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(71) Applicant: **Vaillant GmbH**
42859 Remscheid (DE)

(72) Inventor: **Jose Acedo Navarrete, Jose Acedo**
01010 Vitoria (Araba) (ES)

(74) Representative: **Hocker, Thomas**
Vaillant GmbH
Berghauser Strasse 40
42859 Remscheid (DE)

(54) Heat pump system with integrated economizer

(57) The present invention discloses a heat pump system including a compressor for compressing a refrigerant, a condenser downstream of the compressor for cooling the refrigerant, an expansion device downstream of the condenser for lowering the pressure of the refrigerant, an evaporator downstream of the expansion device for vaporizing the refrigerant, and an economizer for allowing an economizer flow and a refrigerant flow to pass therethrough and contact with each other in a heat transfer relationship. The economizer is integrated with one of the condenser and the evaporator to form an integral heat exchanger. In this way, conduits or piping between existing economizers and condensers/evaporators can be omitted, which results in a reduction cost in components and an increasement of space for layout of other components.

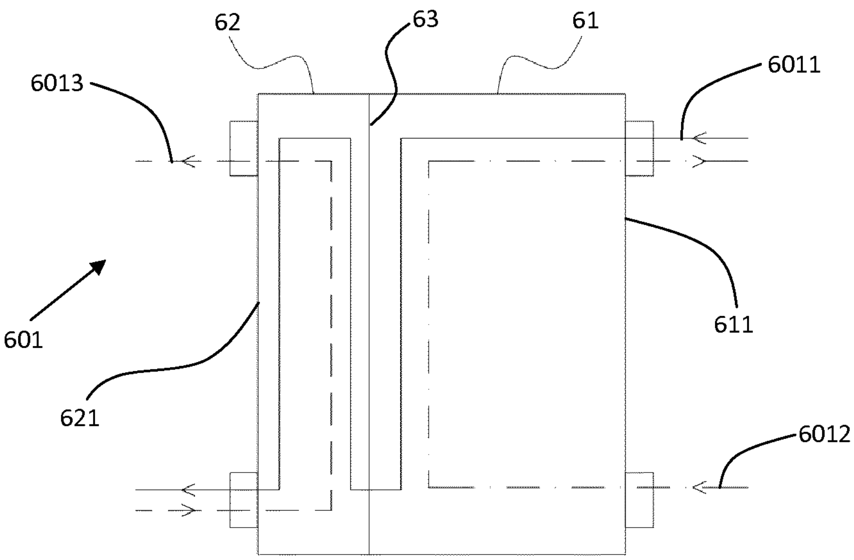

Fig. 1A

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a heat pump system, and more particularly to a heat pump system employing an economizer.

BACKGROUND OF THE INVENTION

[0002] A basic heat pump system typically has a compressor, a condenser, an expansion device, and an evaporator. These components are generally serially connected via conduits or piping and are well known in the art. During operation of the system, the compressor acts on relatively cool gaseous refrigerant to raise the temperature and pressure of the refrigerant. From the compressor, the high temperature, high pressure gaseous refrigerant flows into the condenser where it is cooled and exits the condenser as a high pressure liquid refrigerant. The high pressure liquid refrigerant then flows to an expansion device, which controls the amount of refrigerant entering into the evaporator. The expansion device lowers the pressure of the liquid refrigerant before allowing the refrigerant to flow into the evaporator. In the evaporator, the low pressure, low temperature refrigerant absorbs heat and exits the evaporator as a saturated vapor having essentially the same pressure as when it entered the evaporator. The suction of the compressor then draws the gaseous refrigerant back to the compressor where the cycle begins again.

[0003] It is well known to utilize economizers to improve the COP (Coefficient Of Performance) of the heat pump systems. The economizer can be a typical heat exchange device which is made of an aluminum and stainless steel alloy. As shown in Figs. 4A through 4C, the economizer 70 includes two pairs of inlet/outlet ports respectively for a refrigerant flow 701 and a secondary flow 702 (also called an economizer flow in this case) passing therethrough and contacting with each other in a heat transfer relationship. Fig. 4D shows one application of the economizer in a subcooler/superheater function. The system typically has a compressor 81, a condenser 82, an expansion device 83, and an evaporator 84. The economizer 70 is connected between the output of the condenser 82 and the input to the expansion device 83, and between the output of the evaporator 84 and the input to the compressor 81. In operation of the system 801, the higher temperature liquid refrigerant exists the condenser 82 and flows into the economizer 70, in the meantime, the lower temperature gaseous refrigerant (namely the economizer flow) flows from the evaporator 84 into the economizer 70 to contact with the higher temperature liquid refrigerant in a heat exchange relationship. As a result, the liquid refrigerant leaving from the condenser 82 is further cooled and has a higher temperature difference after leaving the economizer 70, thereby absorbing more heat as it flows through the evaporator 84.

[0004] Fig. 4E shows another application of the economizer in evaporator for vapor injection function. In this case, the economizer 70 taps off a part of the refrigerant flow (namely the economizer flow) downstream of the condenser 82. The tapped refrigerant passes through an additional expansion device 831, and then through the economizer 70 in a heat transfer relationship with the main refrigerant flow flowing through a separate conduit within the economizer 70. Then the tapped refrigerant returns through a vapor injection line to an intermediate-pressure point of the compressor 81 to have a higher mass flow in the compressor 81 and thus a higher heating capacity. Fig. 4F shows an alternative case of the economizer for vapor injection function. Compared with the case as shown in Fig. 4E, the main difference is that an additional expansion device 832 takes a part of the refrigerant flow after the high pressure side of the economizer 70.

[0005] However, introduction of economizers in heat pump systems obviously increases the cost and size of the system, therefore, it is desired to obtain a saving cost and compact size heat pump system with improved efficiency as an economizer is introduced.

SUMMARY OF THE INVENTION

[0006] It is an object of present invention to provide a heat pump system employing an integrated economizer, thereby reducing the cost and saving the space.

[0007] According to one aspect of the present invention there is provided a heat pump system including a compressor for compressing a refrigerant, a condenser downstream of the compressor for cooling the refrigerant, an expansion device downstream of the condenser for lowering the pressure of the refrigerant, an evaporator downstream of the expansion device for vaporizing the refrigerant, and an economizer for allowing an economizer flow and a refrigerant flow to pass therethrough and contact with each other in a heat transfer relationship. The economizer is integrated with one of the condenser and the evaporator to form an integral heat exchanger. In this way, conduits or piping between existing economizers and condensers/evaporators can be omitted, which results in a reduction cost in components and an increasement of space for layout of other components.

[0008] Preferably, the integral heat exchanger includes an economizer part and a condenser/evaporator part; wherein the refrigerant flow passes through the condenser/evaporator part and the economizer part, and the economizer flow exchanges heat with the refrigerant flow in the economizer part, and a secondary flow which is different from the refrigerant flow, such as water flow or air flow, exchanges heat with the refrigerant flow in the condenser/evaporator part.

[0009] Preferably, the integral heat exchanger is a plate-to-plate heat exchanger.

[0010] Preferably, the integral heat exchanger includes a refrigerant inlet port disposed at a first side thereof, a refrigerant outlet port disposed at a second side thereof, a secondary inlet port and a secondary outlet port disposed at the first side, and an economizer inlet port and an economizer outlet port disposed at the second side; wherein the refrigerant flow passes from the refrigerant inlet port to the refrigerant outlet port, the economizer flow passes from the economizer inlet port to the economizer outlet port and exchanges heat with the refrigerant flow, and a secondary flow which is different from the refrigerant flow, such as water flow or air flow, passes from the secondary inlet port to the secondary outlet port and exchanges heat with the refrigerant flow.

