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(54) **HEAT EXCHANGER**

(57) The present invention discloses a heat exchanger for heat exchange between a first fluid and a second fluid. The heat exchanger includes a first manifold, a second manifold, and heat exchange tubes. The 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 the first fluid direction and the second fluid flows between the heat exchange tubes in the second fluid direction perpendicular to the first fluid direction. The heat exchanger further includes a fin section provided in contact with the heat exchange tubes for facilitating heat exchange between the first fluid and the second fluid. The fin section further includes a primary louver located on the fin section and a secondary louver location on the primary louver.

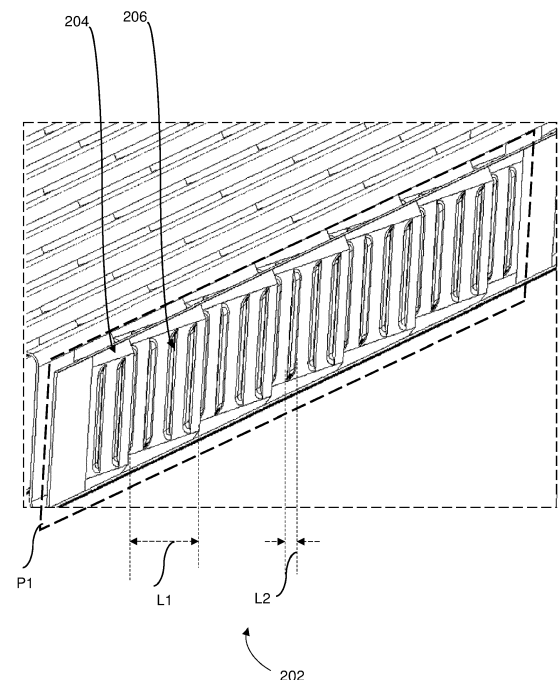


FIG. 4

Description

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

[0002] Conventionally, the heat exchanger may include two fluid circuits configured to be in a heat exchange configuration. Specifically, one fluid circuit may be adapted for airflow, and other fluid circuit may be adapted for a coolant. Further, fins are provided in the airflow fluid circuit of the heat exchanger, and in contact with heat exchange tubes to increase heat exchange between airflow and the coolant. The fins may increase pressure drop of airflow across the airflow fluid circuit and the fins are adapted to force the airflow remain in turbulent regime, thereby, increasing heat exchange surface between the air flowing in the airflow fluid circuit and the coolant flowing in another fluid circuit. Further, the fins are provided with louvers to further increase pressure drop across the airflow fluid circuit. The louvers may be formed in a form of small cuts defined on the fins. The louver may be bended along their length to increase air pressure drop across the airflow fluid circuit.

[0003] Further, the louvers formed in fins may be in same length, so the pressure drop of the airflow across the core of the heat exchanger is homogenous. Such fins with the homogenous louvers may increase the pressure drop of the airflow at some areas of the heat exchange tubes and may reduce the pressure drop of the airflow at some areas of the heat exchange tubes. As a result, the heat exchange between the airflow and the coolant affected at some areas, thereby causing thermal shock at the heat exchange tubes. For example, the pressure drop of airflow at the inlet area of airflow fluid is more than the rest of area of the tubes. In such case, 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 and thermal shock due to non-uniform heat exchange between the two fluids and 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 provided with non-uniform louvers in fins to achieve homogenous pressure drop across the core of the heat exchanger. Further, there remains another need for at least two different louver sections strategically defined on the fins of the heat exchanger that creates heterogeneous pressure drop across the core of the heat exchanger, thereby attaining uniform heat exchange between the two fluids across the core and 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 forgoing, the present invention discloses a heat exchanger for heat exchange between a first fluid and a second fluid. The heat exchanger includes a first manifold, a second manifold, and a plurality of heat exchange tubes. 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 the first fluid direction and the second fluid flows between the heat exchange tubes in the second fluid direction perpendicular to the first fluid direction. The heat exchanger further includes a fin section provided 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 primary louver located on the fin section and at least one secondary louver location on the primary louver.

[0007] In one embodiment, the length of the primary louver is bigger than of the secondary louver, wherein the length is measured along the general axis of extension of the primary louver and the secondary louver.

[0008] In another embodiment, the length of the primary louver is smaller than of the secondary louver, wherein the length is measured along the general axis of extension of the primary louver and the secondary louver.

[0009] In yet another embodiment, the length of the primary louver is equal to the secondary louver, wherein the length is measured along the general axis of extension of the primary louver and the secondary louver.

