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(54) A HEAT EXCHANGER

(57) A heat exchanger for heat exchange between a first fluid and a second fluid is disclosed. The heat exchanger includes a pair of manifolds, heat exchange tubes extending between the pair of manifolds, and a first and second fin sections. The first fluid flows between the pair of manifolds in a 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 first and second fin sections are provided in contact with the heat exchange tubes. The first fin section includes a first louver having a first louver length and the second fin section includes a second louver having a second louver length. The first louver length is greater than the second louver length and the length is measured along the general axis of extension of the first and second louvers.

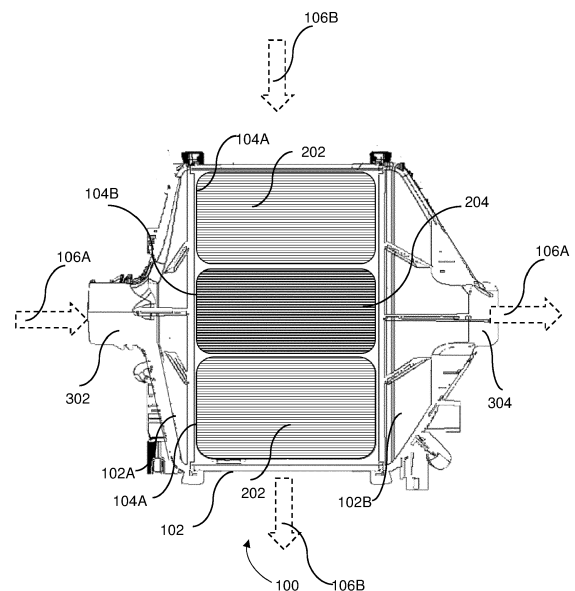


FIG. 3

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Description

[0001] The present invention relates to a heat exchanger. In particular, the invention relates to heat exchanger having various sizes of louvers provided in-contact with heat exchange tubes of a heat exchanger.

[0002] Conventionally, the heat exchanger may include two fluid circuits configured to be in a heat exchange configuration. Further, 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, thereby, increasing heat exchange 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 longer side to increase air pressure drop across the airflow fluid circuit.

[0003] Further, the louvers formed in the fins may be of same length, so pressure drop of the airflow across the core of the heat exchanger is homogenous. In some case, an inlet and outlet for the charged air may be provided in the heat exchanger at symmetrical axis of the core. The term "symmetrical axis" means the inlet and outlet are in-line to each other. In such case, the pressure drop across the tubes corresponding to and in-line to the inlet and outlet is smaller compared to rest of the tubes, due to velocity of the airflow entering from the inlet to the tubes in-line to the inlet. Hence, it causes heterogeneous airflow across the core of the heat exchanger, thereby causing non-uniform heat exchange between the air and the coolant. Particularly, heat exchange between the air and the coolant across the tubes, corresponding to and in-line to the inlet and outlet, is less than of the heat exchange between the air and the coolant across rest of the tubes. As a result, the heat exchange tubes, corresponding to and in-line to the inlet and outlet, may undergo high stress, thereby causing cracks on the heat exchange tubes and reduce service life of the heat exchanger. Further, the non-uniform heat exchange between the charged air and the coolant across the heat exchange tubes may reduce thermal performance and efficiency of the heat exchanger.

[0004] Accordingly, there is a need for a heat exchanger provided non-uniform louver section in fins to achieve heterogeneous pressure drop across the core of the heat exchanger and uniform heat exchange between air and the coolant across the tubes. Further, there is another need for heterogeneous louver sections defined on the fins of the heat exchanger that creates heterogeneous 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 forgoing, the present invention relates to 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 axially extending and provided a fluidal communication between the first and second manifolds for the first fluid. 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 at least one first fin section and a second fin section. The first and second fin sections are provided in contact with the heat exchange tubes for facilitating heat exchange between the first fluid and the second fluid. Further, the first fin section includes at least one first louver having a first louver length and the second fin section includes at least one second louver having a second louver length. The first louver length is greater than the second louver length and the length is measured along the general axis (P1) of extension of the first and second louvers.

[0007] In one embodiment, the second fin section is provided in-contact with the heat exchange tubes that are in-line to an inlet and outlet provided in the first manifold and the second manifold of the heat exchanger.

[0008] Further, the second fin section is parallelly arranged to the first fin section along the direction of the intended first fluid flow direction.

[0009] In one embodiment, the first louver and the second louver are formed as angled slats on the first fin section and the second fin section respectively.

[0010] In one example, the first louver and the second louver are angled at same angle with respect to the general axis of the extension of the first louver and the second louver.

[0011] In another example, the first louver and the second louver are angled at different angles with respect to the general axis of the extension of the first louver and the second louver.

[0012] In another aspect, the heat exchanger includes the first fin section having a plurality of first louvers sloping in opposing directions.

[0013] Further, the heat exchanger includes the second fin section having a plurality of second louvers sloping in opposing directions.

[0014] In one embodiment, the number of first louvers in the first fin section is less than of the number of second louvers in the second fin section.

