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# (54) A HEAT EXCHANGER

(57) The present invention herein provides a heat exchanger for heat exchange between a first fluid and at least one second fluid. The heat exchanger includes a stack of primary plates forming at least one first channel for the first fluid and at least one second channel for the second fluid. Further, the primary plates comprise primary openings having a first cross-section and the primary openings being configured to form first manifolds for enabling first fluid circulation in the first channels and second manifolds for enabling second fluid circulation in the second channels. The heat exchanger further comprises at least one secondary plate disposed between the consecutive stacks of primary plates. Further, the secondary plate comprises secondary openings having a second cross-section. The secondary openings are complementary to and fluidically connected to the primary openings forming the first and second manifolds. In addition, the first cross-section is different from the second cross-section.

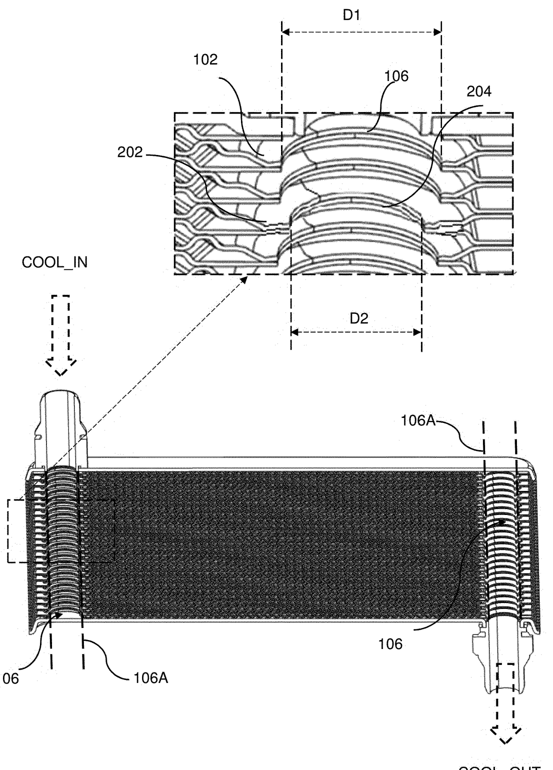


FIG. 3

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## Description

**[0001]** The present invention relates to a heat exchanger. In particular, this invention relates to the heat exchanger having two sets of heat exchange plates with different cross-sections of openings to enable optimum heat exchange between the two fluids flowing therein.

**[0002]** Plate-type heat exchangers may include a plurality of plates stacked together to form two fluid channels. The two fluid channels are fluidically isolated from each other, yet thermal coupled with each other. In one example, adjacent plates of the stacked plates delimit the paths for the fluid channels. The fluid channels are alternately formed on each other to form the core of the heat exchanger. The fluid channels can be refrigerant and coolant channels. Both the channels are in heat-exchange configuration to enable heat exchange between the fluids in the refrigerant channel and the coolant channel. Each plate may include openings for enabling fluid flow into the respective fluid channels. The openings provided in the stack of plates form conduits that transfers the fluid to the respective fluid channels. The openings forming the conduits may act as a manifold to enable fluid flow into the respective channels. Further, the openings may include collars to fluidically connect the conduits with the respective fluid channels.

**[0003]** For example, the plate may include the openings for refrigerant flow, referred to as refrigerant openings and the opening for coolant flow, referred to as coolant openings. The refrigerant openings and coolant openings formed on the plates are adapted to form the respective manifolds to enable refrigerant flow in the refrigerant channels and the coolant flow in the coolant channels. The openings generally can be circular openings or any other shape. Conventionally, the refrigerant openings and coolant openings formed in the plates are of same cross-section. Here, the cross-section of the refrigerant openings is same as the cross-section of the coolant openings. In other words, diameter of the refrigerant openings is same as the diameter of the coolant openings. As a result, the coolant manifold and the refrigerant manifold may carry same volume of the respective fluid in the respective manifold.

**[0004]** It is well known that refrigerant such as difluoromethane (also called difluroromethylene, or R-32) and coolant such as water-glycol mixture may have different thermophysical properties. As explained above, the refrigerant manifold and the coolant manifold are having uniform volume of fluid flowing therein. Therefore, the coolant flowing into the coolant channels and the refrigerant flowing into the refrigerant channels are having uniform. Hence, there is a possibility that the heat exchange between the refrigerant and the coolant is sub-optimum, as phase change temperature of both the refrigerant and the coolant are different. As a result, thermal performance of the heat exchanger is reduced. To avoid such problems, pressure drop and flow of the refrigerant flowing into the refrigerant channel is controlled. However, controlling flow of the refrigerant is cumbersome, as the refrigerant flows in high pressure; it requires complex techniques to control the flow of the refrigerant.

**[0005]** Accordingly, there remains a need for a design in a heat exchanger to control flow of the coolant in the heat exchanger. Further, there remains another need for a technique to optimize thermal performance in the heat exchanger.

**[0006]** In the present description, some elements or parameters may be indexed, such as a first element and a second element. In this case, unless stated otherwise, this indexation is only meant to differentiate and name elements, which are similar but not identical. No idea of priority should be inferred from such indexation, as these terms may be switched without betraying the invention. Additionally, this indexation does not imply any order in mounting or use of the elements of the invention.

**[0007]** In view of the foregoing, an embodiment provides a heat exchanger for heat exchange between a first fluid and at least one second fluid. The heat exchanger includes a stack of primary plates forming at least one first channel for the first fluid and at least one second channel for the second fluid. Further, the primary plates comprise primary openings having a first cross-section and the primary openings being configured to form first manifolds for enabling first fluid circulation in the first channels and second manifolds for enabling second fluid circulation in the second channels. The heat exchanger further comprises at least one secondary plate disposed between the consecutive stacks of primary plates. Further, the secondary plate comprises secondary openings having a second cross-section. The secondary openings are complementary to and fluidically connected to the primary openings forming the first and second manifolds. In addition, the first cross-section is different from the second cross-section.

**[0008]** In one example, the second cross-section of the secondary opening is smaller than the first cross-section of the primary openings formed in the primary plates.

**[0009]** Further, the secondary openings of the secondary plates are coaxial to the primary openings providing fluid to the second channels.

**[0010]** In one example, the secondary opening is formed on the secondary plate at an inlet manifold amongst the second manifolds of the second channel.

**[0011]** In another example, the secondary opening is formed on the secondary plate at an outlet manifold amongst the second manifolds of the second channel.

**[0012]** In yet another example, the secondary opening is formed on the secondary plate at the both inlet and outlet manifolds amongst the second manifolds of the second channel.

