may be delivered into the second capillary tube **160** through the fourth pipe **202***d*.

According to the disclosure, refrigeration performance may be maintained by collecting the refrigerant left in the hot pipe **140** through the first capillary tube **150** and simultaneously, forcing the refrigerant discharged from the condenser **120** to flow into the second capillary tube **160**.

FIG. **19** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a fridge mode, according to an embodiment. FIG. **20** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a freezer mode, according to an embodiment.

When the valve device **400** operates in the third mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the capillary tubes **150** and **160**.

The controller **60** may control the valve device **400** to close both the first port **283** and the second port **285** in the third mode. Furthermore, the controller **60** may control the valve device **400** to connect the input port **223** to the output port **284** or **286** in the third mode.

Accordingly, the third mode may be defined as a hot pipe-detour mode.

When the refrigerator **1** operates in the fridge mode and the valve device **400** operates in the third mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the first capillary tube **150**.

When the refrigerator **1** operates in the freezer mode and the valve device **400** operates in the third mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the second capillary tube **160**.

Hence, the third mode may be divided into two modes, e.g., fridge-third and freezer-third modes, according to the operation mode of the refrigerator **1**.

Referring to FIG. **19**, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 5-way valve device **200** to close both the first port **283** and the second port **285** in the third mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 5-way valve device **200** to close the second output port **286** in the third mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 5-way valve device **200** to connect the input port **223** to the first output port **284** in the third mode.

In the fridge-third mode, the refrigerant discharged from the condenser **120** and flowing into the input port **223** may flow into the first output port **284** through the open cavity **295**, and the refrigerant flowing into the first output port **284** may be delivered into the first capillary tube **150** through the third pipe **202***c*.

In this case, the refrigerant delivered into the first capillary tube **150** may not pass through the hot pipe **140**.

According to the disclosure, the shortage of refrigerant may be prevented by forcing the refrigerant to detour around the hot pipe **140** and be directly delivered to the evaporator **170** in a situation where there is no need to put the refrigerant into the hot pipe **140**.

Referring to FIG. **20**, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 5-way valve device **200** to close both the first port **283** and the second port **285** in the third mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 5-way valve device **200** to close the first output port **284** in the third mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 5-way valve device **200** to connect the input port **223** to the second output port **286** in the third mode.

In the freezer-third mode, the refrigerant discharged from the condenser **120** and flowing into the input port **223** may flow into the second output port **286** through the open cavity **295**, and the refrigerant flowing into the second output port **286** may be delivered into the second capillary tube **160** through the fourth pipe **202***d*.

In this case, the refrigerant delivered into the second capillary tube **160** may not pass through the hot pipe **140**.

According to the disclosure, the shortage of refrigerant may be prevented by forcing the refrigerant to detour around the hot pipe **140** and be directly delivered to the evaporator **170** in a situation where there is no need to put the refrigerant into the hot pipe **140**.

FIG. **21** illustrates flows of a refrigerant through a valve device operating in a fourth mode.

The controller **60** may switch the valve device **400** into the fourth mode based on the compressor **110** being off in **1000**, in **1400**.

Referring to FIG. **21**, the controller **60** may control the valve device **400** to close the output ports **284** and **286** in the fourth mode.

In an embodiment, the controller **60** may control the 5-way valve device **200** to close the first output port **284** and the second output port **286** based on the compressor **110** being off.

In various embodiments, the controller **60** may open one of the first port **283** or the second port **285** based on the compressor **110** being off.

In the fourth mode, as one of the first port **283** or the second port **285** is opened and the other is closed, flow-in of the refrigerant to the valve device **400** and/or the hot pipe **140** may be stopped due to a difference in pressure between inside and outside of the hot pipe **140**.

Accordingly, the fourth mode may be defined as a differential pressure mode.

As the compressor **110** is off, movement of the refrigerant disappears, but the refrigerant having been in the 5-way valve device **200** may flow into the hot pipe **140** through the open cavity **295**.

According to the disclosure, when the compressor **110** is off, a problem of dew formation around the door **21**, **22** or **31** may be prevented by leaving hot refrigerant in the hot pipe **140**.

Flows of refrigerant in the cold air supplier **100**A or **100**B including the 5-way valve device **200** have thus far been described with reference to FIGS. **15** to **21**.

Flows of refrigerant in the cold air supplier **100**C including the 4-way valve device **410** and the 3-way valve device **420** will now be described with reference to FIGS. **22** to **28**.

FIG. **22** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in a fridge mode, according to an embodiment. FIG. **23** illustrates flows of a refrigerant through a valve device operating in a first mode when a refrigerator operates in a freezer mode, according to an embodiment.

When the valve device **400** operates in the first mode, the refrigerant discharged through the outlet of the condenser **120** may be supplied into the capillary tubes **150** and **160** via the hot pipe **140**.

The controller **60** may control the valve device **400** such that one of the first port **414** and the second port **415** is connected to the input port **411** and the other is connected to the output port **418** or **419**.

Accordingly, the first mode may be defined as a hot pipe-pass mode.

