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(54) **HEAT EXCHANGER**

(57) A heat exchanger for heat exchange between a first fluid and a second fluid is provided. The heat exchanger includes a first manifold, a second manifold, heat exchange tubes and a fin section. The heat exchange tubes is axially extending and providing a fluidal communication between the first manifold and the second manifold for the first fluid. The second fluid flows between the heat exchange tubes. The fin section is in contact with the heat exchange tubes for facilitating heat exchange between the first fluid and the second fluid. The fin section includes a first louver section having louvers of first louver length and a second louver section having louvers of second louver length. The second louver section is arranged subsequently to the first louver section with respect to transverse direction of intended fluid flow direction. Further, the second louver length is different from the first louver length.

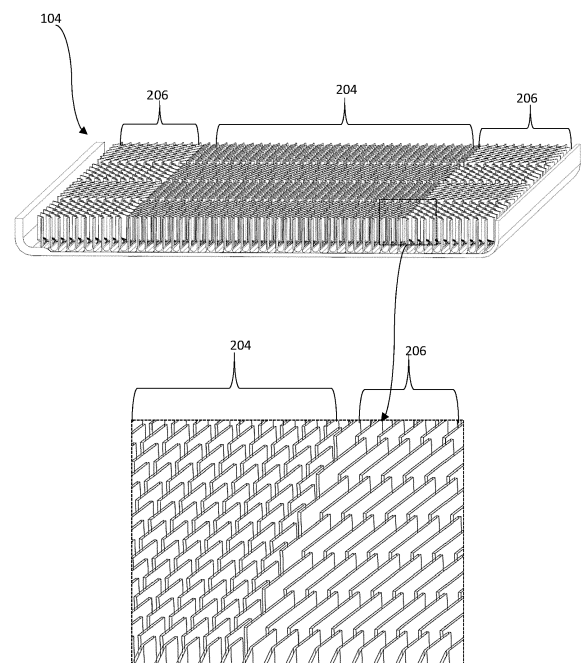


FIG. 6

Description

[0001] The present invention relates to a heat exchanger. In particular, the invention relates to the heat exchanger fins having various sizes of louvers provided in a heat exchanger.

[0002] Conventionally, heat exchangers for automobiles are designed to perform heat exchange between a first fluid allowed to flow through a first fluid circuit, and a second fluid allowed to flow through a second fluid circuit. The first fluid circuit includes a heat exchanger core having a plurality of fluid conduits or tubes connected between a first manifold and a second manifold. The area around the tubes enclosed in a housing defines the second fluid circuit. To improve the heat transfer rate between the first fluid circuit and the second fluid circuit, heat exchanger fins are in contact with the heat exchange tubes. Specifically, in heat exchanger such as radiator, fin is provided between adjacent heat exchange tubes, where the first fluid is usually coolant and the second fluid is usually air. In heat exchanger such as water charge air cooler, fin is provided within the tubes, where the first fluid is usually air and the second fluid is usually coolant. In general, air is passed through the circuit including fins and coolant is passed through the other circuit. The fins are provided with number of louvers to increase the heat transfer between the surfaces of the heat exchanger, which include the surfaces of the fins and the outside surfaces of the tubes, and the airflow. The louvers direct air stream over the fin surface and through the fin surface, create a controlled degree of turbulence and are intended to enhance the heat transfer between the air-stream or any other flow medium and the fin for higher thermal efficiency.

[0003] However, the louvers provided across the fins are of same length, which may result in non-homogenous airflow across the heat exchanger core and may cause significant air pressure drop. A higher air pressure drop can result in a lower heat transfer rate. In addition to that, there is a temperature difference between airflow in the inlet area of the airflow fluid circuit and the outlet area of the airflow fluid circuit. Therefore, the non-homogenous airflow pressure drop across the core may cause non-uniform heat exchange between the air and the coolant. For example, the air entering into the airflow fluid circuit may have higher temperature, in case the heat exchanger is charge air cooler, than the air flowing the outlet area of the airflow fluid circuit. In case the pressure drop across the core is non-homogenous, the heat exchange between the air and the coolant is higher at the inlet area of the airflow fluid circuit than of the outlet area of the airflow fluid circuit. As a result, the heat exchange tubes may undergo high stress due to temperature gradient between the inlet area and outlet area of the airflow fluid circuit, thereby causing cracks on the heat exchange tubes and reduce service life of the heat exchanger.

[0004] Accordingly, there remains a need for a heat exchanger fin to achieve homogeneous pressure drop

across the core of the heat exchanger. Further, there remains another need for louver sections defined on the fins of the heat exchanger that creates uniform pressure drop across the core of the heat exchanger, thereby optimizing thermal performance of the heat exchanger.

[0005] 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.

[0006] In view of foregoing, the present invention relates to a heat exchanger for heat exchange between a first fluid and a second fluid, particularly, heat exchanger fins. The heat exchanger includes a first manifold, a second manifold, a plurality of heat exchange tubes and a fin section. The plurality of heat exchange tubes is axially extending and providing a fluidal communication between the first manifold and the second manifold for the first fluid. Further, the first fluid flows from the first manifold to the second manifold in a first fluid direction and the second fluid flows between the heat exchange tubes in a second fluid direction. The fin section is in contact with the heat exchange tubes for facilitating heat exchange between the first fluid and the second fluid. The fin section further includes at least one first louver section having a number of louvers of first louver length and at least one second louver section having a number of louvers of second louver length. The first louver section is arranged subsequently to the second louver section with respect to transverse direction of intended first fluid flow direction. The louvers are formed as angled slats on a surface of the fin section. Further, the first louver length is different than the second louver length.

[0007] In one embodiment, the first louver length is greater than the second louver length.

[0008] In another embodiment, the first louver length is smaller than the second louver length.

[0009] In one embodiment, the first louver section and the second louver section comprises equal number of louvers.

[0010] In another embodiment, the first louver section comprises different number of louvers than the second louver section.

[0011] Further, the louvers of the first louver section are aligned at a first louver angle and the louvers of the second louver section are aligned at a second louver angle. In one embodiment, the second louver angle is different than the first louver angle. In another embodiment, the second louver angle is same as that of the first louver angle.