[0011] Preferably, the integral heat exchanger includes a spacer plate disposed between the first and the second sides, and the spacer plate separates the economizer flow and the secondary flow while allowing the refrigerant flow to pass therethrough. By this means, the spacer plate forms a boundary or a connection between the condenser/evaporator and the economizer, which can be a common plate that constitutes the last plate of the condenser/evaporator and the first plate of the economizer.

[0012] Preferably, the economizer flow includes at least a part of the refrigerant flow. In one case, the economizer flow consists of a part of the refrigerant flow tapped from a main refrigerant flow; and in another case, the economizer flow consists of a refrigerant flow at different temperature or status with respect to the refrigerant flow at the time in heat transfer relationship with the economizer flow.

[0013] In one example, the integral heat exchanger combines the economizer and the condenser, and the refrigerant flow passes from the compressor to the integral heat exchanger, to the expansion device, to the evaporator, and back to the integral heat exchanger as the economizer flow, and then returns to the compressor.

[0014] In another example, the integral heat exchanger combines the economizer and the evaporator, and the refrigerant flow passes from the compressor to the condenser, to the integral heat exchanger as the economizer flow, and then to the expansion device, to the integral heat exchanger again for being vaporised, and returns to the compressor.

[0015] In another example, the integral heat exchanger combines the economizer and the condenser, and the refrigerant flow passes from the compressor to the integral heat exchanger, to the expansion device, to the evaporator, and returns to the compressor. Moreover, the heat pump system includes an additional expansion device; wherein a part of the refrigerant flow exiting from the integral heat exchanger is supplied to the additional expansion device, and then goes back to the integral heat exchanger as the economizer flow. In one embodiment, the part of the refrigerant flow is tapped from the main refrigerant flow exiting from the integral heat exchanger, and in an alternative embodiment, the part of the refrigerant flow is tapped from the main refrigerant flow within the integral heat exchanger. Furthermore, the part of the refrigerant flow returns to the compressor through a vapor injection line; in a variable embodiment, the compressor includes a first-stage compressor means and a second-stage compressor means that are connected by an interstage line, and the part of the refrigerant flow is further supplied to the interstage line.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

Fig. 1A is a plane view schematically showing an integral heat exchanger in accordance with a first embodiment of present invention;

Fig. 1B is a perspective view of the integral heat exchanger as shown in Fig. 1 A;

Figs. 1C and 1D are cross-sectional views respectively taken along lines A1-A1, B1-B1 of Fig. 1B for schematically showing a refrigerant flow, a secondary flow, and an economizer flow passing through the integral heat exchanger as show in Fig. 1 A;

Fig. 1E shows an example of the heat pump system with the integral heat exchanger as shows in Fig. 1A, wherein the integral heat exchanger combines a condenser and an economizer in subcooler/superheater function;

Fig. 1F shows another example of the heat pump system with the integral heat exchanger as shown in Fig. 1A, wherein the integral heat exchanger combines a condenser and an economizer for vapor injection application;

Fig. 1G shows another example of the heat pump system with the integral heat exchanger as shown in Fig. 1A, wherein the integral heat exchanger combines a condenser and an economizer for two-stage compressor application;

Fig. 2A is a plane view schematically showing an integral heat exchanger in accordance with a second embodiment of present invention;

Fig. 2B is a perspective view of the integral heat exchanger as shown in Fig. 2A;

Figs. 2C and 2D are cross-sectional views respectively taken along lines A3-A3, B3-B3 of Fig. 2B for schematically showing a main refrigerant flow, a secondary flow, an economizer flow, and a tapped refrigerant flow passing through the integral heat exchanger as show in Fig. 2A;

Fig. 2E shows an example of the heat pump system with the integral heat exchanger as shown in Fig. 2A, wherein the integral heat exchanger combines a condenser and an economizer for vapor injection application;

Fig. 2F shows another example of the heat pump system with the integral heat exchanger as shown in Fig. 2A, wherein the integral heat exchanger combines a condenser and an economizer for two-stage compressor application;

Fig. 3A is a plane view schematically showing an integral heat exchanger in accordance with a third embodiment of present invention;

Fig. 3B is a perspective view of the integral heat exchanger as shown in Fig. 3A;

Figs. 3C and 3D are cross-sectional views respectively taken along lines A2-A2, B2-B2 of Fig. 3B for schematically showing a refrigerant flow, a secondary flow, and an economizer flow passing through the integral heat exchanger as show in Fig. 3A;

Fig. 3E shows an example of the heat pump system with the integral heat exchanger as shows in Fig. 3A, wherein the integral heat exchanger combines an evaporator and an economizer in subcooler/superheater function;

Fig. 4A is a perspective view schematically showing an economizer heat exchanger in state of art;

Figs. 4B and 4C are cross-sectional views respectively taken along lines A-A, B-B of Fig. 4A for schematically showing a refrigerant flow and a secondary flow passing through the economizer heat exchanger as shown in Fig. 4A;

Fig. 4D shows an example of the heat pump system with the economizer heat exchanger as shown in Fig. 4A, wherein the economizer heat exchanger is employed for subcooler/superheater function;

Fig. 4E shows another example of the heat pump system with the economizer heat exchanger as shown in Fig. 4A, wherein the economizer heat exchanger is employed for vapor injection application;

Fig. 4F shows another example of the heat pump system similar to that in Fig. 4E, and the main difference is that an additional expansion device takes a part of the refrigerant flow after the high pressure side of the economizer heat exchanger.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] Reference will now be made to the drawing figures to describe the preferred embodiments of the present invention in detail. However, the embodiments can not be used to restrict the present invention. Changes such as structure, method and function obviously made to those of ordinary skill in the art are also protected by the present invention.

[0018] Heat pumps can be used for heating purpose, like supplying hot sanitary water, or heating building interiors. Refer to Figs. 1E and 3E, a heat pump typically includes a compressor 20, a condenser 30, an expansion device 40, and an evaporator 50. These components are generally serially connected via conduits or piping. The compressor 20 generally uses electrical power to compress a refrigerant form a low pressure gaseous state to a high pressure gaseous state thereby increasing the temperature, enthalpy and pressure of the refrigerant. The condenser 30 is typically in form of a heat exchanger well known in the state of art. The gaseous refrigerant leaves from the compressor 20 and then flows through the condenser 30 for being condensed at a substantially constant pressure to a saturated liquid state. As a result, the heat transfers from the refrigerant to a secondary flow, for example a water flow, created by a DC pump, such as indicated 90 in Fig. 1E. The expansion device 40 is used to control the amount of refrigerant entering into the evaporator 50. The liquid refrigerant from the condenser 30 flows through the expansion device 40, result in the pressure of the liquid is decreased. In the process, the refrigerant evaporates partially causing the refrigerant to change to a mixed liquid-gaseous state, reducing its temperature down to a value that makes possible heat exchanges in the evaporator. The evaporator 50 is a heat exchanger where the heat energy available in a secondary flow, such as an external air flow, passes through it and transfers to the refrigerant flow that evaporates inside from liquid to gas. Heat pumps can further include components in the refrigerant circuit for inversion of the refrigerant cycle, thus, heat pumps can also be used for cooling building interiors.