When the refrigerator **1** operates in the fridge mode and the valve device **400** operates in the first mode, the refrigerant discharged through the outlet of the condenser **120** may be supplied into the first capillary tube **150** via the hot pipe **140**.

When the refrigerator **1** operates in the freezer mode and the valve device **400** operates in the first mode, the refrigerant discharged through the outlet of the condenser **120** may be supplied into the second capillary tube **160** via the hot pipe **140**.

Hence, the first mode may be classified into two modes, e.g., fridge-first and freezer-first modes, according to the operation mode of the refrigerator **1**.

Referring to FIG. **22**, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 4-way valve device **410** such that the input port **411** is connected to the first port **414** and the second port **415** is connected to the other output port **416** in the first mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 3-way valve device **420** to connect the input port **417** to the first output port **418** connected to the first capillary tube **150** in the first mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 3-way valve device **420** to close the second output port **419** in the first mode.

Consequently, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the valve device **400** such that the second port **415** is connected to the first output port **418** and the first port **414** is connected to the input port **411** in the first mode.

In the fridge-first mode, the refrigerant discharged from the condenser **120** and flowing into the input port **411** of the 4-way valve device **410** may flow into the first port **414**, the refrigerant flowing into the first port **414** may pass through the hot pipe **140** and flow into the second port **415**, the refrigerant flowing into the second port **415** may flow into the input port **417** of the 3-way valve device **420** through the other output port **416**, and the refrigerant flowing into the input port **417** may be delivered into the first capillary tube **150** through the first output port **418**.

Referring to FIG. **23**, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 4-way valve device **410** such that the input port **411** is connected to the first port **414** and the second port **415** is connected to the other output port **416** in the first mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 3-way valve device **420** to connect the input port **417** to the second output port **419** connected to the second capillary tube **160** in the first mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 3-way valve device **420** to close the first output port **418** in the first mode.

Consequently, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the valve device **400** such that the second port **415** is connected to the second output port **419** and the first port **414** is connected to the input port **411** in the first mode.

In the freezer-first mode, the refrigerant discharged from the condenser **120** and flowing into the input port **410** of the 4-way valve device **410** may flow into the first port **414**, the refrigerant flowing into the first port **414** may pass through the hot pipe **140** and flow into the second port **415**, the refrigerant flowing into the second port **415** may flow into the input port **417** of the 3-way valve device **420** through the other output port **416**, and the refrigerant flowing into the input port **417** may be delivered into the second capillary tube **160** through the second output port **419**.

In the disclosure, the refrigerator **1** may have the refrigerant having passed the hot pipe **140** supplied to the different capillary tube **150** or **160** depending on the operation mode of the refrigerator **1**.

FIG. **24** illustrates flows of a refrigerant through a valve device operating in a second mode when a refrigerator operates in a fridge mode, according to an embodiment. FIG. **25** illustrates flows of a refrigerant through a valve device operating in a second mode when a refrigerator operates in a freezer mode, according to an embodiment.

When the valve device **400** operates in the second mode, the refrigerant left in the hot pipe **140** may be collected through the capillary tube **150** or **160**.

The controller **60** may control the valve device **400** such that one of the first port **414** and the second port **415** is closed and the other is connected to the output port **418** or **419**.

Accordingly, the second mode may be defined as a refrigerant collection mode.

In an embodiment, when the refrigerator **1** operates in the fridge mode and the valve device **400** operates in the second mode, the refrigerant left in the hot pipe **140** may be collected to the evaporator **170** through the first capillary tube **150**.

In an embodiment, when the refrigerator **1** operates in the freezer mode and the valve device **400** operates in the second mode, the refrigerant left in the hot pipe **140** may be collected to the evaporator **170** through the second capillary tube **160**.

Hence, the second mode may be classified into two modes, e.g., fridge-second and freezer-second modes, according to the operation mode of the refrigerator **1**.

Referring to FIG. **24**, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 4-way valve device **410** such that the first port **414** is closed and the second port **415** is connected to the other output port **416** in the second mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 3-way valve device **420** to connect the input port **417** to the first output port **418** connected to the first capillary tube **150** in the second mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 3-way valve device **420** to close the second output port **419** in the second mode.

Consequently, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the valve device **400** such that the second port **415** is connected to the first output port **418** and the first port **414** is closed in the second mode.

As the compressor **110** operates, the refrigerant is moved in a direction from the evaporator **170** to the compressor **110**.

In the fridge-second mode, as the first port **414** is closed, the refrigerant left in the hot pipe **140** may not move toward the first port **414**. In the meantime, as the second port **415** is connected to the other output port **416**, the refrigerant left in the hot pipe **140** is discharged toward the other output port **416**.

As the refrigerant left in the hot pipe **140** is discharged toward the output port **416**, the refrigerant may be collected to the first capillary tube **150** through the input port **417** and the output port **418** of the 3-way valve device **420**.

According to the disclosure, the refrigerant may be collected while the refrigeration performance is maintained to a certain extent by collecting the refrigerant left in the hot pipe **140** to the evaporator **170** through the first capillary tube **150**.