[0015] In one embodiment, the first and second fin sec-

tions are provided within the heat exchange tubes. 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.

[0016] In another embodiment, the first and second fin sections are 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.

[0017] 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 illustrates another schematic view of the heat exchanger of Fig. 2 showing the two set of heat exchange tubes having two sets of fin sections;

Fig. 4 illustrates a front view of a first fin section along its longitudinal axis depicting a first louver, wherein the first fin section is in contact with a first set of tubes of Figs. 2 and 3;

Fig. 5 illustrates a top cross-sectional view of the first fin section of Fig. 2 showing along its longitudinal axis;

Fig. 6 illustrates a perspective of the second fin section provided in contact with the heat exchange tubes Fig. 2.

[0018] 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.

[0019] The present invention may disclose 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 fin sections that are in contact to the heat exchange tubes and homogenous size of louvers formed on the fin sections. As the louvers formed on the fin sections are of same length, airflow and pressure drop across the heat exchange tubes are uniform. As velocity of the airflow across the tubes that are in-line to an air

inlet and outlet is different from the rest of the tubes, heat exchange between two fluids flowing therein is non-uniform. Such non-uniform heat exchange between two fluids can lead to thermal shock on some of the heat exchange tubes. To overcome such problems, heterogeneous sizes of louvers are formed on the fin sections of a heat exchanger, particularly two different fin sections are formed with two different size of louvers. The heat exchanger includes a plurality of heat exchange elements extended between a pair of manifolds, and a first and second fin sections 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.

[0020] Figs. 1, 2 and 3 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. Generally, the heat exchange tubes 104 are stacked together in the heat exchanger 100. 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 encapsulated 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.

[0021] 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. 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.

[0022] Fig. 3 illustrates another schematic view of the heat exchanger 100 showing two sets of heat exchange tubes. Further, the heat exchanger 100 may include an inlet 302 and outlet 304 to introduce and receive the first fluid to/from the heat exchanger 100, particularly, the inlet 302 is connected to the first manifold 102A and the outlet 304 is connected to the second manifold 102B, so that the first fluid may flow from the first manifold 102A to the second manifold 102B through the heat exchange tubes 104. In one example, the inlet 302 and the outlet 304 is formed on a symmetrical axis of the heat exchanger 100. Here the term "symmetrical axis" means the inlet 302 and the outlet 304 are in-line with each other, i.e. it lies in a straight line. Similarly, the housing 102 may include another inlet and outlet (not shown in Figures) for ingress and egress of the second fluid into the housing 102. As shown in Figs. 2 and 3, the heat exchange tubes 104 are divided as at least one first set of tubes 104A and a second set of tubes 104B. Further, the second set of tubes 104B are disposed in between the first manifold 102A and the second manifold 102B in such way that the second set of tubes 104B are in-line to the inlet 302 and outlet 304. In the present embodiment, the second set of tubes 104B is sandwiched by the first set of tubes 104A.

[0023] The heat exchanger 100 may further comprise at least one first fin section 202 and a second fin section 204 provided in contact with the heat exchange tubes 104. Particularly, the first fin section 202 is provided in contact with the first set of tubes 104A and the second fin section 204 is provided in contact with the second set of tubes 104B. The first fin section 202 and the second fin section 204 having fins are provided in contact with the heat exchange tubes 104 in such a way that the first and second fin sections 202, 204 facilitate heat exchange between the first fluid and the second fluid. The first and second fin sections 202, 204 are 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 first and second fin sections 202, 204 are 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 first and second fin sections 202, 204 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 first and second fin sections 202, 204 can be corrugated fins or flat fins. Further, the first fin section 202 includes at least one first louver and the second fin section 104 includes at least one second louver. Further, the first louver and second louver are different in size. Usually, the heat exchanger 100 may include a plurality

of first fin section 202 and a plurality of second fin section 204 to improve heat exchange between the first fluid and the second fluid. Further, the first fin section 202 may include a plurality of first louvers 206 and the second fin section 202 may include a plurality of second louvers 208 to increase the pressure drop so that the heat exchange efficiency increases thereof. The first fin section 202 and the second fin section 204 are provided in the heat exchanger 100 in such a way that the first and second fin sections 202, 204 extend along the heat exchange tubes 104.