[0019] In this invention, an economizer heat exchanger is introduced. The economizer heat exchanger is integrated with the condenser heat exchanger or the evaporator heat exchanger to form an integral heat exchanger. Figs. 1A, 2A, and 3A show integral heat exchangers 601, 602, 603 in accordance with three embodiments of present invention. These integral heat exchangers have very similar configurations, but fluid passes through them in different ways for different applications. Also refer to Figs. 1B through 1D, 2B through 2D, and 3B through 3D, the integral heat exchanger 601, 602, 603 is preferably a plate-to-plate heat exchanger which consists of a number of plates made of stainless steel, and it includes a condenser/evaporator part 61 and an economizer part 62. The "condenser/evaporator part" may be referred as "condenser part" in some examples and "evaporator part" in other examples, which will be exemplified and described in details hereinafter. A refrigerant flow 6011, 6021, 6031 passes through the condenser/evaporator part 61 and the economizer part 62, an economizer flow 6013, 6023, 6033 contacts with the refrigerant flow 6011, 6021, 6031 in the heat transfer relationship in the economizer part 62, and a secondary flow 6012, 6022, 6032 which is different from the refrigerant flow, such as a water flow or an air flow, contacts with the refrigerant flow 6011, 6021, 6031 in a heat transfer relationship in the condenser/evaporator part 61. The integral heat exchanger 60 has a first side 611, a second side 621 opposite to the first side 611, and a spacer plate 63 disposed between the first and the second sides 611, 621. The spacer plate 63 forms a boundary or connection between the condenser/evaporator part 61 and the economizer part 62, and it separates the economizer flow 6013, 6023, 6033 and the secondary flow 6012, 6022, 6032 while allowing the refrigerant flow 6011, 6021, 6031 to pass therethrough.

[0020] Refer to Figs. 1B through 1D, in the first embodiment, the integral heat exchanger 601 defines a refrigerant inlet port 641, a secondary inlet port 643, a secondary outlet port 644 at the first side, and defines a refrigerant outlet port 642, an economizer inlet port 645, an economizer outlet port 646 at the second side. The refrigerant flow 6011 passes from the refrigerant inlet port 641 to the refrigerant outlet port 642, and the economizer flow 6013 passes from the economizer inlet port 645 to the economizer outlet port 646 and exchanges heat with the refrigerant flow 6011, and the secondary flow 6012 passes from the secondary inlet port 643 to the secondary outlet port 644 and exchanges heat with the refrigerant flow 6011.

[0021] Fig. 1E shows an example of a heat pump system 101 employing the integral heat exchanger 601 in accordance with the first embodiment. In this example, the integral heat exchanger 601 combines a condenser and an economizer in subcooler/superheater function, and the refrigerant flow 6011 passes from the compressor 20 to the integral heat exchanger 601, to the expansion device 40, to the evaporator 50, and back to the integral heat exchanger 601 as the economizer flow 6023, and then returns to the compressor 20. Fig. 1F shows another example of a heat pump system 102 with the integral heat exchanger 601, wherein the integral heat exchanger 601 combines a condenser and an economizer for vapor injection application. In this example, the heat pump system 102 further includes an additional expansion device 41. A part of the refrigerant flow tapped from the main refrigerant flow 6011 exiting from the integral heat exchanger 601 is supplied to the additional expansion device 41, and goes back to the integral heat exchanger 601 as the economizer flow 6013, then the economizer flow 6013 returns to the compressor 20 through a vapor injection line 201.

[0022] Fig. 1G shows an example of a heat pump system 103 similar to that shown in Fig. 1F. The heat pump system 103 employs the integral heat exchanger 601 which combines a condenser and an economizer for two-stage compressor application. In this example, the compressor includes a first-stage compressor means 21 and a second-stage compressor means 22. The two compressor means 21, 22 may be separate compressors or two portions of the same compressor, and they are connected by an interstage line 211 and serially compress gaseous refrigerant to a higher pressure and temperature. Similar to the heat pump system 102 shown in Fig. 1F, a part of the refrigerant flow tapped from the main refrigerant flow 6011 exiting from the integral heat exchanger 601 is supplied to the additional expansion device 41, and goes back to the integral heat exchanger 601 as the economizer flow 6013. The economizer flow 6013 leaving from the integral heat exchanger 601 is further supplied to the interstage line 211 and then into the second-stage compressor means 22.

[0023] Figs. 2A through 2D show a second embodiment of an integral heat exchanger 602. With respect to the integral heat exchanger 601 of the first embodiment, in this embodiment, there is a condenser outlet port 647 defined at the first side of the integral heat exchanger 602. When the refrigerant flow 6021 sequentially passes through the condenser/evaporator part 61 and the economizer part of the integral heat exchanger 602, a part of the refrigerant flow 6024 is tapped from the main refrigerant flow 6021 after the main refrigerant flow 6021 exchanging heat with the secondary flow 6022 and then flows out of the integral heat exchanger 602 through the condenser outlet port 647.

[0024] Fig. 2E shows an example of a heat pump system 104 employing the integral heat exchanger 602. The heat pump system 104 combines a condenser and an economizer for vapor injection application. In this example, the heat pump system 104 also includes an additional expansion device 42. The tapped refrigerant flow 6024 exiting from the integral heat exchanger 602 through the condenser outlet port 647 is supplied to the additional expansion device 42, and goes back to the integral heat exchanger 602 as the economizer flow 6023, then the economizer flow 6023 returns to the compressor 20 through a vapor injection line 201.

[0025] Fig. 2F shows another example of a heat pump system 105 employing the integral heat exchanger 602 combining a condenser and an economizer. Same as the compressor of the example show in Fig. 1G, in this example, the compressor includes the first-stage compressor means 21 and the second-stage compressor means 22 that are connected by the interstage line 211. The tapped refrigerant flow 6024 exiting from the integral heat exchanger 602 is supplied to the additional expansion device 42, and goes back to the integral heat exchanger 602 as the economizer flow 6023. The economizer flow 6023 leaving from the integral heat exchanger 602 is further supplied to the interstage line 211 and then into the second-stage compressor means 22.

[0026] Figs. 3A through 3D show a third embodiment of an integral heat exchanger 603. In this embodiment, the integral heat exchanger 603 combines an evaporator and an economizer. Fig. 3E shows an example of a heat pump system 106 employing the integral heat exchanger 603 in subcooler/superheater function. The refrigerant flow 6031 passes from the compressor 20 to the condenser 30, to the integral heat exchanger 603 as the economizer flow, to the expansion device 40, and back to the integral heat exchanger 603 for being vaporized, and then returns to the compressor 20.

[0027] The integral heat exchangers described in previous embodiments can take a complete same configuration with four inlet/outlet ports disposed at each of the front and the back sides thereof, and these inlet/outlet ports can be selectively adopted according to different applications.

[0028] The integral heat exchanger communicates an economizer and a condenser/evaporator internally, which omits conduits or piping between existing economizers and condensers/evaporators, resulting in a reduction cost in components and an increasement of space for layout of other components.

[0029] It is to be understood, however, that even though numerous, characteristics and advantages of the present invention have been set forth in the foregoing description, together with details of the structure and function of the invention, the disclosed is illustrative only, and changes may be made in detail, especially in matters of number, shape, size, and arrangement of parts within the principles of the invention to the full extent indicated by the broadest general meaning of the terms in which the appended claims are expressed.

Claims

1. A heat pump system comprising:

> a compressor for compressing a refrigerant, a condenser downstream of the compressor for cooling the refrigerant, an expansion device downstream of the condenser for lowering the pressure of the refrigerant, an evaporator downstream of the expansion device for vaporizing the refrigerant; and
> an economizer for allowing an economizer flow and a refrigerant flow to pass therethrough and contact with each other in a heat transfer relationship; wherein
> the economizer is integrated with one of the condenser and the evaporator to form an integral heat exchanger.

2. A heat pump system according to claim 1, wherein the integral heat exchanger comprises an economizer part and a condenser/evaporator part; wherein the refrigerant flow passes through the condenser/evaporator part and the economizer part, and the economizer flow exchanges heat with the refrigerant flow in said economizer part, and a secondary flow which is different from the refrigerant flow exchanges heat with the refrigerant flow in said condenser/evaporator part.