According to the disclosure, as the refrigerant left in the hot pipe **140** is collected to the evaporator **170**, the shortage of refrigerant in the cold air supplier **100** may be prevented.

Furthermore, according to the disclosure, by securing a sufficient amount of refrigerant required for a cooling cycle through the second mode, frequency of the compressor **110** may be lowered, thereby saving energy.

Referring to FIG. **25**, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 4-way valve device **410** such that the first port **414** is closed and the second port **415** is connected to the other output port **416** in the second mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 3-way valve device **420** to connect the input port **417** to the second output port **419** connected to the second capillary tube **160** in the second mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 3-way valve device **420** to close the first output port **418** in the second mode.

Consequently, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the valve device **400** such that the second port **415** is connected to the second output port **419** and the first port **414** is closed in the second mode.

As the compressor **110** operates, the refrigerant is moved in a direction from the evaporator **170** to the compressor **110**.

In the freezer-second mode, as the first port **414** is closed, the refrigerant left in the hot pipe **140** may not move toward the first port **414**. In the meantime, as the second port **415** is connected to the other output port **416**, the refrigerant left in the hot pipe **140** is discharged toward the other output port **416**.

As the refrigerant left in the hot pipe **140** is discharged toward the output port **416**, the refrigerant may be collected to the second capillary tube **160** through the input port **417** and the output port **419** of the 3-way valve device **420**.

According to the disclosure, the refrigerant may be collected while the refrigeration performance is maintained to a certain extent by collecting the refrigerant left in the hot pipe **140** to the evaporator **170** through the second capillary tube **160**.

According to the disclosure, as the refrigerant left in the hot pipe **140** is collected to the evaporator **170**, the shortage of refrigerant in the cold air supplier **100** may be prevented.

Furthermore, according to the disclosure, by securing a sufficient amount of refrigerant required for a cooling cycle through the second mode, frequency of the compressor **110** may be lowered, thereby saving energy.

FIG. **26** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a fridge mode, according to an embodiment. FIG. **27** illustrates flows of a refrigerant through a valve device operating in a third mode when a refrigerator operates in a freezer mode, according to an embodiment.

When the valve device **400** operates in the third mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the capillary tubes **150** and **160**.

The controller **60** may control the valve device **400** to close both the first port **414** and the second port **415** in the third mode. Furthermore, the controller **60** may control the valve device **400** to connect the input port **223** to the output port **284** or **286** in the third mode.

Accordingly, the third mode may be defined as a hot pipe-detour mode.

When the refrigerator **1** operates in the fridge mode and the valve device **400** operates in the third mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the first capillary tube **150**.

When the refrigerator **1** operates in the freezer mode and the valve device **400** operates in the third mode, the refrigerant discharged through the outlet of the condenser **120** may detour around the hot pipe **140** and be supplied into the second capillary tube **160**.

Hence, the third mode may be classified into two modes, e.g., fridge-third and freezer-third modes, according to the operation mode of the refrigerator **3**.

Referring to FIG. **26**, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 4-way valve device **410** such that the first port **414** and the second port **415** are all closed and the other output port **416** is connected to the input port **411** in the third mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 3-way valve device **420** to connect the input port **417** to the first output port **418** connected to the first capillary tube **150** in the third mode.

Furthermore, when the refrigerator **1** operates in the fridge mode, the controller **60** may control the 3-way valve device **420** to close the second output port **419** in the third mode.

In the fridge-third mode, the refrigerant discharged from the condenser **120** and flowing into the input port **411** may flow into the output port **416**, and the refrigerant flowing into the output port **416** may be delivered into the first capillary tube **150** through the 3-way valve device **420**.

In this case, the refrigerant delivered into the first capillary tube **150** may not pass through the hot pipe **140**.

According to the disclosure, the shortage of refrigerant may be prevented by forcing the refrigerant to detour around the hot pipe **140** and be directly delivered to the evaporator **170** in a situation where there is no need to put the refrigerant into the hot pipe **140**.

Referring to FIG. **27**, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 4-way valve device **410** such that the first port **414** and the second port **415** are all closed and the other output port **416** is connected to the input port **411** in the third mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 3-way valve device **420** to connect the input port **417** to the second output port **419** connected to the second capillary tube **160** in the third mode.

Furthermore, when the refrigerator **1** operates in the freezer mode, the controller **60** may control the 3-way valve device **420** to close the first output port **418** in the third mode.

In the freezer-third mode, the refrigerant discharged from the condenser **120** and flowing into the input port **411** may flow into the output port **416**, and the refrigerant flowing into the output port **416** may be delivered into the second capillary tube **160** through the 3-way valve device **420**.

In this case, the refrigerant delivered into the second capillary tube **160** may not pass through the hot pipe **140**.

According to the disclosure, the shortage of refrigerant may be prevented by forcing the refrigerant to detour around the hot pipe **140** and be directly delivered to the evaporator **170** in a situation where there is no need to put the refrigerant into the hot pipe **140**.

FIG. **28** illustrates flows of a refrigerant through a valve device operating in a fourth mode.

