



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
03.08.2011 Bulletin 2011/31

(51) Int Cl.:
F28D 7/10 (2006.01)

(21) Application number: **11150572.3**

(22) Date of filing: **11.01.2011**

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

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(30) Priority: **12.01.2010 KR 20100002865**

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(54) **Heat exchanger comprising three concentric tubes**

(57) A heat exchanger (800) is provided which may include a first heat exchange tube (100) in a pipe shape, including a first fluid inlet (102), into which a first fluid may be introduced and flow, and a first fluid outlet (105), through which the first fluid may be discharged; a second heat exchange tube (200) that passes through the first heat exchange tube (100), including a second fluid inlet (202), into which a second fluid may be introduced and flow, and a second fluid outlet (205), through which the second fluid may be discharged; and a third heat exchange tube (300) that includes a third fluid inlet (302), into which the second fluid discharged through the second fluid outlet (205) may be introduced and flow, and a third fluid outlet (305), through which the second fluid may be discharged, the third heat exchange tube (300) enclosing an external surface of the first heat exchange tube (100).

Fig. 1

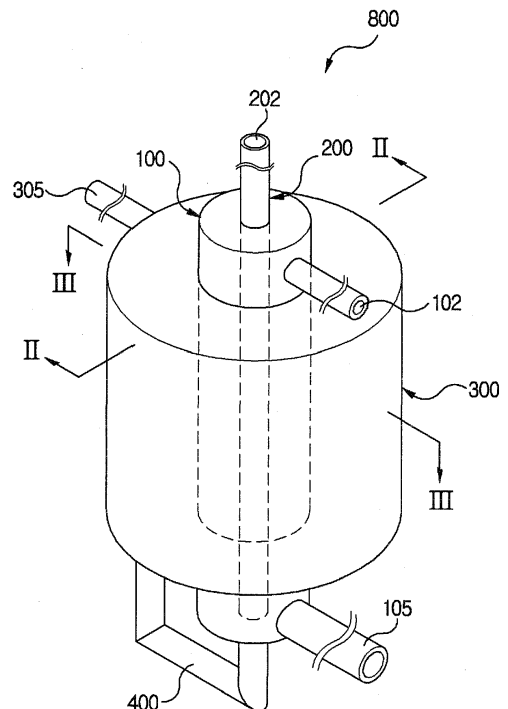
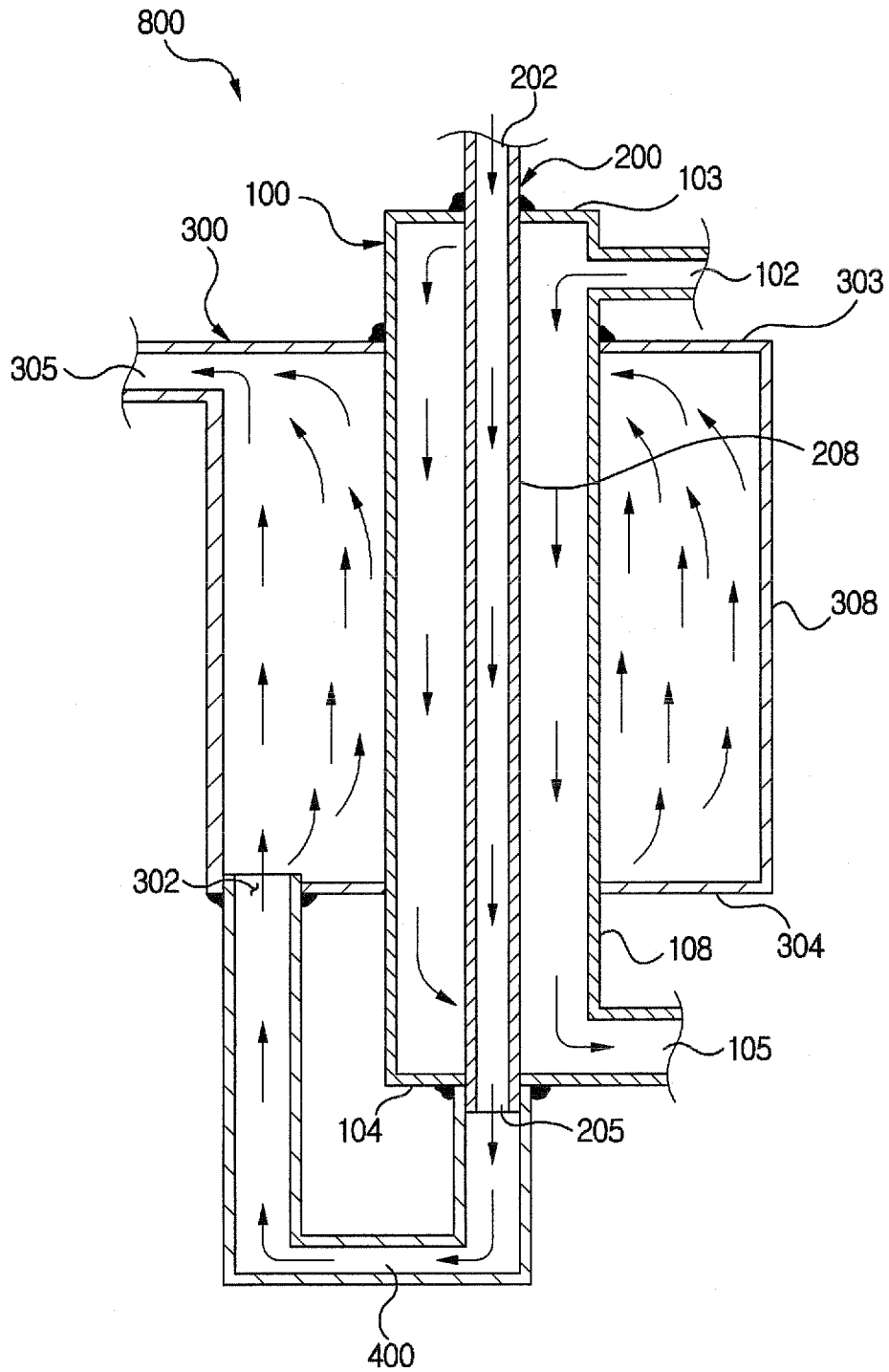


Fig. 3



Description

[0001] A heat exchanger is disclosed herein.

[0002] Heat exchangers are known. However, they suffer from various disadvantages.