3. A heat pump system according to claim 1, wherein the integral heat exchanger is a plate-to-plate heat exchanger.

4. A heat pump system according to claim 3, wherein the integral heat exchanger comprises a refrigerant inlet port disposed at a first side thereof, a refrigerant outlet port disposed at a second side thereof, a secondary inlet port and a secondary outlet port disposed at said first side, and an economizer inlet port and an economizer outlet port disposed at said second side; wherein the refrigerant flow passes from the refrigerant inlet port to the refrigerant outlet port, the economizer flow passes from the economizer inlet port to the economizer outlet port and exchanges heat with the refrigerant flow, and a secondary flow which is different from the refrigerant flow passes from the secondary inlet port to the secondary outlet port and exchanges heat with the refrigerant flow.

5. A heat pump system according to claim 4, wherein the integral heat exchanger further comprises a spacer plate disposed between said first and said second sides, and said spacer plate separates the economizer flow and the secondary flow while allowing the refrigerant flow to pass therethrough.

6. A heat pump system according to claim 1, wherein the economizer flow includes at least a part of the refrigerant flow.

7. A heat pump system according to claim 1, wherein the integral heat exchanger combines the economizer and the condenser, and the refrigerant flow passes from the compressor to the integral heat exchanger, to the expansion device, to the evaporator, and back to the integral heat exchanger as the economizer flow, and then returns to the compressor.

8. A heat pump system according to claim 1, wherein the integral heat exchanger combines the economizer and the evaporator, and the refrigerant flow passes from the compressor to the condenser, to the integral heat exchanger as the economizer flow, and then to the expansion device, to the integral heat exchanger again for being vaporised, and returns to the compressor.

9. A heat pump system according to claim 1, wherein the integral heat exchanger combines the economizer and the condenser, and the refrigerant flow passes from the compressor to the integral heat exchanger, to the expansion device, to the evaporator, and returns to the compressor.

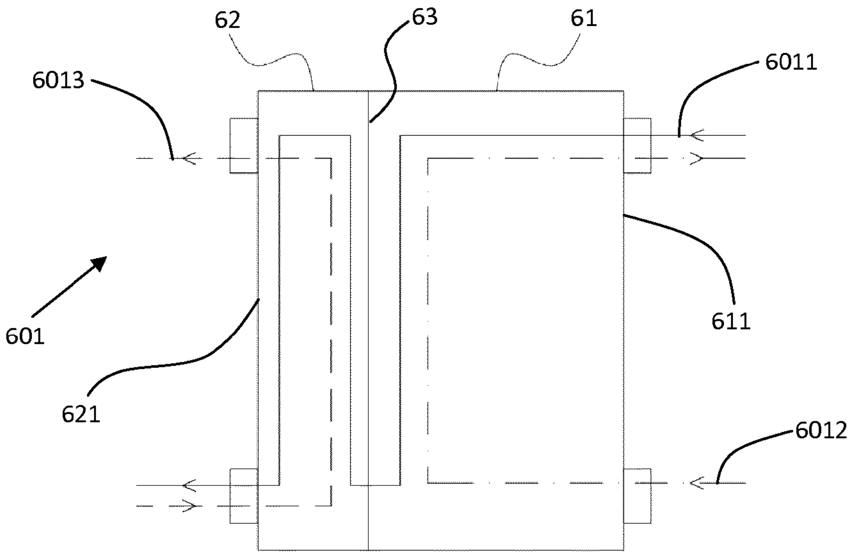
10. A heat pump system according to claim 9, further comprising an additional expansion device; wherein a part of the refrigerant flow exiting from the integral heat exchanger is supplied to said additional expansion device, and then goes back to the integral heat exchanger as the economizer flow.

11. A heat pump system according to claim 10, wherein said part of the refrigerant flow is tapped from the main refrigerant flow exiting from the integral heat exchanger.

12. A heat pump system according to claim 10, wherein said part of the refrigerant flow is tapped from the main refrigerant flow within the integral heat exchanger.

13. A heat pump system according to claim 10, wherein said part of the refrigerant flow returns to the compressor through a vapor injection line.

14. A heat pump system according to claim 10, wherein the compressor comprises a first-stage compressor means and a second-stage compressor means, and the first-stage and the second-stage compressor means are connected by an interstage line; wherein said part of the refrigerant flow is further supplied to said interstage line.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621
6012

Fig. 1A

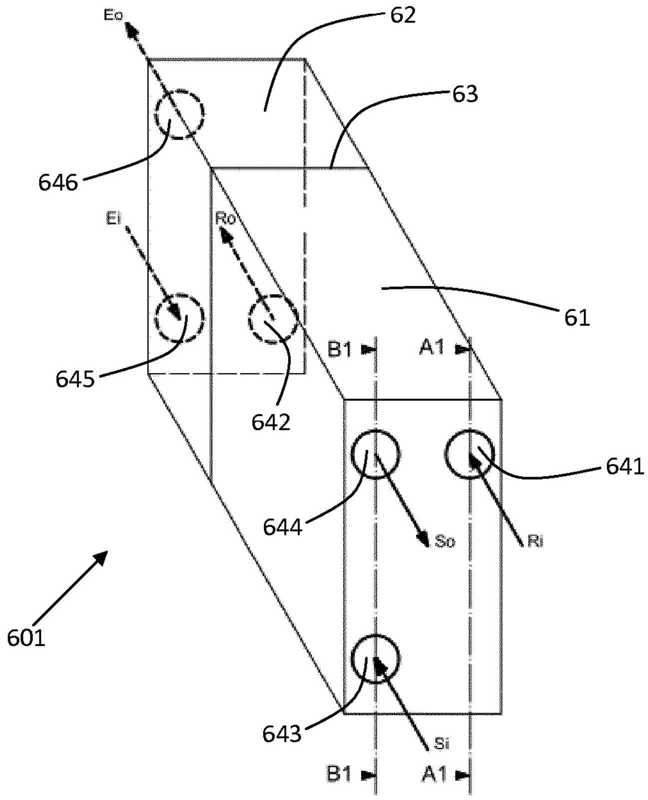
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Fig. 1B