[0025] Figs. 4 and 5 illustrate different views of the first fin section 202 provided in contact with the heat exchange tubes 104, for example, with the first set of tubes 104A of Figs. 1 and 2. Fig. 6 illustrates a perspective view of the second fin section 204 provided in contact with the heat exchange tubes 104, particularly with the second set of tubes 104B of Figs. 1 and 2. In this example, Fig. 4 illustrates a front view of the first fin section 202 along its longitudinal axis depicting the first louver 206 and Fig. 5 illustrates a top cross-sectional view of the first fin section 202 showing along its longitudinal axis. As discussed above, the first fin section 202 includes at least one first louver 206 having a first louver length "L1" and the second fin section 204 includes at least one second louver 208 having a second louver length "L2". In the preferred embodiment, the first louver length "L1" is greater than the second louver length "L2", when the length is measure along the general axis "P1" of extension of the first and second louvers 206, 208. In other words, the second louver length "L2" is smaller than the first louver length "L1", when the length is measure along the general axis "P1" of extension of the first and second louvers 206, 208. At the same time, number of second louvers 208 in the second fin section 204 is more than the number of the first louvers 206 in the first fin section 202. In this embodiment, the first and second fin sections 202, 204 are corrugated fins having lateral walls extending along the heat exchange tubes 104, and the first louver 206 and second louver 208 are formed on both the lateral walls of the first and second fin sections 202, 204. In the preferred embodiment, the number of first louvers 206 in the first fin section 202 is less than the number of the second louvers 208 in the second fin section 204.

[0026] In the preferred embodiment, the second fin section 204 is provided in-contact with the heat exchange tubes 104 that are in-line to the inlet 302 and the outlet 304 provided in the first manifold 102A and the second manifold 102B of the heat exchanger 100. More particularly, the second fin section 204 is provided in-contact with the first set of tubes 104A that are in-line and corresponding to the inlet 302 and the outlet 304 provided in the heat exchanger 100. In one embodiment, the first fin section 202 and the second fin section 204 are provided in-contact with the heat exchange tubes 104 in such way that the second fin section 204 is parallelly arranged to the first fin section 202 along the direction of the intended first fluid direction 106A.

[0027] As the inlet 302 of the first fluid is in-line to the outlet 304 of the first fluid, the velocity of the first fluid entering into the heat exchanger 100 is different across the heat exchange tubes 104. Particularly, the velocity of the first fluid flowing across the first set of tubes 104A having the first fin section 202 is more than the velocity of the first fluid flowing across the second set of tubes 104B having the second fin section 204. Hence, the first fluid may easily pass through the first set of tubes 104A rather than through the second set of tubes 104B. To avoid this, the second louver 208 having smaller length than the first louver 206 is provided in contact with the second set of tubes 104B, so that the pressure drop of the first fluid is increased across the first set of tubes 104A.

[0028] Usually, louvers are in the fin section to increase pressure drop across the heat exchange tubes 104. In this case, the first louver 206 and the second louver 208 are of different size may increase pressure drop of the first fluid to a different level across the first set of tubes 104A and the second set of tubes 104B. Particularly, the pressure drop of the first fluid across the first fin section 202 provided in contact with the first set of tubes 104A is lesser than the pressure drop of the first fluid across the second fin section 204. As the second length "L2" of the second louver 208 is smaller than of the first length "L1" of the first louver 206, the pressure drop across the second fin section 204 is more than of the first fin section 202, thereby attaining heterogeneous pressure drop across the heat exchange tubes 104.

[0029] Further, the first louver 206 and the second louver 208 are formed angled slats in the first fin section 202 and the second fin section 204 respectively. Usually, the first fin section 202 includes the plurality of first louvers 206 sloping in opposite directions. In one example, a few of the first louvers 206 may be sloping in a direction along the intended first fluid flow direction and other first louvers 206 may be sloping in a direction opposite to the intended first fluid flow direction. Similarly, a few of the second louvers 208 may be sloping in a direction along the intended first fluid flow direction and other second louvers 208 may be sloping in a direction opposite to the intended first fluid flow direction. In another example, the first louvers 206 formed on a lateral wall of the first fin section 202 are sloped in a direction along the intended first fluid flow direction and the first louvers 206 formed on other lateral wall of the first fin section 202 are sloped in a direction opposite to the intended first fluid flow direction. In one example, the direction of the intended first fluid flow is the first fluid direction 106A. In other words, the direction of the fluid intended to flow can be the direction of the first fluid while flowing from the first manifold 102A to the second manifold 102B. In another example, the direction of the fluid intended to flow can be the direction of the first fluid while flowing from the second manifold 102B to the first manifold 102A.

[0030] The length of each louver may be defined as the dimension between the leading and trailing edges.

In other words, the louver length is measured relatively to the direction in which it elongates. The width of each louver may be defined as the dimension between the two ends wherein the louver is connected to the fin section. In other words, the width of the louver may be measured transversely with respect to the direction of elongation of the louver.

[0031] The first and second louver angles may be measured with respect to the intended first fluid flow direction, the first louver angle corresponding to the first louver section being located earlier within the fluid flow in which the fin section is intended to be located than the second angle corresponding to the second louver section being located later within the fluid flow in which the fin section is intended to be located.

[0032] In one embodiment, the first louver 206 of the first fin section 202 and the second louver 208 of the second fin section 204 are angled at same angle with respect to the general axis "P1" of the extension of the first louver 206 and the second louver 208. In other words, angle of the first louver 206 is same as the angle of the second louver 208 with respect to the general axis "P1" of the extension of the first louver 206 and the second louver 208. In another embodiment, the first louver 206 of the first fin section 202 and the second louver 208 are angled at different angles with respect to the general axis "P1" of the extension of the first louver 206 and the second louver 208.