Referring to FIG. **28**, the controller **60** may switch the valve device **400** into the fourth mode based on the compressor **110** being off.

The controller **60** may control the valve device **400** to close the output ports **418** and **419** in the fourth mode.

In an embodiment, the controller **60** may control the 3-way valve device **420** to close the first output port **418** and the second output port **419** based on the compressor **110** being off.

In various embodiments, the controller **60** may open one of the first port **414** or the second port **415** based on the compressor **110** being off.

In the fourth mode, as one of the first port **414** or the second port **415** is opened and the other is closed, flow-in of the refrigerant to the valve device **400** and/or the hot pipe **140** may be stopped due to a difference in pressure between inside and outside of the hot pipe **140**.

Accordingly, the fourth mode may be defined as a differential pressure mode.

As the compressor **110** is off, movement of the refrigerant disappears, but the refrigerant having been in the 4-way valve device **410** may flow into the hot pipe **140** through the first port **414** or the second port **415**.

According to the disclosure, when the compressor **110** is off, a problem of dew formation around the door **21**, **22** or **31** may be prevented by leaving hot refrigerant in the hot pipe **140**.

Flows of refrigerant in the cold air supplier **100**C including the 3-way valve device **420** and the 4-way valve device **410** will now be described with reference to FIGS. **22** to **28**.

According to the disclosure, a limited amount of refrigerant may be efficiently used by switching the valve device **400** into the first mode to third mode during operation of the compressor **110**.

Especially, according to the disclosure, the first mode, the second mode and the third mode are divided into fridge-first mode and freezer-first mode, fridge-second mode and freezer-second mode, and fridge-third mode and freezer-third mode, respectively, thereby flexibly handling fridge operation and freezer operation of the refrigerator **1**.

In an embodiment, based on the operation mode of the refrigerator **1** being switched to the freezer mode from the fridge mode while the valve device **400** is operating in the fridge-first mode, the controller **60** may switch the valve device **400** into the freezer-first mode. Furthermore, based on the operation mode of the refrigerator **1** being switched to the fridge mode from the freezer mode while the valve device **400** is operating in the freezer-first mode, the controller **60** may switch the valve device **400** into the fridge-first mode.

In an embodiment, based on the operation mode of the refrigerator **1** being switched to the freezer mode from the fridge mode while the valve device **400** is operating in the fridge-second mode, the controller **60** may switch the valve device **400** into the freezer-second mode. Furthermore, based on the operation mode of the refrigerator **1** being switched to the fridge mode from the freezer mode while the valve device **400** is operating in the freezer-second mode, the controller **60** may switch the valve device **400** into the fridge-second mode.

In an embodiment, based on the operation mode of the refrigerator **1** being switched to the freezer mode from the fridge mode while the valve device **400** is operating in the fridge-third mode, the controller **60** may switch the valve device **400** into the freezer-third mode. Furthermore, based on the operation mode of the refrigerator **1** being switched to the fridge mode from the freezer mode while the valve device **400** is operating in the freezer-third mode, the controller **60** may switch the valve device **400** into the fridge-third mode.

In various embodiments, the place of the second mode may come between the first mode and the third mode.

In an embodiment, the controller **60** may control the valve device **400** to sequentially operate in the first, second and third modes. Furthermore, the controller **60** may control the valve device **400** to sequentially operate in the second, third and first modes.

In other words, the controller **60** may control the valve device **400** to perform a cycle including the first mode, the second mode and the third mode at least once during operation of the compressor **110**.

Operation of the cold air supplier **100** is not, however, limited thereto, and when an operation period of the first mode is set to be long, the controller **60** may control the valve device **400** to operate only in the first mode during operation of the compressor **110**.

The controller **60** may switch the valve device **400** into a fourth mode based on the compressor **110** being off while the valve device **400** is operating in the first, second, or third mode.

After this, based on the compressor **110** being activated again, the controller **60** may switch the valve device **400** into one of the first to third modes.

For example, the controller **60** may operate the valve device **400** in the first mode based on the compressor **110** being started to operate. Hence, dew formation may be efficiently prevented by supplying the refrigerant to the hot pipe **140** as soon as the compressor **110** operates.

In another example, the controller **60** may operate the valve device **400** in the second mode based on the compressor **110** being started to operate. Hence, the shortage of refrigerant may be prevented by collecting the refrigerant left in the hot pipe **140** during operation of the compressor **110**.

In various embodiments, the controller **60** may activate the compressor **110** according to a preset period or a preset condition to maintain the temperature of the storeroom **20** or **30**.

The controller **60** may switch the valve device **400** into the first mode, the second mode and the third mode in sequence during operation of the compressor **110**.

In the meantime, the controller **60** may determine duration of the first mode based on at least one of outside temperature or outside humidity.

In an embodiment, the controller **60** may determine duration of the first mode based on outside temperature.

For example, the controller **60** may set the duration of the first mode to be longer the higher the outside temperature. In another example, the controller **60** may set the duration of the first mode to be longer the larger the difference between the outside temperature and the inside temperature.

In an embodiment, the controller **60** may determine the duration of the first mode based on outside humidity.