[0003] Embodiments will be described in detail with reference to the following drawings in which like reference numerals refer to like elements, and wherein:

[0004] FIG. 1 is a perspective view of a heat exchanger according to an embodiment;

[0005] FIG. 2 is a cross sectional view of the heat exchanger of FIG. 1, taken along line II-II;

[0006] FIG. 3 is a longitudinal-sectional view of the heat exchanger of FIG. 1, taken along line 111-111 of FIG. 1;

[0007] FIG. 4 is a sectional view of a heat exchanger according to another embodiment;

[0008] FIG. 5 is a sectional view of a heat exchanger according to another embodiment;

[0009] FIG. 6 is a perspective view of a heat exchanger according to another embodiment;

[0010] FIG. 7 is a sectional view of the heat exchanger of FIG. 6; and

[0011] FIG. 8 is a sectional view of a heat exchanger according to another embodiment.

[0012] Hereinafter, embodiments will be described with reference to the accompanying drawings. In this disclosure, the size and shape of components shown in the drawings may be exaggerated for the sake of clarity and convenience. Further, terms that are specifically defined in consideration of construction and operation of the disclosed embodiments may be changed according to an operator's intention or custom. Definition of such items should be made on the basis of the entire contents of this disclosure.

[0013] A heat exchanger is an apparatus that reduces a temperature of a high temperature fluid and increases a temperature of a low temperature fluid by transferring thermal energy from the high temperature fluid to the relatively low temperature fluid. Such a heat exchanger may be utilized in, for example, a heater, a cooler, an evaporator, or a condenser.

[0014] In such a heat exchanger, a heat transfer medium used to transfer heat to a fluid to be heated may be referred to as a heat medium, and a heat transfer medium used to take heat from a fluid may be referred to as a refrigerant. The heat medium or refrigerant may be, for example, air or a liquid.

[0015] A double-pipe heat exchanger is a heat exchanger that includes an internal tube, through which a first fluid may be introduced or pass, and an external tube, which encloses the internal pipe and through which a second fluid may be introduced or pass. Heat exchange may be performed between the fluids using a side wall of the internal tube as a heat transfer wall.

[0016] The double-pipe heat exchanger may have a low heat exchange efficiency, because a heat transfer area where an external wall of the internal tube and a

second fluid contact each other may be small. Therefore, in order to increase the heat transfer efficiency, a size of the double-pipe heat exchanger must be enlarged or a length of the double-pipe elongated. However, due to the increased volume of the double-pipe heat exchanger, it may be difficult to elongate the length of the double-pipe heat exchanger or enlarge the size of the double-pipe heat exchanger.

[0017] FIG. 1 is a perspective view of a heat exchanger according to an embodiment. FIG. 2 is a cross-sectional view of the heat exchanger of FIG. 1, taken along line 11-11 of FIG. 1. FIG. 3 is a longitudinal-sectional view of the heat exchanger of FIG. 1, taken along line 111-111 of FIG. 1.

[0018] Referring to FIGS. 1 to 3, a heat exchanger 800 may include a first heat exchange tube 100, a second heat exchange tube 200, and a third heat exchange tube 300. In addition, the heat exchanger 800 may include a connection tube 400 that connects the second and third heat exchange tubes 200 and 300.

[0019] The first heat exchange tube 100 may be a tube into which a first fluid may be introduced and flow. The first heat exchange tube 100 may include an upper wall 103, a lower wall 104, and a side wall 108 disposed between the upper and lower walls and connecting them. Further, the first heat exchange tube 100 may be formed in a pipe shape.

[0020] An upper portion of the side wall 108 of the first heat exchange tube 100 may be connected to a first fluid inlet 102, into which the first fluid may be introduced and flow, and a lower portion of the side wall 108 of the first heat exchange tube 100 facing the upper portion of the side wall may be connected to a first fluid outlet 105, through which the first fluid may be discharged.

[0021] The first fluid may be introduced through the first fluid inlet 102 of the first heat exchange tube 100 and discharged through the first fluid outlet 105. In this embodiment, the first fluid may have a first temperature.

[0022] The second heat exchange tube 200 may be provided with a second fluid whose temperature is different from that of the first fluid. A diameter of the second heat exchange tube 200 may be formed to be smaller than a diameter of the first heat exchange tube 100, and the second heat exchange tube 200 may pass through the first heat exchange tube 100 in a longitudinal direction. Referring to FIG. 3, the second heat exchange tube 200 may be disposed at a center of the first heat exchange tube 100 so that their axes are concentric.

[0023] A second fluid inlet 202, into which the second fluid may be introduced and flow, may be formed at one end of the second heat exchange tube 200, and a second fluid outlet 205 may be formed at the other end of the second heat exchange tube 200, the second fluid outlet 205 discharging the second fluid to a connection tube 400 described hereinbelow. The second fluid introduced into the second heat exchange tube 200 through the second fluid inlet 202 may have a second temperature lower than the first temperature of the first fluid.

[0024] The second heat exchange tube 200 may be a straight tube, that is, formed in a straight line shape in the first heat exchange tube 100. Side walls 108, 208 of the first heat exchange tube 100 and the second heat exchange tube 200 may be used as heat transfer walls, through which heat exchange may be performed between the first and second fluids.

[0025] The second fluid, which flows through the second heat exchange tube 200 and connection tube 400, may flow into the third heat exchange tube 300. A diameter of the third heat exchange tube 300 may be greater than a diameter of the first heat exchange tube 100 and may be disposed outside of the first heat exchange tube 100 to enclose a side wall 108 of the first heat exchange tube 100.

[0026] Referring to FIG. 3, the third heat exchange tube 300 may be disposed so that axes of the first heat exchange tube 100 and the third heat exchange tube 300 are concentric. The third heat exchange tube 300 may have an upper wall 303, a lower wall 304, and a side wall 308 disposed between the upper and lower walls 303, 304 and connecting them. The side wall 308 may be formed in a cylindrical shape. A third fluid inlet 302, into which the second fluid which has passed through the second heat exchange tube 200 may flow, may be formed on the lower wall 304 of the third heat exchange tube 300, and a third fluid outlet 305, through which the second fluid may be discharged, may project from the side wall 308 on an upper portion of the third heat exchange tube 300.

[0027] Centers of the upper and lower walls 303, 304 may be open, so that the first heat exchange tube 100 may be inserted therethrough. Further, an empty space whose diameter is greater than that of the first heat exchange tube 100 may be formed in the third heat exchange tube 300.

[0028] Because the second fluid when it flows into the third heat exchange tube 300 is in the state in which its heat has been primarily exchanged with that of the first fluid while in the second heat exchange tube 200, a temperature of the second fluid may be slightly higher than that of the second fluid when it flows into the second heat exchange tube 200.

[0029] The second and third heat exchange tubes 200 and 300 may be formed as one body. Alternatively, the second and third heat exchange tubes 200 and 300 may communicate with each other via the connection tube 400.