[0033] Referring to Fig. 6, width of the second louver 208 formed in the second fin section 204 is same throughout the second fin section 204. Similarly, width of the first louver 206 formed in the first fin section 202 is same throughout the first fin section 204. As the inlet 302 and outlet 304 are formed in the symmetrical axis of the heat exchanger 100, the pressure drop across the first set of tubes 104A, corresponding to the inlet 302 and outlet 304, is more than the pressure drop across the rest of tubes i.e., the second set of tubes 104B. As a result, the pressure drop of the first fluid, i.e., charged air, is heterogeneous and velocity of the first fluid across the heat exchange tubes 104 is not uniform. Hence, the heat exchange between the first fluid and the second fluid is optimum even though the inlet 302 and outlet 304 are placed in a straight line in the heat exchanger 100 and eliminating damages of the tubes due to stress and thermal shock. Therefore, thermal performance and efficiency of the heat exchanger 100 is increased.

[0034] 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
 at least one first fin section (202) and a second fin section (204) provided in contact with the heat exchange tubes (104) for facilitating heat exchange between the first fluid and the second fluid, **characterized in that**,
 the first fin section (202) comprises at least one first louver (206) having a first louver length (L1);
 the second fin section (204) comprises at least one second louver (208) having a second louver length (L2), wherein the first louver length (L1) is greater than the second louver length (L2), wherein the length is measured along the general axis (P1) of extension of the first and second louvers (206, 208).
2. The heat exchanger (100) as claimed in claim 1, wherein the second fin section (204) is provided in contact with the heat exchange tubes (104) that are in-line to an inlet (302) and outlet (304) provided in the first manifold (102A) and the second manifold (102B) of the heat exchanger (100).
 3. The heat exchanger (100) as claimed in claim 1, wherein the second fin section (204) is parallelly arranged to the first fin section (202) along the direction of the intended first fluid flow direction (106A).
 4. The heat exchanger (100) as claimed in any of the preceding claims, wherein the first louver (206) and the second louver (208) are formed as angled slats on the first fin section (202) and the second fin section (204) respectively.
 5. The heat exchanger (100) as claimed in any of claim 4, wherein the first louver (206) and the second louver (208) are angled at same angle with respect to the general axis (P1) of the extension of the first louver (206) and the second louver (208).
 6. The heat exchanger (100) as claimed in any of claim 4, wherein the first louver (206) and the second louver (208) are angled at different angles with respect to the general axis (P1) of the extension of the first louver (206) and the second louver (208).
 7. The heat exchanger (100) as claimed in any of the preceding claims, wherein the heat exchanger (100) comprises the first fin section (202) having a plurality of first louvers (206) sloping in opposing directions.
 8. The heat exchanger (100) as claimed in claim 7, wherein the heat exchanger (100) comprises the second fin section (204) having a plurality of second louvers (208) sloping in opposing directions.
 9. The heat exchanger (100) as claimed in any of the preceding claims, wherein the number of first louvers (206) in the first fin section (202) is less than of the number of second louvers (208) in the second fin section (204).
 10. The heat exchanger (100) according to any preceding claim, wherein the first fin section (202) and the second fin section (204) are provided within heat exchange tubes (104).
 11. The heat exchanger (100) according to claim 10, 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.
 12. The heat exchanger (100) according to any of claims 1-9, wherein the first fin section (202) and the second fin section (204) are interlaced between adjacent heat exchange tubes (104).
 13. The heat exchanger (100) according to claim 12, 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.

