(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 317 881 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.02.2024 Bulletin 2024/06

(21) Application number: **22188220.2**

(22) Date of filing: **02.08.2022**

(51) International Patent Classification (IPC):
F28D 1/04 *(2006.01)* ***F28D 7/00*** *(2006.01)*
F28D 7/10 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F28D 1/05391; F01P 3/18; F28D 1/0443; F28D 1/0461; F28D 7/0066; F28D 7/10; F28F 1/022; F28F 9/0204; F28F 9/0214;
F01P 2003/185; F25B 39/04; F28F 2001/027; F28F 2275/04

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

(71) Applicant: **VALEO SYSTEMES THERMIQUES**
78320 Le Mesnil Saint-Denis (FR)

(72) Inventors:
- **SEKTI, Condro**
  96476 BAD RODACH (DE)
- **AZZOUZ, Kamel**
  78322 LE MESNIL SAINT DENIS CEDEX (FR)

(74) Representative: **Valeo Systèmes Thermiques**
Service Propriété Intellectuelle
8, rue Louis Lormand
La Verrière
78320 Le Mesnil Saint Denis (FR)

(54) A HEAT EXCHANGER ASSEMBLY

(57) A heat exchanger assembly (100) for a motor vehicle includes at least two heat exchanger cores, comprising first and second heat exchanger cores (114) and (116), fluidically connected between a first header tank assembly (102) and a second header tank assembly (108) for circulating at least one of a first fluid and a second fluid. The first heat exchanger core (114) comprises a set of first tubes (118). Each first tube (118) comprises an outer wall (119), an inner wall (120) and partitions (123) located in-between the outer wall (119) and the inner wall (120). The second heat exchanger core (116) comprises a set of second tubes (122) and a set of third tubes (124). Each third tube (124) comprises first micro-channels (132) and received inside the corresponding second tube (122) such that a first annular space (121) is defined between the second tube (122) and the third tube (124).

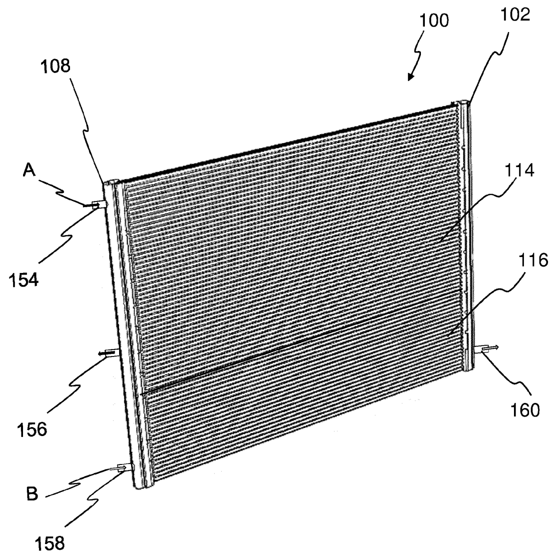

FIG. 1

EP 4 317 881 A1

Description

FIELD OF INVENTION

[0001] The present invention relates to a heat exchanger, more specifically, the present invention relates to a multifunction heat exchanger for a vehicle.

BACKGROUND

[0002] A vehicle may be equipped with several heat exchangers for example, a radiator and a condenser, a charged air cooler, etc. The condenser is a part of an air-conditioning loop, whereas the radiator is part of a drive-cooling loop that can be at least one of engine cooling loop or battery/ motor cooling loop depending upon whether the vehicle is any one of internal combustion engine driven vehicle hybrid vehicle and electric vehicle. The condenser may be an air condenser that may be located at a front end of vehicle or a water-cooled condenser (WCDS) that may be located somewhere in an engine compartment to release heat from a passenger compartment and additional heat due to friction of compressor work.

[0003] The radiator and the air condenser are both disposed at front of the vehicle to be impinged by ram air acting as cooling fluid, the operating heat exchange fluids flowing through the radiator and the air condenser undergo heat exchange with cooling air flowing there across, as the vehicle traverses. More specifically, a coolant flowing through the radiator rejects heat picked up from a drive to the environment, particularly, air flowing across the radiator. The refrigerant flowing through the condenser rejects heat to the outside air, particularly, ram air for causing the phase change of the refrigerant from vapour to liquid state. The inlet temperature of the coolant entering the radiator is in a range of 80 - 120 degree Celsius and has coolant flow rate about 7500 l/h. The outlet temperature of the coolant egressing the radiator is in the range of 40-60 degree Celsius. The inlet temperature of the refrigerant entering the condenser is maximum 140 degree Celsius and the outlet temperature of the refrigerant is 10-15 degree above temperature of ambient air.

[0004] Generally, the radiator and the condenser are arranged in an overlapping manner with respect to one other in the direction of the ram air. Generally, the radiator is disposed downstream of the condenser in the direction of ram air. With such arrangement of the radiator and the condenser, the air reaches the radiator after picking heat rejected by the condenser as such the air reaching the radiator is at elevated temperature than the ambient air. Accordingly, the heat rejecting performance of the radiator is substantially reduced. Inefficient performance of the radiator can have serious implications on the drive cooled by the radiator and in worst circumstances can cause seizure or mechanical failure of the drive due to over-heating thereof. Similarly, in case the condenser is disposed downstream of the radiator in the direction of ram air, the air reaches the condenser after picking heat rejected by the radiator and the air reaching the condenser is at elevated temperature than the ambient air. Accordingly, the efficiency and performance of the condenser is substantially reduced.

[0005] In addition, in some vehicles the water-cooled condenser (WCDS) is connected to the radiator, such as the low temperature radiator, and a water charge air cooler in a low temperature loop. The radiator which has function to release heat from the liquid coolant, i.e. water, which absorbs heat either from the water-cooled condenser or other connected component in the loop like the water charge air cooler, to ambient through ambient/ram air. However, due to limitation of the efficiency of the radiator, the liquid coolant temperature at the low temperature radiator's outlet or WCDS's inlet cannot reach the ambient temperature or even closer. Therefore, the temperature of the coolant received in the water-cooled condenser is insufficient to cool the refrigerant at higher ambient temperature. Accordingly, the efficiency and performance of the water-cooled condenser is reduced.

[0006] Further, the radiator and the condenser are required to be disposed sufficiently spaced apart to achieve sufficient and proper air-flow there across. Such an overlapping arrangement of the radiator and the condenser occupies more space thereby resulting in packaging issues.

[0007] Therefore, there is a need for an efficient heat exchanger arrangement, which can overcome the abovementioned problems associated with the existing heat exchanger arrangement.

SUMMARY

[0008] The present invention discloses a heat exchanger assembly (hereinafter, also referred to as multifunction heat exchanger) for a motor vehicle that can obviate the disadvantages caused by overlapping configuration of the conventional heat exchangers, for example air flow to one heat exchanger being obstructed by the other, and the downstream heat exchanger receiving air at elevated temperature due to air being preheated after passing through the other heat exchanger disposed upstream thereof.

[0009] The disclosed multifunction heat exchanger can replace the conventional air condenser and the radiator in order to simplify the cooling module of the vehicle, i.e., the disclosed heat exchanger can combine functions of two heat exchangers in one heat exchanger, thereby overcoming the disadvantages caused by overlapping configuration of the conventional heat exchangers, packaging issues, reliability issues and reducing overall weight.

[0010] The disclosed heat exchanger assembly incorporates two or more than two heat exchanger cores, where all heat exchanger cores being arranged on a common plane perpendicular to the direction of the flow of the air through the heat exchanger assembly. Therefore, the disclosed heat exchanger assembly can overcome problems of reduced efficiency and performance of the conventional heat exchanger due overlapping configuration of the conventional heat exchangers.

[0011] In accordance with an embodiment of the present invention, the disclosed heat exchanger assembly includes a first header tank assembly and a second header tank assembly spaced apart from the first header tank assembly. The first header tank assembly includes a first tank and a second tank. The second header tank assembly includes a third tank and a fourth tank. Both the first header tank assembly and the second header tank assembly are configured for circulating at least one of a first fluid and a second fluid. The heat exchanger assembly further includes at least two heat exchanger cores, including a first heat exchanger core and a second heat exchanger core, fluidically connected between the first header tank assembly and the second header tank assembly for circulating at least one of a first fluid and a second fluid across the heat exchanger assembly.

[0012] In accordance with an embodiment of the present invention, the first fluid may be any of a coolant or a refrigerant.

[0013] In accordance with an embodiment of the present invention, the second fluid may be any of a coolant or a refrigerant.

[0014] The first heat exchanger core includes a set of first tubes for circulating at least one of the first fluid and the second fluid across the heat exchanger assembly, and a plurality of first fins located in-between the neighboring first tubes. Each first tube may include an outer wall and an inner wall, both extending along an axis of elongation of the respective first tube, and at least one partition located in-between the outer wall and the inner wall to fix the inner wall to the outer wall.

[0015] The second heat exchanger core may include a set of second tubes and a set of third tubes. Both the set of second tubes and the set of third tubes are adapted for circulating at least one of the first fluid and the second fluid across the heat exchanger assembly. At least one third tube includes a plurality of first micro-channels and received inside at least one second tube such that a first annular space is defined between the corresponding second tube and the third tube. The third tube with the plurality of first micro-channels may be formed through extrusion process.

[0016] In accordance with an embodiment of the present invention, the third tube may be co-axially arranged with the corresponding second tube.

[0017] In accordance with another embodiment of the present invention, the third tube may be eccentrically arranged with the corresponding second tube.

[0018] In accordance with an embodiment of the present invention, first dimples may be formed on opposite sides of the second tube and extended inwardly into the respective first annular space to increase turbulence in flow of the second fluid.

[0019] In addition, the first header tank assembly is formed through a first header with a plurality of first apertures configured spaced apart, a first cover configured such that the first cover at least partially receives first header, and a second header configured between the first header and the first cover. In addition, the second header incorporates a plurality of second apertures configured spaced apart. Besides, the first tank is defined between the first header and the second header, and the second tank is defined between the second header and the first cover.

[0020] The second header tank assembly is formed through a third header with a plurality of third apertures configured spaced apart, a second cover configured such that the second cover at least partially receives third header, and a fourth header configured between the third header and the second cover. In addition, the second header incorporates a plurality of forth apertures configured spaced apart. Besides, the third tank is defined between the third header and the fourth header, and the fourth tank is defined between the fourth header and the second cover.

[0021] In accordance with an embodiment of the present invention, the set of first tubes may be fluidically connected between the second tank of the first header tank assembly and the fourth tank of the second header tank assembly through the corresponding second apertures and the fourth apertures respectively.

[0022] In accordance with an embodiment of the present invention, the set of second tubes may be fluidically connected between the first tank of the first header tank assembly and the third tank of the second header tank assembly through the corresponding first apertures and the third apertures respectively. Similarly, the set of third tubes may be fluidically connected between the second tank of the first header tank assembly and the fourth tank of the second header tank assembly through the corresponding second apertures and the fourth apertures respectively.

[0023] In accordance with another embodiment of the present invention, the set of first tubes may be fluidically connected between the first tank of the first header tank assembly and the third tank of the second header tank assembly through the corresponding first apertures and the third apertures respectively.

[0024] In accordance with another embodiment of the present invention, the disclosed heat exchanger assembly may further include a third heat exchanger core fluidically connected between the first header tank assembly and the second header tank assembly. Third heat exchanger core includes a set of fourth tubes and a set of fifth tubes for circulating at least one of the first fluid and the second fluid across the heat exchanger assembly. In addition, at least one fifth tube can include a plurality of second micro-channels and received inside at least one fourth tube such that a second annular space is defined between the corresponding fourth tube and the fifth tube. The fifth tube with the plurality of second micro-channels may be formed through extrusion process.

[0025] In accordance with an embodiment of the present invention, the fifth tube may be co-axially arranged with the corresponding fourth tubes.

[0026] In accordance with another embodiment of the present invention, the fifth tube is eccentrically arranged with the corresponding fourth tubes.

[0027] In accordance with an embodiment of the present invention, the disclosed heat exchanger assembly may include a receiver drier for sub-cooling /forced sub-cooling of at least one of the first fluid and the second fluid.

[0028] In another embodiment, the present invention further discloses a motor vehicle including a heat exchanger assembly as disclosed above. The heat exchanger assembly may be fluidically connected to at least one of an engine-cooling loop and an air-conditioning loop of the vehicle, wherein at least one of the first fluid and the second fluid may circulating through at least one of the the engine-cooling loop and the air-conditioning loop.

[0029] In accordance with an embodiment of the present invention, the at least one of the first fluid and the second fluid cools at least one at least one heat generating component, of the cooling circuit, disposed outside of the heat exchanger assembly. At least one heat-generating component may be any of an engine, an e-motor and a battery pack of the vehicle that is either one of internal-combustion engine driven, electric motor driven or a hybrid vehicle.

[0030] 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.

BRIEF DESCRIPTION OF DRAWINGS

[0031] Other characteristics, details and advantages of the invention may 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 an isometric view of a heat exchanger assembly with a first heat exchanger core and a second heat exchanger core in accordance with an embodiment of the present invention;

FIG. 2 illustrates a top view of a first header tank assembly of the heat exchanger assembly;

FIG. 3 illustrates an exploded view of a first header tank assembly of the heat exchanger assembly;

FIG. 4 illustrates a top view of a second header tank assembly of the heat exchanger assembly;

FIG. 5 illustrates an exploded view of a second header tank assembly of the heat exchanger assembly;

FIG. 6 illustrates an isometric front view of the first heat exchanger core of the heat exchanger assembly;

FIG. 7 illustrates a sectional view depicting internal details of the first and second header tank assemblies where the a first tube is fluidically connected between a second tank and a fourth tank of the first and second header tank assemblies in accordance with an embodiment of the present invention;

FIG. 8 illustrates a sectional view depicting internal details of the first and second header tank assemblies where the a first tube is fluidically connected between a first tank and a third tank of the first and second header tank assemblies in accordance with an embodiment of the present invention;

FIG. 9 illustrates a side view depicting internal details of the first tube of the first heat exchanger core;

FIG. 10 illustrates an isometric view of a second heat exchanger core of the heat exchanger assembly;

FIG. 11 illustrates a sectional view depicting internal details of the first and second header tank assemblies with second and third tubes of the second heat exchanger core;

FIG. 12 illustrates a tube in tube configuration, wherein a third tube that includes a plurality of micro-channels is received and held inside a second tube.