[0030] The connection tube 400 may connect the second and third heat exchange tubes 200 and 300 so that the second fluid having passed through the second heat exchange tube 200 may flow into the third heat exchange tube 300. That is, one end of the connection tube 400 may communicate with the second fluid outlet 205 of the second heat exchange tube 200, and the other end of the connection tube 400 may communicate with a third fluid inlet 302 of the third heat exchange tube 300.

[0031] FIG. 4 is a sectional view of a heat exchanger

according to another embodiment. The heat exchanger 800A shown in FIG. 4 has substantially the same construction as the heat exchanger shown in FIG. 3, except for the second heat exchange tube. Accordingly, like reference members have been used to indicate like elements, and repetitive disclosure omitted.

[0032] Referring to FIG. 4, in the heat exchanger 800A, the second heat exchange tube 220 disposed in the first heat exchange tube 100 may include a bent tube, which may be bent at least once in the first heat exchange tube 100.

[0033] FIG. 5 is a sectional view of a heat exchanger according to another embodiment. The heat exchanger 800B shown in FIG. 5 has substantially the same construction as the heat exchanger shown in FIG. 3, except for the second heat exchange tube. Accordingly, like reference members have been used to indicate like elements, and repetitive disclosure omitted.

[0034] Referring to FIG. 5, in the heat exchanger 800B, the second heat exchange tube 230 disposed in the first heat exchange tube 100 may include a curved tube having at least one curve, which is curved at a predetermined curvature, in the first heat exchange tube 100.

[0035] FIG. 6 is a perspective view of a heat exchanger according to another embodiment. FIG. 7 is a sectional view of the heat exchanger of FIG. 6. Referring to FIGS. 6 and 7, the heat exchanger 800C may include a high temperature heat exchange tube 500 and a low temperature heat exchange tube 600.

[0036] The high temperature heat exchange tube 500 may be a tube into which a first fluid, being the target fluid, may be introduced and flow. The high temperature heat exchange tube 500 may include an upper wall 503, a lower wall 504, and a side wall 508 disposed between the upper and lower walls 503, 504 and connecting them. The high temperature heat exchange tube 500 may be formed in a cylindrical shape. A first fluid inlet 502, into which the first fluid may be introduced and flow, may project from the side wall 508 of an upper portion of the high temperature heat exchange tube 500, and a first fluid outlet 505, through which the first fluid may be discharged, may project from the sidewall 508, which may be a heat transfer wall, on a lower portion of the high temperature heat exchange tube 500.

[0037] Further, an empty space having the same shape as the high temperature heat exchange tube 500 may be formed therein, and the first fluid inlet 502 and first fluid outlet 505 may communicate with the empty space. Accordingly, the first fluid introduced into the high temperature heat exchange tube 500 through the first fluid inlet 502 may flow toward the first fluid outlet 505 through the empty space.

[0038] The low temperature heat exchange tube 600 may include a low temperature heat exchange tube portion 610, a connection portion 620, and a second low temperature heat exchange tube portion 630. The first low temperature heat exchange tube portion 610, the second low temperature heat exchange tube portion 630,

and the connection portion 620 may be formed as one body. The low temperature heat exchange tube 600 may be provided with the second fluid whose temperature is lower than that of the first fluid.

[0039] The first low temperature heat exchange tube portion 610 may have a diameter which is smaller than a diameter of the high temperature heat exchange tube 500, and may pass through the high temperature heat exchange tube 500 in a longitudinal direction and be disposed therein.

[0040] The first low temperature heat exchange tube portion 610 may be disposed in a center of the high temperature heat exchange tube 500 so that the axes of the first low temperature heat exchange tube portion 610 and the high temperature heat exchange tube 500 are concentric. A second fluid inlet 612, into which the second fluid may be introduced and flow, may be formed at one end of the first low temperature heat exchange tube portion 610.

[0041] The first low temperature heat exchange tube portion 610 may be in the form of a straight tube formed in a straight line shape in the high temperature heat exchange tube 500, a bent tube which may be bent at least once in the high temperature heat exchange tube 500, or a curved tube which may be curved at least once at a predetermined curvature in the high temperature heat exchange tube 500.

[0042] The connection portion 620 may be a "U"-shaped tube that connects the first low temperature heat exchange tube portion 610 and the second low temperature heat exchange tube portion 630. Further, the connection portion 620 may extend from the other end of the first low temperature heat exchange tube portion 510 opposite the second fluid inlet 612 to a bottom of the second low temperature heat exchange tube portion 630.

[0043] The second fluid having passed through the first low temperature heat exchange tube portion 610 and the connection portion 620 may flow into the second low temperature heat exchange tube portion 630. The second low temperature heat exchange tube portion 630 may have a diameter greater than a diameter of the high temperature heat exchange tube 600 and may be disposed outside of the high temperature heat exchange tube 500 to enclose the side wall 508 (a heat transfer surface) of the high temperature heat exchange tube 500. Axes of the second low temperature heat exchange tube portion 630 and the high temperature heat exchange tube 500 may be concentric.

[0044] The second low temperature heat exchange tube portion 630 may have an upper wall 603, a lower wall 604, and a side wall 608 formed between the upper and lower walls 603, 604 and connecting them. The second low temperature heat exchange tube portion 630 may be formed in a cylindrical shape. A second fluid outlet 635 may project from an upper portion of the second low temperature heat exchange tube portion 630, from which the second fluid having passed through the first low temperature heat exchange tube portion 610, the connection

portion 620, and the second low temperature heat exchange tube portion 630 may be discharged.

[0045] Centers of the upper and lower walls 603, 604 of the second low temperature heat exchange tube portion 630 may be open so that the high temperature heat exchange tube 500 may be inserted therethrough, and an empty space may be formed therein whose diameter is greater than a diameter of the high temperature heat exchange tube 500 in the second low temperature heat exchange tube portion 630. The empty space may communicate with the second fluid outlet 635.

[0046] Because the second fluid having flowed into the second heat exchange tube portion 630 is in a state in which its heat has been primarily exchanged with that of the first fluid in the first heat exchange tube portion 610, the temperature of the second fluid may be slightly higher than the temperature of the second fluid when it is introduced into the first heat exchange tube portion 610.

[0047] FIG. 8 is a sectional view of a heat exchanger according to another embodiment. Referring to FIG. 8, a heat exchanger 800D may include a first heat exchange tube 100, into which a first fluid, being the objective fluid or target, may be introduced and flow, a second heat exchange tube 200, which may be disposed in the first heat exchange tube 100 and into which a second fluid may flow, a third heat exchange tube 300, into which the second fluid, whose temperature is substantially the same as a temperature of the fluid introduced into the first heat exchange tube 100, may flow and which encloses an external surface of the first heat exchange tube 100, and a connection tube 700 that connects the second and third heat exchange tubes 200 and 300 and provides the second and third heat exchange tubes 200 and 300 with the second fluid having the same temperature.

