



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
27.09.2023 Bulletin 2023/39

(51) International Patent Classification (IPC):
F25B 13/00 ^(2006.01) **F25B 41/20** ^(2021.01)
F25B 41/31 ^(2021.01) **F25B 41/30** ^(2021.01)

(21) Application number: **23162972.6**

(52) Cooperative Patent Classification (CPC):
F25B 41/20; F25B 13/00; F25B 41/30;
F25B 2313/02741; F25B 2400/13; F25B 2400/16;
F25B 2600/2509

(22) Date of filing: **20.03.2023**

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

(72) Inventors:
• **ZHANG, Yilin**
Shanghai, 201206 (CN)
• **SU, Peng**
Shanghai, 201206 (CN)

(74) Representative: **Dehns**
St. Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(30) Priority: **18.03.2022 CN 202210268739**

(71) Applicant: **Carrier Corporation**
Palm Beach Gardens, FL 33418 (US)

(54) **HEAT PUMP SYSTEM AND THE CONTROL METHOD THEREOF**

(57) The present application provides a heat pump system and a control method thereof. The heat pump system comprises: a compressor (1); a reversing valve (2) configured to selectively connect the compressor inlet (12) and the compressor outlet (11) to a first flow path (31) and a second flow path (32); a heat source-side heat exchanger (4) on the first flow path (31); a user-side heat exchanger (5) on the second flow path (32); a first branch (62) and a second branch (61) between the first flow path (31) and the second flow path (32), wherein the first branch (62) is provided with a first valve (72) and a second

valve (71), and the second branch (61) is provided with a first throttling device (82) and a second throttling device (81); and an economizer (9; 90; 900) connected between a first position (621) between the first valve (72) and the second valve (71) on the first branch (62) and a second position (611) between the first throttling device (82) and the second throttling device (81) on the second branch (61). The system and method according to the embodiments of the present invention improves the system capacity using an economizer (9; 90; 900) in the cooling and heating modes, and has stronger reliability.

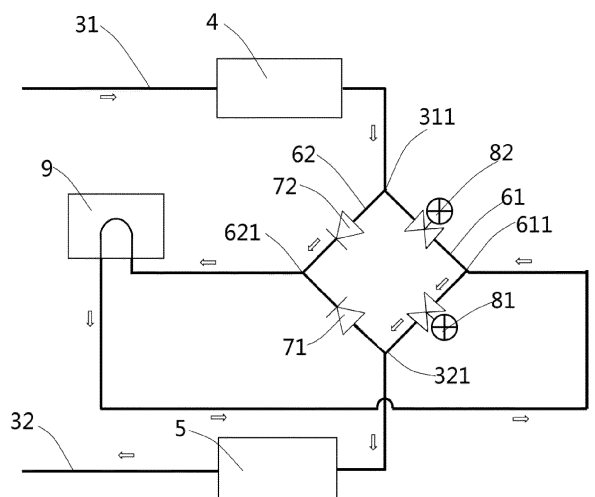


Figure 1

Description

[0001] The present invention relates to the field of heat pumps, in particular to a heat pump system with an economizer capable of operating in both cooling and heating modes.

[0002] In order to improve the comfort of air conditioning systems, common air conditioning systems have a heating mode. Air conditioning systems with both cooling and heating modes are also referred to as heat pump systems. In order to improve the capacity of the heat pump system in the heating mode, an Enhanced Vapor Injection (EVI) compressor and an economizer located in front of the throttling device are often used. This structure can increase the heating capacity of the system by about 10%.

[0003] In order to enable the EVI compressor and the economizer to also operate in the cooling mode, i.e., to improve the capacity of the system in the cooling mode, it is usually necessary to employ a complicated pipeline structure with four check valves and one expansion valve, which challenges the reliability of the check valves.

[0004] The object of at least the preferred embodiments of the present application is to solve or at least alleviate the problems existing in the prior art.

[0005] According to one aspect, a heat pump system is provided, which comprises:

- a compressor having a compressor inlet and a compressor outlet;
- a reversing valve configured to selectively connect the compressor inlet and the compressor outlet to a first flow path and a second flow path;
- a heat source-side heat exchanger on the first flow path;
- a user-side heat exchanger on the second flow path;
- a first branch and a second branch between the first flow path and the second flow path, wherein the first branch is provided with a first valve and a second valve, and the second branch is provided with a first throttling device and a second throttling device; and
- an economizer connected between a first position between the first valve and the second valve on the first branch and a second position between the first throttling device and the second throttling device on the second branch.