[0012] Further, the louvers of the first louver section have a first louver width and the louvers of the second louver section have a second louver width. In one embodiment, the first louver width is same as that of the

second louver width. In another embodiment, the first louver width is different than the second louver width.

[0013] The first louver section and the second louver section comprises a number of louver sets sloping alternately away and towards the fin section in the direction of the first fluid intended to flow there-through. In one embodiment, each louver have a primary louver and at least one secondary louver extending from a surface of the primary louver.

[0014] Further, the fin section is formed of at least three louver sections arranged subsequently and repeatedly in an order comprising the first louver section, the second louver section and a repeat of the first louver section. In another embodiment, the fin section is formed of at least three louver sections arranged subsequently and repeatedly in an order comprising the second louver section, the first louver section and a repeat of second louver section.

[0015] 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 perspective view of a heat exchanger, in accordance with an embodiment of the present invention;

Fig. 2 illustrates a schematic view of the heat exchanger of Fig. 1 without a housing, and showing heat exchange tubes;

Fig. 3 exemplarily illustrates a perspective view of heat exchanger tube of Fig. 2 wherewith is associated a fin section;

Fig. 4 exemplarily illustrates a cross sectional view of the heat exchange tube of Fig. 2 showing the fin section having louvers of the first louver section;

Fig. 5 exemplarily illustrates a cross sectional view of the heat exchange tube of Fig. 2 showing the fin section having louvers of the second louver section;

Fig. 6 exemplarily illustrates a schematic view of a fin section disposed within the heat exchange tubes of Fig. 2, showing the arrangement of the first louver section and the second louver section;

Fig. 7 exemplarily illustrates a schematic view of a fin section disposed within the heat exchange tubes of Fig. 2, showing the arrangement of the first louver section and the second louver section, according to another embodiment of the present invention;

[0016] It must be noted that the figures disclose the invention in a detailed enough way to be implemented, said figures helping to better define the invention if needs be. The invention should however not be limited to the embodiment disclosed in the description.

[0017] The present invention envisages a heat exchanger provided with fin and louvers pattern to achieve uniform heat exchange between two fluid flowing there through. The heat exchanger includes a plurality of heat exchange elements extending between a pair of manifolds, and a fin section in contact with the heat exchange elements. Further, a first fluid flows from the first manifold to the second manifold in a first fluid flow direction and a second fluid flows between the heat exchange tubes in a second fluid flow direction. In an aspect, the heat exchanger can be configured for operation as a water charge air cooler. In such case, the first fluid is air and second fluid is a liquid coolant. In another aspect, the heat exchanger can be configured for operation as a radiator. In such case, the first fluid is a liquid coolant and the second fluid is air.

[0018] Figs. 1 and 2 illustrate schematic views of a heat exchanger 100, in accordance with an embodiment of the present invention. In the present example, Fig. 1 is a perspective view of the heat exchanger 100, and Fig. 2 is a perspective view of the heat exchanger 100 without a housing 102. The heat exchanger 100 includes a first manifold 102A, a second manifold 102B spaced apart from the first manifold 102A and a plurality of heat exchange elements 104. Further, the plurality of heat exchange elements 104 can be heat exchange tubes. The plurality of heat exchange elements 104, hereinafter referred to as heat exchange tubes, is axially extending between the first manifold 102A and the second manifold 102B and is providing a fluidic communication between the first manifold 102A and the second manifold 102B. The heat exchanger 100 further includes a housing 102 in which the heat exchange tubes 104 are disposed. In other words, the heat exchange tubes 104 are at least partially enclosed by the housing 102. Further, at least two fluid flows are defined in the housing 102 and they are in heat exchange configuration with each other. In particular, a first fluid flow and a second fluid flow fluidically isolated from the first fluid flow, but thermally coupled with the second fluid flow. Further, the first fluid flow defined in a first fluid circuit and the second fluid flow defined in a second fluid circuit

[0019] In the present example, the first fluid flows from the first manifold 102A to the second manifold 102B through the heat exchange tubes 104 in the first fluid direction 106A. Further, the first fluid circuit is formed through the heat exchange tubes 104 in such a way the first fluid flows from the first manifold 102A to the second manifold 102B in the first fluid direction 106A. The second fluid flows between the heat exchange tubes 104 in the second fluid direction 106B. The second fluid direction 106B is perpendicular to the first fluid direction 106A. Further, the housing 102 defines a path for the second

fluid between the heat exchange tubes 104. Further, an inlet and outlet may be connected to housing 102 to introduce and receive the second fluid to/from the heat exchanger 100.

[0020] The heat exchanger 100 further comprises a fin section 202 as shown in Fig. 3. The fin section 202 is in contact with the heat exchange tubes 104. The fin section 202 having fins is provided in contact with the heat exchange tubes 104 in such a way that the fin section 202 facilitates heat exchange between the first fluid and the second fluid. The fin section 202 is provided in the heat exchanger 100 to increase pressure drop of the airflow flowing there through, so that the thermal performance of the heat exchanger 100 may be increased. In case the heat exchanger 100 is adapted for an operation as charged air coolers, the fin section 202 is disposed within the heat exchange tubes 104. In such case, the first fluid is air and the second fluid is liquid coolant. In case the heat exchanger 100 is adapted for an operation as radiators, the fin section 202 can be interlaced between adjacent heat exchange tubes 104. In such case, the first fluid is a liquid coolant and the second fluid is air. The fin section 202 can be corrugated fins or flat fins.

[0021] Referring to Fig. 3, the fin section 202 defines a thin metallic or conductive sheet of material formed in a plurality of undulations 208, which establishes a straight length of walls that extend within the tubes 104. The peaks 210 of the undulations 208 conductively connected to and contacts the flat side of the tube walls (104A, 104B). The peaks are generally brazed to the flat sides of the heat exchange tube 104. A number of louvers are formed by partially cutting and raising respective flat portion of the fin section 202 to form angled slats. The louvers are provided with louver geometry elements including length, width and inclination angle. Referring to Fig. 4 and Fig. 5, each louver includes a leading edge 212A and a trailing edge 212B with the leading edge facing the incoming airflow side of the heat exchanger 100. The length of each louver is defined as the dimension between the leading 212A and trailing edges 212B. Therefore, the louver length is measured relatively to the direction in which it elongates. The width of each louver is defined as the dimension between the two ends (121C, 121D) where the louver is connected to the fin section 202. Therefore, the width of the louver may be measured transversely with respect to the direction of elongation of the louver.