FIG. 13 - FIG. 15 illustrate a tube in tube configuration of second and third tubes, wherein the second tube includes dimples and the third tube includes a plurality of micro-channels;

FIG. 16 - FIG. 17 illustrate isometric views of the heat exchanger assembly of FIG. 1 with a receiver drier in accordance with embodiments of the present invention;

FIG. 18 illustrates an isometric view of a heat exchanger assembly with a first heat exchanger core, a second heat exchanger core and a third heat exchanger core in accordance with an embodiment of the present invention;

FIG. 19 illustrates an isometric view of the third heat exchanger core of the heat exchanger assembly of FIG. 18;

FIG. 20 illustrates a sectional view depicting internal details of the first and second header tank assemblies with fourth and fifth tubes of the third heat exchanger core;

FIG. 21 illustrates a tube in tube configuration of the fourth and fifth tubes, wherein the fifth tube with a plurality of micro-channels is received and held inside the fourth tube;

FIG. 22 - FIG. 23 illustrate a tube in tube configuration of the fourth and fifth tubes, wherein the fourth tube includes dimples and the third tube that includes a plurality of micro-channels;

FIG. 24 illustrates an isometric view of a heat exchanger assembly of FIG. 18 with a receiver drier in accordance with an embodiment of the present invention;

FIG. 25 - FIG. 28 illustrate different configurations of the heat exchanger assembly of FIG. 24 with different positioning of the first heat exchanger core, the second heat exchanger core, the third heat exchanger core and the receiver drier in accordance with embodiments of the present invention;

FIG. 29 - FIG. 31 illustrate different configurations of the heat exchanger assembly where the second fluid/coolant is used for cooling the first fluid/refrigerant flowing through first heat exchanger core/sub-cooler core in accordance with embodiments of the present invention; and

FIG. 32 - FIG. 35 illustrate different configurations of the heat exchanger assembly where a second inlet or coolant inlet and a second outlet or coolant outlet are arranged on different header tank assemblies in accordance with embodiments of the present invention.

DETAILED DESCRIPTION

[0032] 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.

[0033] Although, the present invention is explained in the forthcoming description and the accompanying drawings with an example of heat exchanger assembly for a motor vehicle, particular a heat exchanger assembly that combines functions of two or more heat exchangers in one heat exchanger or heat exchanger assembly. More specifically, the disclosed heat exchanger assembly provides combined functions of a radiator and an air condenser or a water condenser and a radiator or a radiator, an air condenser and a water condenser for a vehicle, thereby eliminating the need for multiple heat exchangers and problems associated with multiple heat exchangers arranged in overlapping configuration, for example packaging issue, performance and efficiency issues. However, the present invention is applicable for any heat exchanger for use in vehicular and non-vehicular environment where it is required to combine functions of at least two heat exchangers into one to address packaging issues, and other problems faced with conventional arrangement of multiple heat exchangers.

[0034] Referring to FIG. 1 to FIG. 15, in accordance with an embodiment, the present invention discloses a heat exchanger assembly 100 comprising a plurality of heat exchanger cores, including, but not limited to, a first heat exchanger core 114 and a second heat exchanger core 116, integrated into a single heat exchange structure. Each heat exchanger core is designed for exchanging heat energy between two or more different heat exchange fluids. The first heat exchanger core 114 and the second heat exchanger core 116 are fluidically connected between a first header tank assembly 102 and a second header tank assembly 108 for circulating at least one of first fluid and second fluid. The first fluid may be a refrigerant or a coolant. Similarly, the second fluid may be a refrigerant or a coolant.

[0035] Referring to FIGs. 2 to 3, the first header tank assembly 102 incudes a first tank 104 and a second tank 106, both the first tank 104 and the second tank 106 are extended along length of the first header tank assembly 102. In addition, the first header tank assembly 102 may be formed by assembling a first header 134, a second header 136 and a first cover 138. The first header 134, the second header 136 and the first cover 138 may be assembled and joined together by using any of the joining processes, such as for example, brazing. However, the present invention is not limited to any particular joining process for forming secure connection between the components and is not limited to brazing. The first cover 138 may be in the form of an enclosure with a stepped configuration that includes a first portion with first opening and second portion with a second opening. The first opening is wider than the second opening to form an intermediate neck/step portion at the interface between the first portion and the second portion of the first cover 138. The first cover 138 is configured such that the first cover 138 at least partially receives first header 134. The second header 136 is configured between the first header 134 and the first cover 138. For instance, side end portions of the second header 136 are sandwiched between the neck/step portion of the first cover 138 and inner ends of the first header 134. This arrangement helps to avoid movement of the second header 136. However, the present invention is not limited to any particular configuration and sequence of connections between the first header134, the second header 136 and the first cover 138 to form the first tank 104 and the second tank 108. In addition, the second header 136 divide an enclosure of the first tank assembly 102 into to the first tank 104 and the second tank 106, i.e., the first tank 104 is defined between the first header 134 and the second header 136, and the second tank 106 is defined between the second header 136 and the first cover 138.

[0036] Further, the neck portion formed on the first cover 138 prevents further advancement of the first header 134 along with the second header 136 within the first cover 138 and to define the first tank 104 and the second tank 106 and/or to avoid unintended change in the volume of the first tank 104 and the second tank 106.

[0037] Furthermore, the first header 134 includes a plurality of first apertures 146 configured spaced apart along length of the first header 134, and the second header 136 includes a plurality of second apertures 148 configured spaced apart along length of the second header 136.

[0038] Referring to Figs 4 and 5, the second header tank assembly 108 includes a third tank 110 and a fourth tank 112, both third tank 110 and the fourth tank 112 are extended along length of the second tank assembly 108. In addition, the second header tank assembly 108 may be formed by assembling a third header 140, a fourth header 144, and a second cover 142. The third header 140, the fourth header 144, and the second cover 142 may be assembled and joined together by using any of the joining processes, such as for example, brazing. However, the present invention is not limited to any particular joining process for forming secure connection between the components and is not limited to brazing. The second cover 142 may be in the form of an enclosure with a stepped configuration that includes a first portion with first opening and second portion with a second opening. The first opening is wider than the second opening to form an intermediate neck/step portion at the interface between the first portion and the second portion of the second cover 142. The second cover 142 is configured such that the second cover 142 at least partially receives third header 140. The fourth header 144 is configured between the third header 140 and the second cover 142. For instance, side end portions of the fourth header 144 are sandwiched between the neck/step portion of the second cover 142 and inner ends of the third header 140. This arrangement helps to avoid movement of the fourth header 144. However, the present invention is not limited to any particular configuration and sequence of connections between the third header140, the fourth header 144 and the second cover 142 to form the third tank 110 and the fourth tank 112. Besides, the fourth header 144 divide an enclosure of the second header tank assembly 108 into to the third tank 110 and the fourth tank 112, i.e., the third tank 110 is defined between the third header 140 and the fourth header 144 and the fourth tank 112 is defined between the fourth header 144 and the second cover 142.

[0039] Further, the neck portion formed on the second covers 142 prevents further advancement of the third header 140 along with the fourth header 144 within the second cover 142 to define the third tank 110 and the fourth tank 112 and/or to avoid unintended change in the volume of the third tank 110 and the fourth tank 112.

[0040] Furthermore, the third header 140 includes a plurality of third apertures 150 configured spaced apart along length of the third header 140, and the fourth header 144 includes a plurality of fourth apertures 152 configured spaced apart along length of the fourth header 144.

[0041] Referring to FIG. 6, the first heat exchanger core 114 includes a set of first tubes 118 for circulating at least one of the first fluid and the second fluid, and a plurality of first fins 126 located in-between the neighbouring first tubes 118. As shown in FIG. 9, each first tube 118 may include an outer wall 119 and an inner wall 120, both the outer wall 119 and the inner wall 120 extending along an axis of elongation of the first tube 118. In addition, each first tube 118 includes a plurality of partitions 123 located in-between the outer wall 119 and the inner wall 120 to fix the inner wall 120 to the outer wall 119. In an embodiment, each of the first tubes 118 may be formed through the extrusion process.

[0042] In addition, each first tube 118 can include a first zone 125 delimited between the inner wall 120 and the outer wall 119, and a second zone 127 delimited by the inner wall 120. Besides, the partitions 123 are extended along the axis of elongation of the first tube 118 to define flow channels 130 in the first zone 125. The flow channels 130 can have square or triangular cross section, however, the present invention is not limited to any particular cross section of the flow channels 130. In an exemplary embodiment, the first zone 125 may be adapted for circulation of the first fluid, wherein the first fluid may be a refrigerant when the first heat exchanger core 114 forms an air condenser. In this case, the first fluid that is the refrigerant may be cooled by the air due to heat exchange between the air outside the first zone 125 and the first fluid circulating through the first zone 125.

[0043] In accordance with another embodiment, each first tube 118 may be formed through an outer tube with the flow channels 130 in the first zone 125 and an inner tube received inside the outer tube and defines the second zone 127. Preferably, the length of the inner tube and the outer tube remain same. In case when, where the inner tube is longer than the outer tube, a volume of the first zone 125 may be greater than a volume of the second zone 127.

[0044] Referring to FIG. 10, the second heat exchanger core 116 includes a set of second tubes 122 and a set of third tubes 124. The set of second tubes 122 and the set of third tubes 124 are adapted for circulating at least one of the first fluid and the second fluid across the heat exchanger assembly 100. In an embodiment, each third tube 124 may include a plurality of first micro-channels

132 and received inside the respective second tube 122 such that a first annular space 121 is defined between the corresponding second tube 122 and the third tube 124, as shown in FIG. 12. The third tube 124 with the plurality of first micro-channels 132 may be formed through extrusion process. The first micro-channels 132 can have square or triangular cross section, however, the present invention is not limited to any particular cross section of the micro-channels 132.

[0045] Further, the third tube 124 is longer than the second tube 122. Furthermore, the adjacent second tubes 122 of the second heat exchanger core 116 are separated by a set of second fins 128.

[0046] In accordance with an embodiment, the third tube 124 may be co-axially arranged with the corresponding second tube 122.

[0047] In accordance with another embodiment, the third tube 124 may be eccentrically arranged with the corresponding second tube 122.

[0048] In accordance with an embodiment, as shown in FIGs. 13- 15, at least one of the second tube 122 and the third tube 124 may include at least one of first dimples 178 and a first protrusion 180 respectively formed thereon. In an embodiment, the first dimples 178 may be formed on opposite sides of the second tube 122 and extended inwardly into the respective first annular space 121 to increase turbulence in flow of the fluid flows through the first annular space 121. The first dimples 178 may be of same size or different size. The first dimples 178 formed on opposite sides of the second tube 122 may be off set from each other. In addition, in case the second tube 122 is formed by bending of a plate joined along the end sides, the end sides may be bent inwardly to form an inwardly the extending first protrusion 180. In another embodiment, the second tube 122 may be formed through the extrusion process.

[0049] In accordance with an embodiment, at least one of the first dimples 178 and the first protrusions 180 may securely hold the respective third tubes 124 inside the second tubes 122.

[0050] In accordance with an embodiment, as shown in FIG. 7, the set of first tubes 118 may be fluidically connected between the second tank 106 of the first header tank assembly 102 and the fourth tank 112 of the second header tank assembly 108 through the corresponding second apertures 148 and the fourth apertures 152 respectively. For instance, the set of first tubes 118 may be connected may be coupled to the second header 136 and fourth header 144 through the corresponding second apertures 148 and the fourth apertures 152 respectively through a joining process such as, but not limited to, brazing. This may help to secure the extreme ends of the set of first tubes 118 with the second apertures 148 and the fourth apertures 152 of the second header 136 and fourth header 144 respectively.

[0051] In accordance with an embodiment, as shown in FIG. 11, the set of second tubes 122 may be fluidically connected between the first tank 104 of the first header tank assembly 102 and the third tank 110 of the second header tank assembly 108 through the corresponding first apertures 146 and the third apertures 150 respectively, and the set of third tubes 124 may be fluidically connected between the second tank 106 of the first header tank assembly 102 and the fourth tank 112 of the second header tank assembly 108 through the corresponding second apertures 148 and the fourth apertures 152 respectively. In addition, the set of second tubes 122 may be coupled to the first header 134 and the third header 140 through the corresponding first apertures 146 and the third apertures 150 respectively through a joining process such as, but not limited to, brazing. This may help to secure the extreme ends of the set of second tubes 122 with the first apertures 146 and the third apertures 150 of the first header 134 and the third header 140 respectively.

[0052] Similarly, the set of third tubes 124 may be coupled to the second header 136 and the fourth header 144 through the corresponding second apertures 148 and the fourth apertures 152 respectively through a joining process such as, but not limited to, brazing. This may help to secure the extreme ends of the set of third tubes 124 with the second apertures 148 and the fourth apertures 152 of the second header 136 and fourth header 144 respectively.

[0053] In accordance with another embodiment, as shown in FIG. 8, the set of first tubes 118 may be fluidically connected between the first tank 104 of the first header tank assembly 102 and the third tank 110 of the second header tank assembly 108 through the corresponding first apertures 146 and the third apertures 150 respectively. In this case, the first tank 104 and the second tank me be fluidically connected to each other through the remaining second apertures 148 of the second header 136, and similarly the third tank 110 and the fourth tank 112 may be fluidically connected to each other through the remaining fourth apertures 152 of the fourth header 144. In addition, the set of first tubes 118 may be coupled to the first header 134 and the third header 140 through the corresponding first apertures 146 and the third apertures 150 respectively through a joining process such as, but not limited to, brazing. This may help to secure the extreme ends of the set of first tubes 118 with the first apertures 146 and the third apertures 150 of the first header 134 and the third header 140 respectively.

[0054] In accordance with an embodiment, the plurality of first apertures 146, the plurality of second apertures 148, the plurality of third apertures 150, and the plurality of fourth apertures 152 may be of different sizes. The different sizes of first apertures 146, the second apertures 148, the third apertures 150, and the fourth apertures 152 allow connection of the first tubes 118 of the first heat exchanger core 114 and the second heat exchanger core 116 in different configurations.

[0055] In accordance with an embodiment, each of the first tank 104, the second tank 106, the third tank 110 and the fourth tank 112 may be divided into multiple section through internal baffles for distribution and collection of the first fluid and the second fluid, i.e., the each of the first tank 104, second tank 106, the third tank 110 and the fourth tank 112 can includes multiple chambers for distribution and collection of the first fluid and the second fluid.

[0056] In accordance with an exemplary embodiment, the first heat exchanger core 114 may forms an air condenser for cooling the first fluid, wherein the first fluid may be a refrigerant flows through flow channels 130 in the first zone 125 of the set of first tubes 118.