[0010] In one example, the primary louver and the secondary louver are formed as angled slats on the fin section.

[0011] In one embodiment, the primary louver and the secondary louver are angled at same angle with respect to general axis of extension of the primary louver and the secondary louver.

[0012] In another embodiment, the primary louver and the secondary louver are angled at different angles with respect to general axis of extension of the primary louver and the secondary louver.

[0013] Further, the number of the primary louvers is less than to the number of the secondary louvers.

[0014] In one aspect, the fin section includes at least two of primary louvers sloping in opposing directions and at least two of secondary louvers formed on the at least one primary louver sloping in opposing directions.

[0015] Further, the secondary louver is arranged obliquely with respect to the primary louver.

[0016] In one embodiment, the fin section is provided within at least one heat exchange tube. In such case, the heat exchanger is configured for operation as a water

charge air cooler, the first fluid being air and the second fluid being a liquid coolant.

[0017] In another embodiment, the fin section is interlaced between adjacent heat exchange tubes. In such case, the heat exchanger is configured for operation as a radiator, the first fluid being a liquid coolant and the second fluid being air.

[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 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 illustrate a cross-sectional view of a standalone heat exchange tube of the heat exchanger of Fig. 2, perpendicularly cut along the longitudinal direction of the heat exchange tube, showing a fin section with a primary louver and a secondary louver;

Fig. 4 illustrates a schematic view of the fin section of Fig. 3; and

Fig. 5 illustrates another cross-sectional view of the heat exchange tube cut along the longitudinal direction of the heat exchange tubes.

[0019] 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.

[0020] The present invention envisages a heat exchanger provided with heterogeneous fin and louvers pattern to achieve uniform heat exchange between two fluid flowing there through. Conventional heat exchanger may include a fin section that is in contact to heat exchange tubes and homogenous size of louvers formed on the fin section. As the louvers formed on the fin section are of same length, airflow and pressure drop across the heat exchange tubes are uniform. As temperature of the airflow at an inlet area and an outlet area of the air flow circuit is different and pressure drop across the heat exchange tubes is uniform, heat exchange between two fluids flowing therein is non-uniform. Such non-uniform heat exchange between two fluids can leads to thermal shock on the heat exchange tubes. To overcome such problems, two different sets of louvers are formed on the

fin section of a heat exchanger, particularly, one set of louvers formed on the other set of louvers. The heat exchanger includes a plurality of heat exchange elements extended between a pair of manifolds, and a fin section in contact with the heat exchange elements. Further, a first fluid flow is defined in between the pair of manifolds, and a second fluid flow is defined in a direction perpendicular to the first fluid flow. 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.

[0021] 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 are axially extending between the first manifold 102A and the second manifold 102B thereby 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 are in heat exchange configuration with each other, particularly, a first fluid flow and a second fluid 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.

[0022] 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. In other example, the first fluid circuit can be formed through the heat exchange tubes 104 in such a way the first fluid flows from the second manifold 102B to the first manifold 102A. The second fluid flows between the heat exchange tubes 104 in the second fluid direction 106B and 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.

[0023] The heat exchanger 100 further include a fin section 202 defined 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 facilitate 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 increase. 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 a 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.

[0024] The fin section 202 can be corrugated fins or flat fins. Further, the fin section 202 includes at least one primary louver and at least one secondary louver. Further, the primary louver and the secondary louver are different in size. In one example, the primary louver is having different length from the secondary louver. The primary and secondary louvers are not shown in Figs. 1 and 2, and will be discussed with respect to the forthcoming figures. Usually, the fin section 202 is provided with a plurality of primary louvers and a plurality of secondary louvers to improve heat exchange efficiency thereof.

[0025] Fig. 3 illustrates a cross-sectional view of a standalone heat exchange tube 104 of Fig. 2 perpendicularly cut along the longitudinal direction of the heat exchange tube 104, showing the fin section 202 with the primary louver 204 and the secondary louver 206. Fig. 4 illustrates a schematic view of the fin section 202 of Fig. 3 and Fig. 5 illustrate another cross-sectional view of the heat exchange tube 104 cut along the longitudinal direction of the heat exchange tubes 104. In this embodiment, the fin section 202 is corrugated fins having lateral walls extending along the heat exchange tubes 104. The primary louvers 204 and secondary louvers 206 are formed on both the lateral walls of the fin section 202. Particularly, the secondary louvers 206 are formed/located on the primary louvers 204 formed on the lateral walls of the fin section 202.