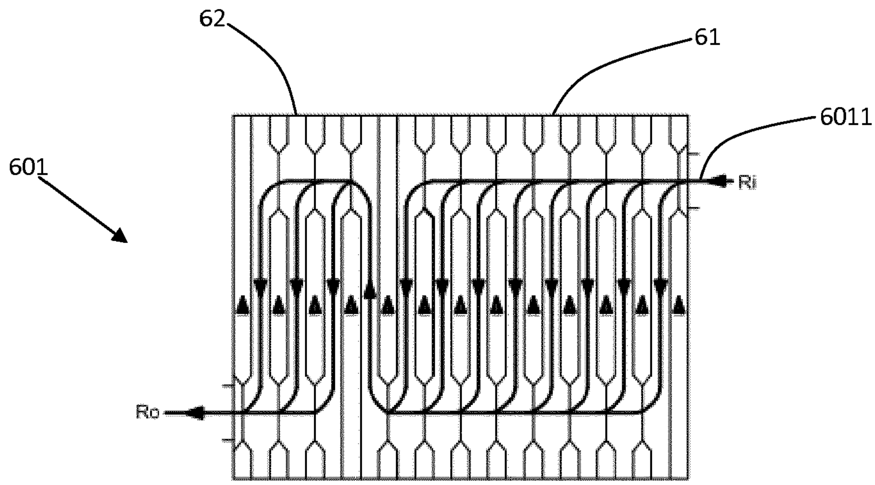


Fig. 1C

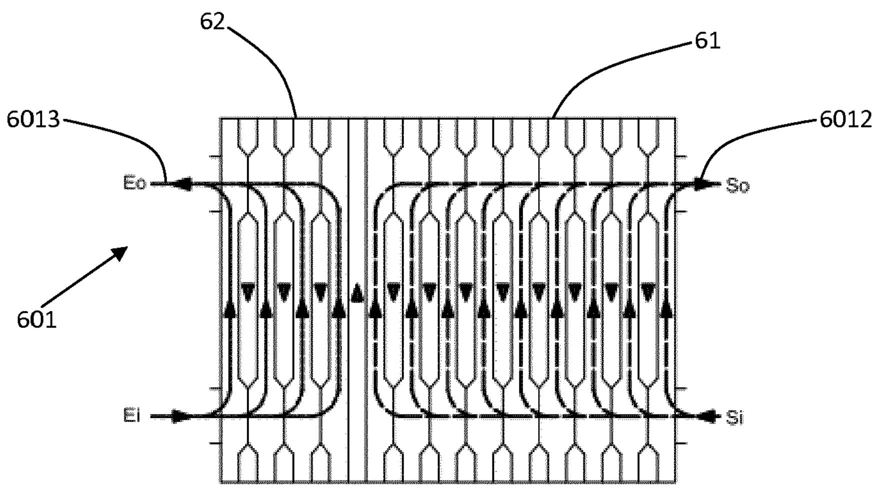
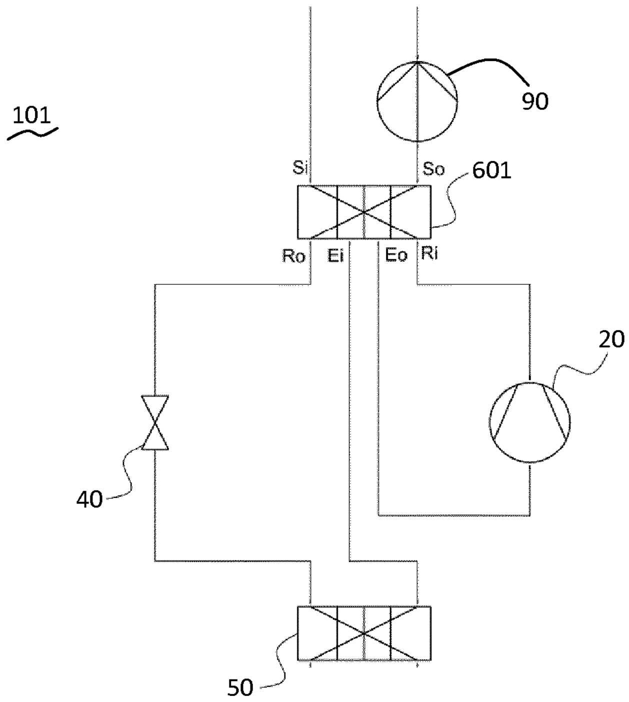


Fig. 1D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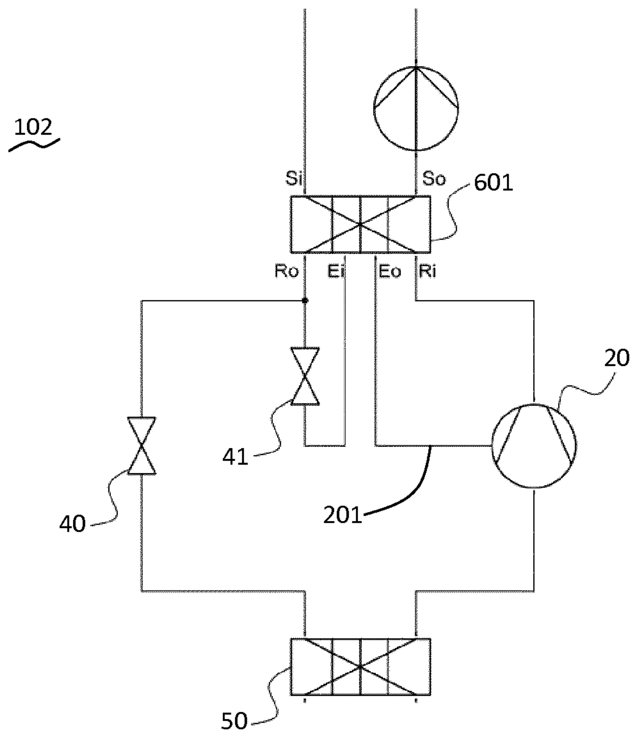
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Fig. 1F

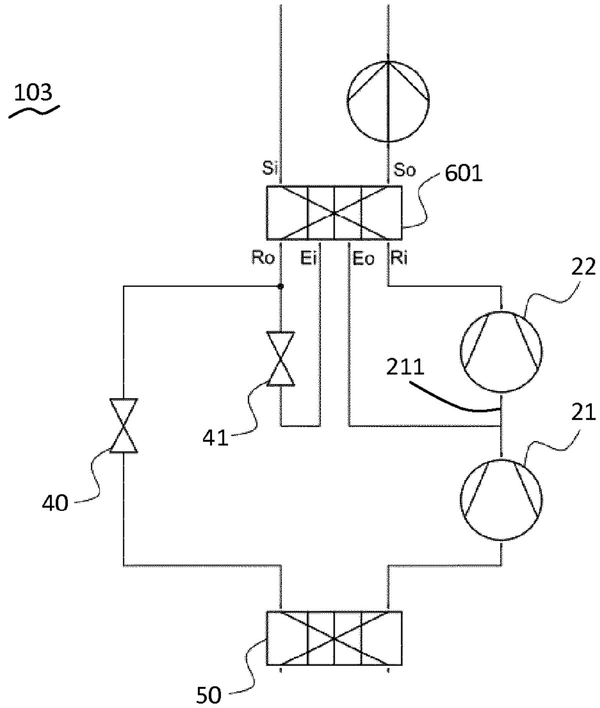
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Fig. 1G

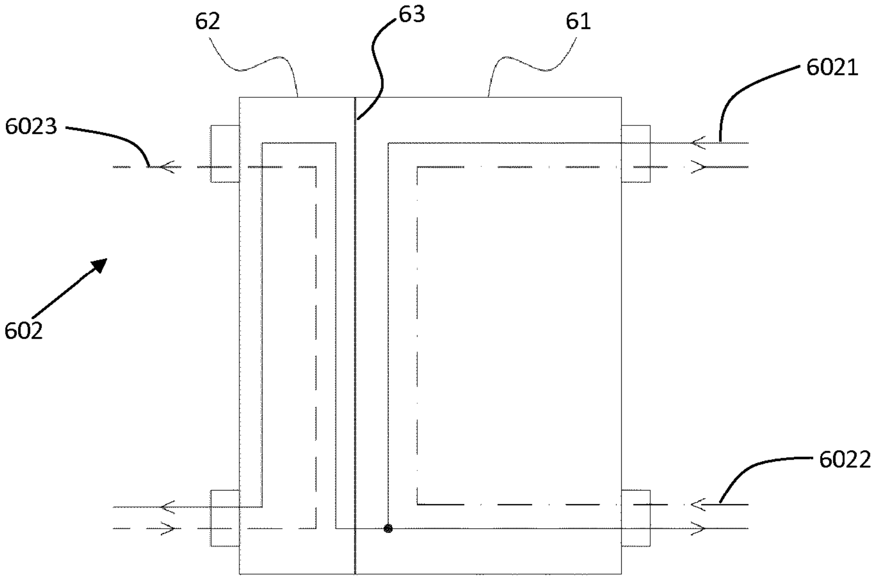
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Fig. 2A