[0057] In accordance with an embodiment, a first inlet port 154 and a first outlet port 156 may be configured on any of the first header tank assembly 102 or the second header tank assembly 108 to enable U-flow of the first fluid, based on requirement. As shown in FIG. 1, the first inlet port 154 and the first outlet port 156 are formed on the second header tank assembly 108. In this case, each of the first inlet port 154 and the first outlet 156 may be fluidically connected to at least one of the third tank 110 and the fourth tank 112. For instance, black arrows A indicate flow of the first fluid.

[0058] In accordance with an embodiment, a second inlet port 158 may be configured on any of the first header tank assembly 102 or the second header tank assembly 108 for ingress of the second fluid with respect to the first header tank assembly 102 or the second header tank assembly 108, based on requirement. Accordingly, a second outlet port 160 may be configured on any of the first header tank assembly 102 and the second header tank assembly 108 for egress of the second fluid with respect to the first header tank assembly 102 or the second header tank assembly 108, based on requirement. For instance, white arrows B indicate flow of the second fluid.

[0059] In an embodiment, as shown in FIG. 1, the second inlet port 158 may be configured on the first header tank assembly 102 and the second outlet port 160 may be configured on the second header tank assembly 108.

[0060] In another embodiment, both the second inlet port 158 and the second outlet port 160 may be configured on any of the first header tank assembly 102 and the second header tank assembly 108, based on requirement.

[0061] In accordance with an exemplary embodiment, the second heat exchanger core 116 may form a radiator for cooling the second fluid. The second fluid may be a liquid coolant circulates through each first annular space 121 defined between the corresponding second tube 122 and the third tube 124.

[0062] In accordance with an exemplary embodiment, the second heat exchanger core 116 may form a water-cooled condenser for cooling the first fluid and the second fluid. The first fluid may be a refrigerant circulates through the first micro channels 132 of the third tube 124, and the second fluid may be a liquid coolant circulates through each first annular space 121 defined between the corresponding second tube 122 and the third tube 124 in a counter-flow relationship to the first fluid to cool the first fluid.

[0063] In accordance with an embodiment, shown in FIGs. 16 and 17, a group of first tubes 118a of the set of first tubes 118 may define a first pass that is a condensing pass while the remaining tubes 18b of the set of first tubes 118 may define second/return pass a sub-cooling pass. The condensing pass may be in fluid communication with the sub-cooling pass via a receiver drier 162. The receiver drier 162 may be configured in fluid communication with any of the first header tank assembly 102 and the second header tank assembly 108. For instance, the receiver drier 162 is configured in fluid communication with the first header tank assembly 102. For instance, as shown in FIGs. 16 and 17, the arrangement of the condensing pass 118a and the sub-cooling pass 18b may be changed based on requirement.

[0064] In accordance with an embodiment, the first receiver drier 162 may include a first opening 162a and a second opening 162b. The first receiver drier 162 receives condensed first fluid that may be a refrigerant egressing the condensing pass 118a of the first heat exchanger core 114 through the first opening 162a to remove incompressible moisture and debris therefrom. Further, the first receiver drier 162 delivers the first fluid to the sub-cooling pass 18b of the first heat exchanger core 114 through the second opening 162b for further sub-cooling the first fluid.

[0065] In accordance with an embodiment of the present invention, as shown in FIG. 18 to FIG. 23, the heat exchanger assembly 100 may further include a third heat exchanger core 164 fluidically connected between the first header tank assembly 102 and the second header tank assembly 108. As shown in FIG. 19 to FIG. 21, the third heat exchanger core 164 may include a set of fourth tubes 166 and a set of fifth tubes 168 for circulating at least one of the first fluid and the second fluid. In an embodiment, each fifth tube 168 may include a plurality of second micro-channels 172 extended along the length of the fifth tube 168. Each fifth tube 168 may be received inside the corresponding fourth tube 166 such that a second annular space 170 is defined between the corresponding fourth tube 166 and the fifth tube 168. Each fifth tube 168 with the plurality of second micro-channels 172 may be formed through extrusion process. The second micro-channels 172 can have square or triangular cross section, however, the present invention is not limited to any particular cross section of the micro- channels 172. In addition, the fifth tubes 168 are longer than the fourth tubes 166.

[0066] In addition, as shown in FIG. 19, the adjacent fourth tubes 166 of the third heat exchanger core 164 are separated by a set of third fins 174.

[0067] In accordance with an embodiment of the present invention, the first fins 126 and the second fins 128 and the third fins 174 may be same or the first fins 126 and the second fins 128 and the third fins 174 fins may be different in terms of pitch size, louvers pattern, material thickness, etc.

[0068] In accordance with an embodiment of the present invention, as shown in FIG. 20, the set of fourth tubes 166 are fluidically connected between the first tank 104 of the first header tank assembly 102 and the third tank 110 of the second header tank assembly 108 through the corresponding first apertures 146 and the third apertures 150 respectively. Similarly, the set of fifth tubes 168 are fluidically connected between the second tank 106 of the first header tank assembly 102 and the fourth tank 112 of the second header tank assembly 108 through the corresponding second apertures 148 and the fourth apertures 152 respectively.

[0069] In accordance with an embodiment, the fifth tube 168 may be co-axially arranged with the corresponding fourth tubes 166.

[0070] In accordance with another embodiment, the fifth tube 168 may be eccentrically arranged with the corresponding fourth tubes 166.

[0071] In accordance with an embodiment, as shown in FIGs. 22 and 23, at least one of the fourth tubes 166 and the fifth tube 168 may include at least one of second dimples 182 and second protrusions 184 formed thereon. In an embodiment, the second dimples 182 may be of same size or different size.

[0072] In accordance with an embodiment, the second dimples 182 may be formed on opposite sides of the fourth tubes 166 and extended inwardly into the respective second annular space 170 to increase turbulence in flow the fluid flows through the second annular space 170. The second dimples 182 formed on opposite sides of the fourth tubes 166 may be off set from each other. In addition, In addition, in case the fourth tube 166 is formed by bending of a plate joined along the end sides, the end sides may be bent inwardly to form an inwardly the extending second protrusion 184. In another embodiment, the fourth tube 166 may be formed through an extrusion process.

[0073] In accordance with an embodiment, at least one of the second dimples 182 and the second protrusions 184 may securely hold the respective fifth tubes 168 inside the fourth tubes 166.

[0074] In accordance with an embodiment, the first heat exchanger core 114, the second heat exchanger core 116, and the third heat exchanger core 164 may all arranged on a common plane perpendicular to the intended flow direction of the air through the heat exchanger assembly 100.

[0075] In accordance with an exemplary embodiment, the third heat exchanger core 164 may forms a water-cooled condenser for cooling the first fluid and the second fluid, wherein the first fluid may be a refrigerant circulates through the second micro-channels 172 of the fifth tube 168, and the second fluid may be a liquid coolant circulates through each second annular space 170 defined between the corresponding fourth tube 166 and the fifth tube 168. In this configuration, the first fluid or the refrigerant is cooled by the second fluid or the liquid coolant.

[0076] In accordance with an embodiment, the first inlet port 154, the first outlet port 156, the second inlet port 158 and the second outlet port 160 may be configure in a manner such that the second fluid circulates in a counter-flow relationship to the first fluid to cool the first fluid. For instance, as shown in FIG. 18, the first inlet port 154, the first outlet port 156, the second inlet port 158 and the second outlet port 160 are configure on the second header tank assembly 108.

[0077] In accordance with an embodiment, when the third heat exchanger core 164 forms the water-cooled condenser, the first heat exchanger core 114 forms an air condenser. In this case, the first fluid or the refrigerant is cooled to be at least partially condescended in the third heat exchanger core 164 and then the at least partially condescended first fluid is further cooled by air to be fully condensed by circulating the first fluid through the flow channels 130 of the first tubes 118 of the first heat exchanger core 114. In addition, when the third heat exchanger core 164 forms the water-cooled condenser core, the second heat exchanger core 116 forms a radiator core and the second fluid which may be a liquid coolant egressing the third heat exchanger core 164 is circulated though the first annular spaces 121 in the second heat exchanger core 116 for cooling second fluid. The cooled second fluid inside the second heat exchanger core 116 is circulated to the third second annular spaces 170 of the third heat exchanger core 164 for cooling the first fluid flowing through the second micro-channels 172 of the third heat exchanger core 164.

[0078] In addition, the flow of the second fluid or the coolant and the first fluid or the refrigerant through the third heat exchanger core 164 may be either parallel flow or counter flow based on the positioning of the first inlet 154, the first outlet 156 for the refrigerant, and the second inlet 158 and the second outlet 160 for the coolant on the first header tank assembly 102 and the second header tank assembly 108.

[0079] In accordance with an embodiment, as shown in FIG. 24, the third heat exchanger core 164 may be in fluid communication with the first heat exchanger core 114 via the receiver drier 162 that is configured in fluid communication with the first header tank assembly 102.

[0080] In accordance with an embodiment, the receiver drier 162 may be configured to receive at least partially condescended first fluid egressing the third heat exchanger core 164 through the first opening 162a to remove incompressible moisture and debris therefrom. The receiver drier 162 further delivers the at least partially condescended first fluid to the first heat exchanger core 114 through the second opening 162b for sub-cooling of the at least partially condescended first fluid in the first heat exchanger core 114 by air.

[0081] In accordance with an embodiment, the receiver drier 162 can ensure the first fluid/refrigerant in liquid state at the first heat exchanger core outlet. In addition, the performance of first heat exchanger 114 and/or the third heat exchanger core 164 may be kept constant during lifetime due to sub-cooling /forced sub-cooling of the first fluid/refrigerant.

[0082] FIG. 25 - FIG. 28 illustrate different configurations of the heat exchanger assembly 100 based on different combinations of the positioning of the first heat exchanger core 114, the second heat exchanger core 116, the third heat exchanger core 164, and the receiver drier 162 for cooling at least one of the first fluid and the second.

[0083] FIG. 29 - FIG. 31 illustrate different configurations of the heat exchanger assembly where the second fluid/coolant is used for cooling the first fluid/refrigerant flowing through the first heat exchanger/sub-cooler core 114. In these configurations, the second fluid may be circulated through the second zone 127 of the first tube 118 of the first heat exchanger/sub-cooler core 114 for cooling the first fluid flowing through the first zones 125 of the first heat exchanger/subcooler core 114. For instance, the first fluid circulating through the first zones 125 of the first heat exchanger/sub-cooler core 114 is received from the third heat exchanger core 164 in which the first fluid is at least partially condensed. Further, the second fluid egressing the first heat exchanger/sub-cooler core 114 may be circulated through the second heat exchanger core 116 for cooling the second fluid/coolant.

[0084] FIG. 32 - FIG. 35 illustrate different configurations of the heat exchanger assembly 100 where the second inlet or coolant inlet 158 and the second outlet or coolant outlet 160 are arranged on different header tank assemblies in accordance with embodiments of the present invention. For instance, as shown in FIGs. 32 and 34, the second/ coolant inlet 158 is configured on the first header tank assembly 102 and the second/ coolant outlet 160 is configured the second header tank assembly 108 for circulating the second fluid or coolant through at least one of the first heat exchanger core 114, the second heat exchanger core 116 and the third heat exchanger core 164. In addition, as shown in FIGs. 31, 33 and 35, the second/coolant inlet 158 is configured on the second header tank assembly 108 and the second/coolant outlet 160 is configured the first header tank assembly 102 for circulating the second fluid or coolant through at least one of the first heat exchanger core 114, the second heat exchanger core 116 and the third heat exchanger core 164.

[0085] In accordance with an embodiment, the heat exchanger assembly 100 may further include one or more connectors including at least one of refrigerant connectors and/or coolant connectors. The refrigerant connectors and/or the coolant connectors may be configured in at least one of the first header tank assembly 102 and the second header tank assembly 108. The refrigerant connectors and/or coolant connectors may be configured for fluidically connecting the tanks 104 and 106 of the first header tank assembly 102, and/or the tanks 110 and 112 of the second header tank assembly 108 to allow flow of the first fluid/refrigerant and/or the second fluid/coolant between the respective tanks. In another embodiment, the refrigerant connector and/or the coolant connector may be configured in the same header tank assembly 102/108 or in different the header tank assemblies 102 and 108, based on requirements.

[0086] It is to be appreciated that the disclosed heat exchanger assembly 100 of the present invention can function as a radiator or an air condenser and a water-cooled condenser or a combination thereof for cooling at least one of a coolant and a refrigerant based on requirement.

[0087] In accordance with an exemplary embodiment, the heat exchanger assembly 100 may be in fluidic communication with at least one of an engine cooling circuit/loop and an air conditioning circuit/loop of the vehicle circulating at least one of the first fluid and the second fluid. At least one of the first fluid and the second fluid may cool at least one at least one heat generating component, of at least one engine cooling circuit, disposed outside of the heat exchanger assembly 100. At least one heat generating component may be any one of an engine, an e-motor and a battery pack in the vehicle. The vehicle may be either one of internal-combustion engine driven, electric motor driven or a hybrid vehicle.

[0088] 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 assembly (100) for a motor vehicle comprising:

   a first header tank assembly (102);
   a second header tank assembly (108) spaced apart from the first header tank assembly (102), the first header tank assembly (102) and the second header tank assembly (108) being configured for circulating at least one of a first fluid and a second fluid; and
   at least two heat exchanger cores (114, 116), comprising a first heat exchanger core (114) and a second heat exchanger core (116), fluidically connected between the first header tank assembly (102) and the second header tank assembly (108),
   characterized in that the first heat exchanger core (114) comprises a set of first tubes (118) for circulating at least one of the first fluid and the second fluid, and a plurality of first fins (126) located in-between the neighboring first tubes (118), wherein each first tube (118) comprises an outer wall (119) and an inner wall (120), both extending along an axis of elongation of the first tube (118), and at least one partition (123) located in-between the outer wall (119) and the

inner wall (120) to fix the inner wall (120) to the outer wall (120);

wherein the second heat exchanger core (116) comprises a set of second tubes (122) and a set of third tubes (124), the set of second tubes (122) and the set of third tubes (124) being adapted for circulating at least one of the first fluid and the second fluid, wherein at least one third tube (124) comprises a plurality of first micro-channels (132) and received inside at least one second tube (122) such that a first annular space (121) is defined between the corresponding second tube (122) and the third tube (124).

2. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the first header tank assembly (102) comprises a first tank (104) and a second tank (106), and wherein the second header tank assembly (108) comprises a third tank (110) and a fourth tank (112).

3. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the first header tank assembly (102) includes a first header (134) with a plurality of first apertures (146) configured spaced apart, a first cover (138) configured such that the first cover (138) at least partially receives first header (134), and a second header (136) configured between the first header (134) and the first cover (138) and includes a plurality of second apertures (148) configured spaced apart, and wherein the first tank (104) is defined between the first header (134) and the second header (136), and the second tank (106) is defined between the second header (136) and the first cover (138).

4. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the second header tank assembly (108) includes a third header (140) with a plurality of third apertures (150) configured spaced apart, a second cover (142) configured such that the second cover (142) at least partially receives third header (140), and a fourth header (144) configured between the third header (140) and the second cover (142) and includes a plurality of forth apertures (152) configured spaced apart, wherein the third tank (110) is defined between the third header (140) and the fourth header (144) and the fourth tank (112) is defined between the fourth header (144) and the second cover (142).

5. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the set of first tubes (118) are fluidically connected between the second tank (106) of the first header tank assembly (102) and the fourth tank (112) of the second header tank assembly (108) through the corresponding second apertures (148) and the fourth apertures (152) respectively.

6. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the set of second tubes (122) are fluidically connected between the first tank (104) of the first header tank assembly (102) and the third tank (110) of the second header tank assembly (108) through the corresponding first apertures (146) and the third apertures (150) respectively, and wherein the set of third tubes (124) are fluidically connected between the second tank (106) of the first header tank assembly (102) and the fourth tank (112) of the second header tank assembly (108) through the corresponding second apertures (148) and the fourth apertures (152) respectively.

7. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the set of first tubes (118) are fluidically connected between the first tank (104) of the first header tank assembly (102) and the third tank (110) of the second header tank assembly (108) through the corresponding first apertures (146) and the third apertures (150) respectively.

8. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the third tube (124) is co-axially arranged with the corresponding second tube (122).

9. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the third tube (124) is eccentrically arranged with the corresponding second tube (122).

10. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein first dimples (178) are formed on opposite sides of the second tube (122) and extended inwardly into the respective first annular space (121) to increase turbulence in flow of the fluid flows through the first annular space (121).

11. The heat exchanger assembly (100) as claimed in any of the previous claims, further comprises a third heat exchanger core (164) fluidically connected between the first header tank assembly (102) and the second header tank assembly (108).

12. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein third heat exchanger core (164) comprises a set of fourth tubes (166) and a set of fifth tubes (168) for circulating at least one of the first fluid and the second fluid, at least one fifth tube (168) comprising a plurality of second micro-channels (172) and received inside at least one fourth tube (166) such that a second annular space (170) is defined between the corresponding fourth tube (166) and the fifth tube (168).

13. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the fifth tube (168) is co-axially arranged with the corresponding fourth tubes (166).

14. The heat exchanger assembly (100) as claimed in any of the previous claims, wherein the fifth tube (168) is eccentrically arranged with the corresponding fourth tubes (166).