[0026] Further, the primary louvers 204 and the secondary louvers 206 are of different sizes, particularly, the length of the primary louvers 204 is different from the length of the secondary louvers 206. As shown in Fig. 4, the secondary louvers 206 are formed on the primary louvers 204 and length of the primary louvers 204 and the secondary louvers are different. In the preferred embodiment, the louver length "L1" of the primary louvers 204 is greater than the louver length "L2" of the secondary louvers 206, wherein the length is measured along the general axis "P1" of extension of the primary louvers 204 and the secondary louvers 206. In other words, the length

of the primary louvers 204 is bigger than of the secondary louvers 206, when the length is measured along the general axis "P1" of the extension of the primary louvers 204 and the secondary louvers 206.

[0027] Alternatively, the length of the primary louvers 204 can be smaller than the secondary louvers 206, wherein the length is measured along the general axis "P1" of extension of the primary louvers 204 and the secondary louvers 206.

[0028] Alternatively, the length of the primary louvers 204 can be equal to the length of the secondary louvers 206 wherein the length is measured along the general axis "P1" of extension of the primary louvers 204 and the secondary louvers 206.

[0029] The primary louvers 204 and the secondary louvers 206 are adapted to increase pressure drop of the first fluid across the fin section 202. In a preferred embodiment, the number of primary louvers 204 are smaller than the number of secondary louvers 206. Alternatively, the number of primary louvers 204 can be equal to the number of secondary louvers 206. Alternatively, the number of primary louvers 204 can be greater than the number of secondary louvers 206.

[0030] In one example, the primary louvers 204 and the secondary louvers 206 are formed as angled slats on the fin section 202. In one embodiment, the primary louvers 204 and the secondary louvers 206 are angled at same angle with respect to general axis (P1) of extension of the primary louvers 204 and the secondary louver 206. In another embodiment, the primary louvers 204 and the secondary louvers 206 are angled at different angles with respect to general axis (P1) of extension of the primary louvers 204 and the secondary louvers 206. Further, the secondary louver 206 can be arranged obliquely with respect to the primary louvers 204. In other words, the secondary louver 206 may be angled with respect to the primary louvers 204. For example, the primary louvers 204 may be angled at range of 0 to 45 degree with respect to the fin section and the secondary louvers 206 may be angled at range of 0 to 45 degree with respect to the primary louvers 204.

[0031] In one embodiment, the primary louvers 204 and the secondary louvers 206 are sloping in opposite directions. In one example, the primary louvers 204 are sloping in a direction of the first fluid flow 106A and the secondary louvers 206 are sloping in a direction opposite to the first fluid flow 106A. In another example, the primary louvers 204 are sloping in a direction opposite to the first fluid flow 106A and the secondary louvers 206 are sloping in a direction of the first fluid flow 106A. In yet another example, both the primary and secondary louvers 204, 206 are either sloping in a direction of the first fluid flow 106A or sloping in a direction opposite to the first fluid flow 106A. In a preferred embodiment, a set of primary louvers 204 may slope in a direction of the first fluid flow 106A and another set of primary louvers 204 may slope in a direction opposite to the first fluid flow 106A. Similarly, a set of secondary louvers 206 may slope

in a direction of the first fluid flow 106A and another set of secondary louvers 206 may slope in a direction opposite to the first fluid flow 106A. Alternatively, the primary louvers 204 formed on a lateral wall of the fin section 204 are sloping in a direction of the first fluid flow 106A and the primary louvers 204 formed on the other lateral wall of the fin section 202 are sloping in a direction opposite to the first fluid flow 106A.

[0032] In one embodiment, the primary louvers 204 and the secondary louvers 206 are formed as a rectangular angled slats as shown in Fig. 4. In another embodiment, the secondary louvers 206 are formed as the angled slats in the primary louvers 204, in which the slats are concavely or convexly bent with respect to the transverse axis of the heat exchange tube 104 as shown in Fig. 3. As shown in Figs. 4 and 5, width of the primary louvers 204 is greater than of the width of the secondary louvers 206. It is evident from the Figs. 3 to 5, the secondary louvers 206 are formed on the primary louvers 204, and the number of the secondary louvers 206 is greater than of the primary louvers 204. As the primary and secondary louvers 204, 206 are of different sizes and lengths, the pressure drop across the heat exchange tubes 104 may be uniform, thereby the heat exchange between the first fluid and the second fluid may be also uniform. As a result, the thermal performance of the heat exchanger 100 is increased and eliminating damages of the heat exchange tubes 104 due to high stress and thermal shock experiencing on the heat exchange tubes 104.