[0048] The first heat exchange tube 100 of the heat exchanger 800D shown in FIG. 8 has substantially the same shape and construction as the heat exchangers according to the previous embodiments. Accordingly, like reference numerals have been used to indicate like elements and repetitive description of the first heat exchange tube 100 has been omitted.

[0049] Referring to FIG. 8, a second heat exchange tube 200 may pass through the first heat exchange tube 100 in a longitudinal direction and be disposed in the first heat exchange tube 100. The second heat exchange tube 200 may be disposed in a center of the first heat exchange tube 100 such that the axes of the first heat exchange tube 100 and the second heat exchange tube 200 may be concentric.

[0050] A second fluid outlet 207 may be formed on or at one end of the second heat exchange tube 200, from which the second fluid having flowed into the second heat exchange tube 200, may be discharged.

[0051] The second heat exchange tube 200 may include have a straight tube formed in a straight line shape in the first heat exchange tube 100, a bent tube which may be bent at least once in the first heat exchange tube 100, or a curved tube which may be curved at least once

at a predetermined curvature in the first heat exchange tube 100.

[0052] The third heat exchange tube 300 may be disposed outside of the first heat exchange tube 100 to enclose a side wall 108 of the first heat exchange tube 100. The third heat exchange tube 300 may also be disposed to have concentric axes with the first heat exchange tube 100.

[0053] The third heat exchange tube 300 may include an upper wall 303, a lower wall 304, and a side wall 308 that is formed between the upper and lower panels and connecting them. The third heat exchange tube 300 may be formed in a cylindrical shape. A third fluid outlet 307, from which the second fluid may be discharged, may project from the side wall 308 on an upper portion of the third heat exchange tube 300. Further, centers of the upper and lower walls 303, 304 of the third heat exchange tube 300 may be open so that the first heat exchange tube 100 may be inserted into them, and an empty space may be formed therein whose diameter is greater than a diameter of the first heat exchange tube 100. The third fluid outlet 307 may communicate with the empty space.

[0054] The second fluid may flow into the second and third heat exchange tubes 200 and 300 so that both tubes 200 and 300 are filled with the same temperature fluid, and the heat exchanger 800D of this embodiment may have a much higher heat exchange efficiency in comparison to prior art heat exchangers.

[0055] According to this embodiment, the second and third heat exchange tubes 200 and 300 may be formed as one body. Alternatively, the second and third heat exchange tubes 200 and 300 may communicate with each other via a connection tube 700. The connection tube 700 may connect the second heat exchange tube 200 and third heat exchange tube 300 in order to provide the second heat exchange tube 200 and third heat exchange tube 300 with the second fluid so that both tubes 200 and 300 are filled with the same temperature fluid. That is, one end of the connection tube 700 may be connected to an end of the second heat exchange tube 200 opposite the second fluid outlet 207, and an other end of the connection tube 400 may be connected to the lower wall 304 of the third heat exchange tube 300.

[0056] The second fluid inlet 702 may communicate with a middle portion of the connection tube 700 so that the second fluid, whose temperature is higher than that of the first fluid, may flow into the connection tube 700.

[0057] According to the above detailed description, the heat exchanger according to embodiments disclosed herein may have the second and third heat exchange tubes disposed inside and outside of the first heat exchange tube into which the first fluid, which may be the objective or target fluid, may flow, heat of the second fluid being exchanged with that of the first fluid, the second fluid flowing into the second and third heat exchange tubes, so that a heat transfer area of the heat transfer wall on which the first fluid and second fluids contact each other becomes increased. Then, a heat exchange per-

formance may be increased compared with a prior art double-pipe heat exchanger having the same volume and length.

[0058] Embodiments disclosed herein provide a heat exchanger capable of increasing a heat exchange performance by increasing a heat transfer area on which first and second fluids contact each other and heat exchange is performed.

[0059] Embodiments disclosed herein further provide a heat exchanger that may include a first heat exchange tube that is in a pipe shape, including a first fluid inlet, into which a first fluid flows, and a first fluid outlet, through which the first fluid is discharged; a second heat exchange tube that passes through the first heat exchange tube, including a second fluid inlet, into which a second fluid flows, and a second fluid outlet, through which the second fluid is discharged; and a third heat exchange tube that includes a third fluid inlet, into which the second fluid is discharged through the second fluid outlet flows again, and a third fluid outlet, through which the second fluid is discharged, the third fluid outlet enclosing an external surface of the first heat exchange tube.

[0060] Embodiments disclosed herein provide a heat exchanger that may include a high temperature heat exchange tube including a first fluid inlet, into which a first fluid flows, and a first fluid outlet, through which the first fluid is discharged; and a low temperature heat exchange tube including a first low temperature heat exchange tube having a second fluid inlet, into which a second fluid flows, and passing through the high temperature heat exchange tube, and a second low temperature heat exchange tube that communicates with the first low temperature heat exchange tube, encloses an external surface of the high temperature heat exchange tube and has a second fluid outlet, through which the second fluid is discharged.

[0061] Embodiments disclosed herein further provide a heat exchanger that may include a first heat exchange tube including a first fluid inlet, into which a first fluid flows, and a first fluid outlet, through which the first fluid is discharged; a second heat exchange tube that passes through the first heat exchange tube and into which the second flows, including a second fluid outlet, through which the second fluid is discharged; and a third heat exchange tube, into which the second fluid flows and which encloses an external surface of the first heat exchange tube and communicates with the second heat exchange tube, including a third fluid outlet, through which the second fluid is discharged, wherein a second fluid inlet tube is included, which is connected to a connector to connect the second and third heat exchange tubes to provide the second and third heat exchange tubes with the second fluid.

[0062] Any reference in this specification to "one embodiment," "an embodiment," "example embodiment," etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in

the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to effect such feature, structure, or characteristic in connection with other ones of the embodiments.