**[0013]** In one embodiment, the primary openings and the secondary openings are in-line to each other to enable fluidal connection between the primary openings and the secondary openings.

**[0014]** Further, the heat exchanger includes at least one separation plate having at least one baffle, and the separation plate being located in between two primary plates to define two fluid flow paths for the first channel and the second channel.

**[0015]** Further, the heat exchanger includes at least one cover plate provided in-contact with the primary plates to encapsulate at least a portion of the primary plates. Further, the cover plate further comprising cover-openings complementary to the primary openings and the secondary opening formed on the primary and secondary plates respectively.

**[0016]** In one example, the primary plates comprise corrugations on its surface.

**[0017]** Further, the heat exchanger is configured for an operation as condenser, the first fluid being a refrigerant and the second fluid being a liquid coolant.

**[0018]** Other characteristics, details and advantages of the invention can be inferred from the description of the invention hereunder. A more complete appreciation of the invention and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying figures, wherein:

Fig. 1 illustrates a schematic view of the heat exchanger, in accordance with an embodiment of the present invention;

Figs. 2 and 3 illustrate different cross-sectional views of the heat exchanger of Fig. 1 showing first channels and the second channels respectively;

Figs. 4 and 5 illustrate schematic views of a primary standalone plate and a secondary standalone plate respectively of Fig. 1;

Fig. 6 illustrates an exploded view of the primary plates and the secondary plates having the secondary openings at an inlet manifold amongst the secondary manifolds of the heat exchanger;

Fig. 7 illustrates another exploded view of the primary plates and the secondary plates having the secondary openings at an outlet manifold amongst the secondary manifolds of the heat exchanger; and

Fig. 8 illustrates another exploded view of the primary plates and the secondary plates having the secondary openings at both the inlet and outlet manifolds amongst the secondary manifolds of the heat exchanger.

**[0019]** It must be noted that the figures disclose the invention in a detailed enough way to be implemented, the figures helping to better define the invention. The invention should however not be limited to the embodiments disclosed in the description.

**[0020]** The present invention relates to a plate-type heat exchanger having two sets of heat exchange plates with different cross-sections of openings to enable optimum heat exchange between the two fluid flowing therein. The conventional plate heat exchangers usually comprise a stack of plates forming the refrigerant and coolant channels. The plates may include openings forming manifolds for enabling refrigerant and coolant flow into the respective channels. The openings are of same cross-section for both refrigerant and coolant manifolds. As a result, flow rate of the refrigerant and the coolant into their respective manifolds is same. As thermo-physical properties of the refrigerant and the coolant are different, heat exchange between the refrigerant and the coolant is inefficient or sub-optimal. For instance, phase temperature of the coolant and the refrigerant is different. It is possible that the heat exchange between the refrigerant and the coolant cannot be optimum in the heat exchanger in case the coolant and refrigerant is flowing at same flow rate and volume into their respective channels. In order to increase heat exchange between the refrigerant and the coolant, pressure drop of the refrigerant is increased, however, such technique is still inefficient to achieve optimum heat exchange between both the refrigerant and coolant. Such technique has some energy loss and requires more energy to create the pressure drop of the refrigerant. To this end, the present invention provides a technique to control the coolant flow in the heat exchanger to optimize heat exchange between the refrigerant and the coolant. As a result, thermal performance of the heat exchanger can be increased. Further, the geometry and design of the present invention are described with the forthcoming figures.

**[0021]** Figs. 1 to 3 illustrate different views a plate heat exchanger 100, in accordance with an embodiment of the present invention. Particularly, Fig. 1 shows a schematic view of the heat exchanger 100 and Figs. 2 and 3 show different cross-sectional views of the heat exchanger 100 of Fig. 1. The heat exchanger 100 may be configured for the heat exchange between a first fluid and a second fluid, for example, a refrigerant and a liquid coolant. The liquid coolant can be water or water-glycol mixture. In this example, the heat exchanger 100 may be configured for an operation as a condenser, here the first fluid being a refrigerant and the second fluid being a liquid coolant. The heat exchanger 100 may comprise a plurality of primary plates 102 stacked together to form at least two fluid channels, namely, first channels 102A being refrigerant channels and second channels 102B being liquid coolant channels. In one embodiment, the primary plates 102 are corrugated plates. In another embodiment, the primary plates 102 may have corrugations on its surface. Generally, the corrugations on the primary plates 102 are to increase pressure drop of the first fluid and the second fluid in order to optimize the thermal performance of the heat exchanger 100.

**[0022]** As shown in detailed view of Fig. 2, the first channels 102A and the second channels 102B are alternately formed with each other by the primary plates 102.

In other words, the primary plates 102 are stacked together so as to delimit one first channel 102A by a bottom surface of a first plate and a top surface of a second plate and to delimit one second channel 102B by a bottom surface of the second plate and a top surface of a third plate. In one embodiment, the primary plates 102 are brazed together into a stack without disturbing the fluid channels formed therein. In one example, at least a portion of the top surface of one plate is brazed to at least a portion of the bottom surface of the adjacent plate without disturbing the fluid flow path defined therein.

**[0023]** Further, the primary plates 102 may comprise primary openings 104, 106 forming first manifolds 104A and second manifolds 106A to enable fluid flow in the first channels 102A and the second channels 102B, respectively. In this example, the first manifolds 104A are refrigerant manifolds and the second manifolds 106A are coolant manifolds. Here, the primary openings 104, 106 may comprise a first cross-section "D1". In one example, the primary openings 104, 106 are circular in shape. In such case, the first cross-section D1 refers to the diameter of the circle forming the openings. In another example, the primary openings 104, 106 are non-circular in shape. In such case, the first cross-section D1 refers to the hydraulic diameter of the openings. Particularly, the primary openings 104, 106 may be classified into two sets of openings, a first set of primary openings 104 enabling the first fluid circulation in the first channels 102A and a second set of primary openings 106 enabling the second fluid circulation in the second channels 102B. As shown in Fig. 2, the first set of primary openings 104 forming the first manifold 104A is to introduce and receive the first fluid to/ from the first channels 102A respectively. Here, the first fluid, i.e., the refrigerant, flowing into the heat exchanger 100 is referred to as "REF_IN" and the first fluid flowing out from the heat exchanger 100 is referred to as "REF_OUT". As shown in Fig. 3, the second set of primary openings 106 forming the second manifold 106A is to introduce and receive the second fluid to or-from the second channels 102B respectively. Here, the second fluid, i.e., the coolant flowing into the heat exchanger 100 is referred to as "COOL_IN" and the first fluid flowing out from the heat exchanger 100 is referred to as "COOL_OUT" in the Figs. 2 and 3. Further, the first set of primary openings 104 and the second set of primary openings 106 formed on the primary plates 102 are clearly shown in Figs. 4 and 5. The primary openings 104, 106 may further comprise collars configured to promote laminar fluid flow between the manifolds 104A, 106A and the respective fluid channels 102A-B.