[0022] Referring to Fig. 4 to Fig. 7, the number of louvers defines a first louver section 204 having first louver length (L1) and a second louver section 206 having a second louver length (L2). Each louver section includes an alternating pattern of a leading and trailing set of louvers. The set of louvers slopes alternately away and towards the fin section 202 in the direction of the fluid intended to flow there-through. The louvers extend at an angle with respect to the planes of the fin. In one embodiment, the louvers at the first louver section 204 are aligned at a first louver angle with respect to the plane

of the fin and the louvers at the second louver section 206 are aligned at a second louver angle with respect to the plane of the fin. In one embodiment, the first louver angle is same as that of the second louver angle. In another embodiment, the first louver angle is different than the second louver angle.

[0023] In one embodiment, the first louver length (L1) is different than the second louver length (L2). In one embodiment, the first louver length (L1) is greater than the second louver length (L2). In another embodiment, the first louver length (L1) is smaller than the second louver length (L2). In one embodiment, the first louver section 204 comprises different number of louvers than the second louver section 206. In another embodiment, the first louver section 204 and the second louver section 206 comprises same number of louvers. In yet another embodiment, the first louver section 204 comprises more number of louvers than the second louver section 206. In yet another embodiment, the first louver section 204 comprises less number of louvers than the second louver section 206. In case the length of the first louver section 204 is larger than the length of the second louver section 206, the number of louver in the first louver section 204 would be smaller than the number of louvers in the second louver section 206. In case the length of the first louver section 204 is smaller than the length of the second louver section 206, the number of louver in the first louver section 204 would be greater than the number of louvers in the second louver section 206.

[0024] In one embodiment, the louvers of the first louver section 204 have a first louver width and the louvers of the second louver section 206 have a second louver width. In one embodiment, the second louver width is different than the first louver width. In another embodiment, the second louver width is same as that of the first louver width. Referring to Fig. 6, the fin section 202 having two different louver sections are arranged alternatively and repeatedly, such that each heat exchange tube 104 houses at least three-louver section. In one embodiment, the three louver sections are arranged in an order comprising the first louver section 204, the second louver section 206 and a repeat of the first louver section 204. Referring to Fig. 7, in another embodiment, the at least three louver sections are arranged in an order comprising the second louver section 206, the first louver section 204 and a repeat of the second louver section 206.

[0025] In operation of the heat exchanger 100, the first fluid or charged fluid, preferably air, passes through the heat exchange tubes 104, heat is absorbed therefrom by the second fluid or a cooling fluid, preferably coolant flowing outside of the heat exchange tubes 104. As the first fluid flows over the fin section 202 having louvers of different louver length, the pressure drop of the first fluid flowing at the different louver sections having different louver length are varied. Particularly, in case the first louver length (L1) is greater than the second louver length (L2), the pressure drop of the fluid flowing through the first louver section 204 is higher than the pressure drop

of the fluid flowing through the second louver section 206. Alternatively, in case the first louver length (L1) is smaller than the second louver length (L2), the pressure drop of the fluid at the first louver section 204 is lower than the pressure drop of the fluid flowing at the second louver section 206.

[0026] In another case, the pressure drop of the fluid is varied by varying the number of louvers and length of louvers. According to this case, if the first louver length (L1) of the first louver section 204 is larger than the second louver length (L2) of the second louver section 206 and the number of louvers at the first louver section 204 is smaller than the number of louvers in the second louver section 206, the pressure drop of the first fluid flowing through the first louver section 204 is lower than pressure drop of the first fluid through the second lower section. If the first louver length (L1) of the first louver section 204 is smaller than the second louver length (L2) of the second louver section 206 and the number of louvers at the first louver section 204 is bigger than the number of louvers in the second louver section 206, the pressure drop of the first fluid flowing through the first louver section 204 is higher than pressure drop of the first fluid through the second louver section.

[0027] In another embodiment, during operation of the heat exchanger 100, the first fluid or charged fluid, preferably air, passes through the fluid circuit including fin section 202, heat is absorbed therefrom by the second fluid or a cooling fluid, preferably coolant flowing through the other circuit. As the first fluid flows over the fin section 202 having louvers of different louver length, the pressure drop of the first fluid flowing at the different louver sections having different louver length are varied. Particularly, in case the first louver length (L1) is greater than the second louver length (L2), the pressure drop of the fluid flowing through the first louver section 204 is higher than the pressure drop of the fluid flowing through the second louver section 206. Alternatively, in case the first louver length (L1) is smaller than the second louver length (L2), the pressure drop of the fluid at the first louver section 204 is lower than the pressure drop of the fluid flowing at the second louver section 206.

[0028] In another case, the pressure drop of the fluid is varied by varying the number of louvers and length of louvers. According to this case, if the first louver length (L1) of the first louver section 204 is larger than the second louver length (L2) of the second louver section 206 and the number of louvers at the first louver section 204 is smaller than the number of louvers in the second louver section 206, the pressure drop of the first fluid flowing through the first louver section 204 is lower than pressure drop of the first fluid through the second lower section. If the first louver length (L1) of the first louver section 204 is smaller than the second louver length (L2) of the second louver section 206 and the number of louvers at the first louver section 204 is greater than the number of louvers in the second louver section 206, the pressure drop of the first fluid flowing through the first louver section

204 is high than pressure drop of the first fluid through the second louver section 206.

[0029] Thus, varying the geometry and number of the louvers at desired section of fins, the pressure drop could be either increased or decreased locally to vary the heat exchange rate. As a result, a uniform heat exchange rate is achieved throughout the core and improves the thermal performance of the heat exchanger 100.

[0030] Further, the air entering into the heat exchanger 100 may have higher temperature than the air flowing the outlet area of the heat exchanger 100. Hence, there would be a non-uniform heat exchange between the air and coolant at the inlet and outlet area of the heat exchanger 100. As a result, the heat exchange tubes 104 may undergo high stress due to temperature gradient between the inlet area and outlet area, thereby causing cracks on the heat exchange tubes 104 and reduce service life of the heat exchanger 100. In this case, the heat exchange rate at the outlet area is increased by decreasing the pressure drop at the outlet area. The decrease in pressure drop is achieved by varying the geometry and number of the louver at the outlet area. Accordingly, based on the requirements of the heat exchanger 100, the geometry and number of louvers disposed at the fin section 202 is defined to locally increase or decrease the internal pressure drop and achieve a uniform heat exchange rate, thereby improving the thermal performance without sacrificing the rigidity of the system.