[0033] 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 the first fluid direction (106A) and the second fluid flows between the heat exchange tubes (104) in the second fluid direction (106B) perpendicular to the first fluid direction (106A); 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 primary louver (204) located on the fin section (202) and at least one secondary louver (206) located on the primary louver (204).

2. The heat exchanger (100) as claimed in claim 1, wherein the length of the primary louver (204) is bigger than of the secondary louver (206), wherein the length is measured along the general axis (P1) of extension of the primary louver (204) and the secondary louver (206).
3. The heat exchanger (100) as claimed in claim 1, wherein the length of the primary louver (204) is smaller than of the secondary louver (206), wherein the length is measured along the general axis (P1) of extension of the primary louver (204) and the secondary louver (206).
4. The heat exchanger (100) as claimed in claim 1, wherein the length of the primary louver (204) is equal to the length of the secondary louver (206), wherein the length is measured along the general axis (P1) of extension of the primary louver (204) and the secondary louver (206).
5. The heat exchanger (100) as claimed in any of the preceding claims, wherein the primary louver (204) and the secondary louver (206) are formed as angled slats on the fin section (202).
6. The heat exchanger (100) as claimed in any of claim 5, wherein the primary louver (204) and the secondary louver (206) are angled at same angle with respect to general axis (P1) of extension of the primary louver (204) and the secondary louver (206).
7. The heat exchanger (100) as claimed in any of claim 5, wherein the primary louver (204) and the secondary louver (206) are angled at different angles with respect to the general axis of extension of the primary louver (204) and secondary louver (206).
8. The heat exchanger (100) as claimed in any of the preceding claims, wherein the number of the primary louvers (204) is smaller than to the number of the secondary louvers (206).
9. The heat exchanger (100) as claimed in any of the preceding claims, wherein the fin section (202) comprises at least two of primary louvers (204) sloping in opposing directions.
10. The heat exchanger (100) as claimed in claim 9, wherein the fin section (202) comprises at least two secondary louvers (206) formed on at least one primary louver (204) sloping in opposing directions.
11. The heat exchanger (100) as claimed in any of the

preceding claims, wherein the secondary louver (206) is arranged obliquely with respect to the primary louver (204).

12. The heat exchanger (100) according to any preceding claim, wherein the fin section (202) is provided within at least one heat exchange tube (104). 5
13. The heat exchanger (100) according to claim 12, wherein the heat exchanger (100) is configured for operation as a water charge air cooler, the first fluid being air and the second fluid being a liquid coolant. 10
14. The heat exchanger (100) according to any of claims 1-9, wherein the fin section (202) is interlaced between adjacent heat exchange tubes (104). 15
15. The heat exchanger (100) according to claim 14, wherein the heat exchanger (100) is configured for operation as a radiator, the first fluid being a liquid coolant and the second fluid being air. 20