**[0024]** Further, the heat exchanger 100 includes at least one cover plate 110 provided in contact with the primary plates 102 to encapsulate at least a portion of the primary plates 102. Further, the cover plate 110 includes cover-openings complementary to the primary openings 104, 106 and the secondary opening 204 formed on the primary and secondary plates 102, 202 respectively. In one example, the heat exchanger 100 further includes a separation plate 110 having a baffle. The separation plate 110 may be located in between two primary plates 102 to define two fluid flow paths for the first channel 102A and the second channel 102B.

**[0025]** As explained above, Fig. 3 is a cross-section view of the heat exchanger 100 showing the coolant flow path inside the heat exchanger 100. The heat exchanger 100 may further comprise at least one secondary plate 202 disposed between the consecutive stack of primary plates 102. The secondary plate 202 may comprise secondary openings 204 having a second cross-section "D2". In other words, the cross-section of the secondary openings 204 is referred to as a second cross-section "D2". In one example, the secondary openings 204 are circular in shape. In such case, the second cross-section D2 refers to the diameter of the circle forming the openings. In another example, the secondary openings 204 are non-circular in shape. In such case, the second cross-section D2 refers to the hydraulic diameter of the openings

**[0026]** Further, the first cross-section "D1" of the primary openings 104, 106 is different from the second cross-section "D2" of the secondary openings 204. In the preferred embodiment, the first cross-section "D1" of the primary openings 104, 106 is greater than the second cross-section "D2" of the secondary openings 204. In other words, second cross-section "D2" is smaller than the first cross-section "D1". As shown in the detailed view of Fig. 3, the secondary opening 204 is in-line to the second set of primary openings 106 of the primary plates 102 forming the second manifolds 106A.

**[0027]** In one example, the secondary openings 204 of the secondary plates 202 are coaxial to the second set of primary openings 106 of the primary plates 102. Here, the secondary openings 204 are defined in-line to the second set of primary openings 106 forming the second manifolds 106A. As a result, the coolant flow into the heat exchanger 100 is controlled. Particularly, the pressure drop of the coolant is increased at the first channels 102A disposed downstream to the secondary plate 202, thereby optimizing the heat exchange between the coolant and refrigerant. In one example, the secondary openings 204 may be in-line with the second manifold 106A introducing the coolant the second channels 102B. In another example, the secondary openings 204 may be in-line with the second manifold 106A receiving the coolant from the second channels 102B. In yet another example, the secondary openings 204 may be provided on both the second manifold 106A providing the coolant to the second channels 102B and the second manifold 106A receiving the coolant from the second channels 102A.

**[0028]** Figs. 4 and 5 illustrate schematic views of the primary standalone plate 102 and the secondary standalone plate 202 respectively of Fig. 1. In the primary plate 102, as shown in Fig. 4, the first set of primary openings 104 is formed on opposite ends of the primary plate 102. In other words, the first set of primary openings 104 providing the first fluid to the first channel 102A is formed on a first end 108A of the primary plates 102, whereas the first set of primary openings 104 receiving the first fluid from the first channels 102A is formed on a second end 108B of the primary plates 102. Similarly, the second set of primary openings 106 is formed on opposite ends of the primary plates 102. In other words, the second set of primary openings 106 providing the second fluid to the second channel 102B is formed on the first end 108A of the primary plates 102, whereas the second set of openings 204 receiving the second fluid from the second channels 102B is formed on the second end 108B of the plates 102.

**[0029]** In another embodiment, the first set of primary openings 104 providing the first fluid to the first channel 102A and the first set of primary openings 104 receiving the first fluid from the first channel 102A are formed on same end of the primary plates 102, i.e. either on the first end 108A or the second end 108B of the primary plates 102. Similarly, the second set of primary openings 106 enabling the second fluid circulation in the second channel 102B are formed on same end of the primary plates 102. In such embodiment, each of the first channel 102A and the second channel 102B may require a partition plate to enable two-pass flow in the heat exchanger 100. The above-mentioned embodiment is not shown in any of the figures.

**[0030]** As shown in Fig. 5, the secondary plate 202 may include the first set of primary openings 104 to enable the refrigerant circulation in the first channel 102A. Further, the secondary openings 204 formed on the secondary plate 202 are coaxial to the second set of primary openings 106. As the secondary openings 204 are having different cross-section than the second set of primary openings 106, the second fluid, i.e. coolant, flow in the second channel 102B is controlled. As mentioned above, the primary openings 106 and the secondary openings 204 can be of a circular shape. Although the shape of the primary openings 106 and the secondary openings 204 are in the circular shape, it is possible to design the openings in non-circular shapes having a hydraulic diameter and such diameter of the openings is referred to as the cross-section of the openings. In the preferred embodiment, the primary openings 104, 106 and the secondary openings 204 are of a circular shape. In such case, the cross-section of the openings means the diameter of the openings. As explained above, the cross-section "D1" of the primary openings 104, 106 is different from the cross-section "D2" of the secondary openings 204. In other words, the diameter "D2" of the secondary openings 204 is smaller than the diameter "D1" of the primary openings 104, 106. In one example, the primary openings 104, 106 and the secondary openings 204 are formed by punching the primary plates 102 and the secondary plates 202 respectively.

**[0031]** Fig. 6 to 8 illustrate exploded views of the primary plates 102 and the secondary plates 202 of the heat exchanger 100 of Fig. 1 according to various embodiments of the present invention. In this example, Fig. 6 is an exploded view of the primary plates 102 and the secondary plates 202 having the secondary openings 204 at the inlet manifold amongst the second manifolds 106A of the heat exchanger 100. Fig. 7 is another exploded view of the primary plates 102 and the secondary plates 202 having the secondary openings 204 at the outlet manifold amongst the second manifolds 106A of the heat exchanger 100. Fig. 8 is another exploded view of the primary plates 102 and the secondary plates 202 having the secondary openings 204 at both the inlet and outlet manifolds amongst the second manifolds 106A of the heat exchanger 100.

**[0032]** According to one embodiment, the secondary openings 204 can formed on the secondary plate 202 at the inlet manifold amongst the second manifolds106A as shown in Fig. 6. In other words, the secondary openings 204 are formed on the secondary plates 202 at the second manifold 106A introducing the second fluid to the second channels 102B. Further, the secondary opening 204 is coaxial to the secondary manifold 106A providing the second fluid to the second channels 102B.