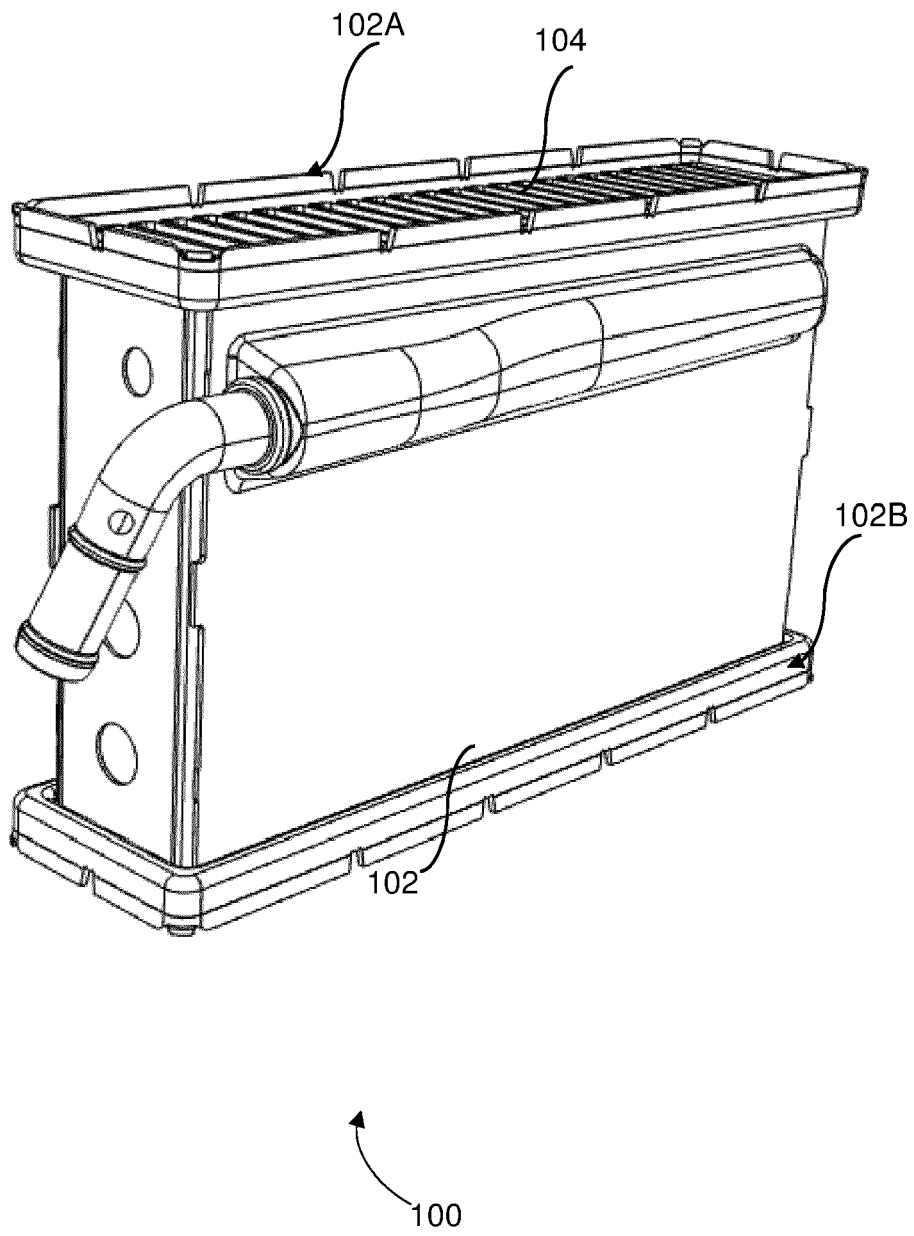


FIG. 1

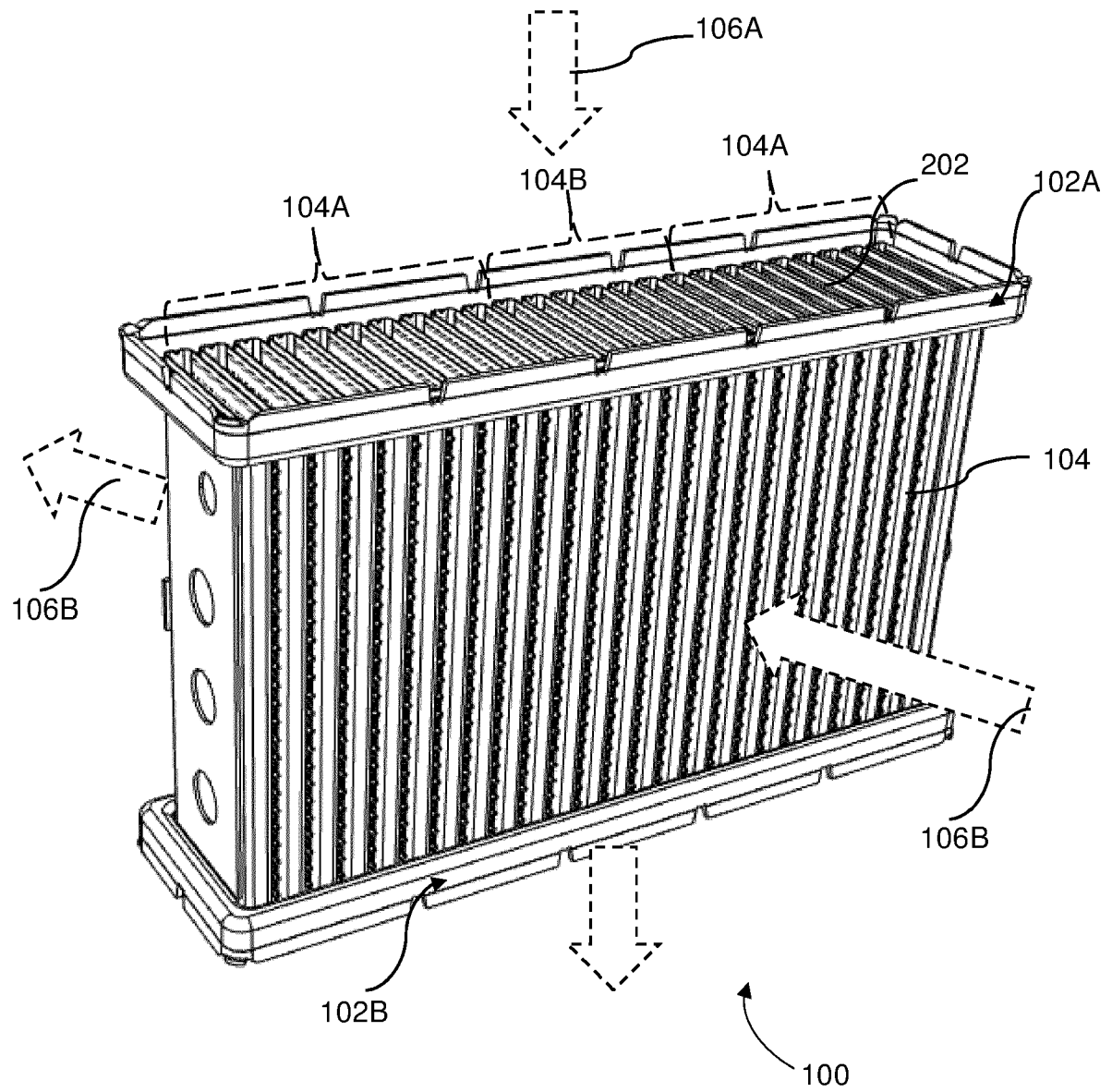


FIG. 2