[0031] 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 a second fluid, comprising:

a first manifold (102A) and a second manifold (102B);

a plurality of heat exchange tubes (104) axially extending and providing a fluidal communication between the first manifold (102A) and the second manifold (102B) for the first fluid, wherein the first fluid flows from the first manifold (102A) to the second manifold (102B) in a first fluid direction (106A) and the second fluid flows between the heat exchange tubes (104) in a second fluid direction (106B), and

a fin section (202) in contact with the heat exchange tubes (104) for facilitating heat exchange between the first fluid and the second fluid, **characterized in that**

the fin section (202) further comprises at least one first louver section (204) having a number of louvers of first louver length (L1) and at least

- one second louver section (206) having a number of louvers of second louver length (L2), wherein the second louver section (206) is arranged subsequently to the first louver section (204) with respect to transverse direction of intended first fluid flow direction (106A), wherein the second louver length (L2) is different than the first louver length (L1). 5
2. The heat exchanger (100) as claimed in claim 1, wherein the first louver length (L1) is greater than the second louver length (L2), wherein the lengths (L1, L2) are measured relatively to the direction in which the louver elongates. 10
 3. The heat exchanger (100) as claimed in claim 1, wherein the first louver length (L1) is smaller than the second louver length (L2), wherein the lengths (L1, L2) are measured relatively to the direction in which the louver elongates. 15
 4. The heat exchanger (100) as claimed in any of the preceding claims, wherein the first louver section (204) and the second louver section (206) comprises equal number of louvers. 20
 5. The heat exchanger (100) according to claims 1-3, wherein the first louver section (204) comprises different number of louvers than the second louver section (206). 25
 6. The heat exchanger (100) as claimed in claim 1, wherein the louvers of the first louver section (204) aligned at a first louver angle and the louvers of the second louver section (206) aligned at a second louver angle, wherein the second louver angle is different than the first louver angle. 30
 7. The heat exchanger (100) as claimed in claim 1, wherein the louvers of the first louver section (204) and the second louver section (206) are arranged at a same louver angle. 35
 8. The heat exchanger (100) as claimed in claim 1, wherein the louvers of the first louver section (204) have a first louver width and the louvers of the second louver section (206) have a second louver width, wherein the second louver width is different than the first louver width, wherein width of the louver is measured perpendicularly with respect to the direction of elongation of the louver. 40
 9. The heat exchanger (100) as claimed in claim 7, wherein the second louver width is same as that of the first louver width, wherein width of the louver is measured perpendicularly with respect to the direction of elongation of the louver. 45
 10. The heat exchanger (100) as claimed in any of the preceding claims, wherein each louver having a primary louver and at least one secondary louver extending from a surface of the primary louver. 50
 11. The heat exchanger (100) as claimed in any of the preceding claims, wherein the first louver section (204) and the second louver section (206) comprises a number of louver sets sloping alternately away and towards the fin section (202) in the direction (106A) of the first fluid intended to flow there-through. 55
 12. The heat exchanger (100) as claimed in any of the preceding claims, wherein the louvers are formed as angled slats on a surface of the fin section (202).
 13. The heat exchanger (100) as claimed in any of the preceding claims, wherein the fin section (202) is formed of at least three louver sections arranged subsequently and repeatedly in an order comprising the first louver section (204), the second louver section (206) and a repeat of first louver section (204).
 14. The heat exchanger (100) as claimed in any of the preceding claims, wherein the fin section (202) is formed of at least three louver sections arranged subsequently and repeatedly in an order comprising the second louver section (206), the first louver section (204) and a repeat of second louver section (206).