[0006] Optionally, in an embodiment of the heat pump system, the compressor is an EVI compressor, wherein the EVI compressor further comprises an air supplement port, and the economizer comprises a port connected with the air supplement port.

[0007] Optionally, in an embodiment of the heat pump system, the economizer is a flash tank, wherein the inlet of the flash tank is connected to the first position, the gas-phase outlet of the flash tank is connected to the air supplement port, and the liquid-phase outlet of the flash tank is connected to the second position.

[0008] Optionally, in an embodiment of the heat pump system, the economizer is a heat exchanger comprising a first pipeline and a second pipeline. The first pipeline is connected between the first position and the second position, and a branch path is branched out at a third position between the first position or the second position and the economizer, wherein the branch path is provided with an additional throttling device, and is connected to the air supplement port of the compressor through the second pipeline of the economizer.

[0009] Optionally, in an embodiment of the heat pump system, the first valve is a check valve that only allows refrigerant fluid to flow from the first flow path to the first position, and the second valve is a check valve that only allows refrigerant fluid to flow from the second flow path to the first position.

[0010] Optionally, in an embodiment of the heat pump system, the first throttling device and the second throttling device are expansion valves.

[0011] Optionally, in an embodiment of the heat pump system, the heat pump system further comprises a controller that controls the first throttling device and the second throttling device. The controller is configured to turn off the first throttling device and allow the second throttling device to play a throttling role in a cooling mode, and turn off the second throttling device and allow the first throttling device to play a throttling role in a heating mode.

[0012] Optionally, in an embodiment of the heat pump system, the first valve and the second valve are cut-off valves. The controller is configured to control the first valve and the second valve, so that the first valve is turned on and the second valve is turned off in the cooling mode, and the second valve is turned on and the first valve is turned off in the heating mode.

[0013] According to another aspect, a control method of a heat pump system is provided, which is for use in the heat pump system according to the various embodiments. The method comprises: turning off the first throttling device and allowing the second throttling device to play a throttling role in the cooling mode, so that the refrigerant passes through the first valve, the economizer and the second throttling device in turn; and turning off the second throttling device and allowing the first throttling device to play a throttling role in the heating mode, so that the refrigerant passes through the second valve, the economizer and the first throttling device in turn.

[0014] Optionally, the method further comprises:

using a flash tank as an economizer, so that after the refrigerant enters the flash tank, gas-phase refrigerant is delivered to the air supplement port of the compressor, and liquid-phase refrigerant is delivered to the first throttling device or the second throttling device; or

using a heat exchanger comprising a first pipeline and a second pipeline as the economizer, and divid-

ing the refrigerant into a first part and a second part before it enters the first pipeline or after it leaves the first pipeline, wherein the first part of the refrigerant is delivered to the first throttling device or the second throttling device, and the second part of the refrigerant is delivered to the air supplement port of the compressor after passing through an additional throttling device and then through the second pipeline of the economizer.

[0015] The system and method according to the embodiments of the present invention improves the system capacity using the economizer in the cooling and heating modes, and has stronger reliability.

[0016] With reference to the accompanying drawings, the disclosure of the present application will become easier to understand. Those skilled in the art would readily appreciate that these drawings are for the purpose of illustration, and are not intended to limit the protection scope of the present application. In addition, in the figures, similar numerals are used to denote similar components, where:

FIG 1 shows a partial schematic diagram of a heat pump system;

FIG 2 shows a schematic diagram of a heat pump system;

FIG 3 shows a schematic diagram of a heat pump system; and

FIG 4 shows a schematic diagram of a heat pump system.