[0063] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

Claims

1. A heat exchanger, **characterized by:**
 - a first heat exchange tube in the shape of a pipe, including a first fluid inlet, into which a first fluid is introduced, and a first fluid outlet through which the first fluid is discharged;
 - a second heat exchange tube that passes through the first heat exchange tube, including a second fluid inlet, into which a second fluid is introduced, and a second fluid outlet, through which the second fluid is discharged; and
 - a third heat exchange tube including a third fluid inlet, into which the second fluid having been discharged through the second fluid outlet is introduced, and a third fluid outlet, through which the second fluid is discharged, the third fluid tube enclosing an external surface of the first heat exchange tube.
2. The heat exchanger according to claim 1, **characterized in that** the first and third heat exchange tubes have concentric axes and have diameters different from each other.
3. The heat exchanger according to claim 2, **characterized in that** the first and second heat exchange tubes have concentric axes and have diameters different from each other.
4. The heat exchanger according to claim 1, **characterized in that** the second heat exchange tube comprises a straight tube disposed in the first heat exchange tube.
5. The heat exchanger according to claim 1, **characterized in that** the second heat exchange tube includes a bent tube disposed in the first heat exchange tube, the bent tube having a shape which is bent at least once.
6. The heat exchanger according to claim 1, **characterized in that** the second heat exchange tube includes a curved tube disposed in the first heat exchange tube, the curved tube having a shape including at least one curve at a predetermined curvature.
7. The heat exchanger according to claim 1, **characterized in that** the first fluid has a first temperature, and the second fluid has a second temperature, which is lower than the first temperature.
8. The heat exchanger according to claim 1, further **characterized by:**
 - a connection tube that connects the second and third heat exchange tubes to each other.
9. A heat exchanger, **characterized by:**
 - a high temperature heat exchange tube including a first fluid inlet, into which a first fluid is introduced, and a first fluid outlet, through which the first fluid is discharged; and
 - a low temperature heat exchange tube including a first low temperature heat exchange tube portion having a second fluid inlet, into which a second fluid is introduced, and passing through the high temperature heat exchange tube, and a second low temperature heat exchange tube portion that communicates with the first low temperature heat exchange tube portion, encloses an external surface of the high temperature heat exchange tube and has a second fluid outlet, through which the second fluid is discharged.
10. The heat exchanger according to claim 9, **characterized in that** the first low temperature heat exchange tube portion includes at least one of a straight tube disposed in the high temperature heat exchange tube, a bent tube disposed in the high temperature heat exchange tube, the bent tube having a shape which is bent at least once, or a curved tube disposed in the high temperature heat exchange tube, the curved tube having a shape including at least one curve curved at a predetermined curvature.
11. The heat exchanger according to claim 9, **characterized in that** the first fluid has a first temperature, and the second fluid has a second temperature, which is lower than the first temperature.
12. The heat exchanger according to claim 9, further

characterized by:

a connector portion that connects the first low temperature heat exchange tube portion and the second low temperature heat exchange tube portion. 5

13. A heat exchanger, characterized by:

a first heat exchange tube including a first fluid inlet, into which a first fluid is introduced, and a first fluid outlet, through which the first fluid is discharged; 10

a second heat exchange tube that passes through the first heat exchange tube and into which a second fluid is introduced, the second heat exchange tube including a second fluid outlet, through which the second fluid is discharged; a third heat exchange tube into which the second fluid is introduced and which encloses an external surface of the first heat exchange tube and communicates with the second heat exchange tube, including a third fluid outlet, through which the second fluid is discharged; and 15 20

a second fluid inlet tube, which is connected to a connector that connects the second and third heat exchange tubes to provide the second and third heat exchange tubes with the second fluid. 25

14. The heat exchanger according to claim 13, characterized in that the second heat exchange tube includes one of a straight tube disposed in the first heat exchange tube, a bent tube that is bent at least once disposed in the first heat exchange tube, or a curved tube that is curved at least once at a predetermined curvature disposed in the first heat exchange tube. 30 35**15. The heat exchange according to claim 13, characterized in that** the first fluid has a first temperature, and the second fluid has a second temperature, which is lower than the first temperature. 40