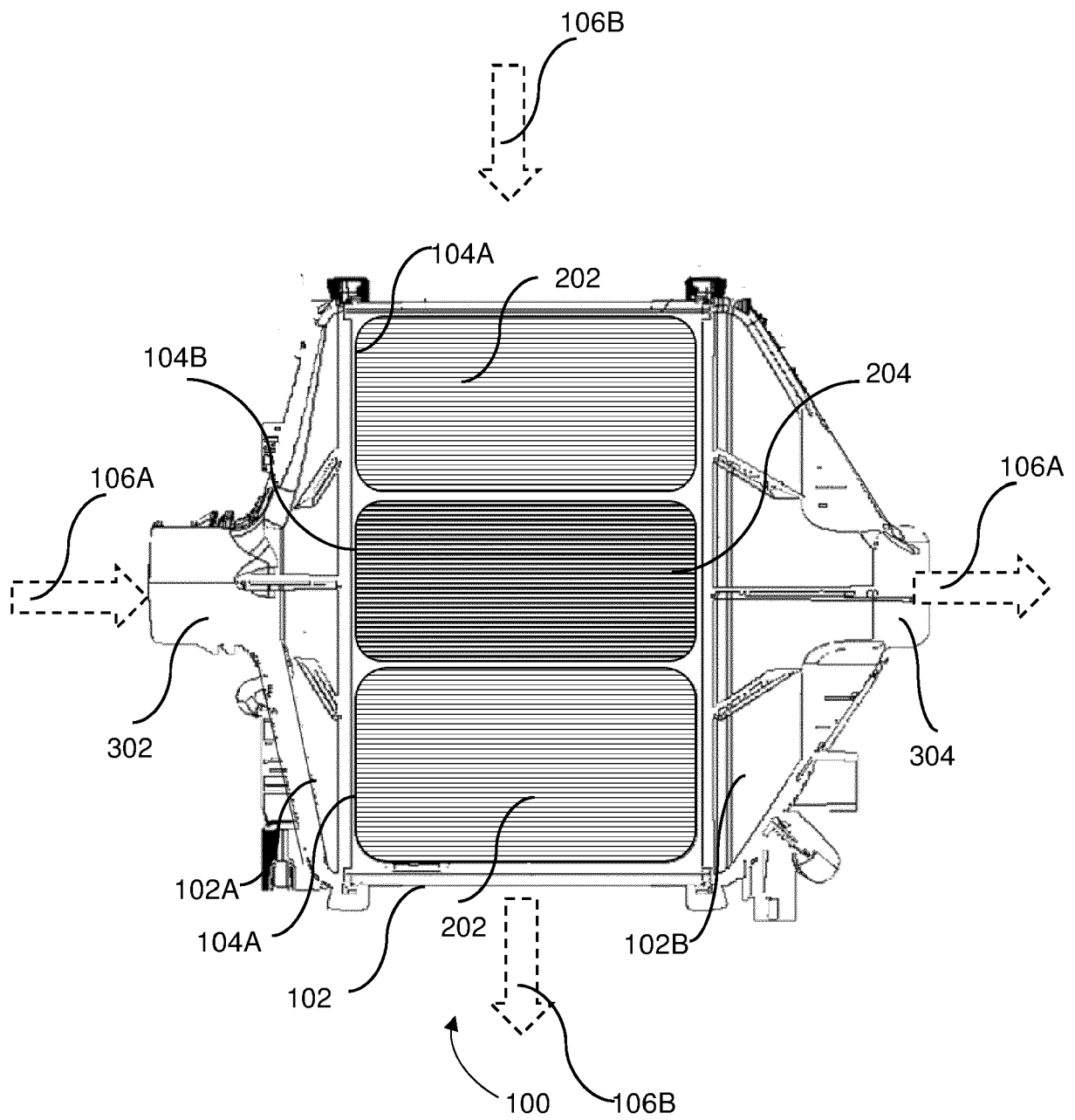


FIG. 3

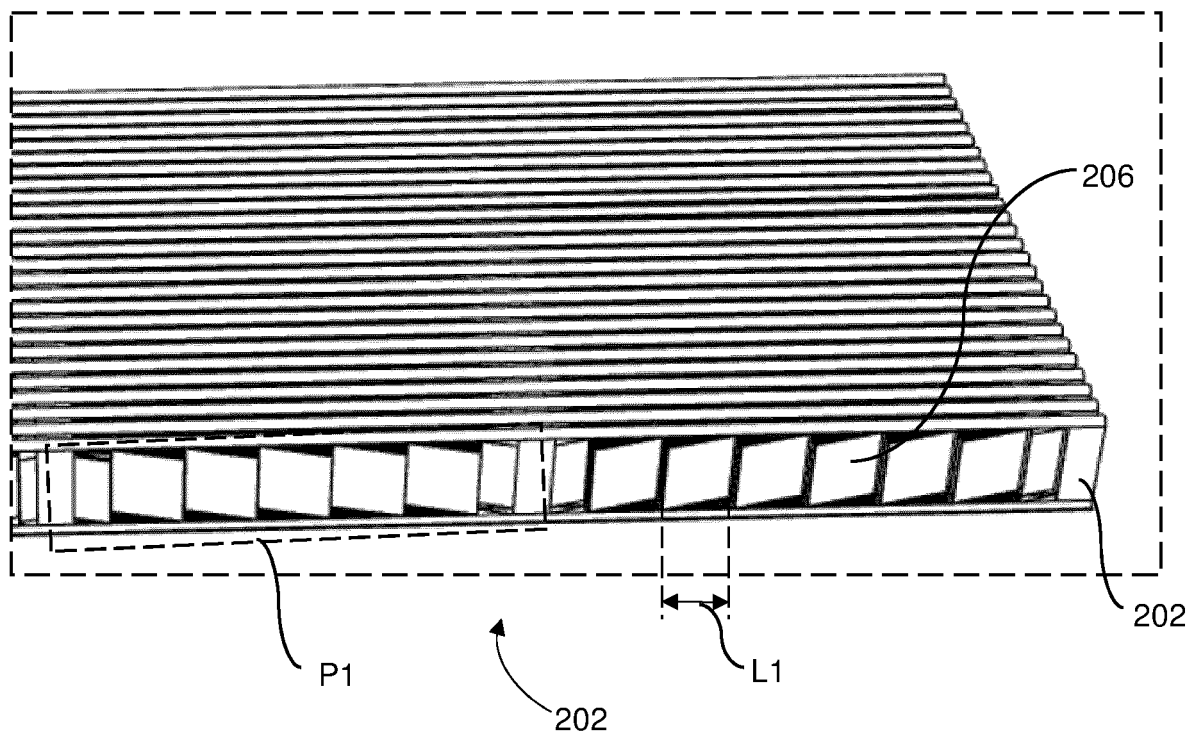


FIG. 4