**[0033]** Similarly, in another embodiment, the secondary openings 204 may be formed on the secondary plate 202 at the outlet manifold amongst the second manifolds106A, as shown in Fig. 7. In other words, the secondary openings 204 may be formed on the secondary plates at the second manifold 106A receiving the second fluid from the second channels 102B. Further, the secondary opening 204 is coaxial to the secondary manifold 106A receiving the second fluid from the second channels 102B.

**[0034]** According to another embodiment, the secondary openings 204 can be formed on the secondary plate 202 at both inlet and outlet manifolds amongst the second manifolds106A as shown in Fig. 8. In other words, the secondary openings 204 may be formed on the secondary plates at the second manifold 106A introducing the second fluid to the second channels 102B and receiving the second fluid from the second channels 102B. Further, the secondary opening 204 is coaxial to the secondary manifold 106A.

**[0035]** As the secondary plate 202 having the secondary openings 204 are provided between the primary plates 102, the pressure drop of the second fluid, i.e. coolant is different between the second channels 102B upstream to the secondary plate 202 and the second channels 102B downstream to the secondary plate 202. In one example, the pressure drop of second fluid in the second channels 102B upstream to the secondary plate 202 is lower than the pressure drop of second fluid in the second channels 102B downstream to the secondary plate 202. Therefore, the second fluid flowing into the heat exchanger 100 can be controlled and the volume of the second fluid flowing into the second channels 102B is less than of volume of the first fluid flowing into the first channels 102A. As a result, heat exchange between the first and second fluids can be optimized, thereby increasing thermal performance of the heat exchanger 100.

**[0036]** In any case, the invention cannot and should not be limited to the embodiments specifically described in this document, as other embodiments might exist. The invention shall spread to any equivalent means and any technically operating combination of means.

## Claims

1. A heat exchanger (100) for heat exchange between a first fluid and at least one second fluid, comprising:

   a stack of primary plates (102) forming at least one first channel (102A) for the first fluid and at least one second channel (102B) for the second fluid, wherein the primary plates (102) comprise primary openings (104, 106) having a first cross-section (D1), the primary openings (104, 106A) being configured to form first manifolds (104A) for enabling first fluid circulation in the first channels (102A) and second manifolds (104B) for enabling second fluid circulation in the second channels (102B),

   **characterized in that**, the heat exchanger (100) further comprises at least one secondary plate (202) disposed between the consecutive stacks of primary plates (102), wherein the secondary plate (202) comprises secondary openings (204) having a second cross-section (D2), wherein the secondary openings (204) are complementary to and fluidically connected to the primary openings (104, 106) forming the first and second manifolds (104A, 104B), wherein the first cross-section (D1) is different than the second cross-section (D2).

2. The heat exchanger (100) according to claim 1, the second cross-section (D2) of the secondary opening (204) is smaller than the first cross-section (D1) of the primary openings (104, 106) formed in the primary plates (102).

3. The heat exchanger (100) according to any of the preceding claims, wherein the secondary openings (204) of the secondary plates (202) are coaxial to the primary openings (106) providing fluid to the second channels (102B).

4. The heat exchanger (100) according to any of the preceding claims, wherein the secondary opening (204) is formed on the secondary plate (202) at an inlet manifold amongst the second manifolds (106A) of the second channel (102B).

5. The heat exchanger (100) according to any of the claims 1 to 3, wherein the secondary opening (204) is formed on the secondary plate (202) at an outlet manifold amongst the second manifolds (106A) of the second channel (102B).

6. The heat exchanger (100) according to any of the claims 1 to 3, wherein the secondary opening (204) is formed on the secondary plate (202) at the both inlet and outlet manifolds amongst the second manifolds (106A) of the second channel (102B).

7. The heat exchanger (100) according to any of the preceding claims, wherein the primary openings (104, 106) and the secondary openings (204) are in-line to each other to enable fluidal connection between the primary openings (104, 106) and the secondary openings (204).

8. The heat exchanger (100) according to any of the preceding claims, further comprising at least one separation plate (112) comprising at least one separation baffle (112) located in between two primary plates (102) to define two fluid flow paths for the first channel (102A) and the second channel (102B).

9. The heat exchanger (100) as claimed in any of the preceding claims, further comprising at least one cover plate (110) provided in-contact with the primary plates (102) to encapsulate at least a portion of the primary plates (102), wherein the cover plate (110) further comprising cover-openings complementary to the primary openings and the secondary opening formed on the primary and secondary plates respectively.

10. The heat exchanger (100) according to any of the preceding claims, wherein the primary plates (102) comprise corrugations on its surface.

11. The heat exchanger (100) according to any of the preceding claims, wherein the heat exchanger (100) is configured for an operation as condenser, the first fluid being a refrigerant and the second fluid being a liquid coolant.