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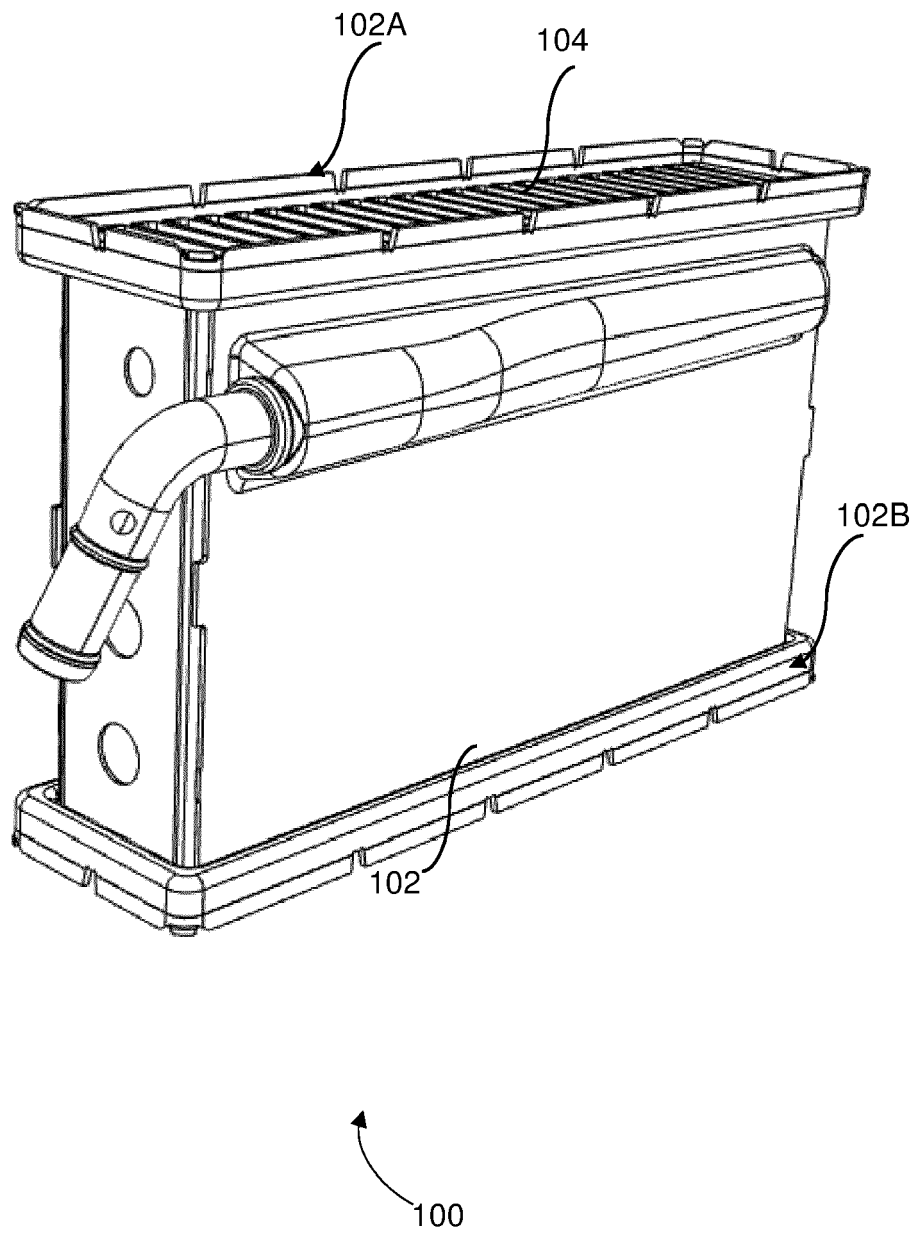