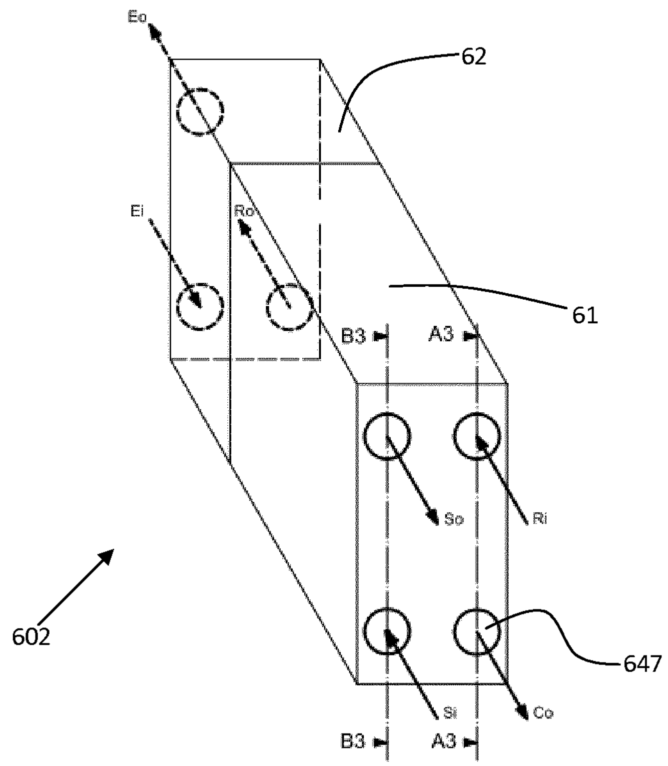
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Fig. 2B

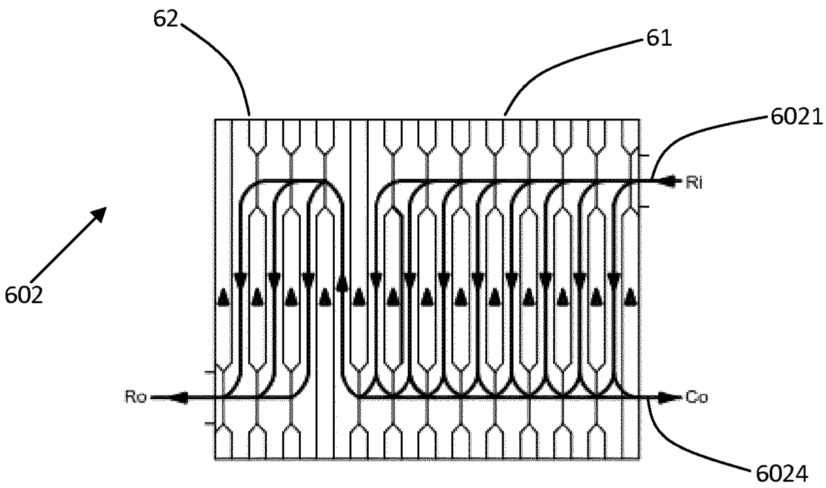
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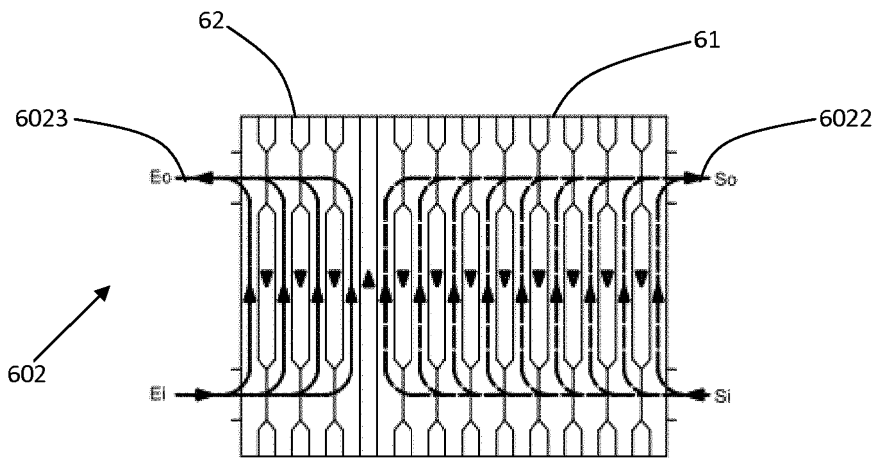
Fig. 2C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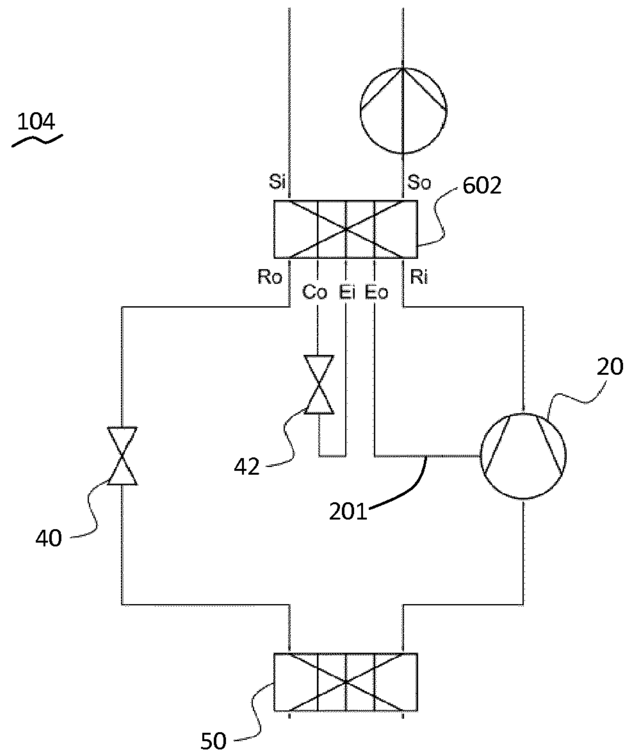
6023
6022
Eo
So
602
Ei
Si

Fig. 2D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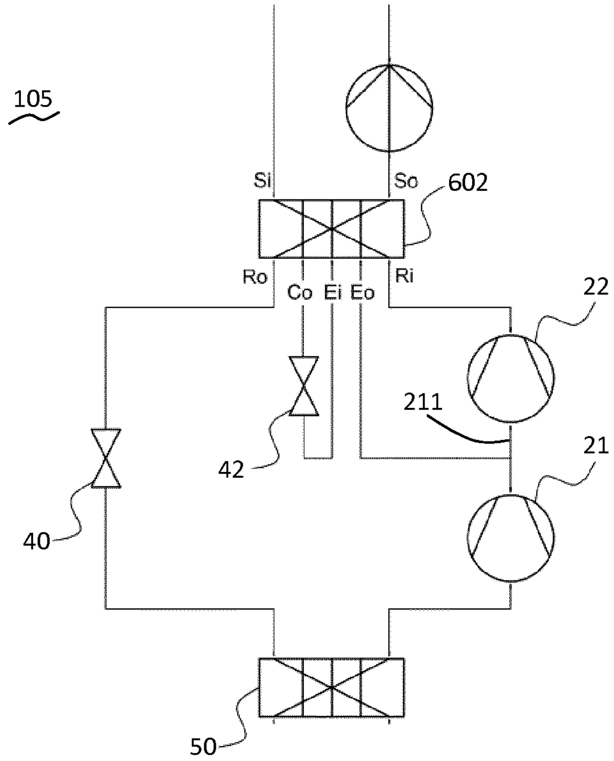
Si
So
602
Ro
Co
Ei
Eo
Ri
20
42
201
40
50