For example, the controller **60** may set the duration of the first mode to be longer the higher the outside humidity. In another example, the controller **60** may set the duration of the first mode to be longer the larger the difference between the outside humidity and the inside humidity.

The duration of the second mode may be determined in advance based on various factors, such as the size of the evaporator **170** or the length of the hot pipe **140**, and data about the duration of the second mode may be stored in the memory **62**.

In an embodiment, the controller **60** may determine duration of the third mode based on inside temperature and set temperature. For example, the controller **60** may set the duration of the third mode to be longer the larger the difference between the inside temperature and the set temperature.

The first mode where the refrigerant circulates through the cold air supplier via the hot pipe **140** requires higher power of the compressor **110** than in the third mode where the refrigerant detours around the hot pipe **140** and circulates through the cold air supplier.

In various embodiments, the controller **60** may adjust the frequency of the compressor **110** to a first value when the valve device **400** operates in the first mode, and adjust the frequency of the compressor **110** to a second value smaller than the first value when the valve device **400** operates in the third mode. Hence, power consumption per hour of the compressor **110** when the valve device **400** operates in the third mode may be lower than that when the valve device **400** operates in the first mode.

According to the disclosure, power consumption may be reduced by adjusting the frequency of the compressor **110** down when the refrigerant detours around the hot pipe **140** and circulates through the cold air supplier **100**.

In various embodiments, the controller **60** may adjust the frequency of the compressor **110** to a third value when the valve device **400** operates in the second mode. In this case, the third value may be set to an optimal value for refrigerant collection.

According to the disclosure, the shortage of refrigerant may be prevented by operating the valve device **400** in the refrigerant collection mode after the hot pipe-pass mode, thereby facilitating saving of the power consumption of the compressor **110**.

A method of controlling the refrigerator **1** including the cold air supplier **100**D will now be described according to an embodiment.

In an embodiment, the cold air supplier **100**D may include the 4-way valve device **410**.

The cold air supplier **100**D may also include the single capillary tube **155** connected to the 4-way valve device **410**.

FIG. **29** illustrates an example of a method of controlling a refrigerator over time, according to an embodiment.

Referring to FIG. **29**, the controller **60** may switch the valve device **400** into the fourth mode based on the compressor **110** being off (e.g., 0 to t**1**, t**5** to t**6** and t**12**~).

During operation (0 to t**6** and t**7** to t**12**) of the compressor **110**, the controller **60** may operate the valve device **400** in a first mode, a second mode or a third mode.

In an embodiment, the controller **60** may switch the valve device **400** into the first mode from the fourth mode based on the compressor **110** being on (t**1**).

In the first mode, the controller **60** may operate the valve device **400** in the fridge-first mode when the refrigerator **1** operates in the fridge mode (t**1** to t**2** and t**11** to t**12**).

In the meantime, in the first mode, the controller **60** may operate the valve device **400** in the freezer-first mode when the refrigerator **1** operates in the freezer mode (t**5** to t**6** and t**7** to t**8**).

In an embodiment, the controller **60** may switch the valve device **400** into the second mode from the first mode based on termination of the first mode (t**2** and t**8**).

In the second mode, the controller **60** may operate the valve device **400** in the fridge-second mode when the refrigerator **1** operates in the fridge mode (t**2** to t**3**).

In the meantime, in the second mode, the controller **60** may operate the valve device **400** in the freezer-second mode when the refrigerator **1** operates in the freezer mode (t**8** to t**9**).

In an embodiment, the controller **60** may switch the valve device **400** into the third mode from the second mode based on termination of the second mode (t**3** and t**9**).

In the third mode, the controller **60** may operate the valve device **400** in the fridge-third mode when the refrigerator **1** operates in the fridge mode (t**3** to t**4** and t**10** to t**11**).

In the meantime, in the third mode, the controller **60** may operate the valve device **400** in the freezer-third mode when the refrigerator **1** operates in the freezer mode (t**4** to t**5** and t**9** to t**10**).

FIG. **29** illustrates mode switching behaviors of the valve device **400** for schematic description, but the mode switching behaviors of the valve device **400** are not limited thereto.

Although a period in which the valve device **400** operates in the first mode is shown in FIG. **29** as being shorter than a period in which the valve device **400** operates in the third mode, the period in which the valve device **400** operates in the third mode may be longer than the period in which the valve device **400** operates in the first mode depending on various conditions.

A period in which the valve device **400** operates in the second mode may be shorter than the period in which the valve device **400** operates in the first mode/third mode.

Furthermore, as described above, the controller **60** may switch the valve device **400** into the second mode from the fourth mode based on the compressor **110** being on (t**1** and t**7**). In this case, the valve device **400** may be switched in the sequence of the second mode, the third mode, and the first mode.

FIG. **30** is a flowchart illustrating an example of a method of controlling a refrigerator, according to an embodiment.

Referring to FIG. **30**, the controller **60** may operate the compressor **110** based on an operation condition of the compressor **110** being satisfied.