[0017] FIG 1 shows a partial schematic diagram of a heat pump system. The heat pump system comprises: a first flow path 31 and a second flow path 32 selectively connected with the compressor inlet and the compressor outlet; a heat source-side heat exchanger 4 on the first flow path 31; a user-side heat exchanger 5 on the second flow path 32; a first branch 62 and a second branch 61 between the first flow path 31 and the second flow path 32, wherein the first branch 62 and the second branch 61 are connected to the end 311 of the first flow path 31 and the end 321 of the second flow path 32 respectively, and the first branch 62 is provided with a first valve 72 and a second valve 71, and the second branch 61 is provided with a first throttling device 82 and a second throttling device 81; and an economizer 9 connected between a first position 621 between the first valve 72 and the second valve 71 on the first branch 62 and a second position 611 between the first throttling device 82 and the second throttling device 81 on the second branch 61. The heat pump system utilizes the four valve elements that are the first valve 72, the second valve 71, the first throttling device 82 and the second throttling device 81 to realize the application of the economizer 9 in the cool-

ing and heating modes, thereby improving the capacity and stability of the heat pump system.

[0018] With reference to FIG. 2, the application of the heat pump system combined with an EVI compressor is shown. The EVI compressor 1 comprises a compressor inlet 12, a compressor outlet 11 and an air supplement port 13. Compressor 1 is connected with the portion of the heat pump system shown in FIG. 1 through a reversing valve 2, and the economizer is also connected to the air supplement port of compressor 1. More specifically, the compressor outlet 11 and the compressor inlet 12 of the EVI compressor 1 are selectively connected with the first flow path 31 and the second flow path 32 through the reversing valve 2 to execute the cooling mode and the heating mode. In FIG 2, the economizer is in the form of a flash tank 90, the inlet 91 of which is connected to a first position 621 on the first flow path 62, the gas-phase outlet 92 of which is connected to the air supplement port 13 of the compressor 1, and the liquid-phase outlet 93 of which is connected to a second position 611 on the second flow path 61. In the cooling mode, the refrigerant leaving from the compressor outlet 11 enters through the port a and leaves from the port b of the reversing valve 2, enters the heat source-side heat exchanger 4 which serves as a condenser, passes through a first valve 72 (the first throttling device 82 is turned off), and then enters the economizer in the form of the flash tank 90. Wherein, the gas-phase refrigerant returns to the air supplement port 13 of the compressor 1 from the gas-phase outlet 92 of the flash tank 90, the liquid-phase refrigerant leaves from the liquid-phase outlet 93 of the flash tank, passes through the second throttling device 81 for throttling, then passes through the user-side heat exchanger 5 which serves as an evaporator, then passes through the second flow path 32, enters from the port c and leaves from the port d of the reversing valve 2, and finally returns to the compressor inlet 12. In the heating mode, the refrigerant leaving from the compressor outlet 11 enters through the port a and leaves from the port c of the reversing valve 2, enters the user-side heat exchanger 5 which serves as a condenser, passes through a second valve 71 (the second throttling device 81 is turned off), and then enters the economizer in the form of the flash tank 90. Wherein, the gas-phase refrigerant returns to the air supplement port 13 of the compressor 1 from the gas-phase outlet 92 of the flash tank, and the liquid-phase refrigerant leaves from the liquid-phase outlet 93 of the flash tank, passes through the first throttling device 82 for throttling, then passes through the heat source-side heat exchanger 4 which serves as an evaporator, passes through the first flow path 31, enters from the port b and leaves from the port d of the reversing valve 2, and finally returns to the compressor inlet 12. It can be seen that the heat pump system realizes the application of the economizer in the cooling and heating modes through four valves, thus improving the system capacity and stability.

[0019] In some embodiments, the first valve 72 is a check valve that only allows refrigerant fluid to flow from

the first flow path 31 to the first position 621, and the second valve 71 is a check valve that only allows refrigerant fluid to flow from the second flow path 32 to the first position 621. In some embodiments, the first throttling device 82 and the second throttling device 81 are both expansion valves, such as electronic expansion valves. In some embodiments, the heat pump system also comprises a controller that controls the first throttling device 82 and the second throttling device 81. The controller is configured to turn off the first throttling device 82 and allow the second throttling device 81 to play a throttling role in the cooling mode, and to turn off the second throttling device 81 and allow the first throttling device 82 to play a throttling role in the heating mode. In some embodiments, the first valve 72 and the second valve 71 can also be cut-off valves. The controller is configured to control the first valve 72 and the second valve 71, so that the first valve 72 is turned on and the second valve 71 is turned off in the cooling mode, and the second valve 71 is turned on and the first valve 72 is turned off in the heating mode. In some embodiments, other suitable types of valves can also be utilized to achieve the above functions.