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Fig. 1

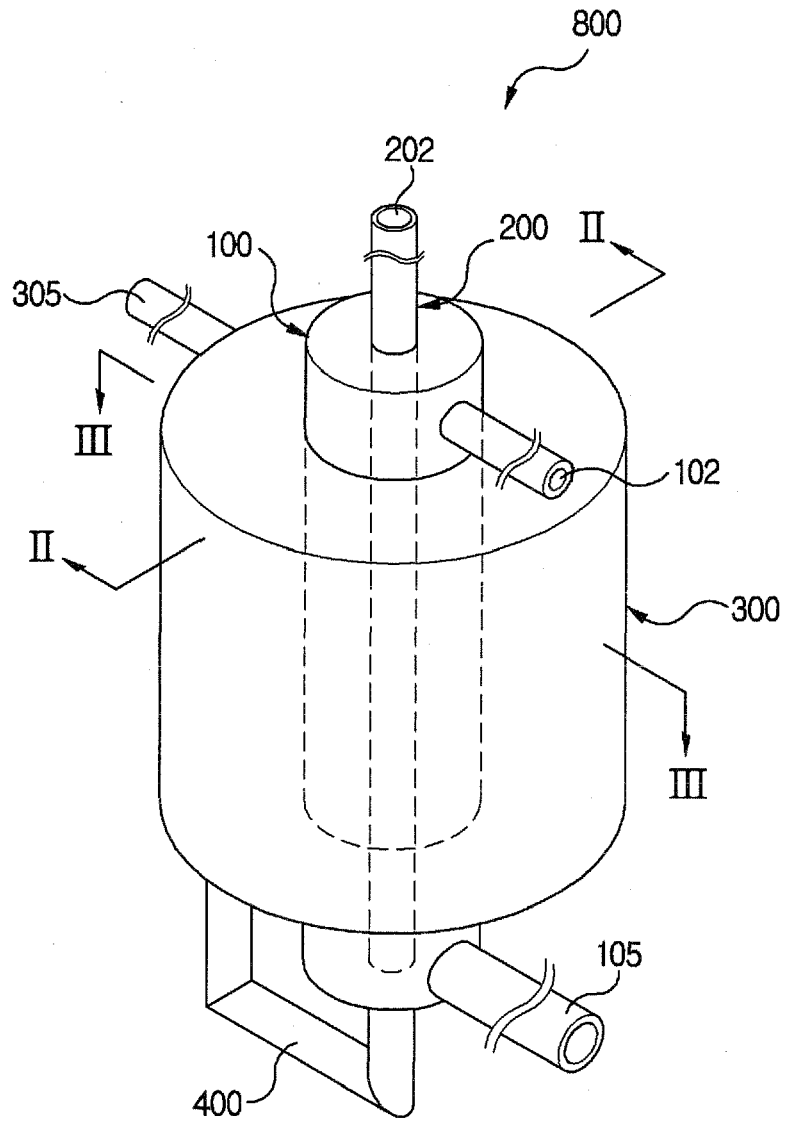


Fig. 2

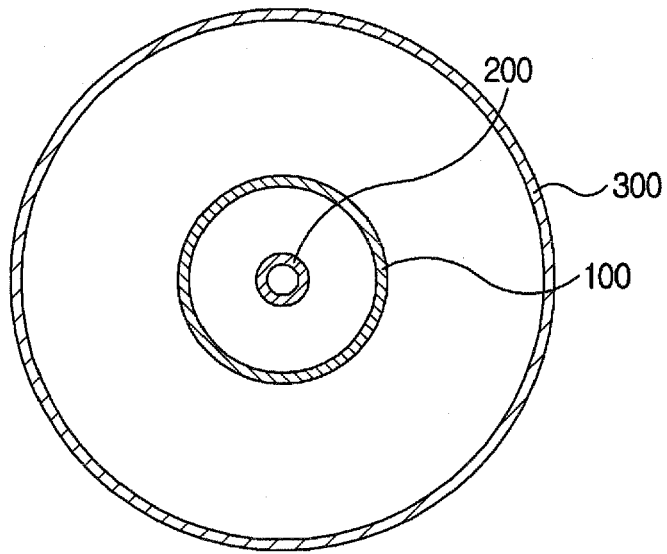