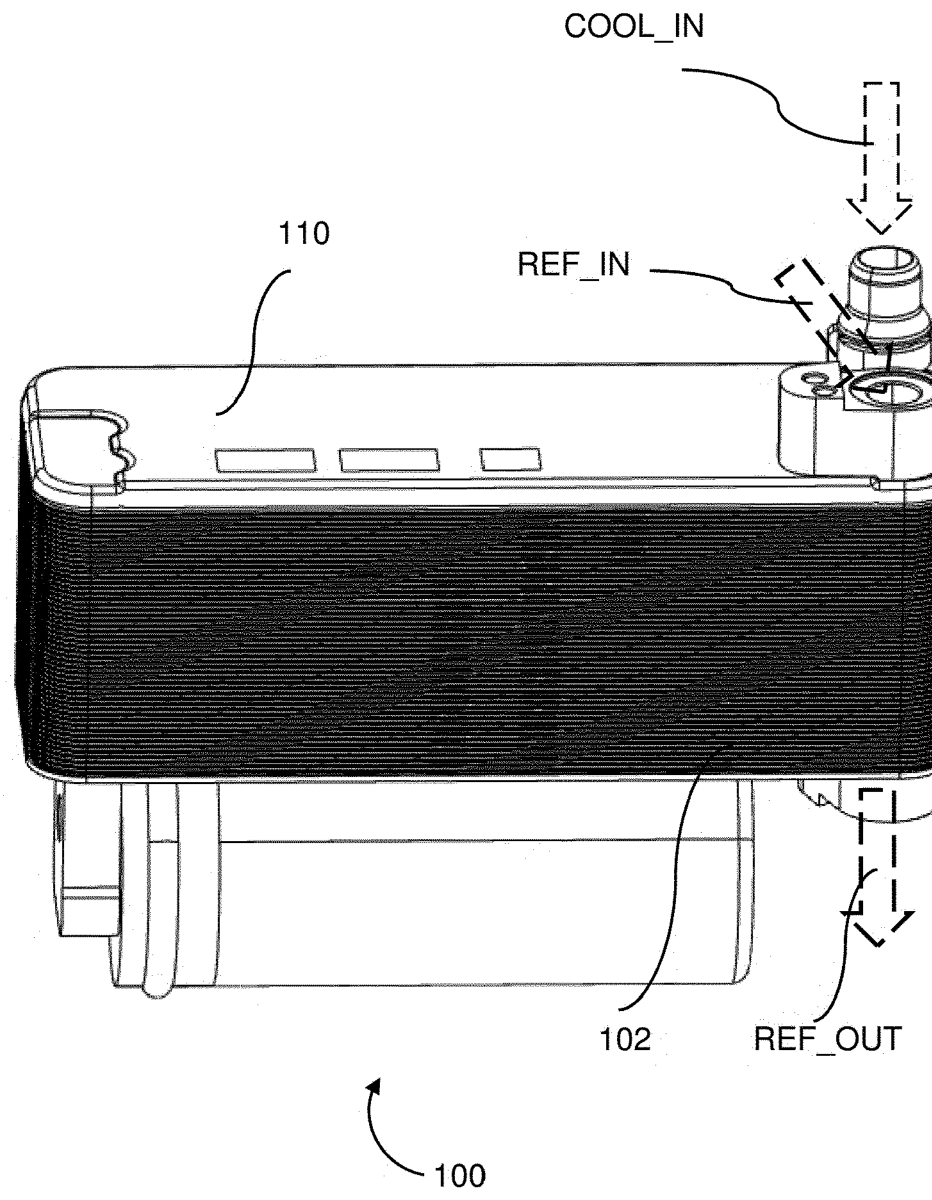


FIG. 1

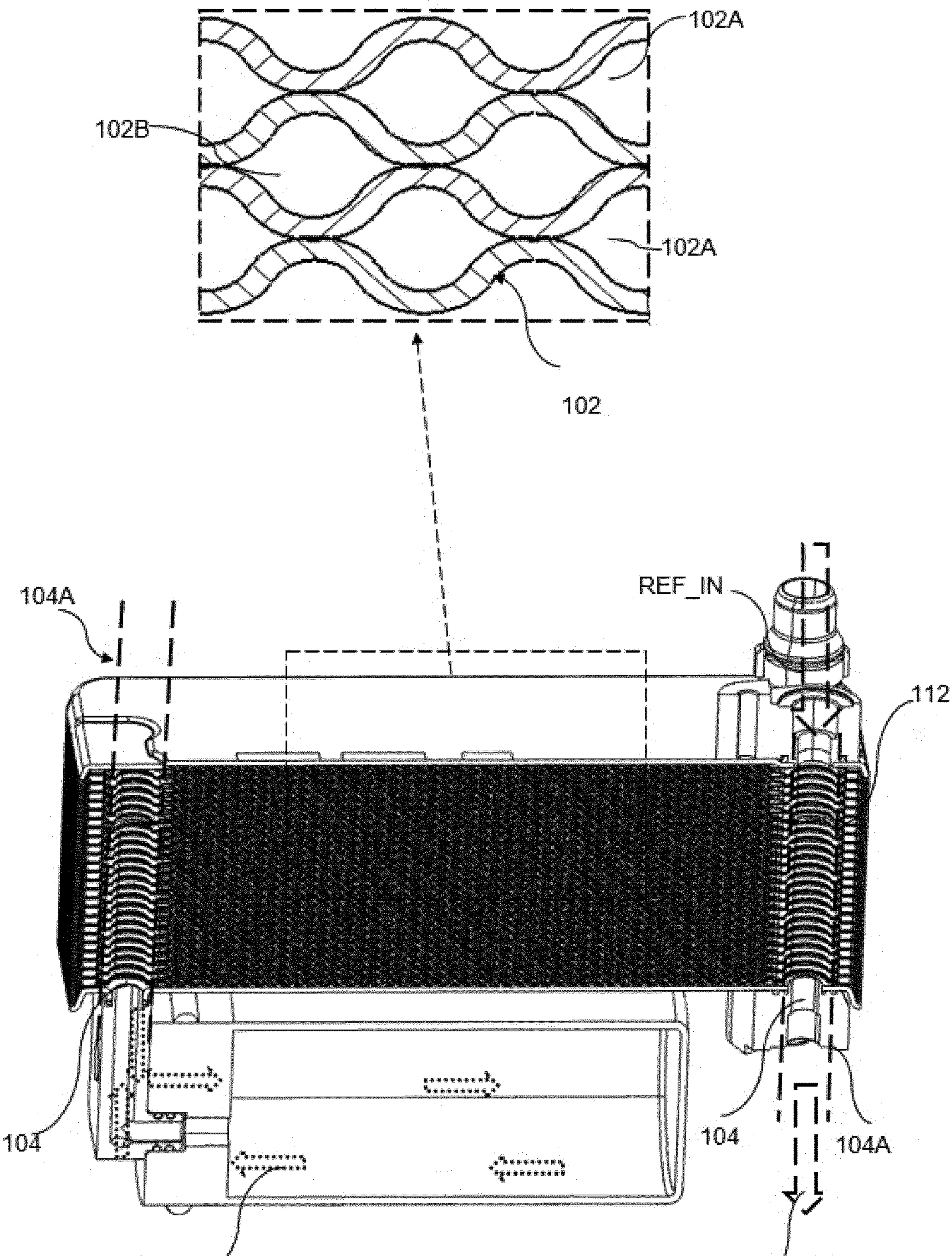


FIG. 2

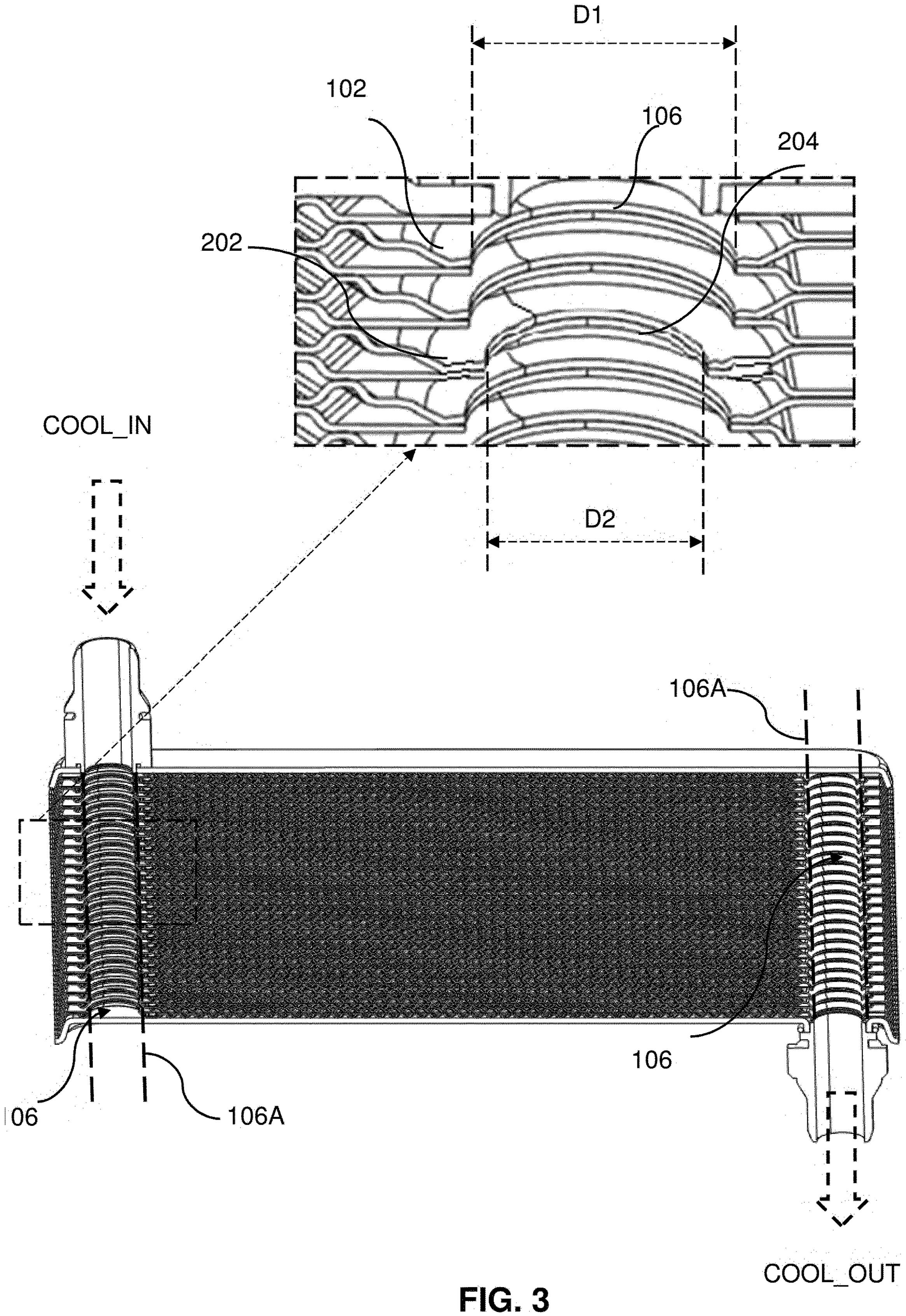


FIG. 3

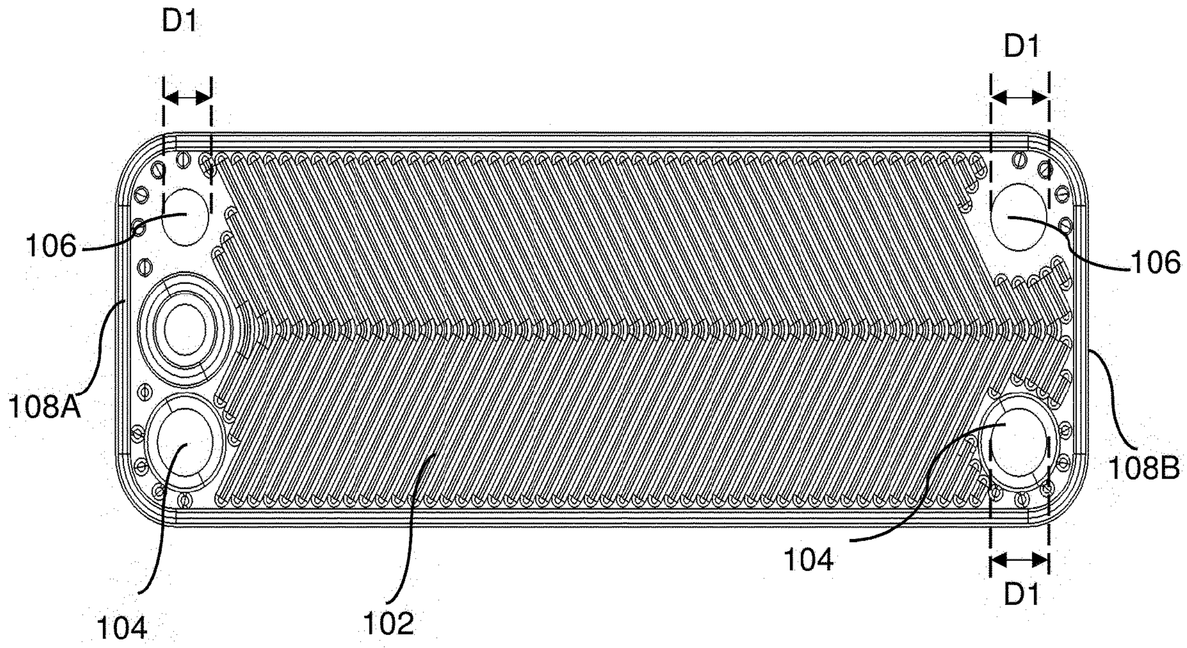


FIG. 4

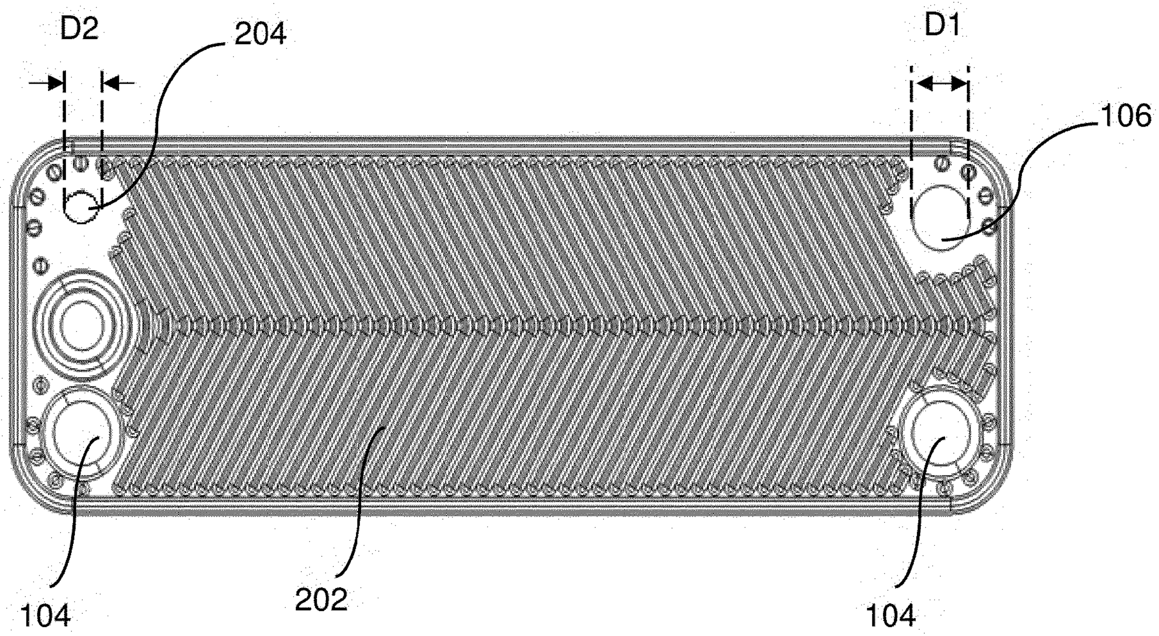