[0020] With reference to FIG 3, an economizer in the form of a heat exchanger 900 is adopted. The heat exchanger 900 comprises a first pipeline 901 and a second pipeline 902, where the fluids in the first pipeline 901 and the second pipeline 902 exchange heat in the economizer 900. The first pipeline 901 is connected between the first position 621 of the first branch 62 and the second position 611 of the second branch 61. A branch path is branched out at a third position 903 between the first position 621 and the economizer 900. The branch path is provided with an additional throttling device 904. The branch path is connected to the air supplement port 13 of the compressor through the second pipeline 902 of the economizer 900. The additional throttling device 904 can be an expansion valve, such as an electronic expansion valve. The proportion of refrigerant delivered to the air supplement port 13 can be adjusted by adjusting the opening degree of the additional throttling device 904.

[0021] In an alternative embodiment, as shown in FIG 4, the third position 903 can also be arranged between the second position 611 and the economizer 900, and the branch path can also be branched out from a third position 903 between the second position 611 and the economizer 900. The branch path can also be provided with an additional throttling device 904, and connected to the air supplement port 13 of the compressor through the second pipeline 902 of the economizer 900.

[0022] In this embodiment, in the cooling mode, the refrigerant leaving from the compressor outlet 11 enters from port a and leaves from port b of the reversing valve 2, enters the heat source-side heat exchanger 4 which serves as a condenser, and then passes through the first valve 72 (the first throttling device 82 is turned off). Then, at the third position 903, the refrigerant is divided into a first part that passes through the first pipeline 901 of the

economizer and a second part that enters the second pipeline 902 of the economizer 900 after passing through the additional throttling device 904. After the first part and the second part of the refrigerant exchange heat in the economizer 900, the second part of the refrigerant returns to the air supplement port 13 of the compressor 1. The first part of the refrigerant passes through the second throttling device 81 for throttling, then passes through the user-side heat exchanger 5 which serves as an evaporator, passes through the second flow path 32, enters from the port c and leaves from port d of the reversing valve 2, and finally returns to the compressor inlet 12. In the heating mode, the refrigerant leaving from the compressor outlet 11 enters from the port a and leaves from port c of the reversing valve 2, enters the user-side heat exchanger 5 which serves as a condenser, and then passes through the second valve 71 (the second throttling device 81 is turned off). Then, at the third position 903, the refrigerant is divided into a first part that passes through the first pipeline 901 of the economizer and a second part that enters the second pipeline 902 of the economizer 900 after passing through the additional throttling device 904. After the first part and the second part of the refrigerant exchange heat in the economizer 900, the second part of the refrigerant returns to the air supplement port 13 of the compressor 1. The first part of the refrigerant passes through the first throttling device 82 for throttling, then passes through the heat source-side heat exchanger 4 which serves as an evaporator, passes through the first flow path 31, enters from the port b and leaves from port d of the reversing valve 2, and finally returns to the compressor inlet 12. It can be seen that in the heat pump system according to FIG 3, the application of the economizer in the cooling and heating modes is also realized through four valves, thus improving the system efficiency and stability. In the heat pump system according to the embodiments of the present invention, two check valves and two electronic expansion valves are used to realize the application of the economizer in the cooling and heating modes. Compared with the existing structure with four check valves and a single expansion valve, the number of valves is reduced, and the number of check valves with relatively poor stability is reduced, so that the system stability is improved.

[0023] A control method of a heat pump system is also provided, the method comprising: turning off the first throttling device and allowing the second throttling device to play a throttling role in the cooling mode, so that the refrigerant passes through the first valve, the economizer and the second throttling device in turn; and turning off the second throttling device and allowing the first throttling device to play a throttling role in the heating mode, so that the refrigerant passes through the second valve, the economizer and the first throttling device in turn.