Fig. 3

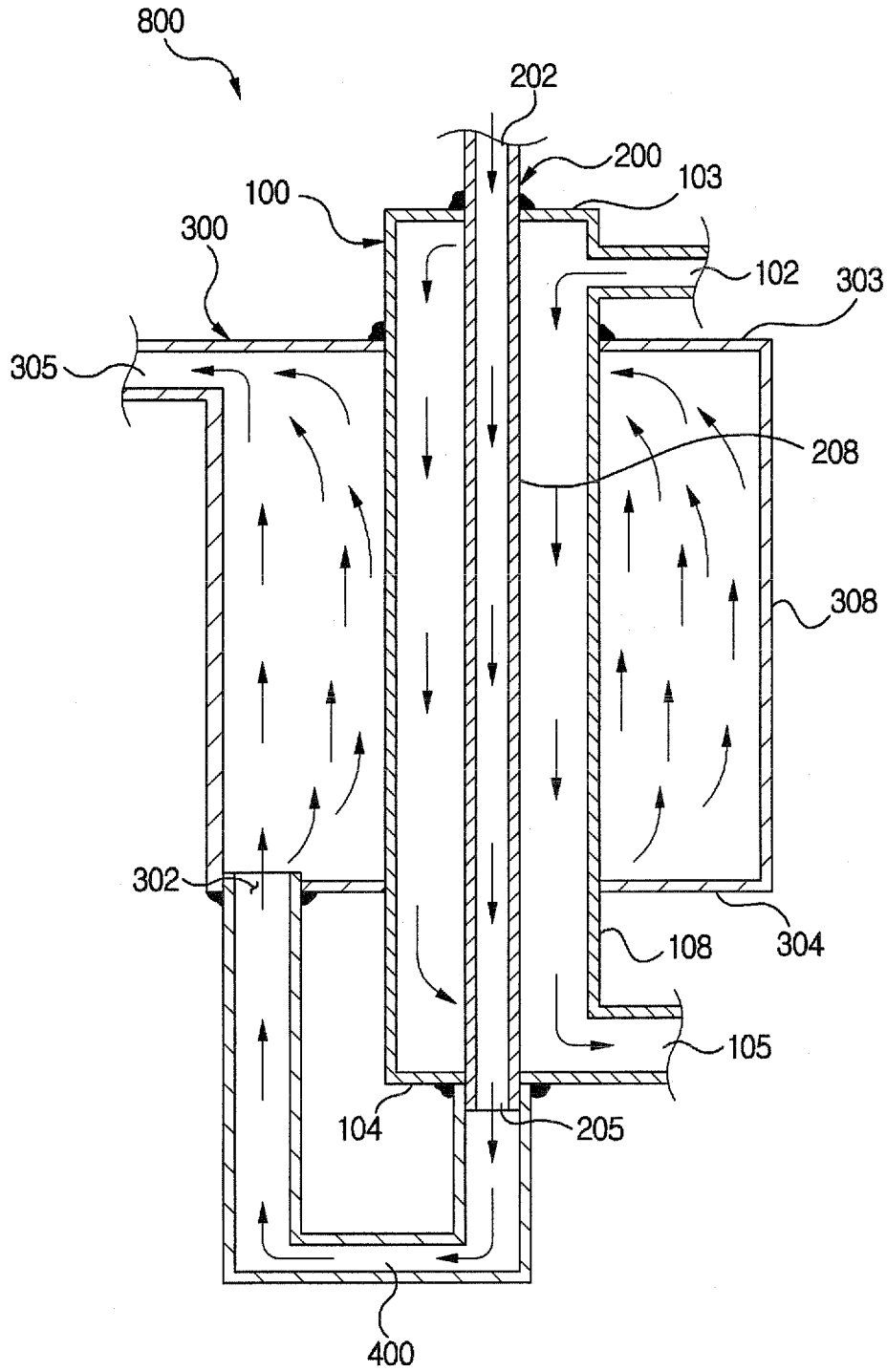


Fig. 4

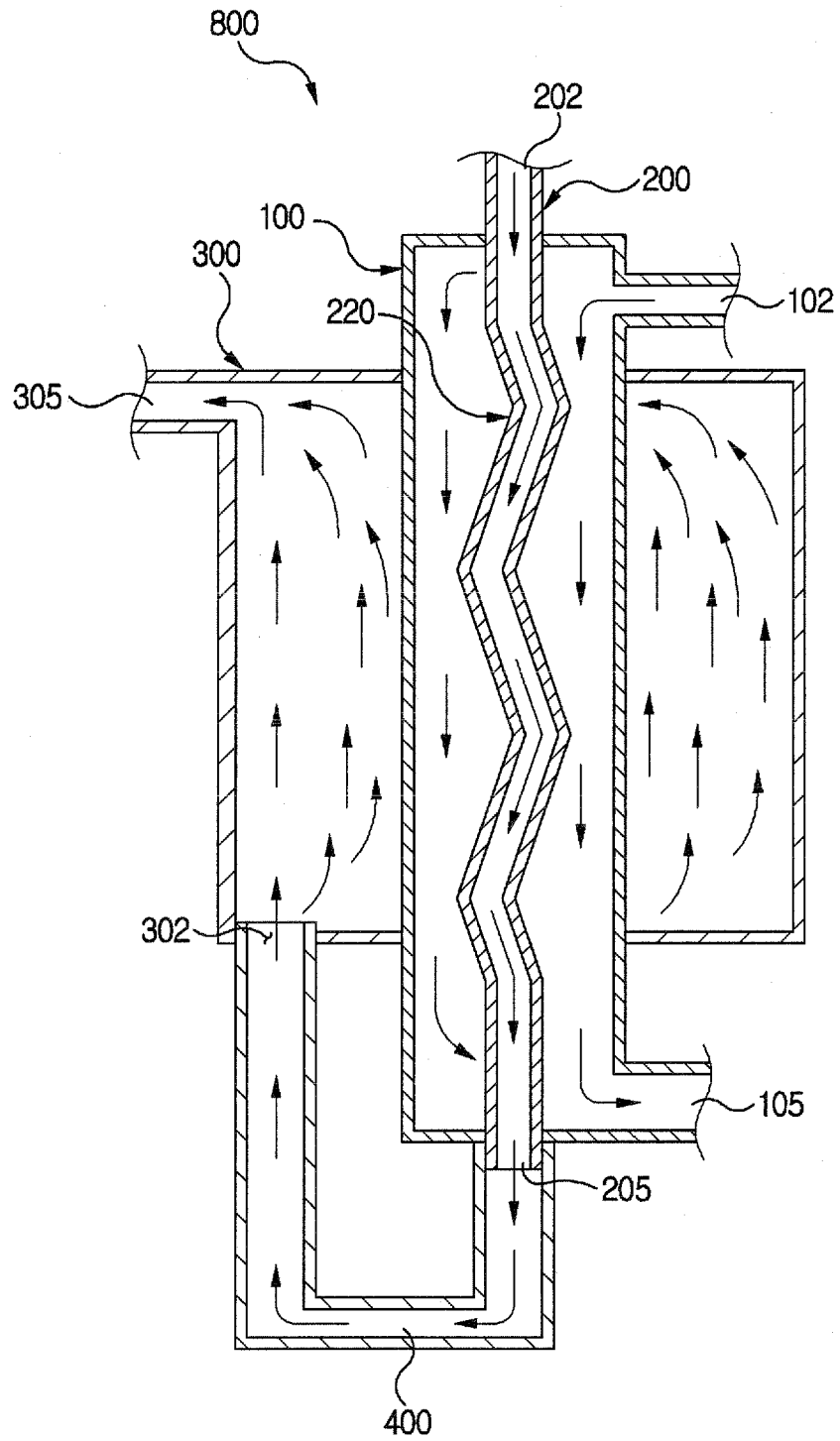


Fig. 5