Fig. 2E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Eo
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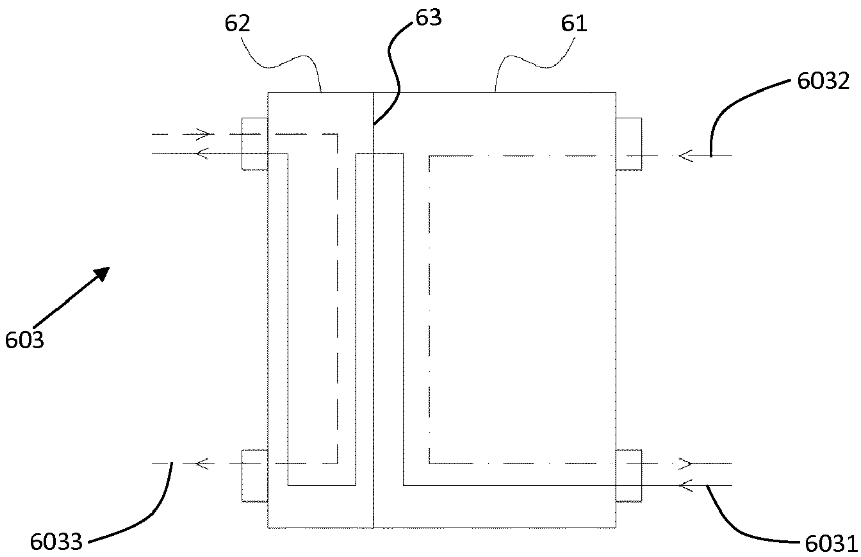
50

Fig. 2F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6031

Fig. 3A

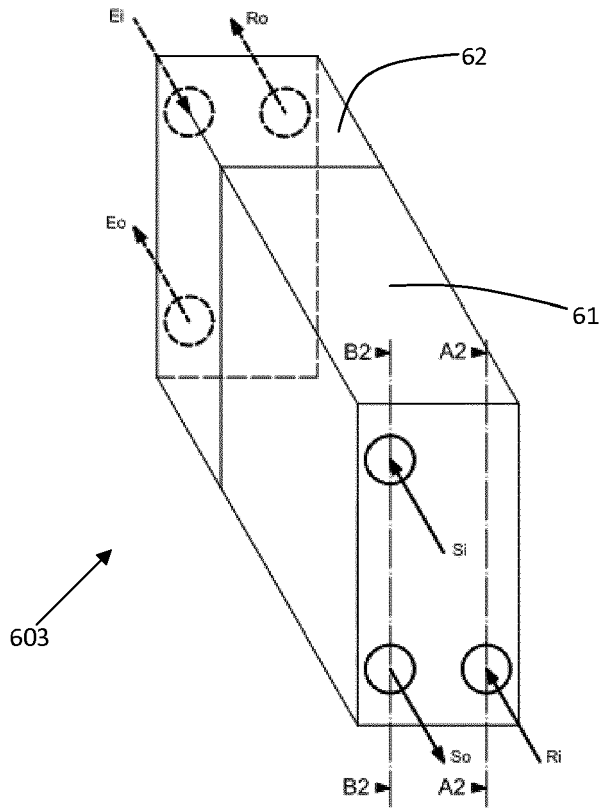

Fig. 3B

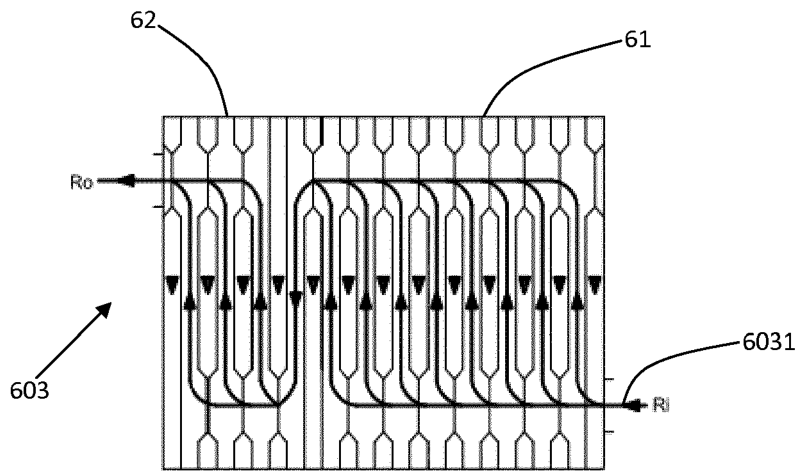

Fig. 3C

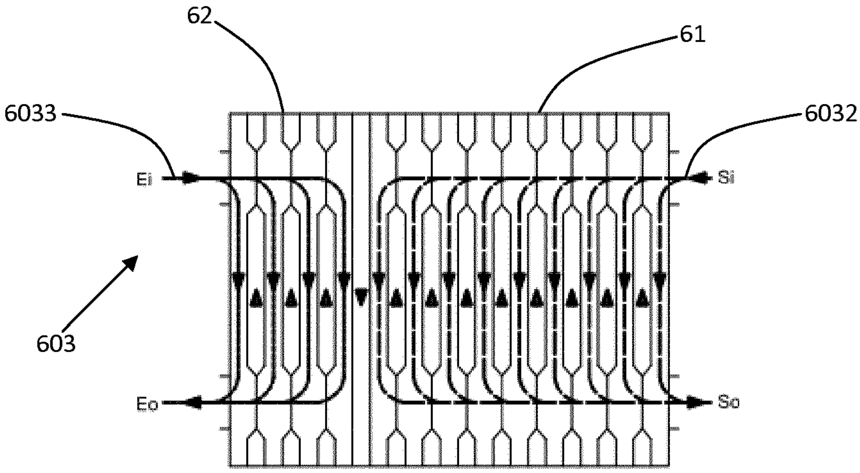

Fig. 3D

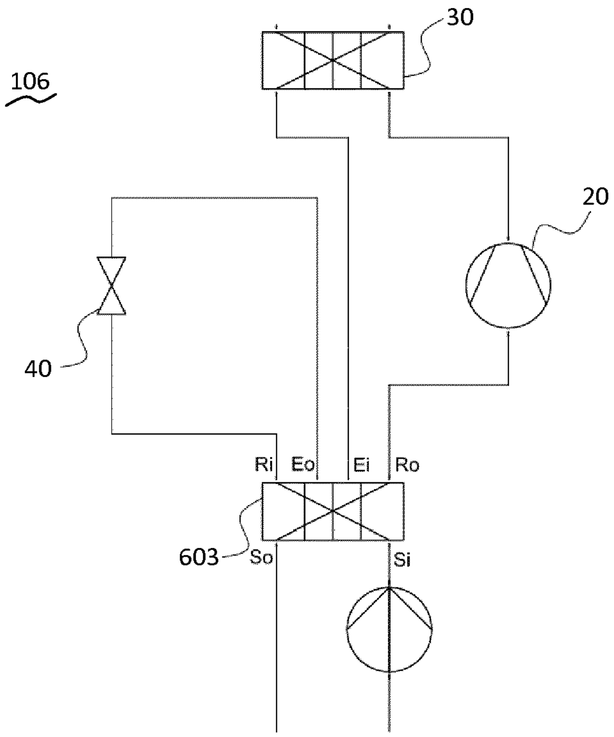

Fig. 3E

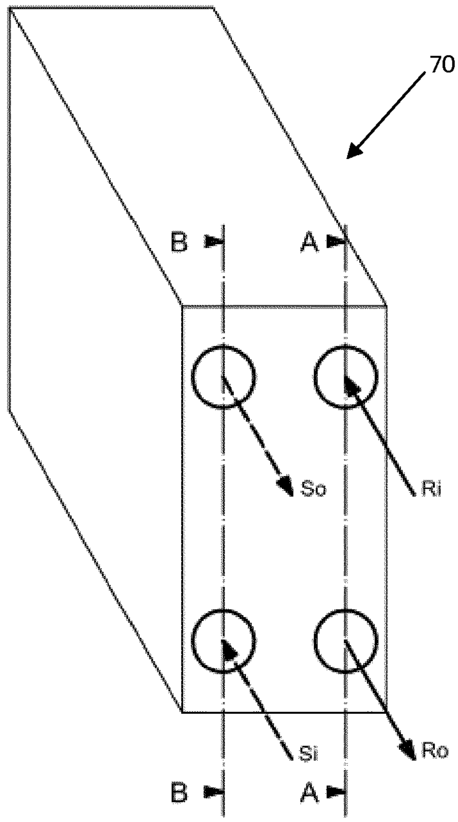

Fig. 4A(State of art)