15. A motor vehicle comprising the heat exchanger assembly (100) according to any of the preceding claims.

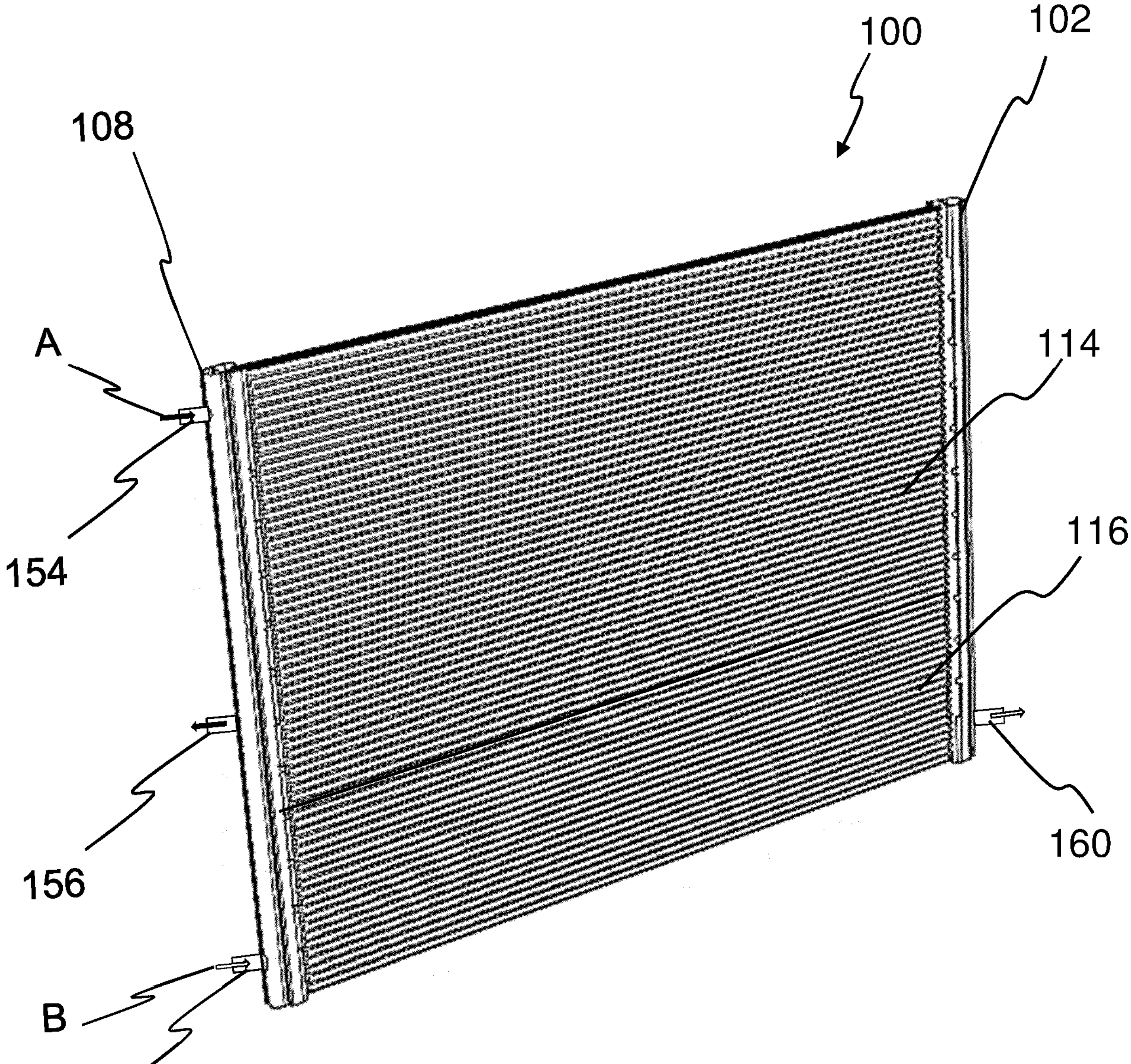

FIG. 1

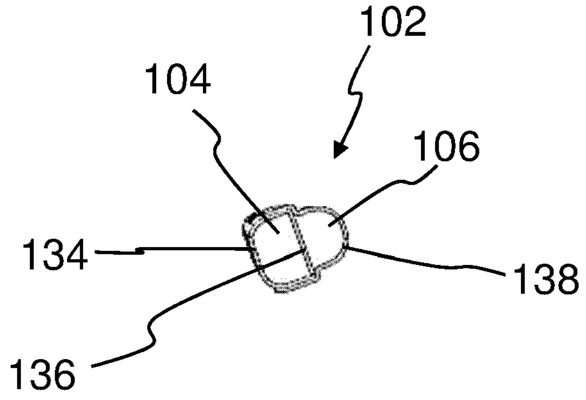

FIG. 2

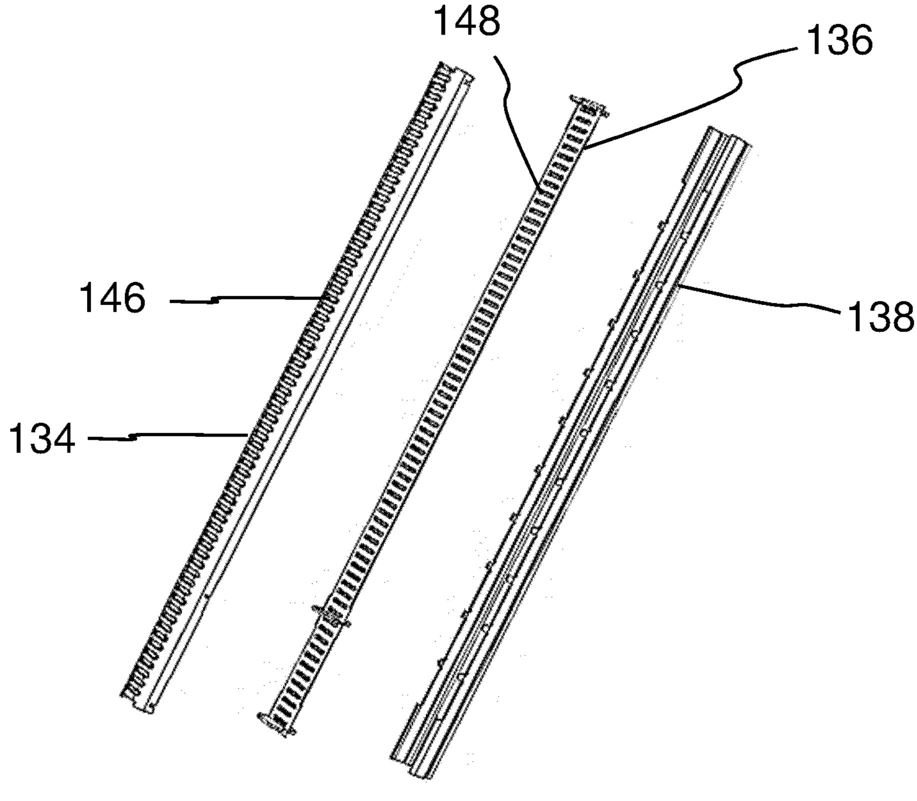

FIG. 3

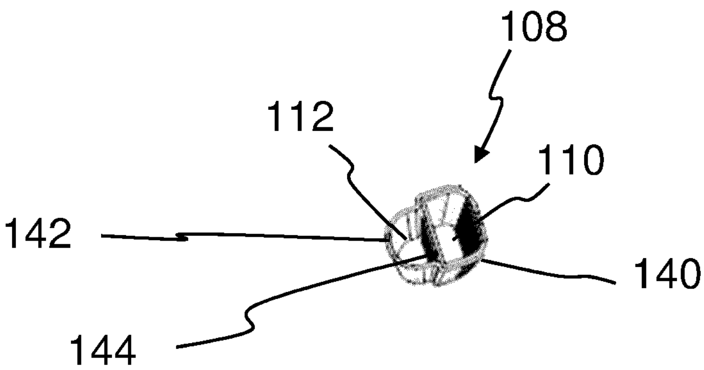

FIG. 4

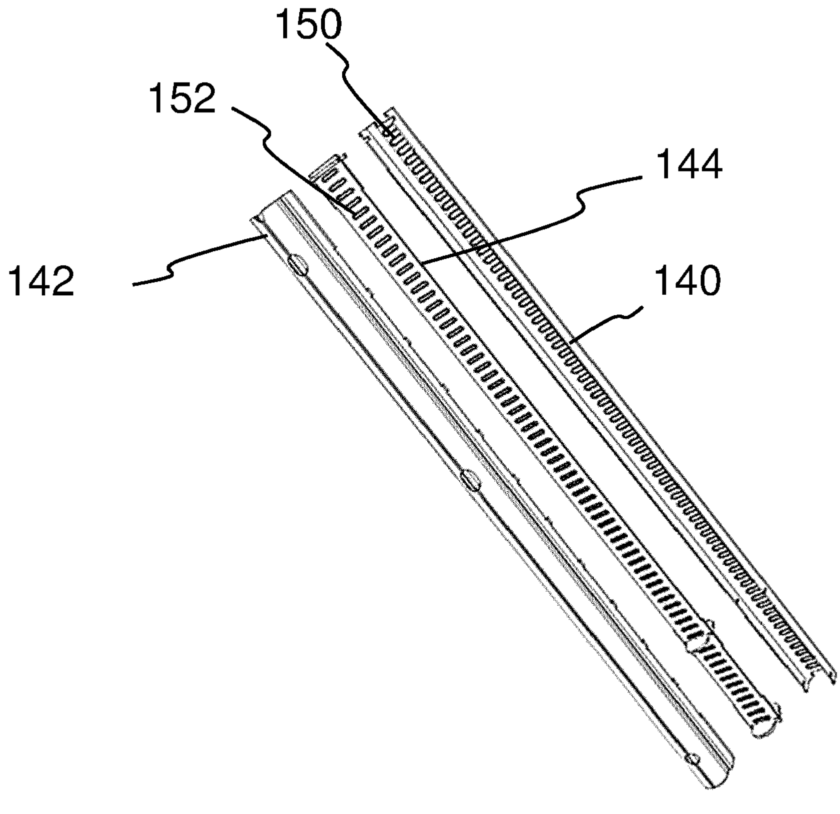

FIG. 5

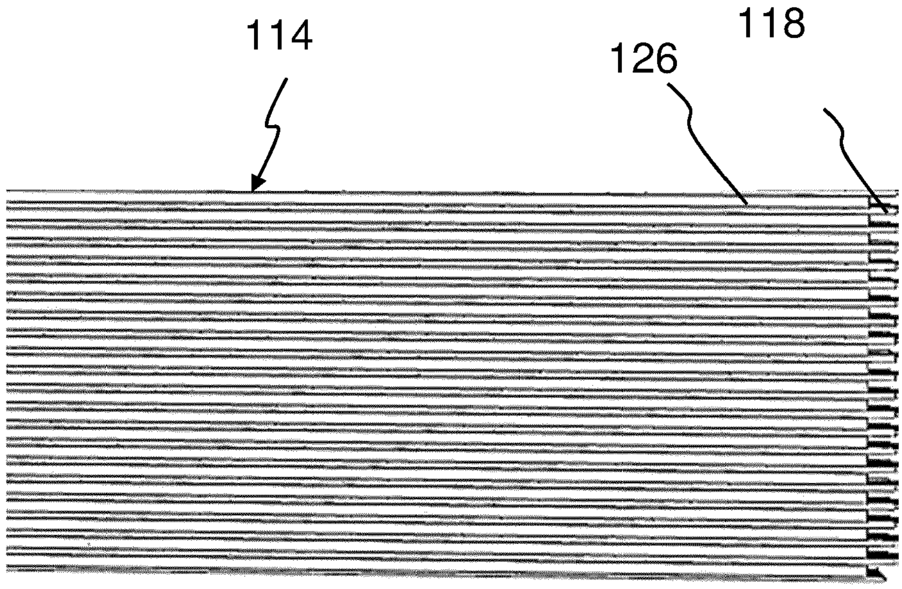

FIG. 6

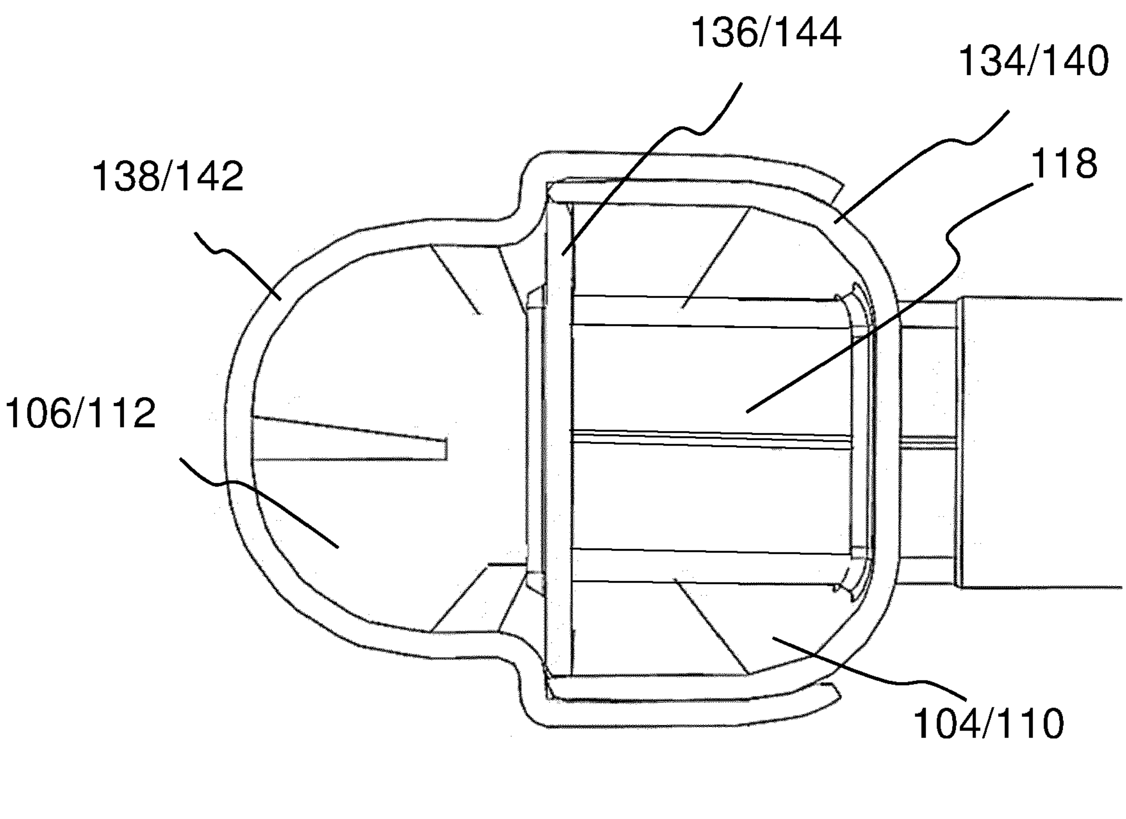

FIG. 7

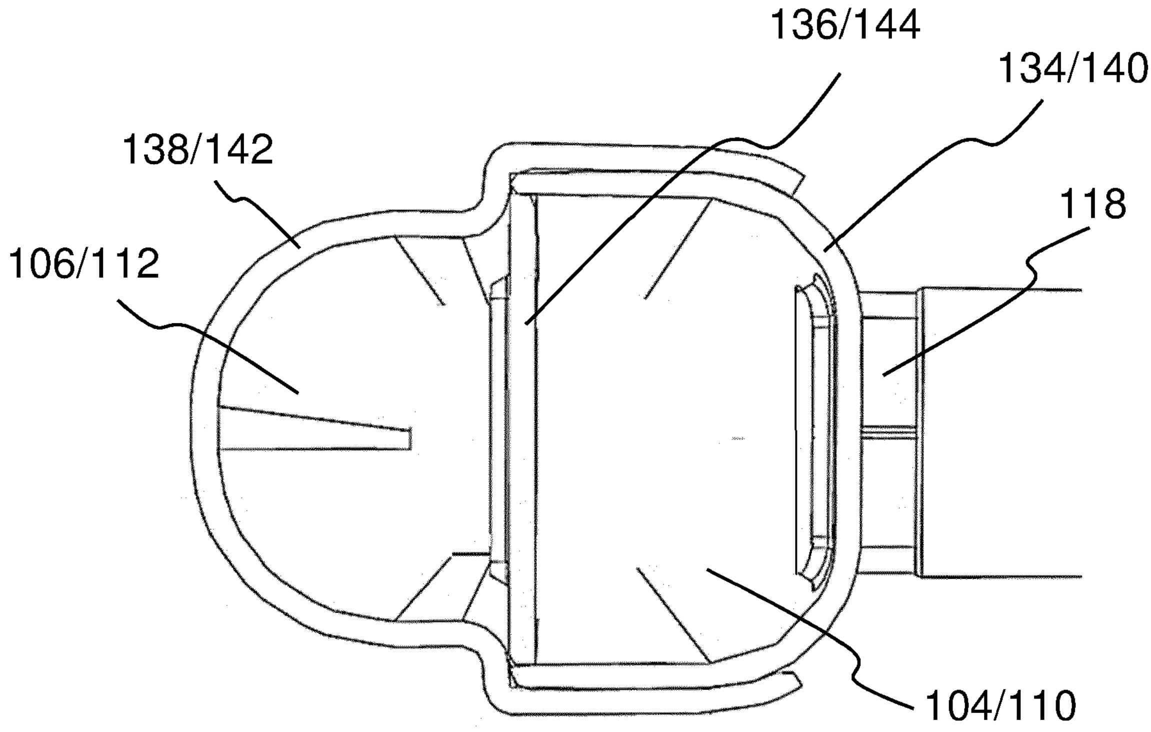
136/144
134/140
138/142
118
106/112
104/110