FIG. 5

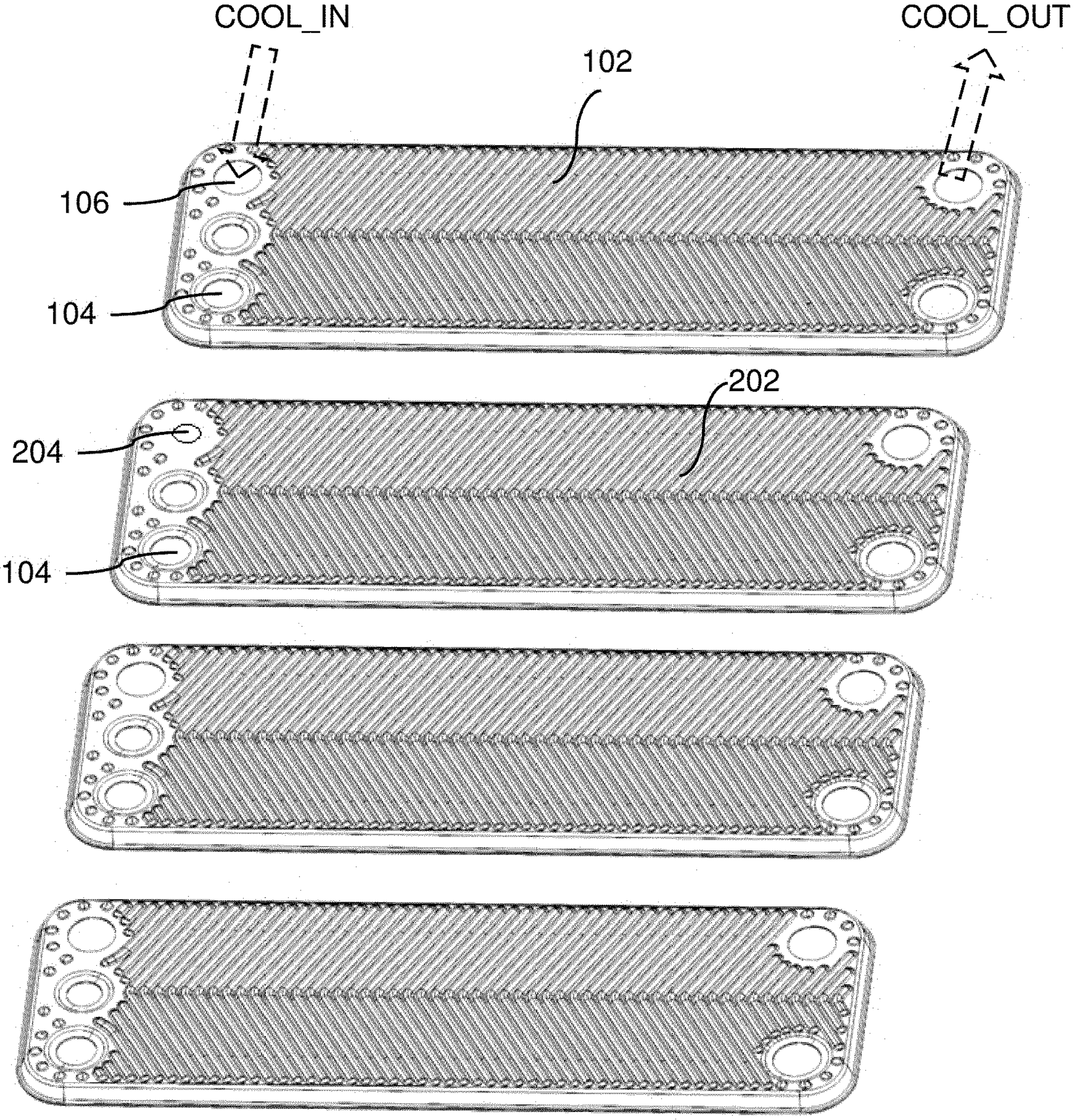


FIG. 6

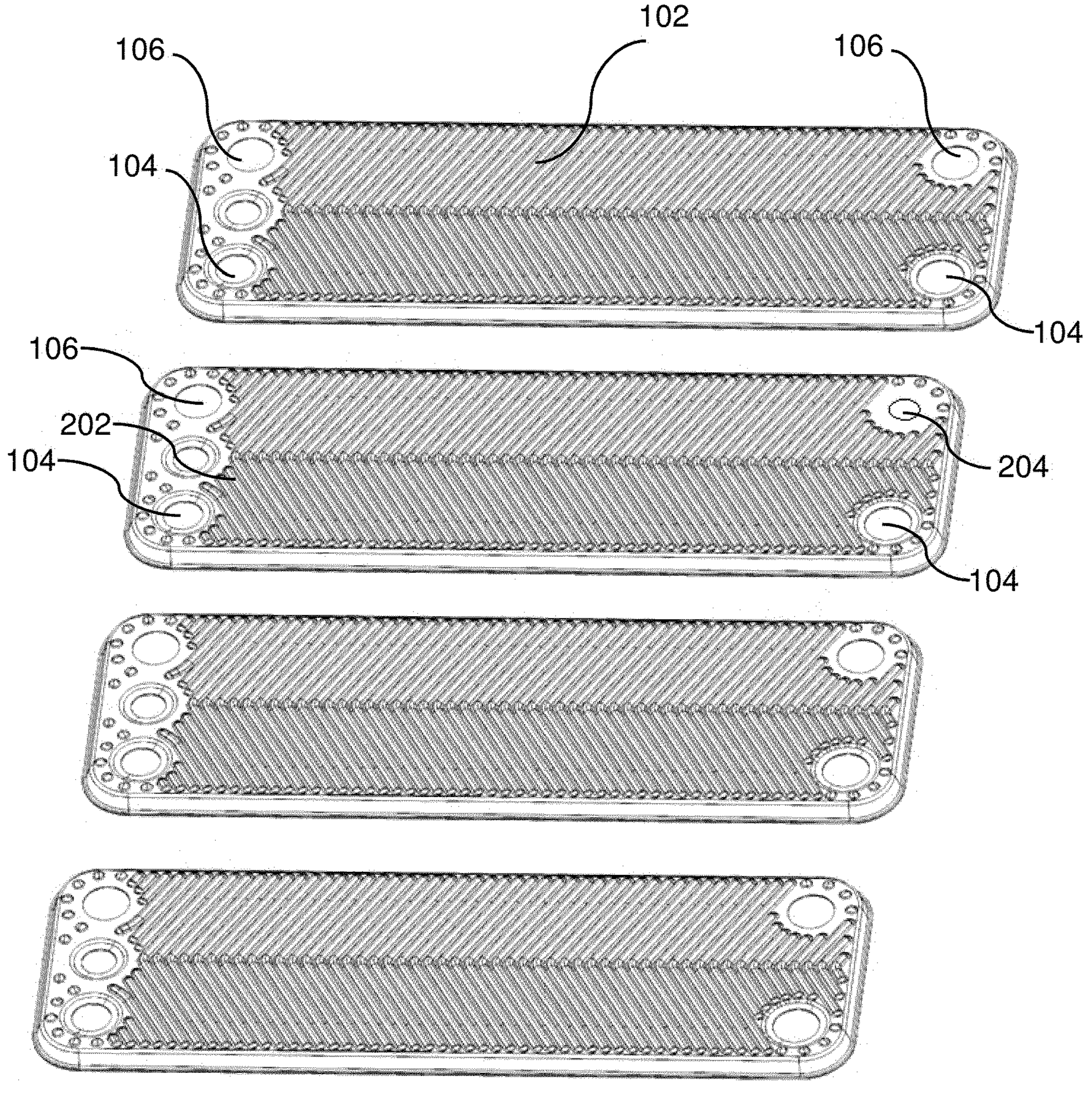


FIG. 7

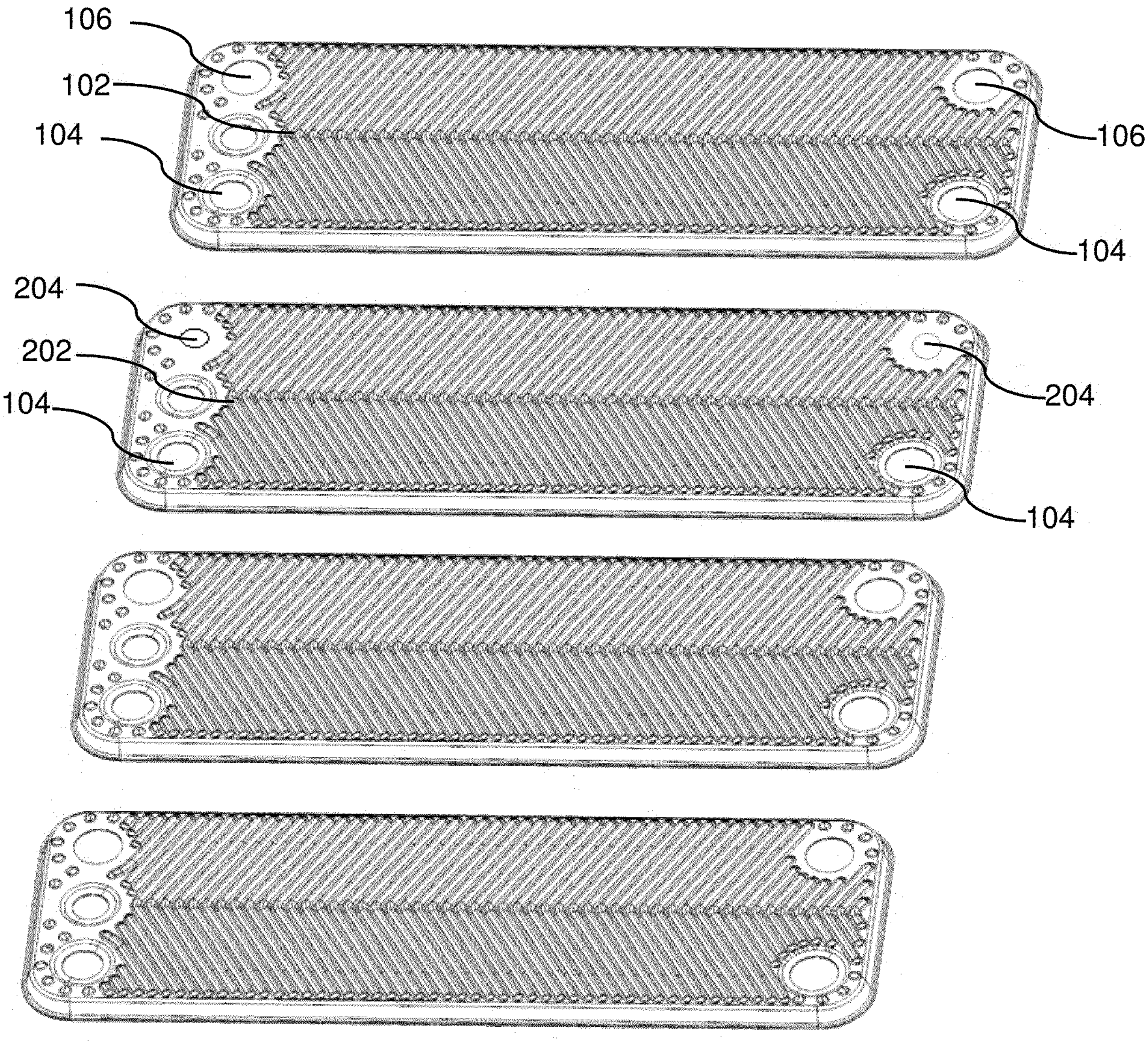


FIG. 8

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# EUROPEAN SEARCH REPORT

Application Number
EP 21 19 5549

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (IPC) |
|---|---|---|---|
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TECHNICAL FIELDS SEARCHED (IPC)
F28D
F28F

2 The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
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| Munich | 1 February 2022 | Martínez Rico, Celia |

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

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