FIG. 1

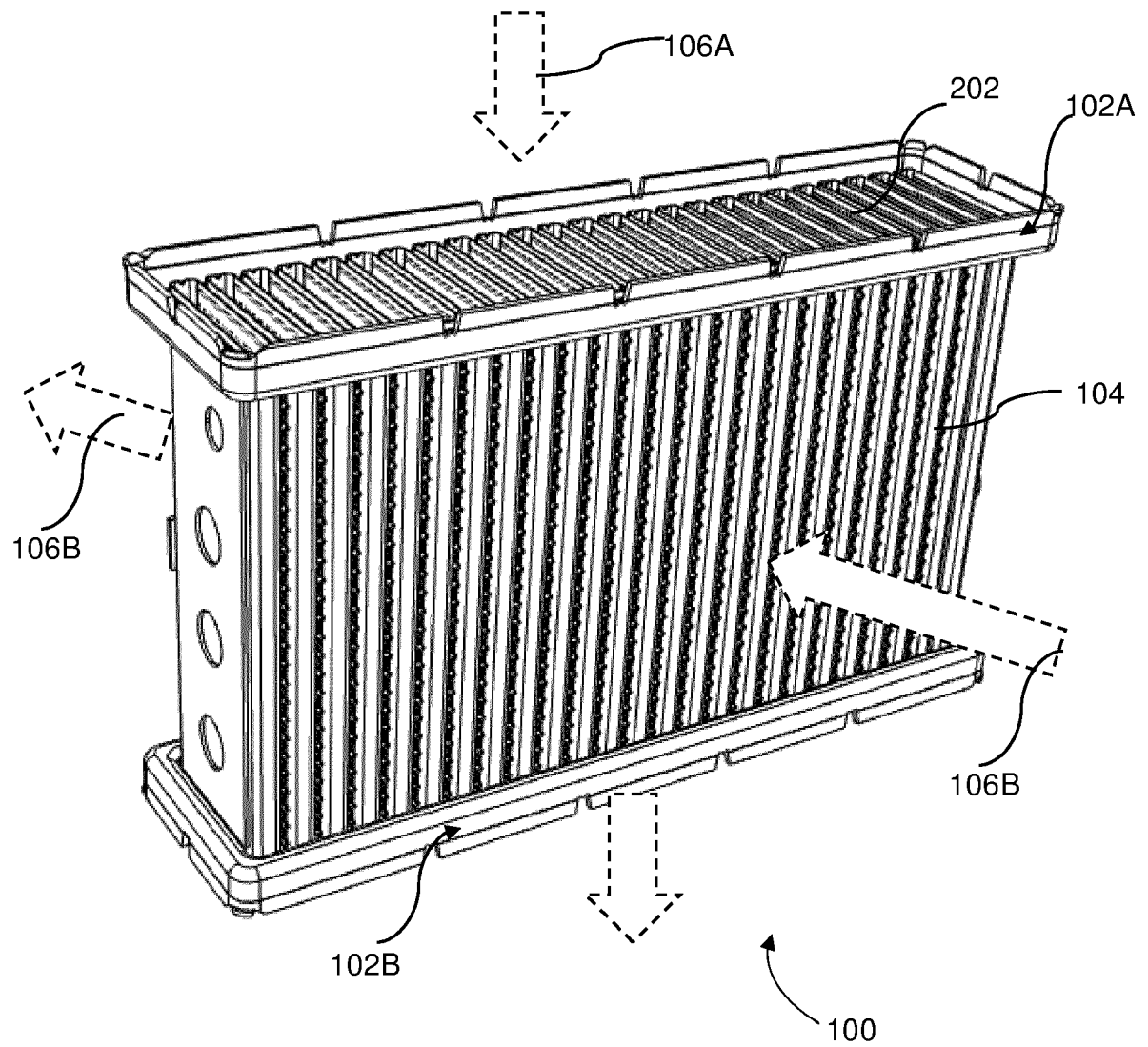


FIG. 2

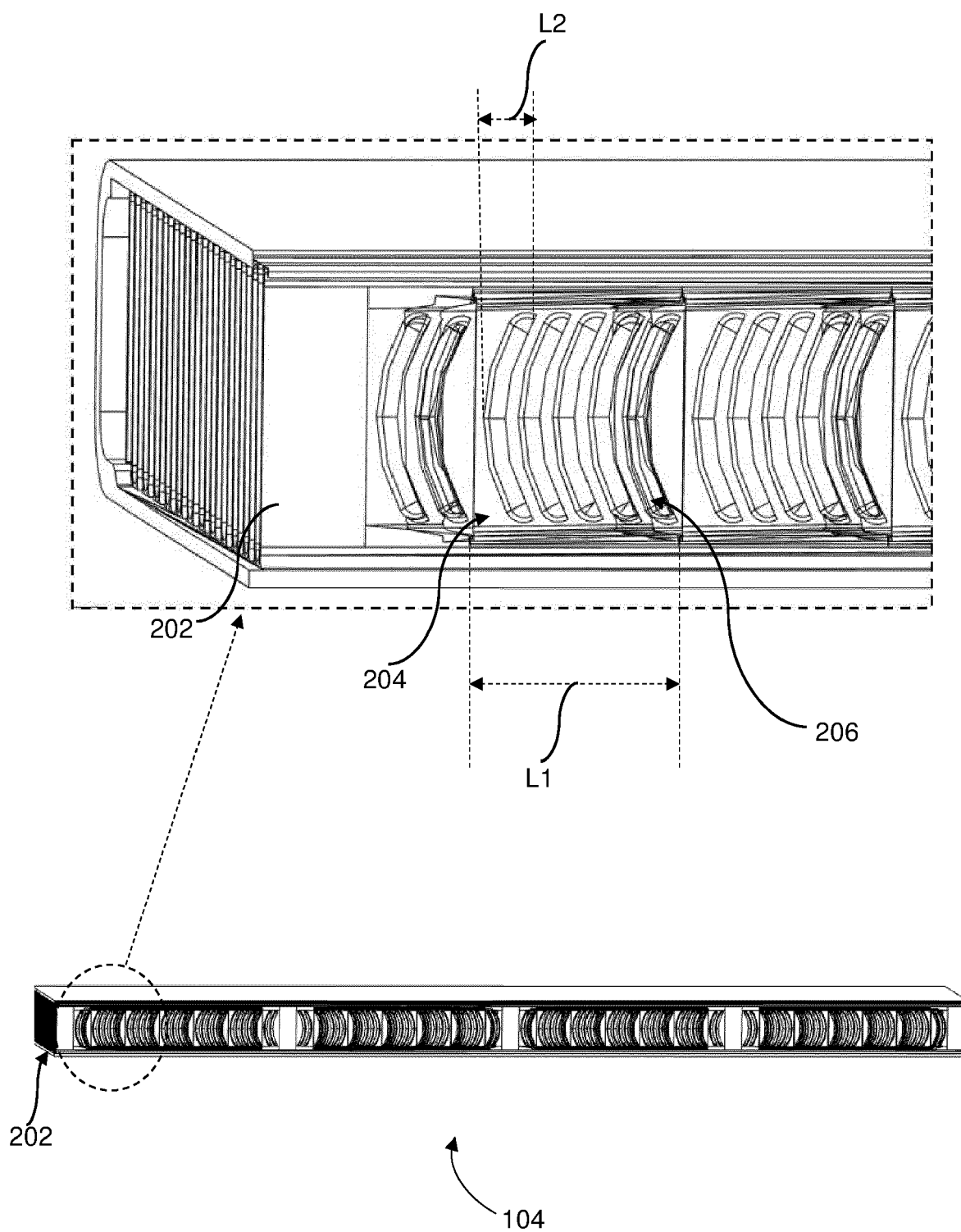


FIG. 3

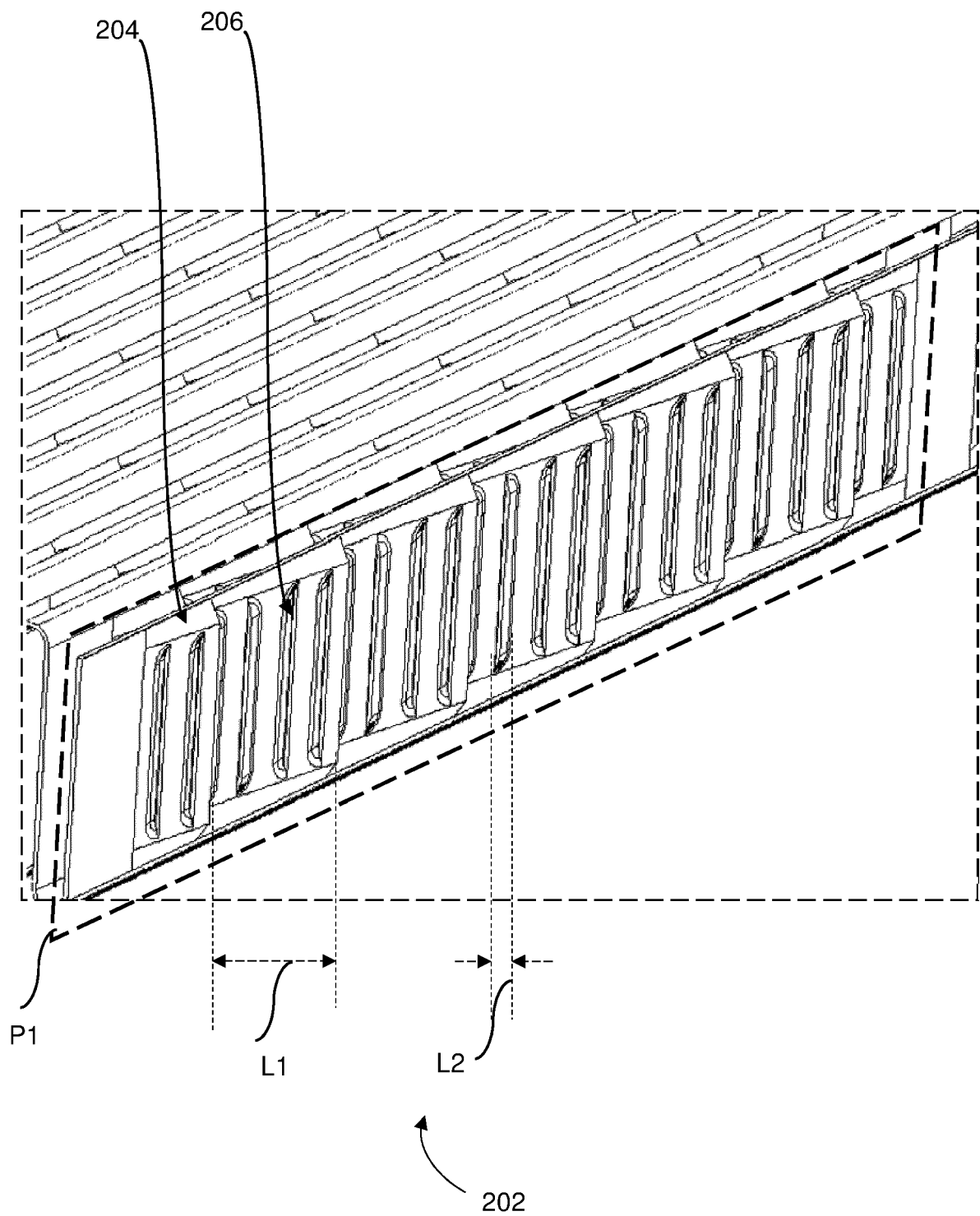


FIG. 4