FIG. 8

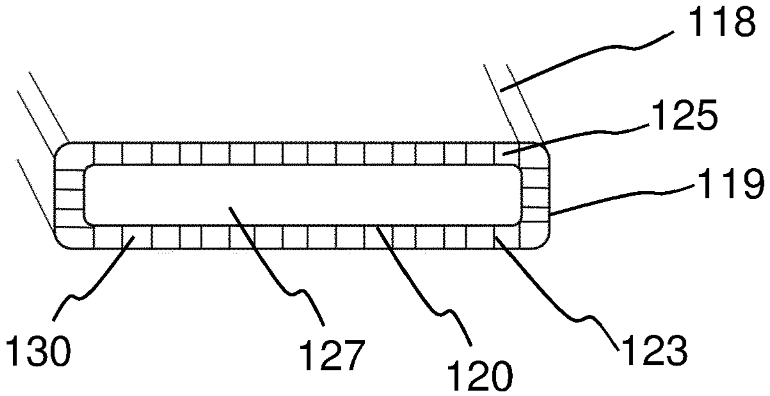
118
125
119
130
127
120
123

FIG. 9

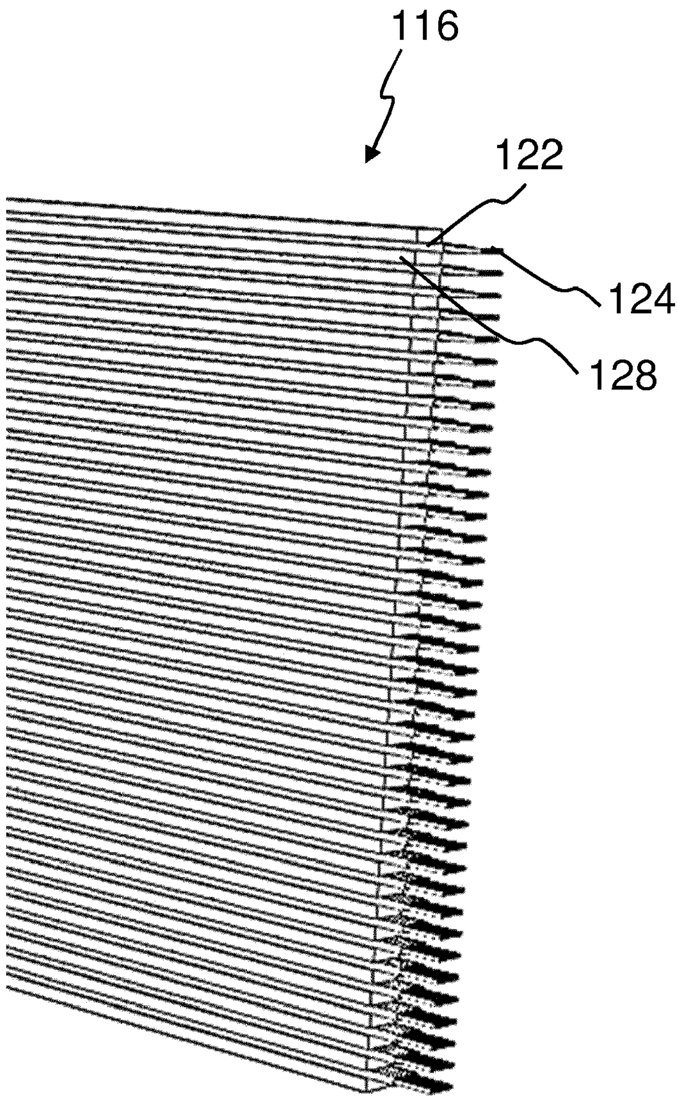

FIG. 10

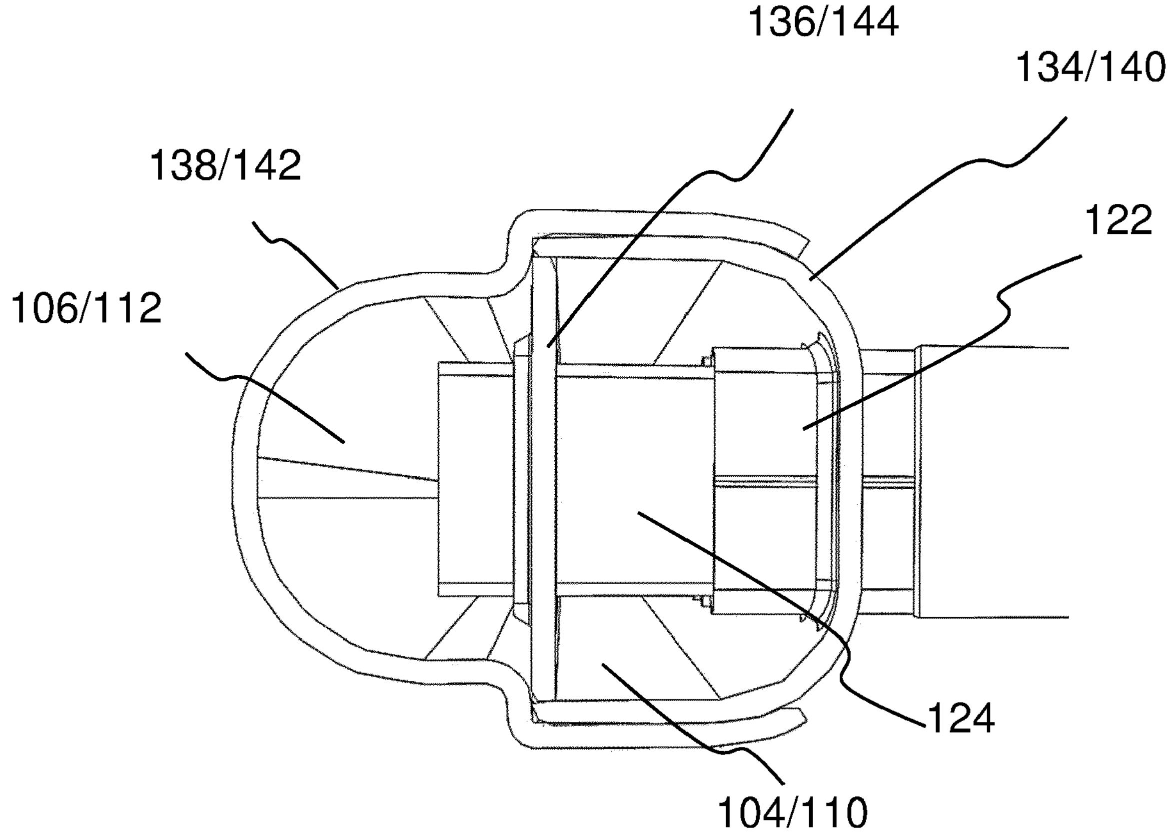

FIG. 11

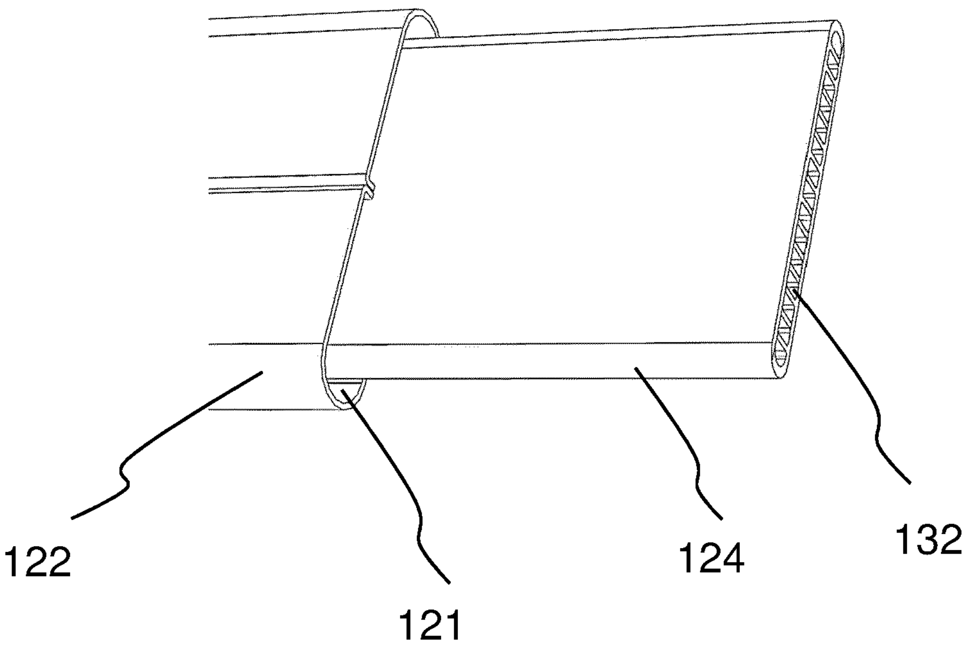

FIG. 12

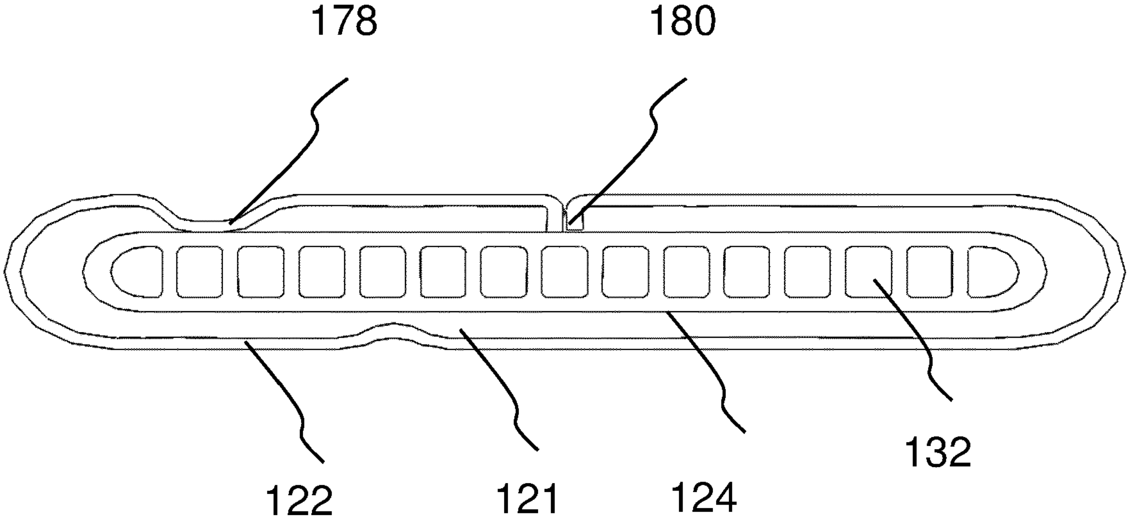

FIG. 13

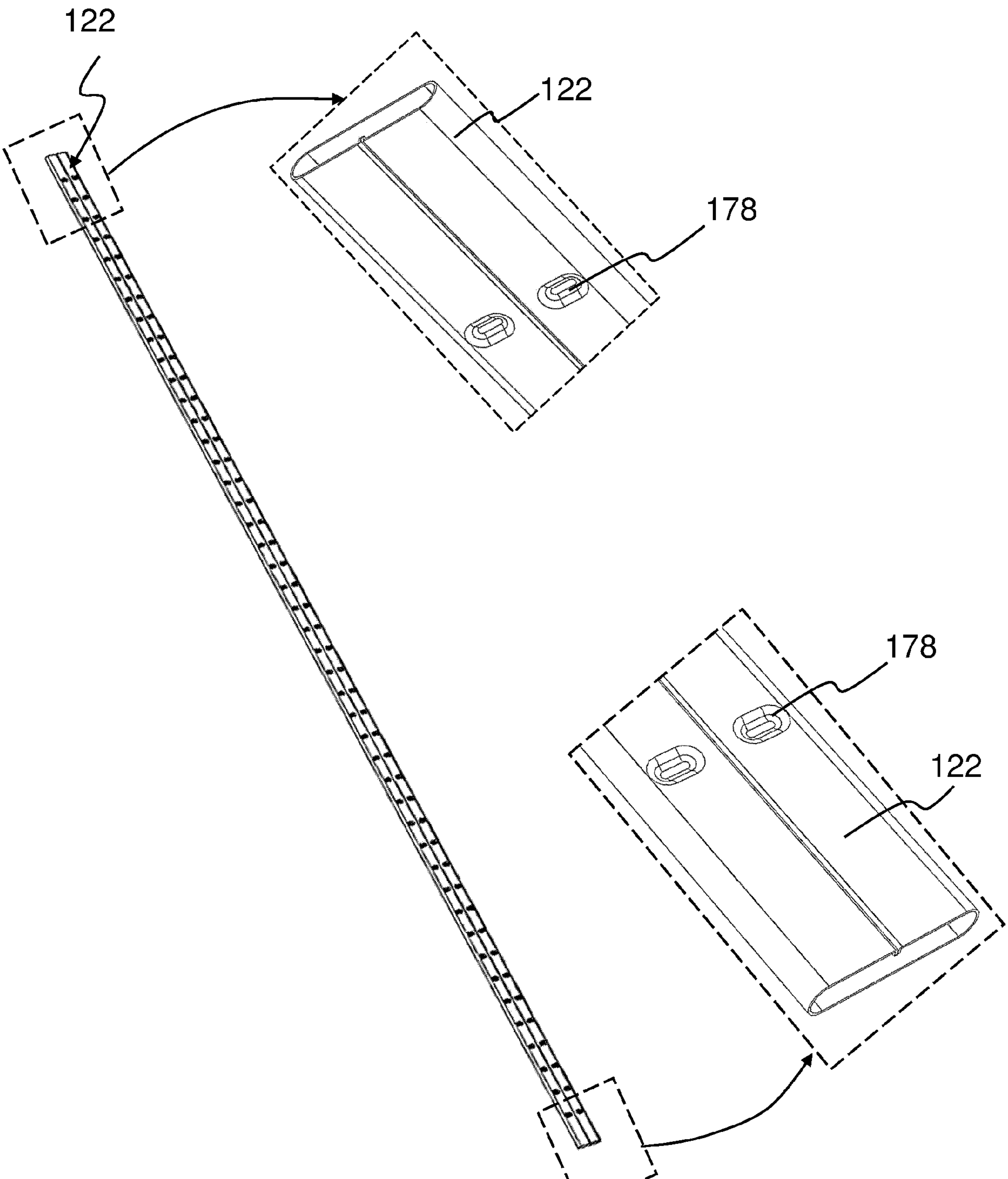

FIG. 14

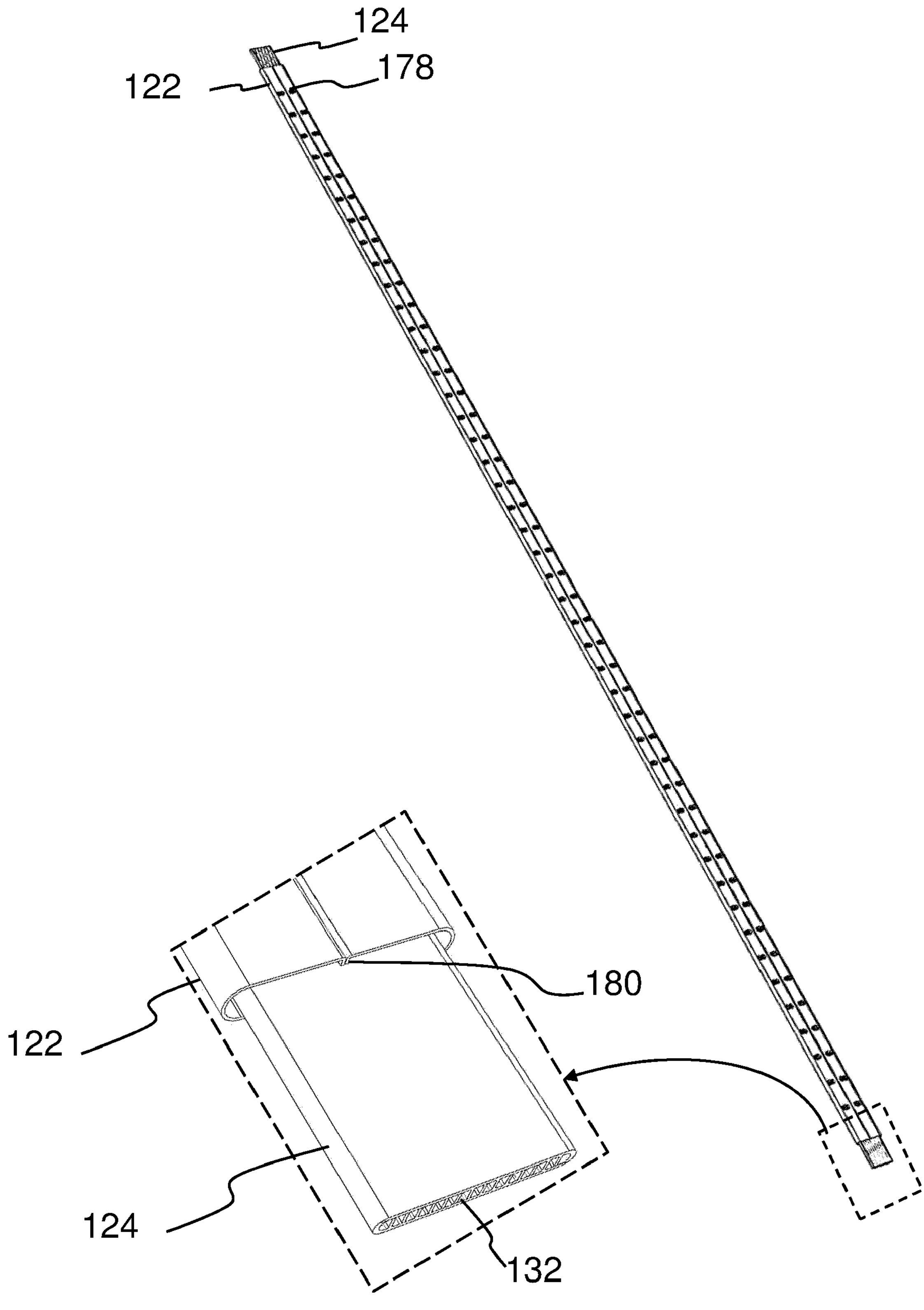

FIG. 15

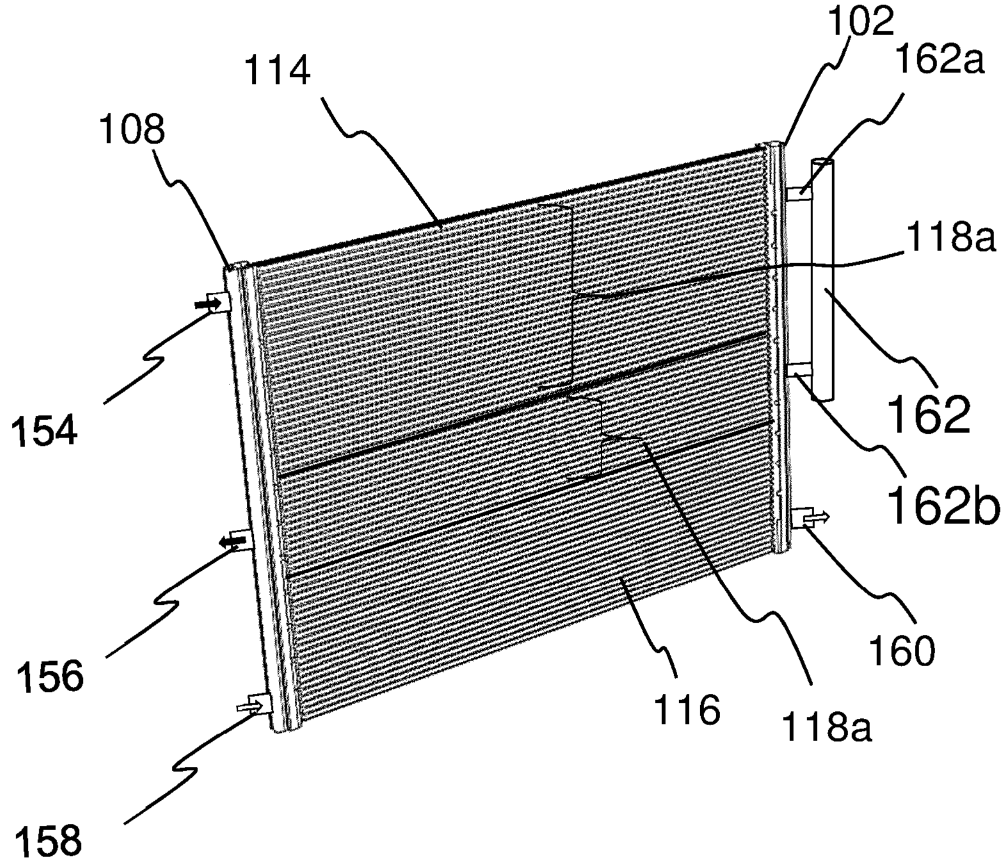
102
162a
114
108
118a
154
162
162b
156
160
116
118a
158