In an embodiment, when the cold air supplier **100**D includes one capillary tube, fridge operation and freezer operation may not be separated.

During operation of the compressor **110** in **2000**, the controller **60** may operate the valve device **400** in a first mode, a second mode and a third mode in **2100**, **2200** and **2300**. The controller **60** may switch the valve device **400** into the fourth mode based on the compressor **110** being off in **1000**, in **2400**.

In this case, unlike the aforementioned embodiment, as the cold air supplier **100**D includes the single capillary tube **155**, each of the first, second and third modes may not be divided into two modes according to the operation mode of the refrigerator **1**.

In other words, unlike in the flowchart as shown in FIG. **14**, the first mode, the second mode and the third mode are not each divided according to the fridge or freezer operation in the flowchart shown in FIG. **30**.

The description of the cold air supplier **100**A, **100**B and **100**C may be applied to the cold air supplier **100**D except that the first, second and third modes are not each divided according to the fridge or freezer operation.

Although it is shown that the controller **60** operates the valve device **400** in a sequence of the first mode, the second mode and the third mode, the controller **60** may operate the valve device **400** in a sequence of the first mode, the second mode and the third mode or the second mode, the third mode and the first mode based on the compressor **110** being started to operate.

For example, the controller **60** may operate the valve device **400** in the first mode based on the compressor **110** being started to operate.

Furthermore, the controller **60** may operate the valve device **400** in the second mode based on the compressor **110** being started to operate.

The controller **60** may switch the valve device **400** from the first mode to the second mode based on a termination condition of the first mode satisfied, switch the valve device **400** from the second mode to the third mode based on a termination condition of the second mode satisfied, and switch the valve device **400** from the third mode to the first mode based on a termination condition of the third mode satisfied, during operation of the compressor **110**.

The controller **60** may switch the valve device **400** to a fourth mode based on the compressor **110** being off in **2000** while the valve device **400** is operating in the first, second, or third mode.

FIG. **31** illustrates flows of a refrigerant through a valve device operating in a first mode.

The controller **60** may operate the valve device **400** in the first mode during operation of the compressor **110**, in **2100**.

In an embodiment, the valve device **400** included in the cold air supplier **100**D may include the input port **411** connected to the outlet of the condenser **120**, the first port **414** connected to an end of the hot pipe **140**, the second port **415** connected to the other end of the hot pipe **140**, and the output port **416** connected to the capillary tube **155**.

Referring to FIG. **31**, the controller **60** may control the valve device **400** such that one of the first port **414** and the second port **415** is connected to the input port **411** and the other is connected to the output port **416** in the first mode.

Specifically, the controller **60** may control the 4-way valve device **410** such that the first port **414** is connected to the input port **411** and the second port **415** is connected to the output port **416** in the first mode.

When the valve device **400** operates in the first mode during operation of the compressor **110**, the refrigerant flowing into the input port **411** may pass through the hot pipe **140** through the first port **414** and flow into the second port **415**, and may be discharged from the second port **415** through the output port **416** and delivered into the capillary tube **155**.

FIG. **32** illustrates flows of a refrigerant through a valve device operating in a second mode.

The controller **60** may operate the valve device **400** in the second mode during operation of the compressor **110**, in **2200**.

Referring to FIG. **32**, the controller **60** may control the valve device **400** to close one **414** of the first port **414** and the second port **415** in the second mode.

Furthermore, the controller **60** may control the valve device **400** such that the other **415** of the first port **414** and the second port **415** is connected to the output port **416** in the second mode.

Specifically, the controller **60** may control the 4-way valve device **410** such that the first port **414** is closed and the second port is connected to the output port **416** in the second mode.

When the valve device **400** operates in the second mode during operation of the compressor **110**, the refrigerant left in the hot pipe **140** may not flow toward the first port **414**.

Accordingly, when the valve device **400** operates in the second mode, the refrigerant left in the hot pipe **140** may be moved toward the second port **415** and delivered to the capillary tube **155** through the output port **416**.

According to the disclosure, the refrigerant left in the hot pipe **140** may be collected to the evaporator **170**.

FIG. **33** illustrates flows of a refrigerant through a valve device operating in a third mode.

The controller **60** may operate the valve device **400** in the third mode during operation of the compressor **110**, in **2300**.

Referring to FIG. **33**, the controller **60** may control the valve device **400** to close both the first port **414** and the second port **415** in the third mode.

Furthermore, the controller **60** may control the valve device **400** to connect the input port **411** to the output port **416** in the third mode.

Specifically, the controller **60** may control the 4-way valve device **410** such that the first port **414** and the second port **415** are closed and the input port **411** is connected to the output port **416** in the third mode.

When the valve device **400** operates in the third mode during operation of the compressor **110**, the refrigerant discharged from the condenser **120** may detour around the hot pipe **140** and be supplied directly into the capillary tube **155**.

Accordingly, when the valve device **400** operates in the third mode, the thermal load required by the hot pipe **140** may be reduced.

FIG. **34** illustrates flows of a refrigerant through a valve device operating in a fourth mode.

The controller **60** may operate the valve device **400** into the fourth mode based on the compressor **110** being off in **2000**, in **2400**.