[0024] In some embodiments, the method further comprises: using a flash tank as an economizer, so that after the refrigerant enters the flash tank, gas-phase refrigerant is delivered to the air supplement port of the com-

pressor, and liquid-phase refrigerant is delivered to the first throttling device or the second throttling device; or using a heat exchanger comprising a first pipeline and a second pipeline as the economizer, and dividing the refrigerant into a first part and a second part before it enters the first pipeline or after it leaves the first pipeline, wherein the first part of the refrigerant is delivered to the first throttling device or the second throttling device, and the second part of the refrigerant is delivered to the air supplement port of the compressor after passing through an additional throttling device and then through the second pipeline of the economizer.

[0025] The specific embodiments described above are merely intended to describe the principles of the present invention more clearly, wherein various components are clearly shown or described to facilitate the understanding of the principles of the present invention. Those skilled in the art may, without departing from the scope of the present invention, make various modifications or changes to the described embodiment. Therefore, it should be understood that the scope of the present invention is defined only by the following claims.

Claims

1. A heat pump system, comprising:

a compressor (1) having a compressor inlet (12) and a compressor outlet (11);
 a reversing valve (2) configured to selectively connect the compressor inlet and the compressor outlet to a first flow path (31) and a second flow path (32);
 a heat source-side heat exchanger (4) on the first flow path;
 a user-side heat exchanger (5) on the second flow path;
 a first branch (62) and a second branch (61) between the first flow path and the second flow path, wherein the first branch is provided with a first valve (72) and a second valve (71), and the second branch is provided with a first throttling device (82) and a second throttling device (81);
 and
 an economizer (9; 90; 900) connected between a first position (621) between the first valve and the second valve on the first branch and a second position (611) between the first throttling device and the second throttling device on the second branch.

2. The heat pump system according to claim 1, wherein the compressor is an Enhanced Vapor Injection compressor, wherein the Enhanced Vapor Injection compressor further comprises an air supplement port (13), and the economizer comprises a port (92) connected with the air supplement port.

3. The heat pump system according to claim 2, wherein the economizer is a flash tank (90), an inlet (91) of the flash tank being connected to the first position, a gas-phase outlet (92) of the flash tank being connected to the air supplement port, and a liquid-phase outlet (93) of the flash tank being connected to the second position.

4. The heat pump system according to claim 2, wherein the economizer is a heat exchanger (900) comprising a first pipeline (901) and a second pipeline (902), where the first pipeline is connected between the first position and the second position, and a branch path is branched out at a third position (903) between the first position or the second position and the economizer, wherein the branch path is provided with an additional throttling device (904), and is connected to the air supplement port of the compressor through the second pipeline of the economizer.

5. The heat pump system according to any of claims 1-4, wherein the first valve is a check valve that only allows refrigerant fluid to flow from the first flow path to the first position, and the second valve is a check valve that only allows refrigerant fluid to flow from the second flow path to the first position.

6. The heat pump system according to any of claims 1-4, wherein the first throttling device and the second throttling device are expansion valves.

7. The heat pump system according to claim 6, wherein the heat pump system further comprises a controller that is configured to control the first throttling device and the second throttling device, where the controller is configured to turn off the first throttling device and allow the second throttling device to play a throttling role in a cooling mode, and to turn off the second throttling device and allow the first throttling device to play a throttling role in a heating mode.

8. The heat pump system according to claim 7, wherein the first valve and the second valve are cut-off valves, and the controller is configured to control the first valve and the second valve, so that the first valve is turned on and the second valve is turned off in the cooling mode, and the second valve is turned on and the first valve is turned off in the heating mode.

9. A control method of a heat pump system according to any of claims 1-8, the method comprising:

turning off the first throttling device and allowing the second throttling device to play a throttling role in the cooling mode, so that refrigerant passes through the first valve, the economizer and the second throttling device in turn; and
 turning off the second throttling device and al-

lowing the first throttling device to play a throttling role in the heating mode, so that refrigerant passes through the second valve, the economizer and the first throttling device in turn.

5

10. The method according to claim 9, further comprising:

using a flash tank (90) as an economizer, so that after refrigerant enters the flash tank, gas-phase refrigerant is delivered to an air supplement port (13) of the compressor, and liquid-phase refrigerant is delivered to the first throttling device or the second throttling device; or

10

using a heat exchanger (900) comprising a first pipeline (901) and a second pipeline (902) as the economizer, and dividing the refrigerant into a first part and a second part before it enters the first pipeline or after it leaves the first pipeline, wherein the first part of the refrigerant is delivered to the first throttling device or the second throttling device, and the second part of the refrigerant is delivered to an air supplement port (13) of the compressor after passing through an additional throttling device (904) and then through the second pipeline of the economizer.