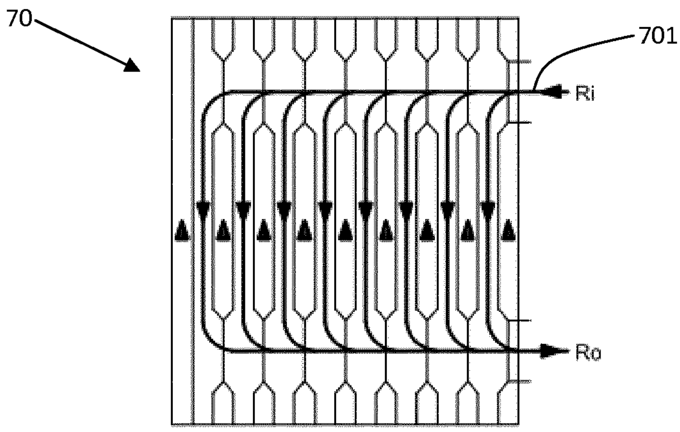

Fig. 4B(State of art)

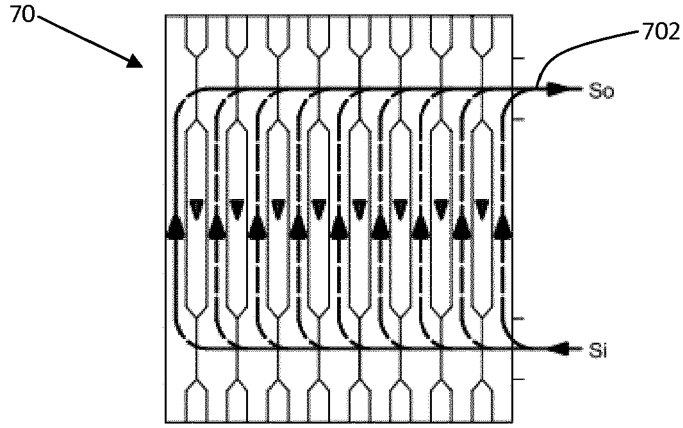

Fig. 4C(State of art)

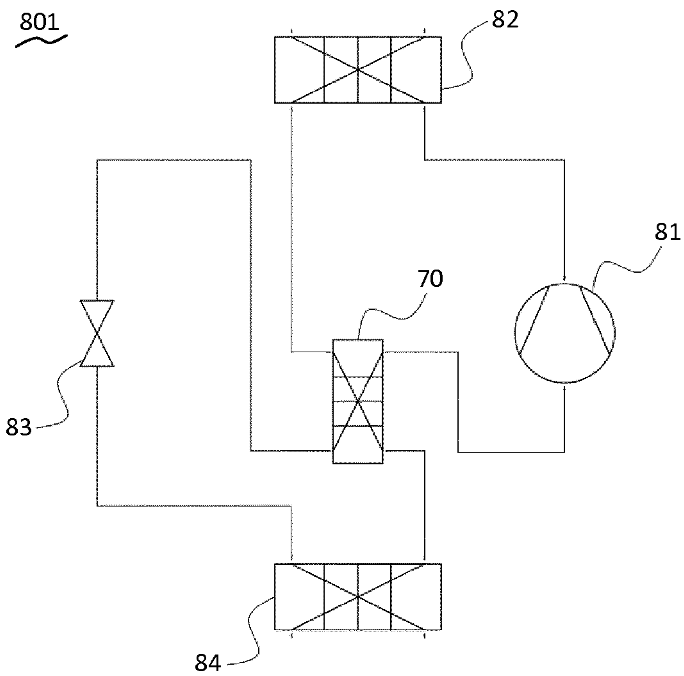

Fig. 4D(State of art)

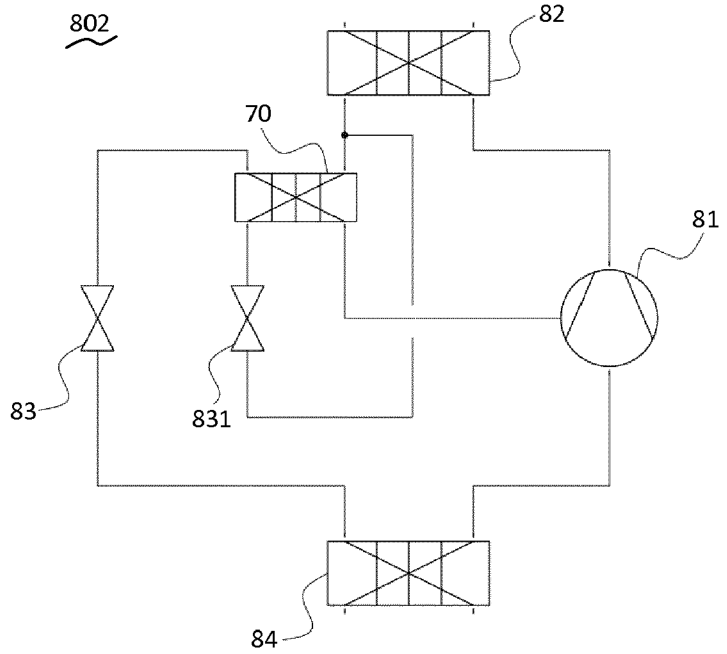

Fig. 4E(State of art)

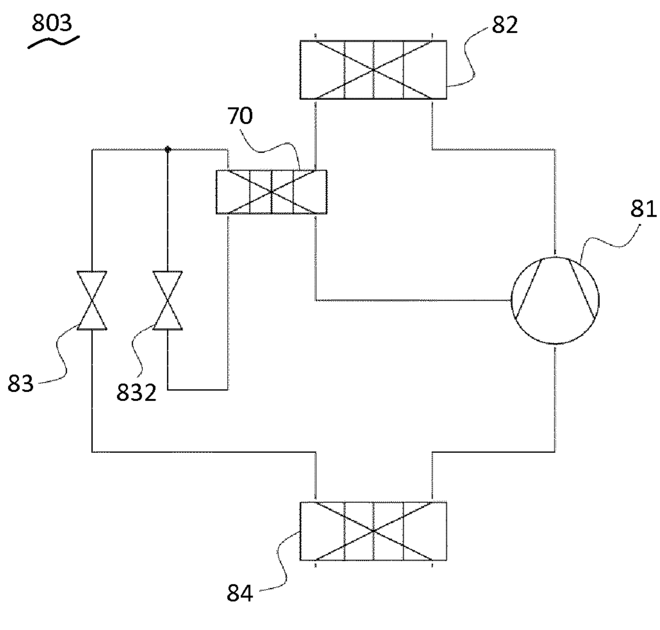

Fig. 4F(State of art)

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EUROPEAN SEARCH REPORT

Application Number
EP 14 17 1467

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 August 2014	Gasper, Ralf

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