FIG. 16

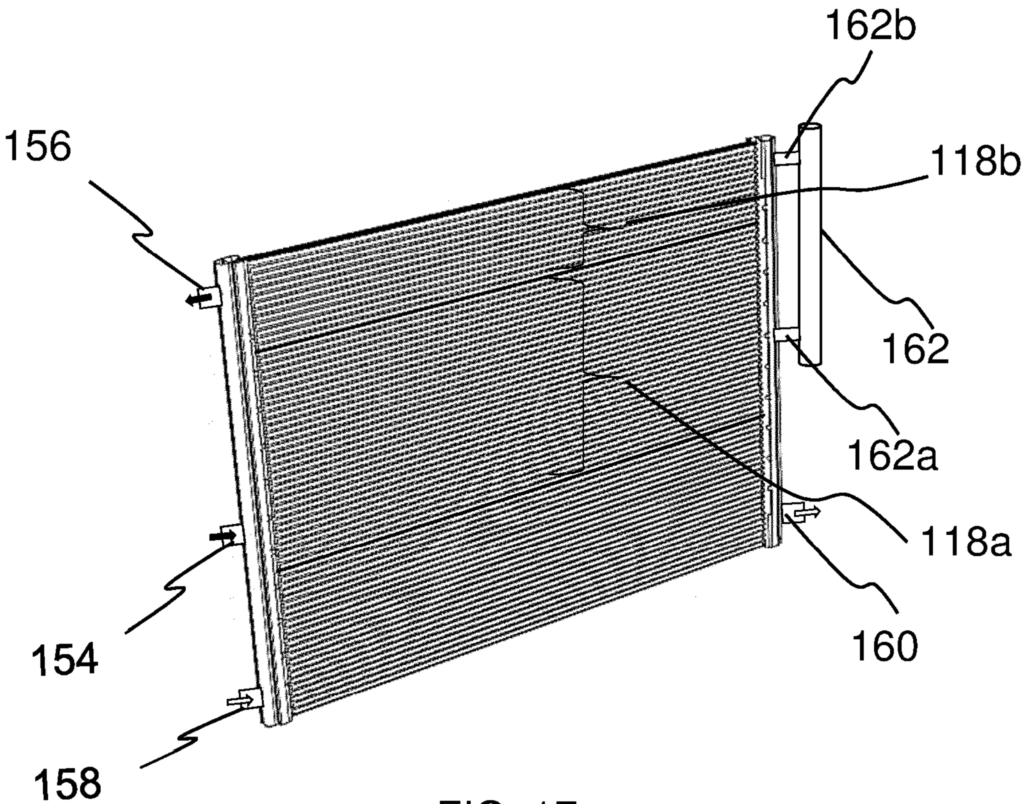
162b
156
118b
162
162a
118a
154
160
158

FIG. 17

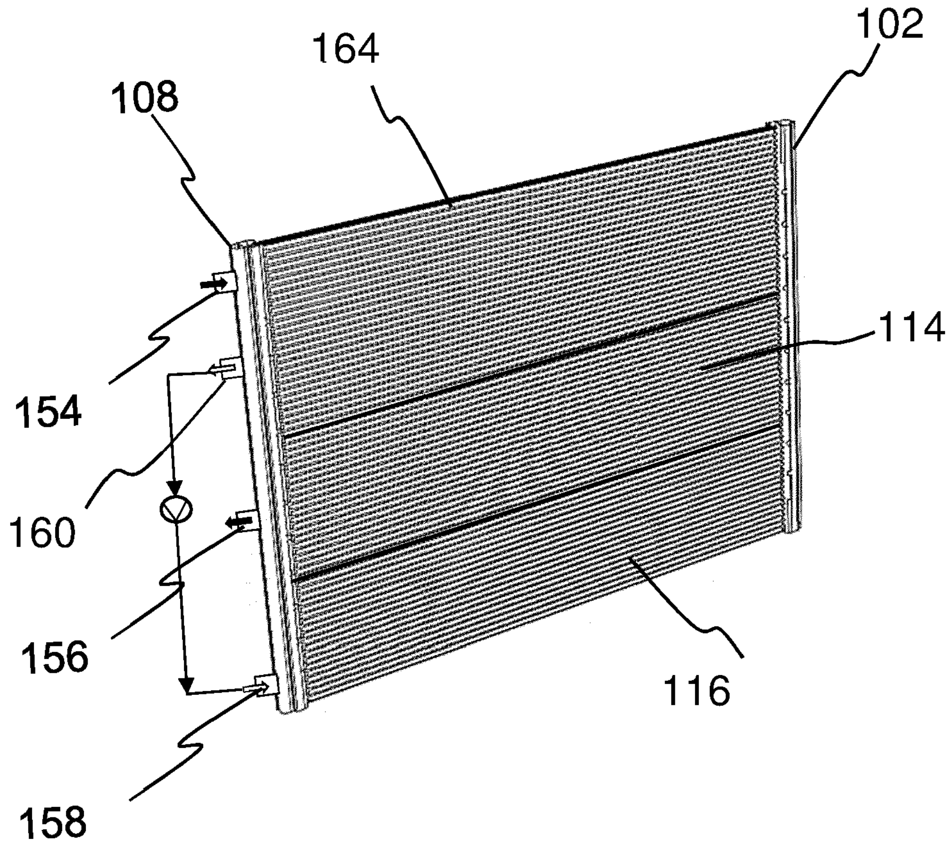

FIG. 18

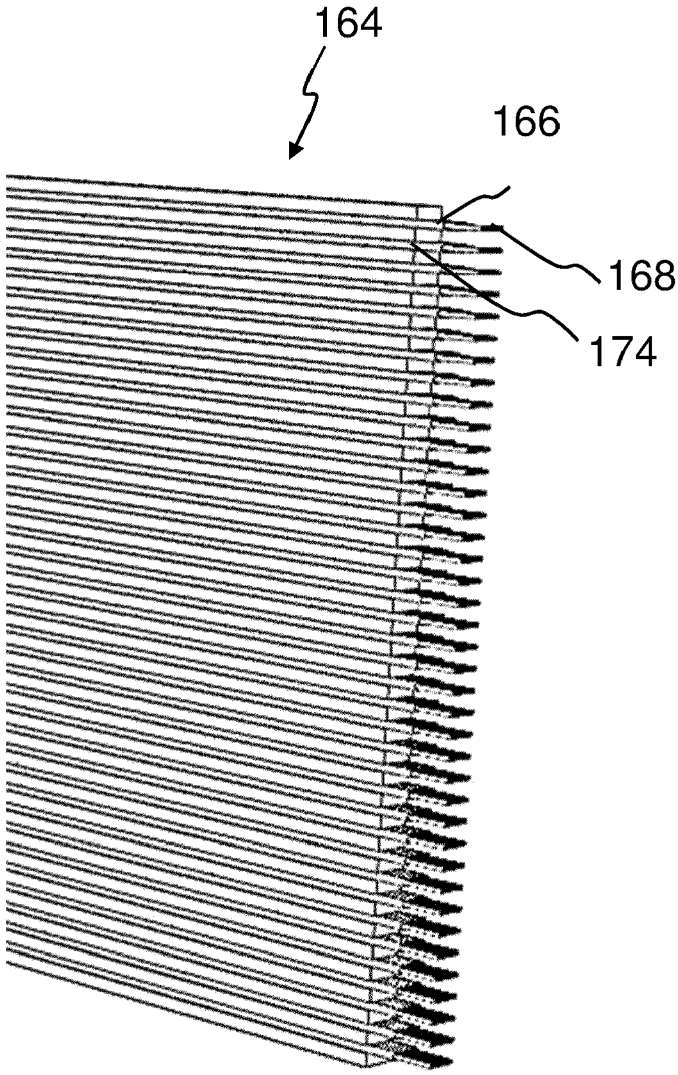

FIG. 19

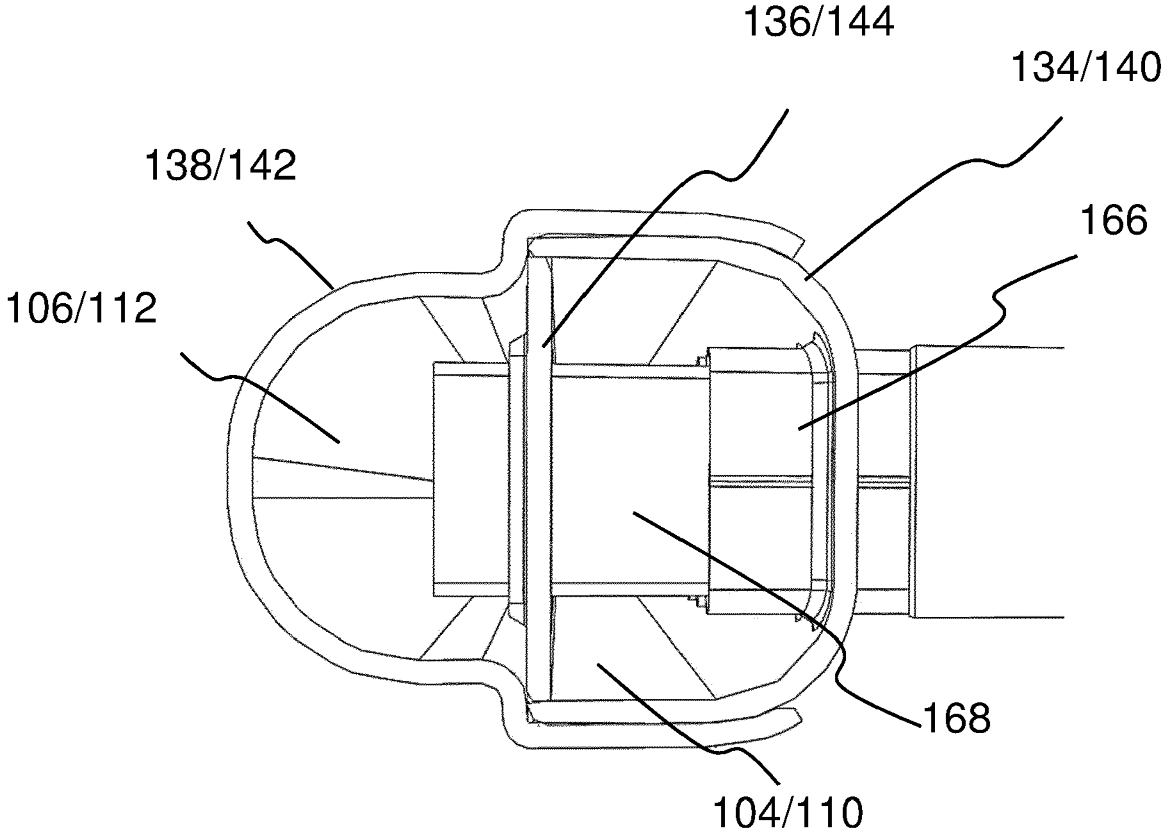

FIG. 20

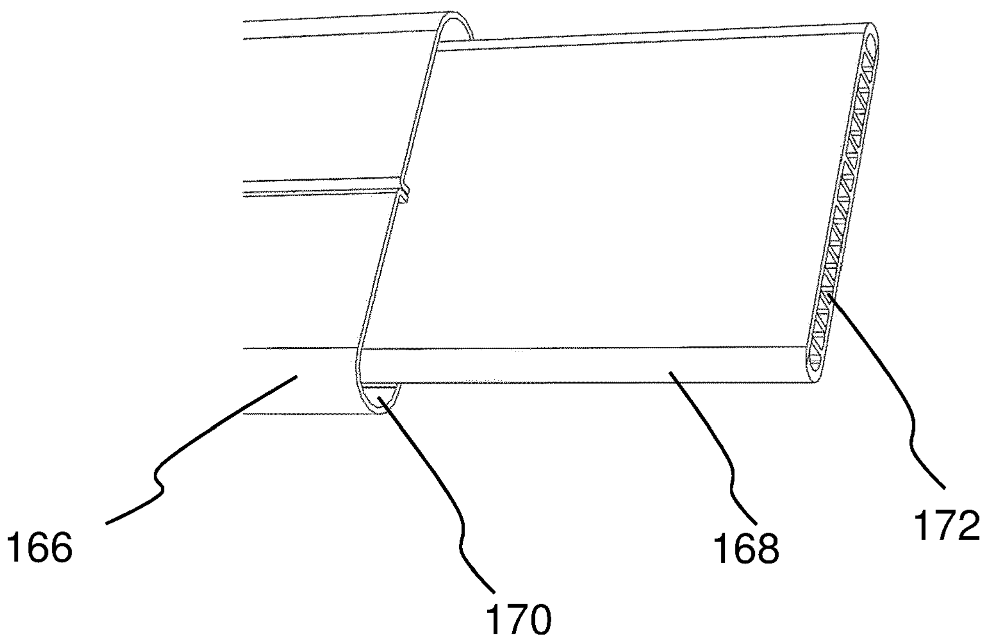

FIG. 21