15

20

25

30

35

40

45

50

55

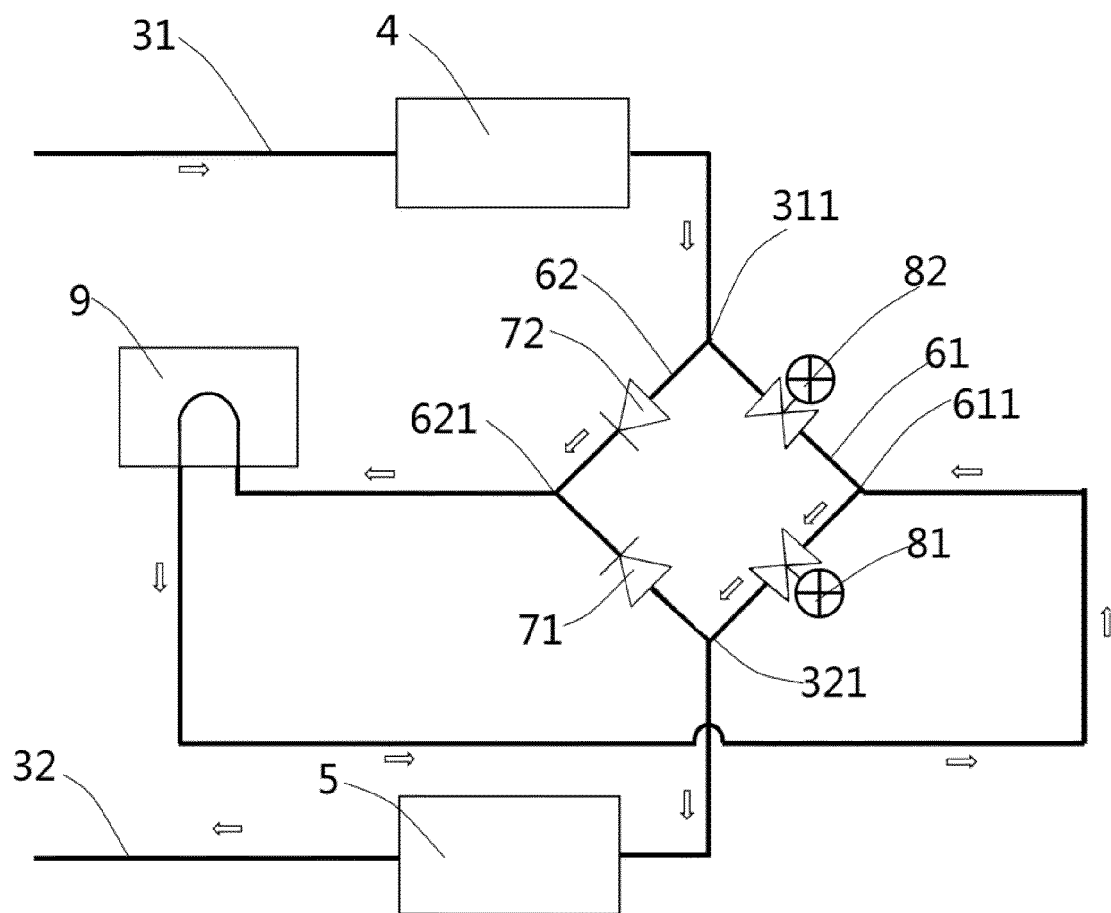


Figure 1

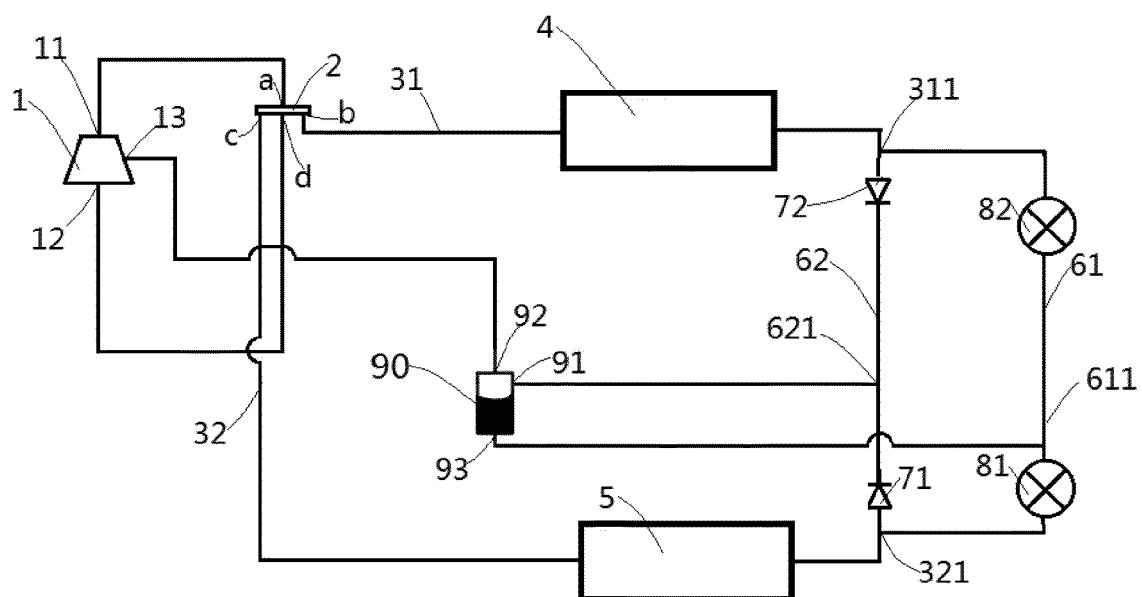


Figure 2

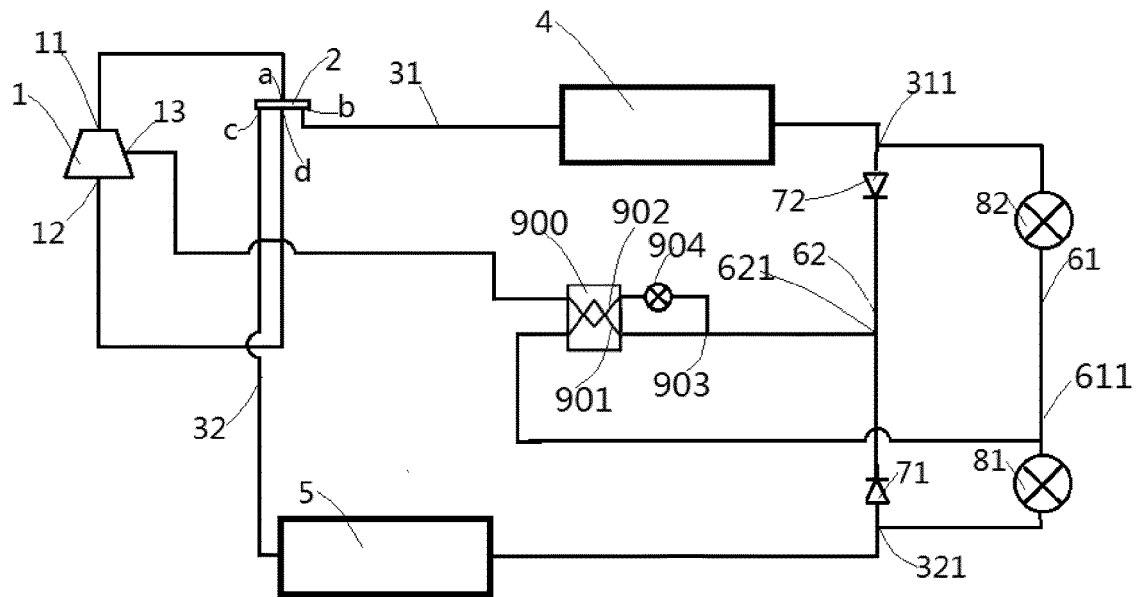


Figure 3

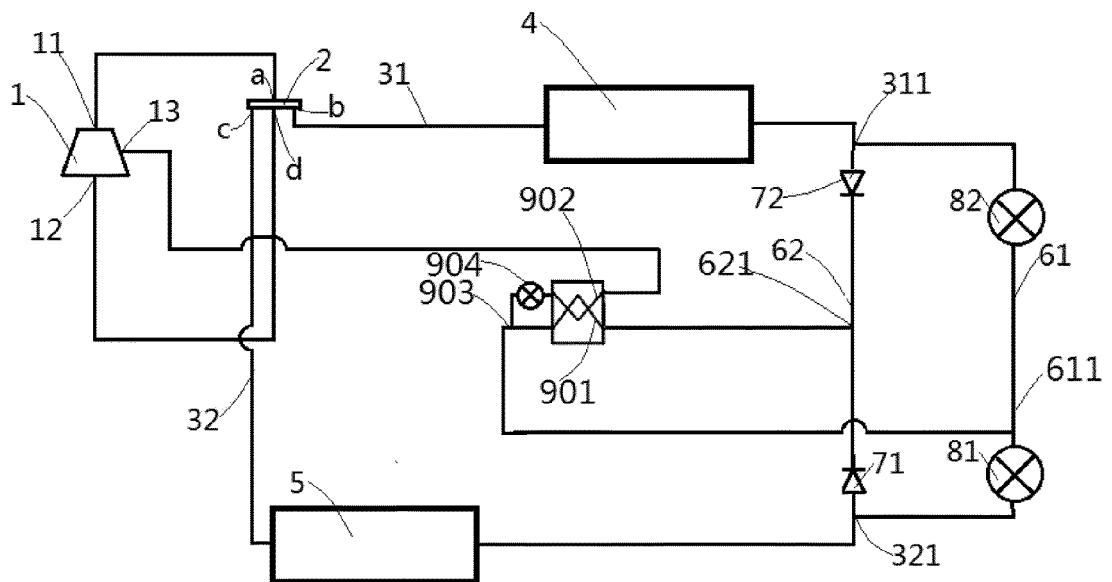


Figure 4



EUROPEAN SEARCH REPORT

Application Number

EP 23 16 2972

5

10

15

20

25

30

35

40

45

50

55

1

EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	CN 110 953 757 A (GREE ELECTRIC APPLIANCES INC ZHUHAI) 3 April 2020 (2020-04-03) * paragraphs [0006] - [0017]; figure 1 * -----	1-10	INV. F25B13/00 F25B41/20 F25B41/31 F25B41/30
X	EP 3 364 128 A1 (GREE ELECTRIC APPLIANCES INC ZHUHAI [CN]) 22 August 2018 (2018-08-22) * paragraphs [0030] - [0042]; figures * -----	1-10	