Referring to FIG. **34**, the controller **60** may control the valve device **400** to close the output port **416** in the fourth mode.

Furthermore, the controller **60** may control the valve device **400** such that one of the first port **414** and the second port **415** is closed and the other is opened in the fourth mode.

Specifically, the controller **60** may control the 4-way valve device **410** such that one of the first port **414** and the second port **415** is closed, the other is connected to the input port **411**, and the output port **416** is closed in the fourth mode.

As the compressor **110** is off, movement of the refrigerant disappears, but the refrigerant having been in the 4-way valve device **410** may flow into the hot pipe **140** through the first port **414** or the second port **415**.

According to the disclosure, when the compressor **110** is off, a problem of dew formation around the door **21**, **22** or **31** may be prevented by leaving hot refrigerant in the hot pipe **140**.

FIG. **35** illustrates an example of a method of controlling a refrigerator over time, according to an embodiment.

Referring to FIG. **35**, the controller **60** may switch the valve device **400** into the fourth mode based on the compressor **110** being off (e.g., 0 to a**1**, a**5** to a**6** and a**9**~). The controller **60** may operate the valve device **400** in the first mode, the second mode or the third mode during operation of the compressor **110** (a**1** to a**5** and a**6** to a**9**).

In an embodiment, the controller **60** may switch the valve device **400** into the first mode from the fourth mode based on the compressor **110** being on (a**1**).

In an embodiment, the controller **60** may switch the valve device **400** into the second mode from the first mode based on termination of the first mode (a**2** and a**7**).

In an embodiment, the controller **60** may switch the valve device **400** into the third mode from the second mode based on termination of the second mode (a**3** and a**8**).

In an embodiment, the controller **60** may switch the valve device **400** into the first mode from the third mode based on termination of the third mode (a**4**).

FIG. **35** illustrates mode switching behaviors of the valve device **400** for schematic description, but the mode switching behaviors of the valve device **400** are not limited thereto.

Although a period in which the valve device **400** operates in the first mode is shown in FIG. **35** as being shorter than a period in which the valve device **400** operates in the third mode, the period in which the valve device **400** operates in the third mode may be longer than the period in which the valve device **400** operates in the first mode depending on various conditions.

A period in which the valve device **400** operates in the second mode may be shorter than the period in which the valve device **400** operates in the first mode/third mode.

Furthermore, as described above, the controller **60** may switch the valve device **400** into the second mode from the fourth mode based on the compressor **110** being on (a**1** and a**6**). In this case, the valve device **400** may be switched in the sequence of the second mode, the third mode, and the first mode.

The refrigerator including the cold air supplier **100** that may operate in the hot pipe-pass mode, the refrigerant collection mode, and the hot pipe-detour mode has thus far been described.

According to the disclosure, the shortage of refrigerant may be prevented by operating the cold air supplier **100** in the refrigerant collection mode before operation in the hot pipe-detour mode.

Meanwhile, the embodiments of the disclosure may be implemented in the form of a recording medium for storing instructions to be carried out by a computer. The instructions may be stored in the form of program codes, and when executed by a processor, may generate program modules to perform operations in the embodiments of the disclosure. The recording media may correspond to computer-readable recording media.

The computer-readable recording medium includes any type of recording medium having data stored thereon that may be thereafter read by a computer. For example, it may be a read only memory (ROM), a random access memory (RAM), a magnetic tape, a magnetic disk, a flash memory, an optical data storage device, etc.

The computer-readable storage medium may be provided in the form of a non-transitory storage medium. The term 'non-transitory storage medium' may mean a tangible device without including a signal, e.g., electromagnetic waves, and may not distinguish between storing data in the storage medium semi-permanently and temporarily. For example, the non-transitory storage medium may include a buffer that temporarily stores data.

In an embodiment, the aforementioned method according to the various embodiments of the disclosure may be provided in a computer program product. The computer program product may be a commercial product that may be traded between a seller and a buyer. The computer program product may be distributed in the form of a recording medium (e.g., a compact disc read only memory (CD-ROM)), through an application store (e.g., Play Store™), directly between two user devices (e.g., smart phones), or online (e.g., downloaded or uploaded). In the case of online distribution, at least part of the computer program product (e.g., a downloadable app) may be at least temporarily stored or arbitrarily created in a recording medium that may be readable to a device such as a server of the manufacturer, a server of the application store, or a relay server.

The embodiments of the disclosure have thus far been described with reference to accompanying drawings. It will be obvious to those of ordinary skill in the art that the disclosure may be practiced in other forms than the embodiments of the disclosure as described above without changing the technical idea or essential features of the disclosure. The above embodiments of the disclosure are only by way of example, and should not be construed in a limited sense.