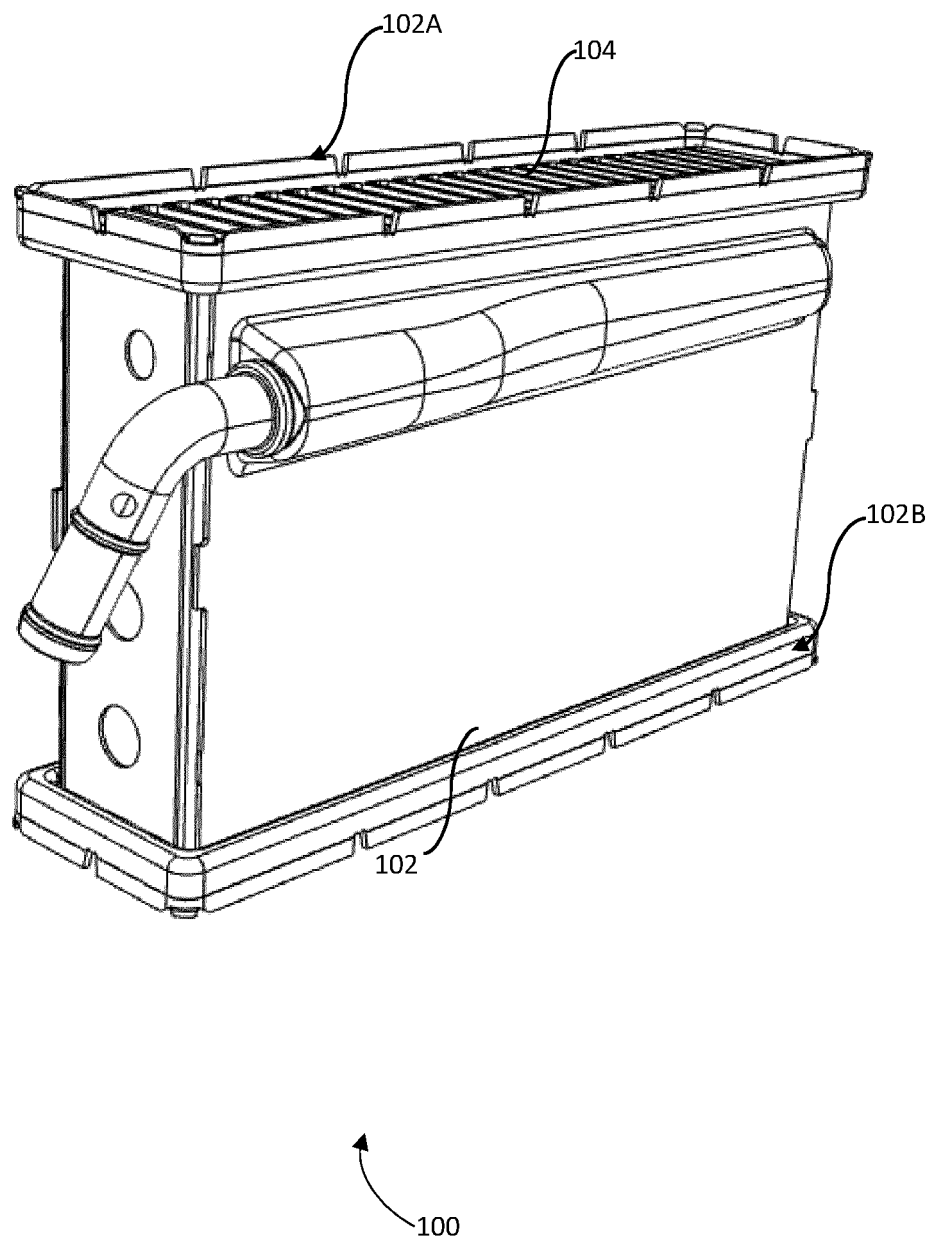


FIG. 1

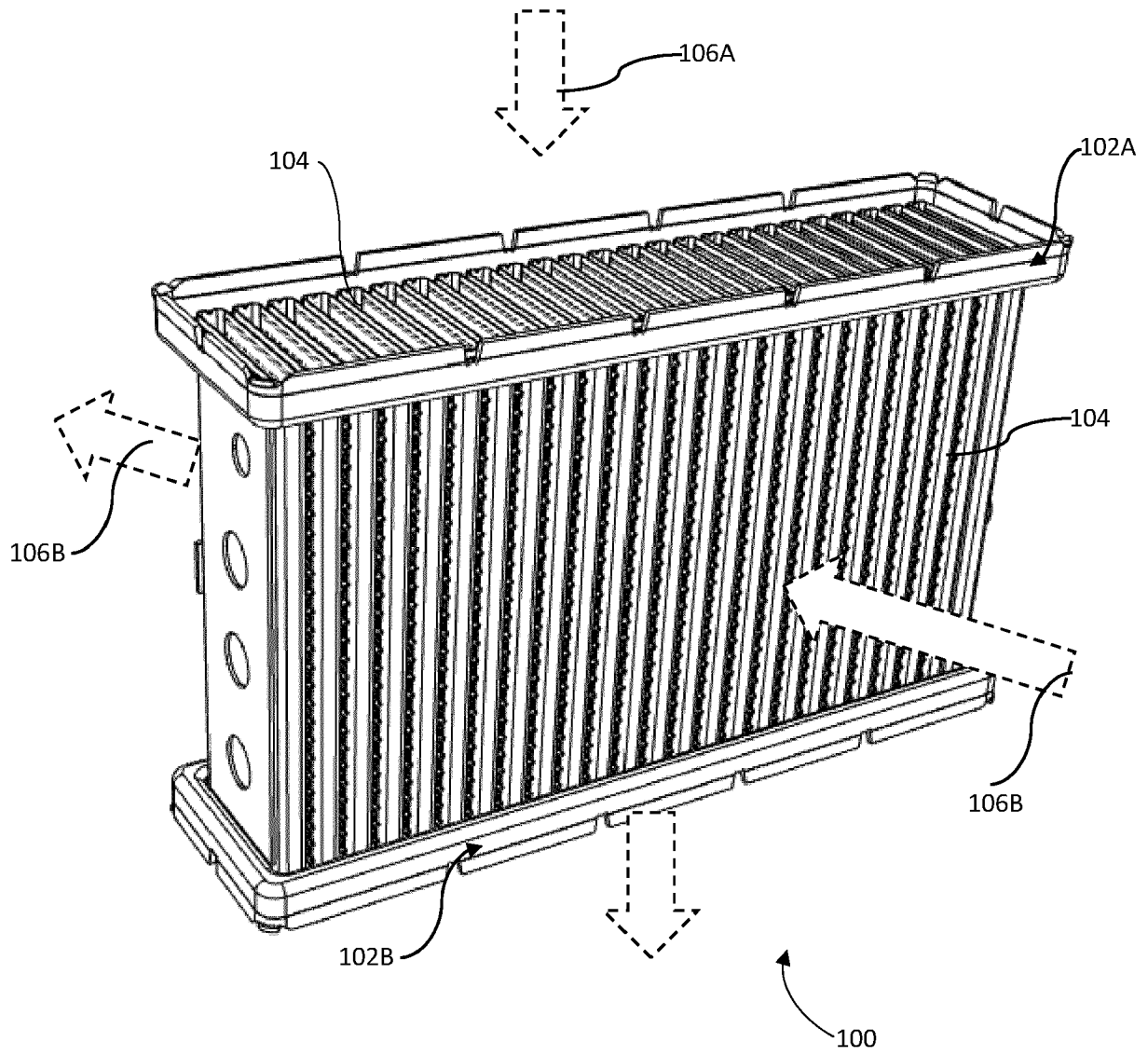


FIG. 2

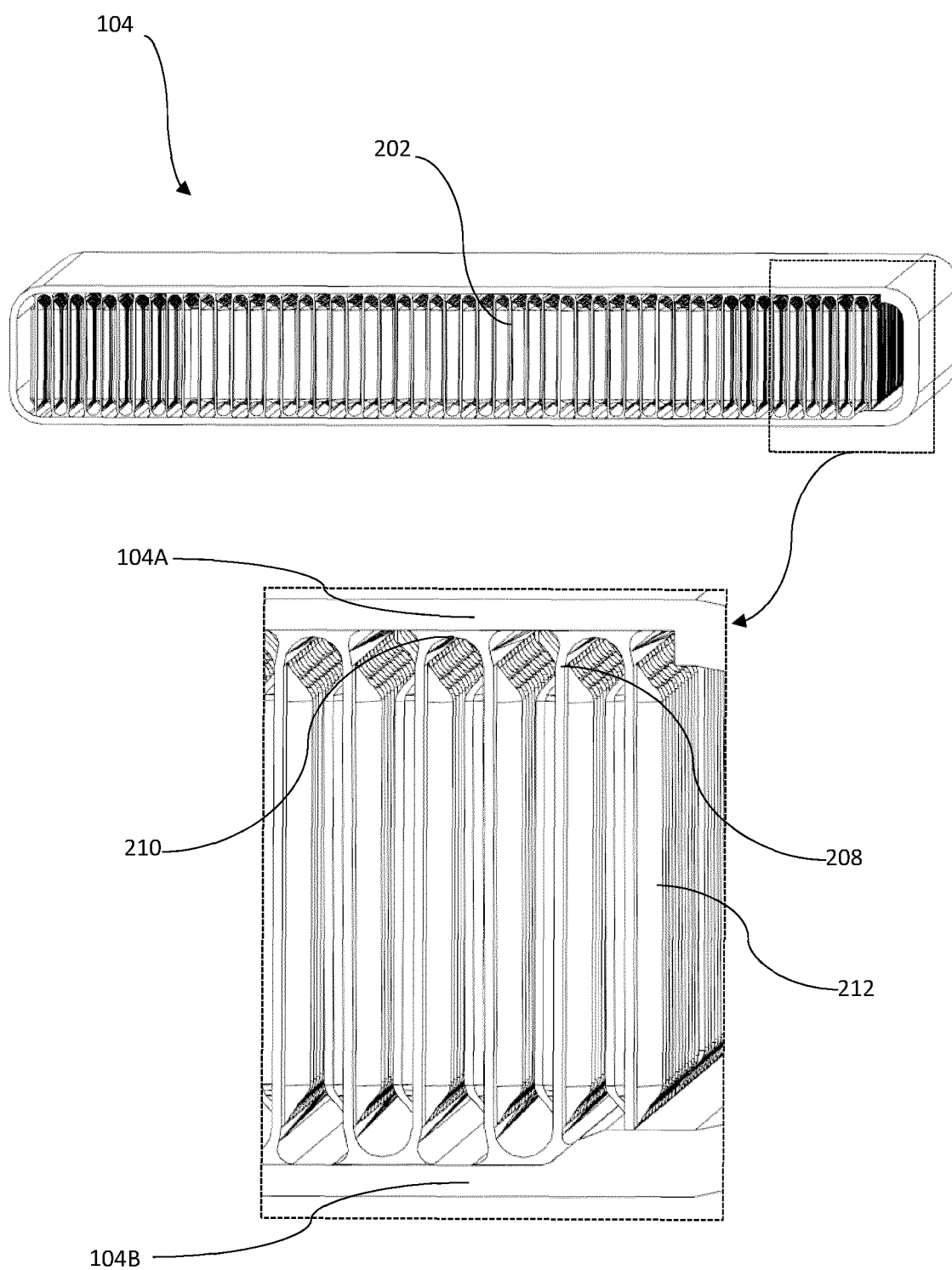


FIG. 3

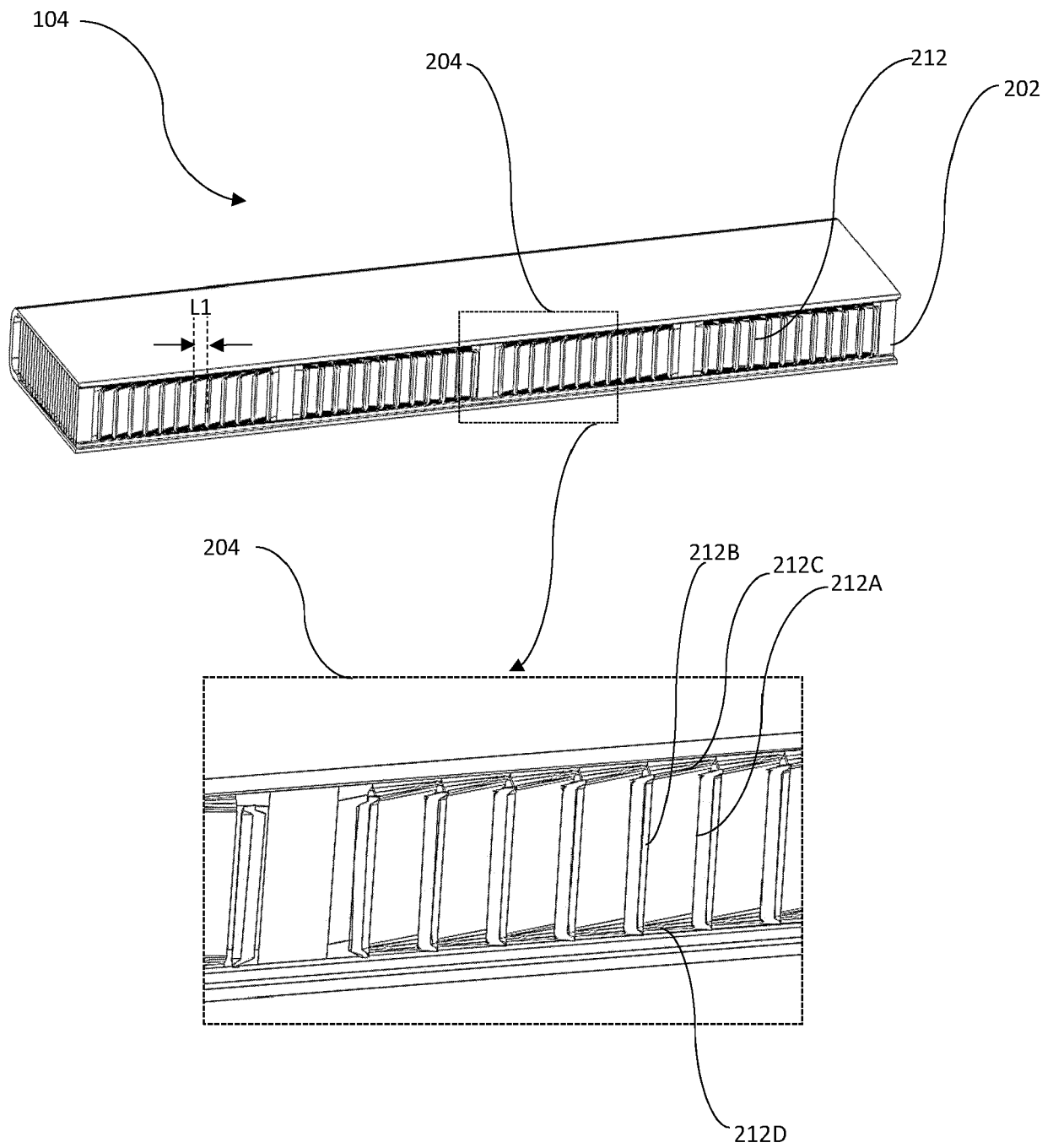


FIG. 4