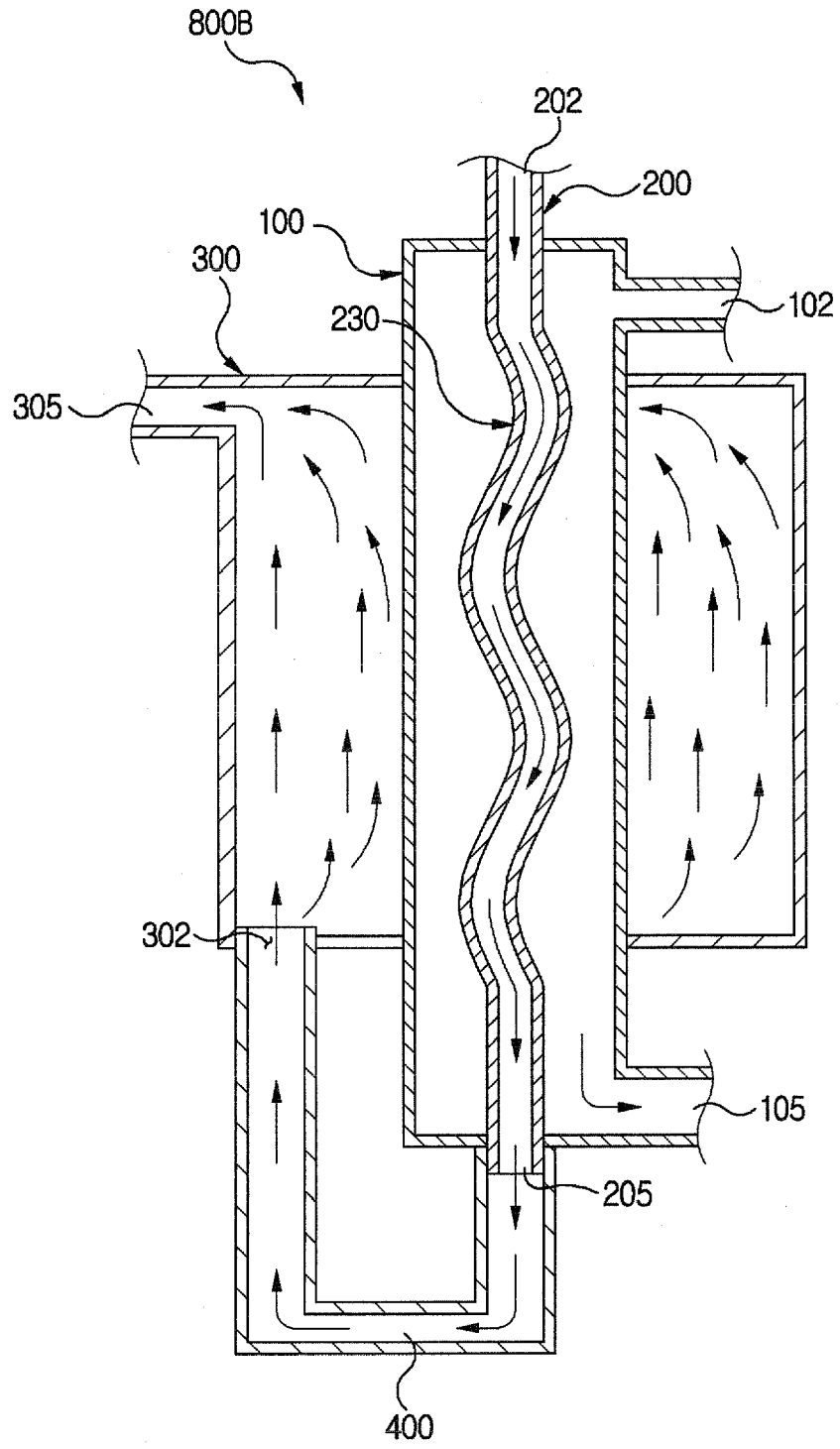


Fig. 6

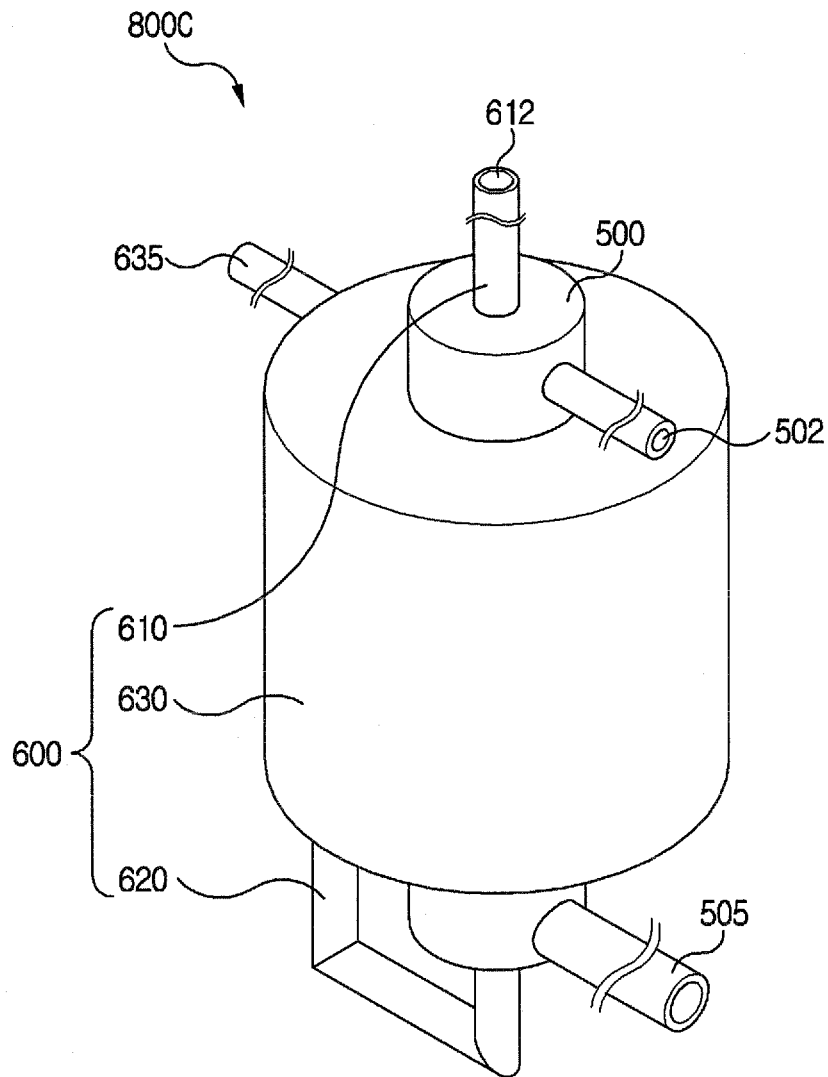


Fig. 7

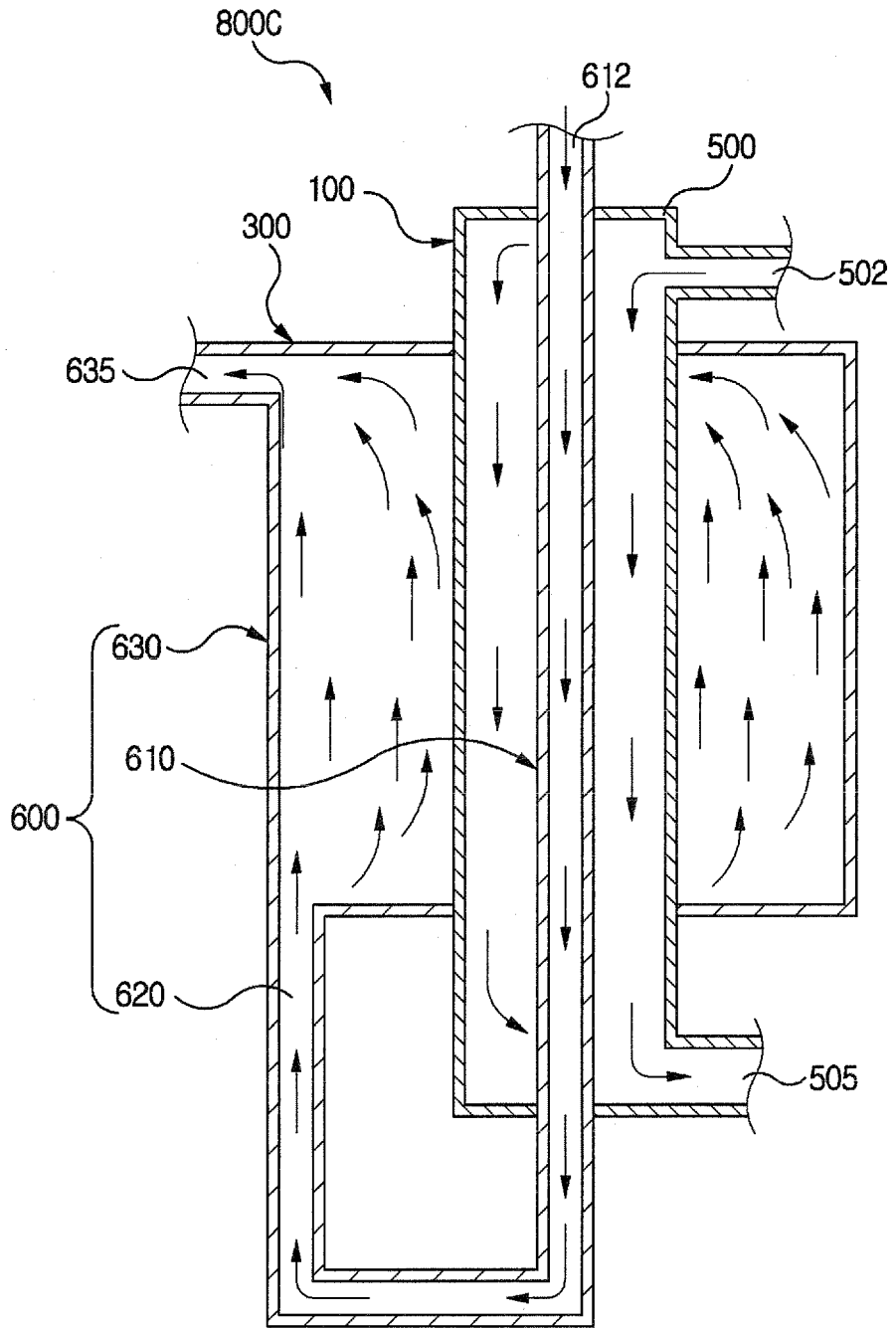


Fig. 8