What is claimed is:

1. A refrigerator comprising:
- a compressor having an inlet and an outlet;
- a condenser having an inlet and an outlet, the inlet of the condenser connected to the outlet of the compressor;
- a hot pipe;
- at least one capillary tube;
- at least one evaporator connected to the at least one capillary tube and the inlet of the compressor;
- a valve device including:
  - an input port connected to the outlet of the condenser;
  - a first port connected to one end of the hot pipe;
  - a second port connected to an other end of the hot pipe; and
  - at least one output port connected to the at least one capillary tube; and
- a controller configured to:
  - control the valve device to operate in a first mode, a second mode, and a third mode during an operation of the compressor,
  - control the valve device to operate in the first mode by connecting one of the first port and the second port to the input port and connecting an other one of the first port and the second port to the output port;
  - control the valve device to operate in the second mode, by closing one of the first port and the second port and connecting an other one of the first port and the second port to the output port; and
  - control the valve device to operate in the third mode, by closing all the first port and the second port.

2. The refrigerator of claim **1**, wherein the controller is configured to control the valve device to operate in an order of the first mode, the second mode, and the third mode or in an order of the second mode, the third mode, and the first mode.

3. The refrigerator of claim **1**, wherein the controller is configured to determine a duration of the first mode based on at least one of outside temperature or outside humidity.

4. The refrigerator of claim **1**, wherein the controller is configured to control the valve device to close the output port based on the compressor being turned off.

5. The refrigerator of claim **1**, wherein the controller is configured to control the valve device to operate in the first mode or the second mode based on the compressor being started to operate.

6. The refrigerator of claim **1**, wherein:
- a refrigerant flowing into the input port passes through the hot pipe, and is discharged to the at least one evaporator in the first mode,
- a refrigerant left in the hot pipe is collected to the at least one evaporator in the second mode, and
- a refrigerant flowing into the input port bypasses the hot pipe, and is discharged to the at least one evaporator in the third mode.

7. The refrigerator of claim **1**, wherein the controller is configured to control a frequency of the compressor to a first value based on the valve device being operating in the first mode and control the frequency of the compressor to a second value lower than the first value based on the valve device being operating in the third mode.

8. The refrigerator of claim **1**, wherein the controller is configured to:
- control the valve device to switch from the first mode to the second mode based on a termination condition of the first mode being satisfied;
- control the valve device to switch from the second mode to the third mode based on a termination condition of the second mode being satisfied, and
- control the valve device to switch from the third mode to the first mode based on a termination condition of the third mode being satisfied, during the operation of the compressor.

9. The refrigerator of claim **1**, wherein the controller is configured to control the valve device to operate in the second mode after an operation in the first mode and before an operation in the third mode.

10. The refrigerator of claim **1**, wherein:
- the at least one capillary tube comprises a first capillary tube and a second capillary tube;
- the at least one output port comprises a first output port connected to the first capillary tube and a second output port connected to the second capillary tube; and
- the controller is configured to control the valve device such that the first port is connected to the first output port and the second port is connected to the input port in the first mode based on the refrigerator being operating in a fridge mode, and control the valve device such that the second port is connected to the second output port and the first port is connected to the input port in the first mode based on the refrigerator being operating in a freezer mode.

11. The refrigerator of claim **1**, wherein:
- the at least one capillary tube comprises a first capillary tube and a second capillary tube;
- the at least one output port comprises a first output port connected to the first capillary tube and a second output port connected to the second capillary tube; and
- the controller is configured to:
  - control the valve device such that the first port is closed and the second port is connected to the second output port in the second mode based on the refrigerator being operating in a fridge mode, and
  - control the valve device such that the second port is closed and the first port is connected to the first output port in the second mode based on the refrigerator being operating in a freezer mode.

12. The refrigerator of claim **11**, wherein the controller is configured to
- control the valve device such that the input port is connected to the first output port in the second mode based on the refrigerator being operating in the fridge mode, and
- control the valve device such that the input port is connected to the second output port in the second mode based on the refrigerator being operating in the freezer mode.

13. The refrigerator of claim 1, wherein:

the at least one capillary tube comprises a first capillary tube and a second capillary tube;

the at least one output port comprises a first output port connected to the first capillary tube and a second output port connected to the second capillary tube; and

the controller is configured to:

control the valve device such that the input port is connected to the first output port in the third mode based on the refrigerator being operating in a fridge mode; and

control the valve device such that the input port is connected to the second output port in the third mode based on the refrigerator being operating in a freezer mode.

14. A method of controlling a refrigerator including a valve device including an input port connected to a condenser, a first port connected to one end of a hot pipe, a second port connected to an other end of the hot pipe, and at least one output port connected to at least one capillary tube, the method comprising:

controlling the valve device to operate in a first mode, a second mode and a third mode during an operation of a compressor;

controlling the valve device to operate in the first mode to connect one of the first port and the second port to the input port and connect an other one of the first port and the second port to the output port;

controlling the valve device to operate in the second mode to close one of the first port and the second port and connect an other one of the first port and the second port to the output port; and

controlling the valve device to operate in the third mode to close all the first port and the second port.

15. The method of claim 14, wherein the controlling of the valve device to operate in the first mode, the second mode, and the third mode during an operation of the compressor comprises

controlling the valve device to operate in an order of the first mode, the second mode and the third mode or in an order of the second mode, the third mode and the first mode.

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