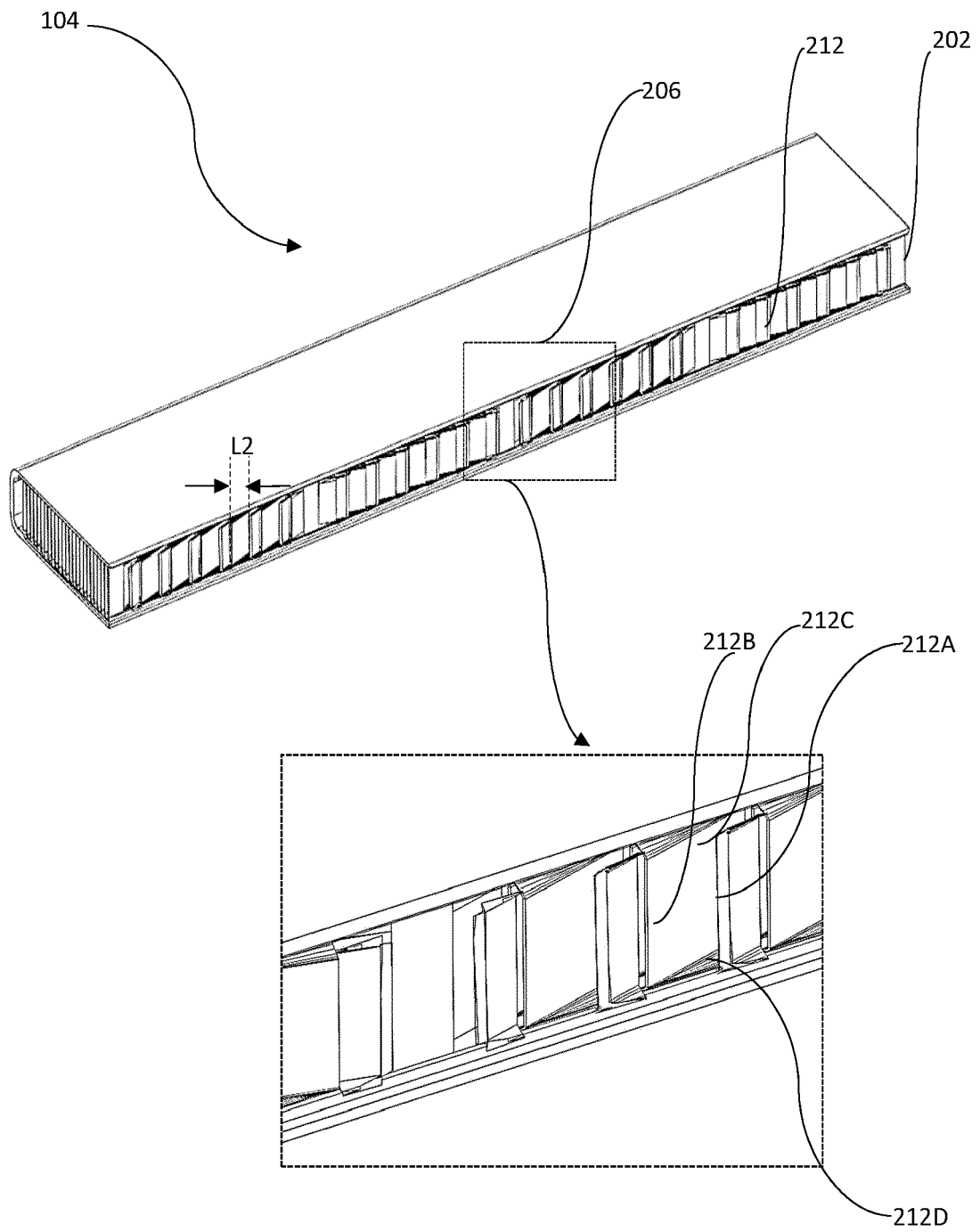


FIG. 5

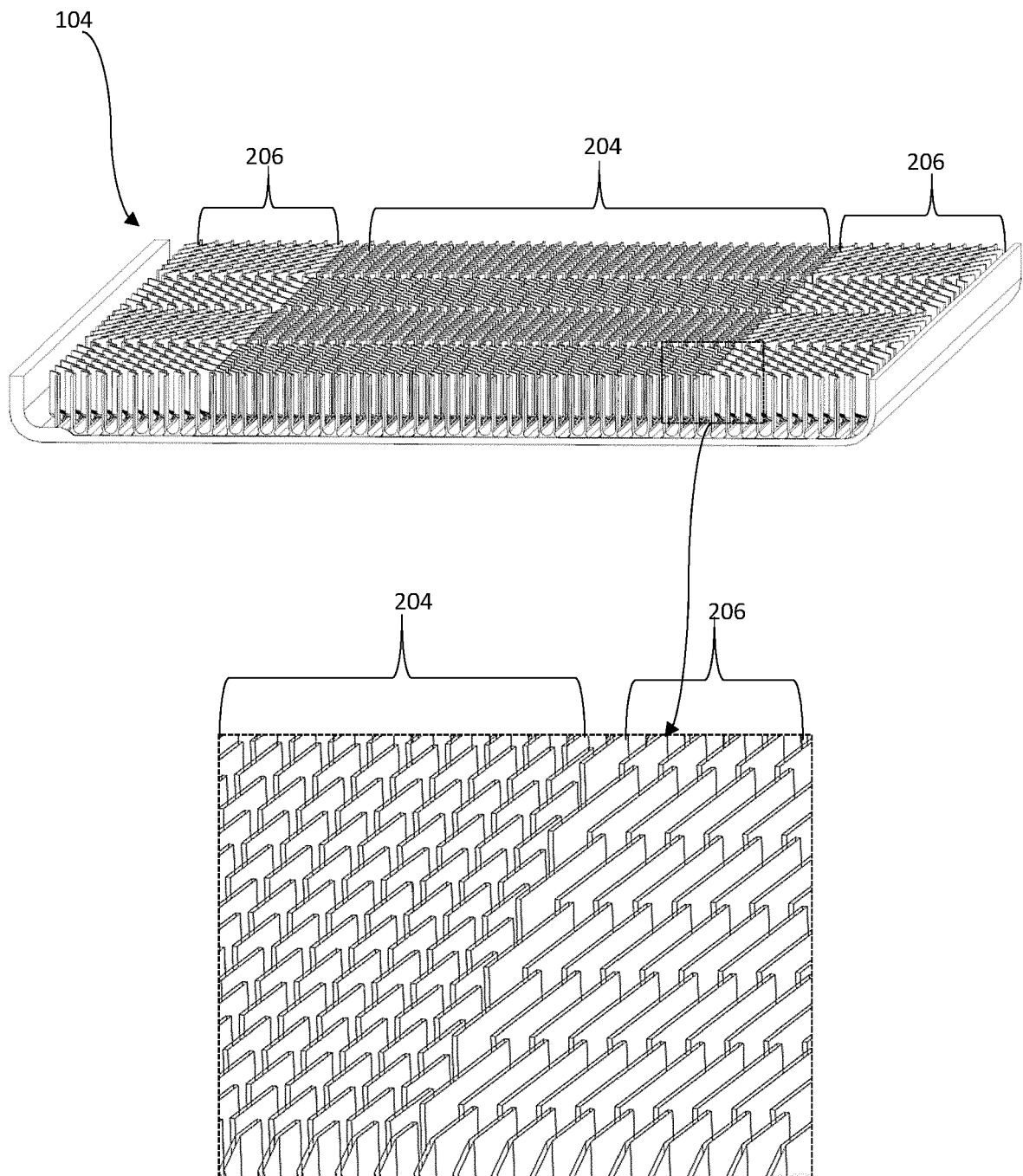


FIG. 6

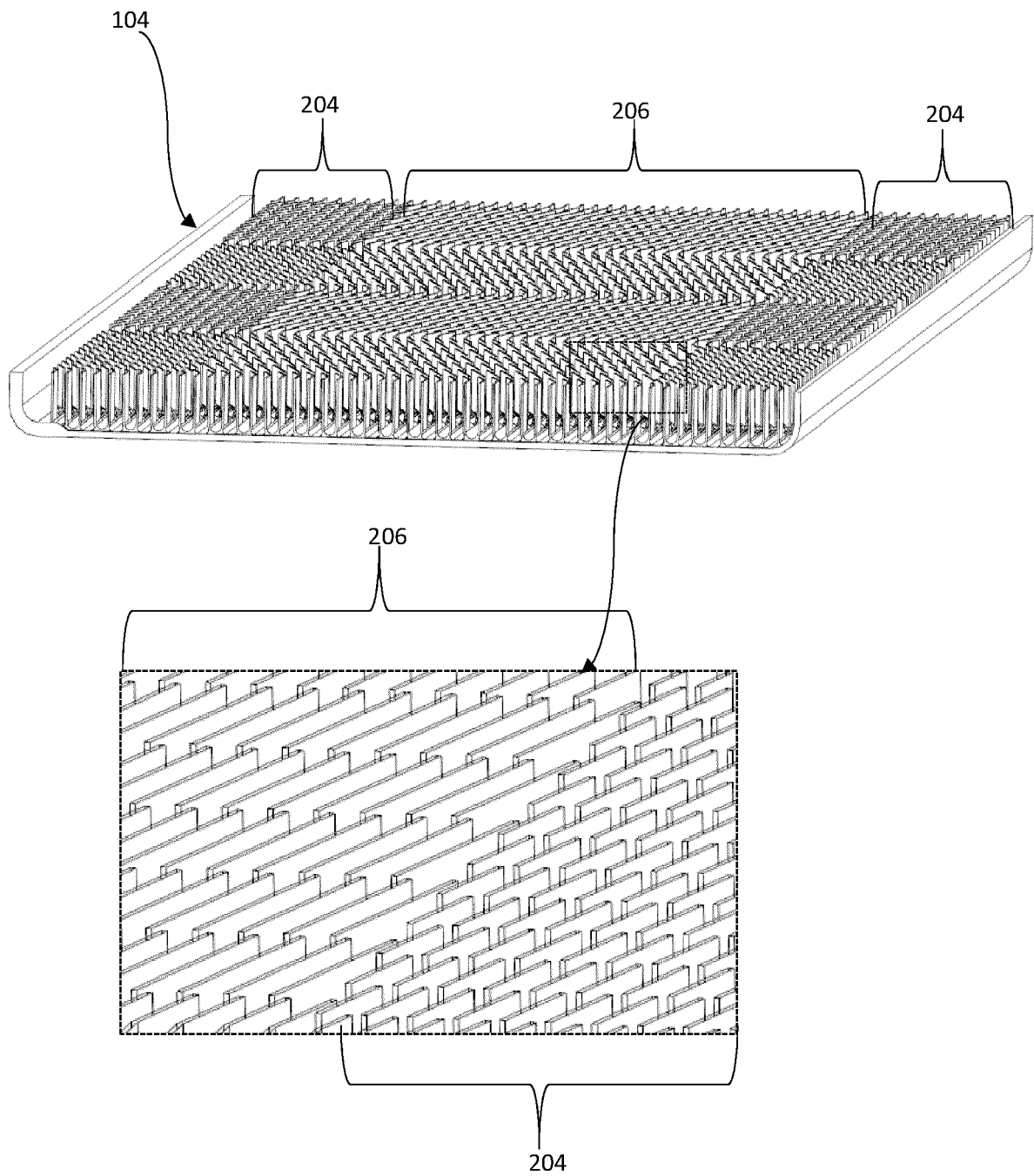


FIG. 7



EUROPEAN SEARCH REPORT

 Application Number
 EP 20 46 1610

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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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Place of search Munich		Date of completion of the search 15 April 2021	Examiner Bain, David
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 46 1610

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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