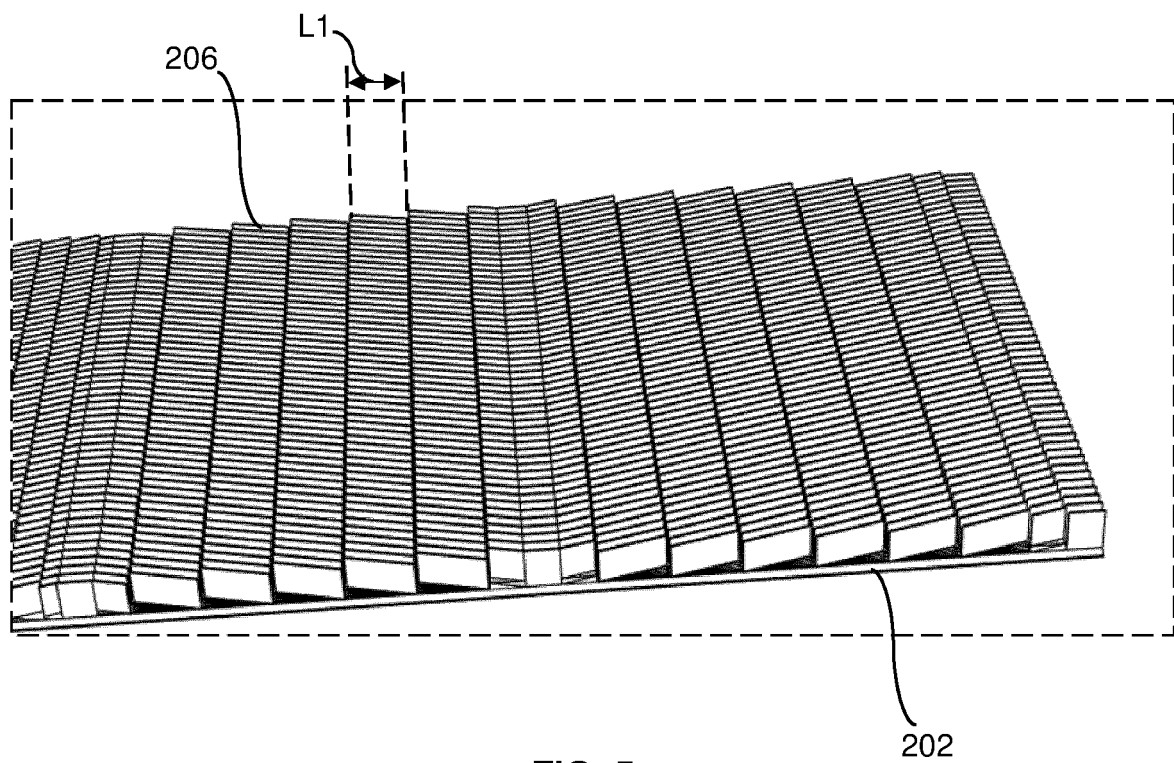


FIG. 5

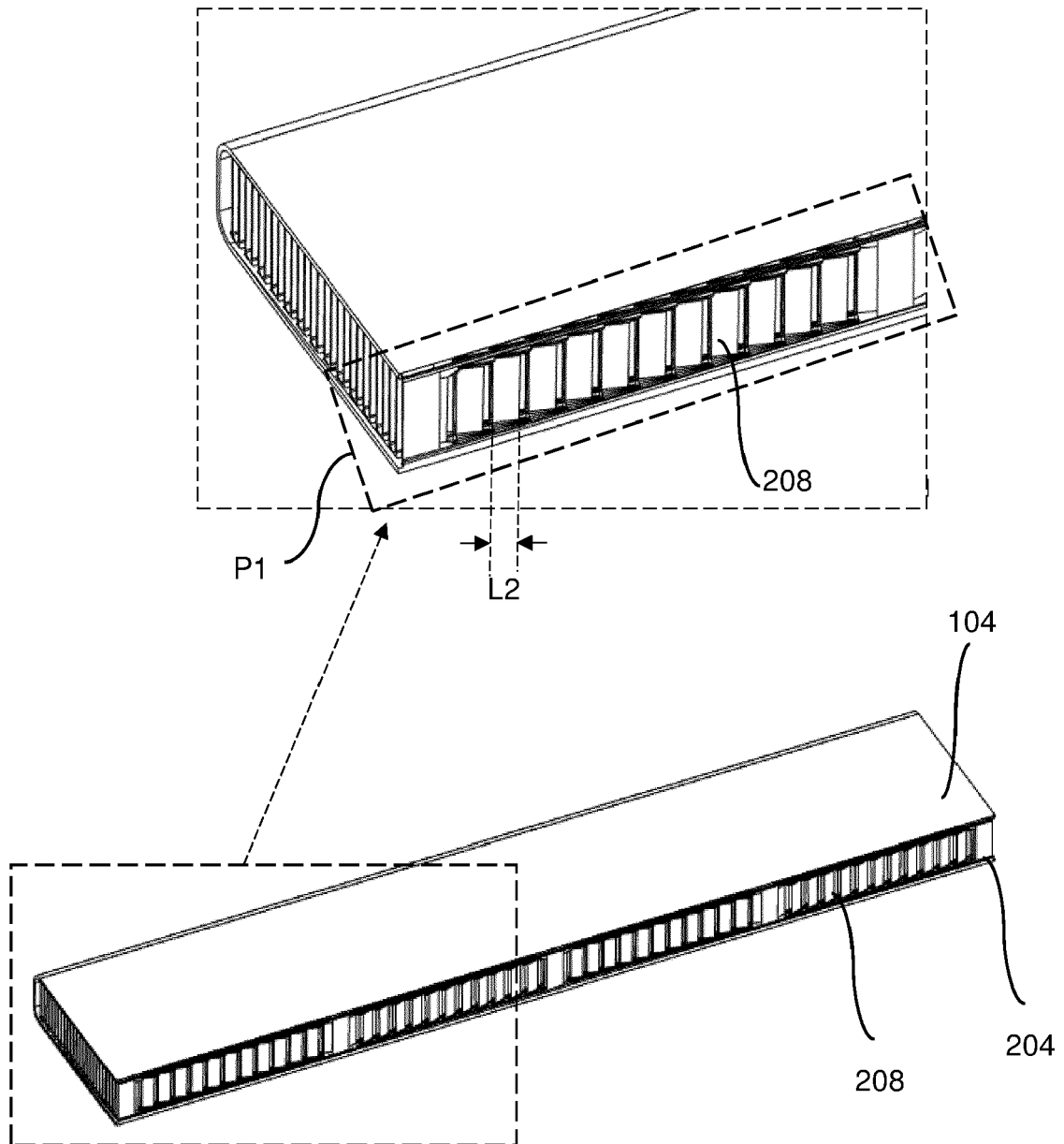


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
EP 20 46 1607

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