A	CN 114 001 484 A (ANHUI MEIZHI PREC MANUFACTURING CO LTD) 1 February 2022 (2022-02-01) * paragraph [0074] * -----	3	
A	WO 2009/131088 A1 (DAIKIN IND LTD [JP]; YOSHIMI ATSUSHI [JP]; FUJIMOTO SHUJI [JP]) 29 October 2009 (2009-10-29) * figures * -----	1-10	
A	US 5 172 564 A (REEDY WAYNE R [US]) 22 December 1992 (1992-12-22) * figures * -----	1-10	TECHNICAL FIELDS SEARCHED (IPC) F25B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 August 2023	Examiner Ritter, Christoph
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 23 16 2972

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

21-08-2023

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 110953757 A	03-04-2020	NONE	
EP 3364128 A1	22-08-2018	AU 2016337938 A1	31-05-2018
		CN 105258393 A	20-01-2016
		EP 3364128 A1	22-08-2018
		ES 2939167 T3	19-04-2023
		US 2018306473 A1	25-10-2018
		WO 2017063591 A1	20-04-2017
CN 114001484 A	01-02-2022	NONE	
WO 2009131088 A1	29-10-2009	AU 2009239043 A1	29-10-2009
		CN 102016457 A	13-04-2011
		EP 2295898 A1	16-03-2011
		JP 2009264606 A	12-11-2009
		KR 20100135923 A	27-12-2010
		US 2011030407 A1	10-02-2011
		WO 2009131088 A1	29-10-2009
US 5172564 A	22-12-1992	CA 2061482 A1	15-11-1992
		ES 2061353 A2	01-12-1994
		IT 1254740 B	10-10-1995
		JP H05223385 A	31-08-1993
		US 5172564 A	22-12-1992