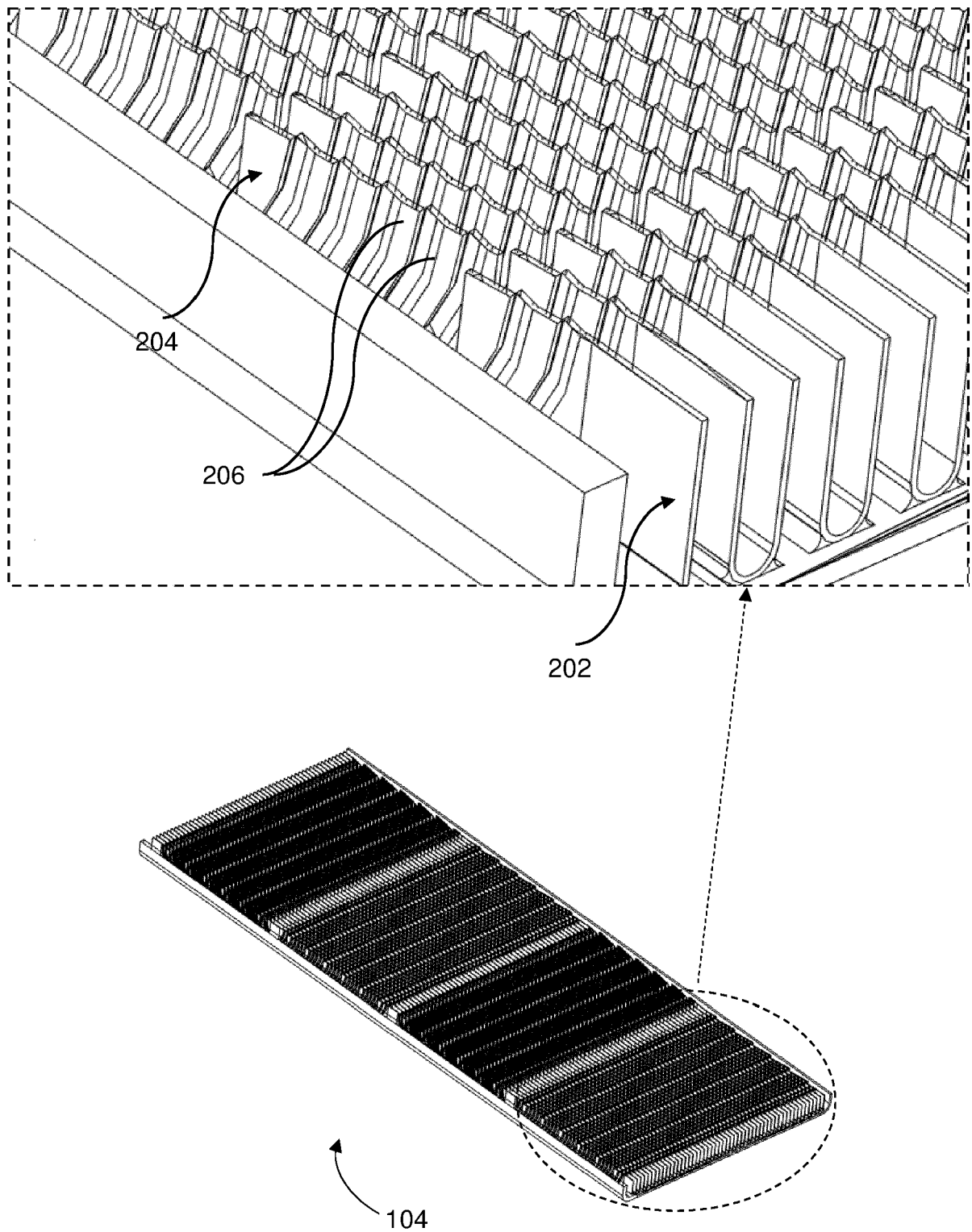


FIG. 5



EUROPEAN SEARCH REPORT

Application Number
EP 20 46 1608

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 13 April 2021	Examiner Bain, David
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 20 46 1608

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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