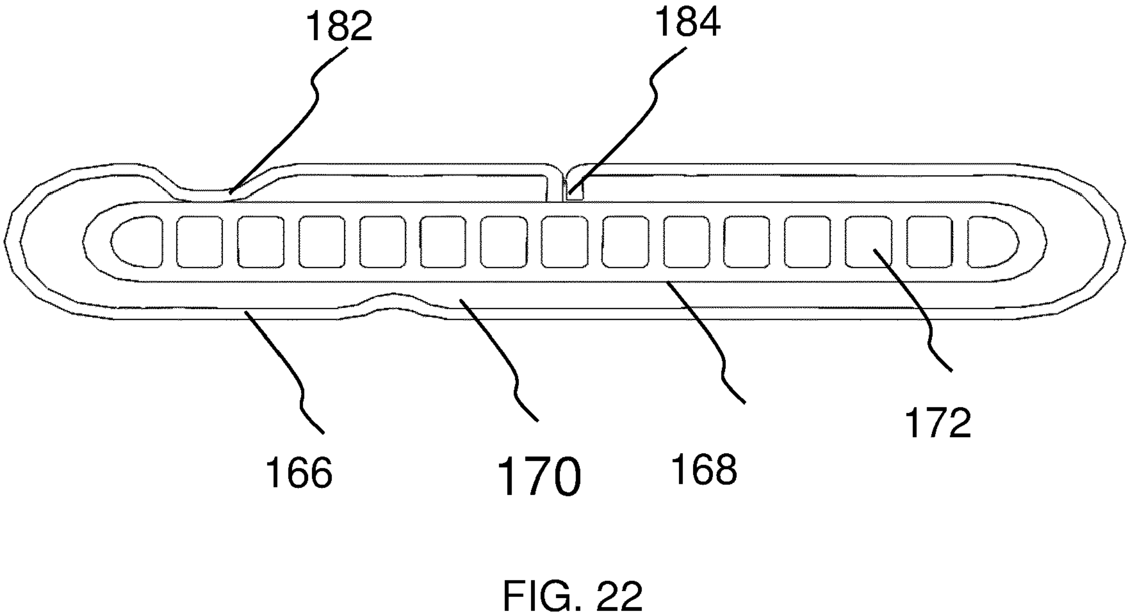

FIG. 22

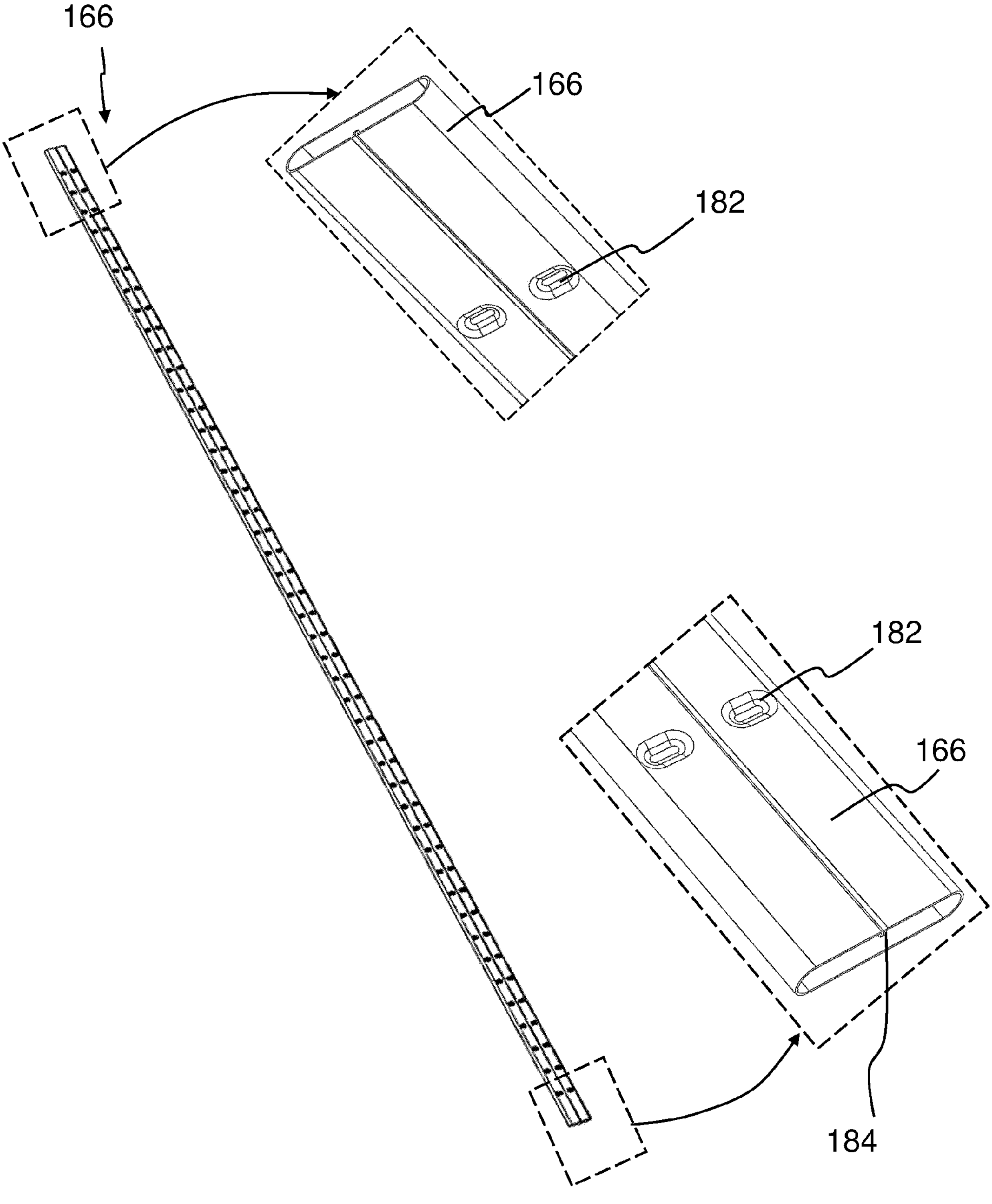

FIG. 23

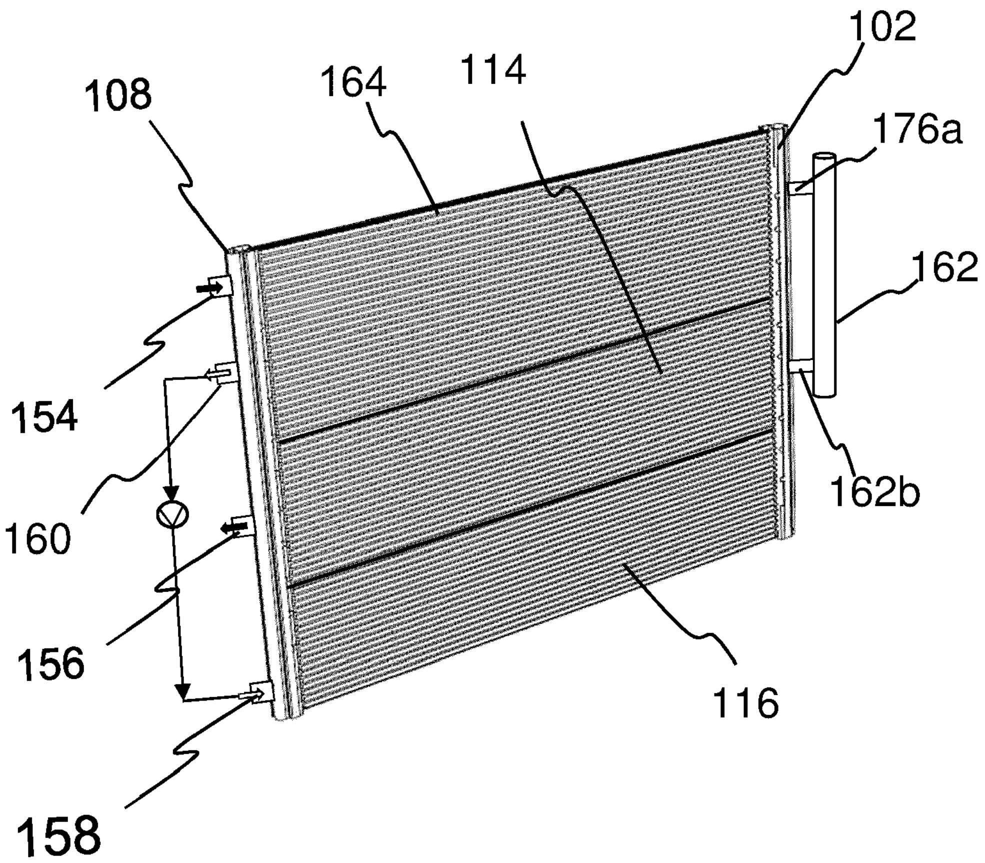

FIG. 24

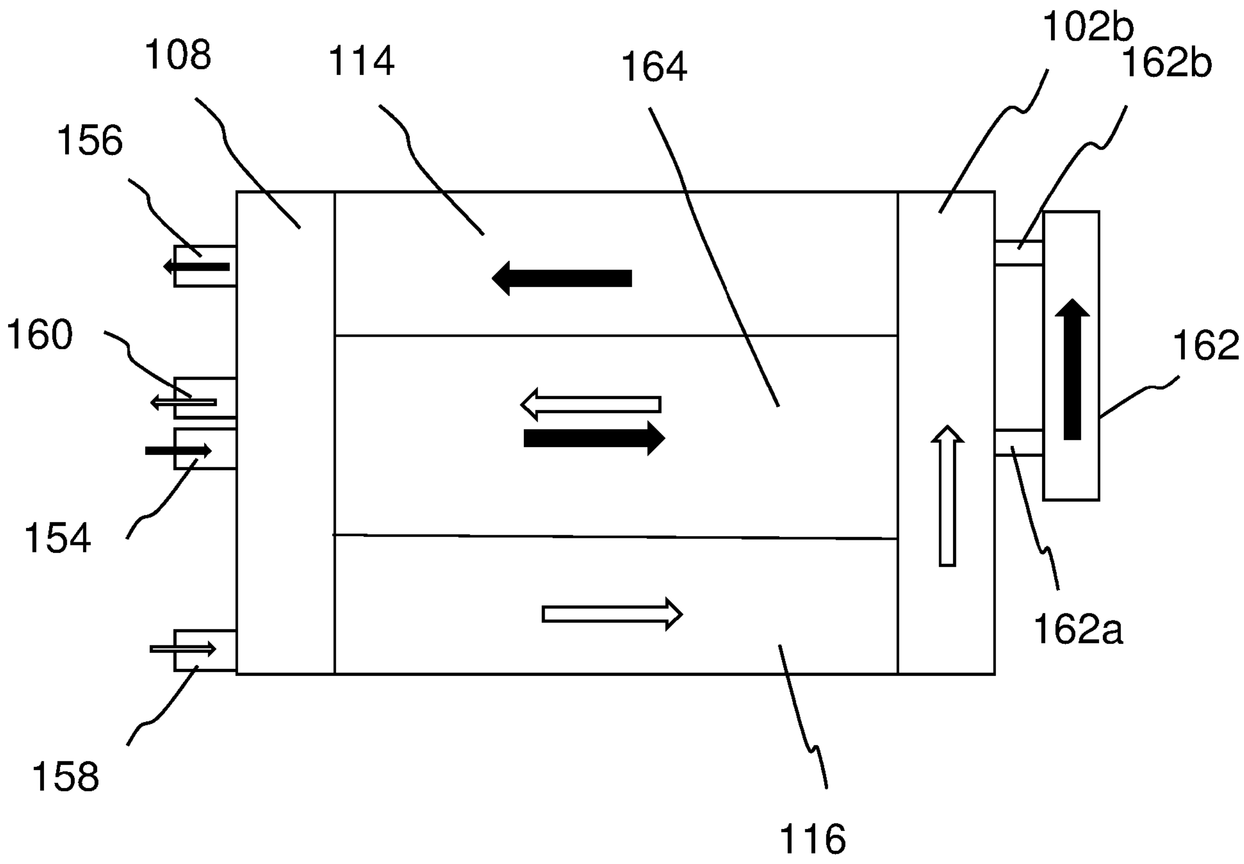

FIG. 25

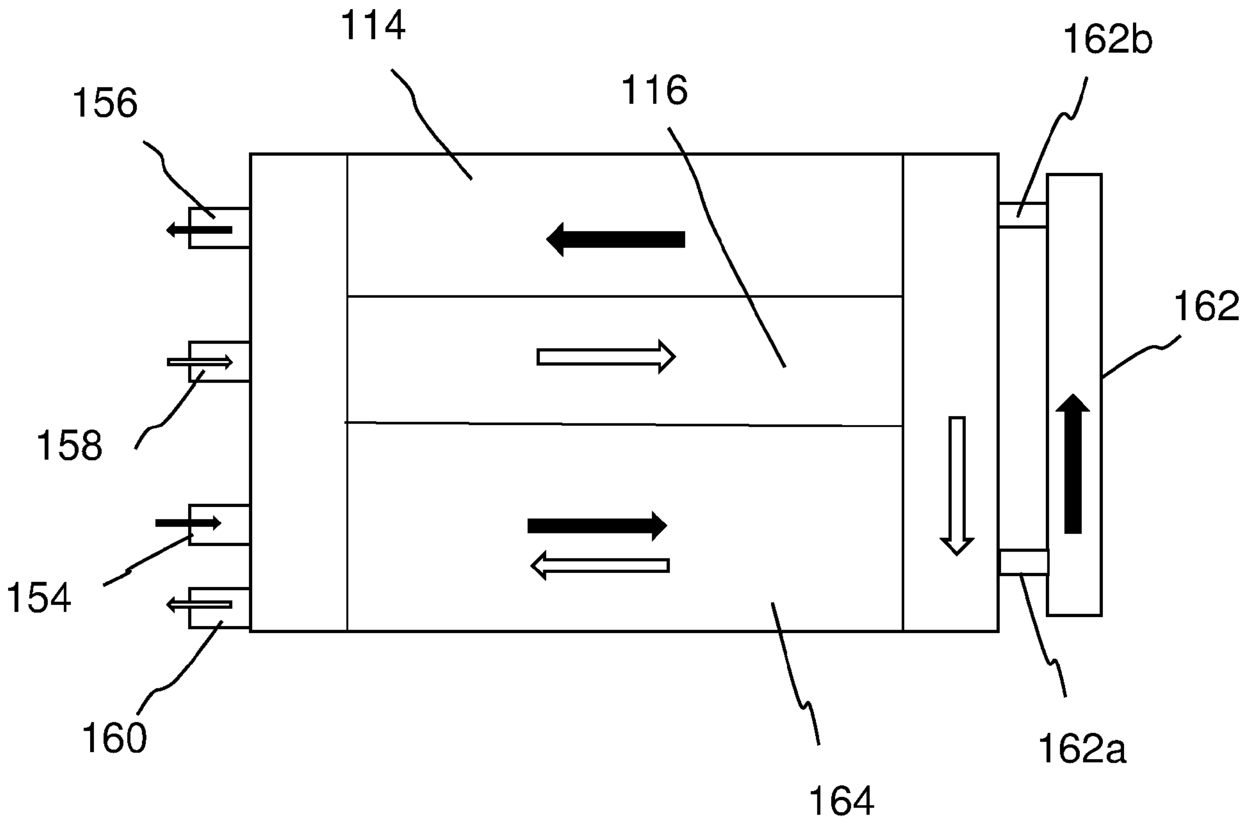

FIG. 26

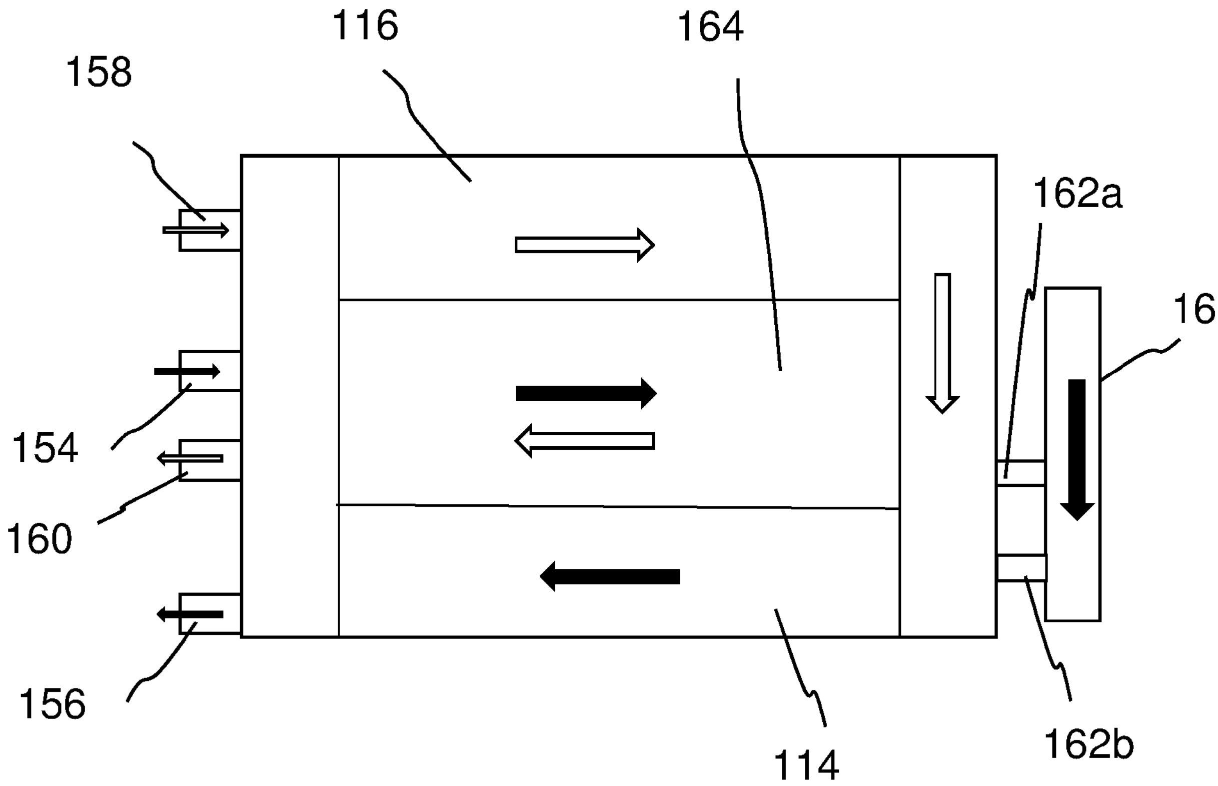

FIG. 27

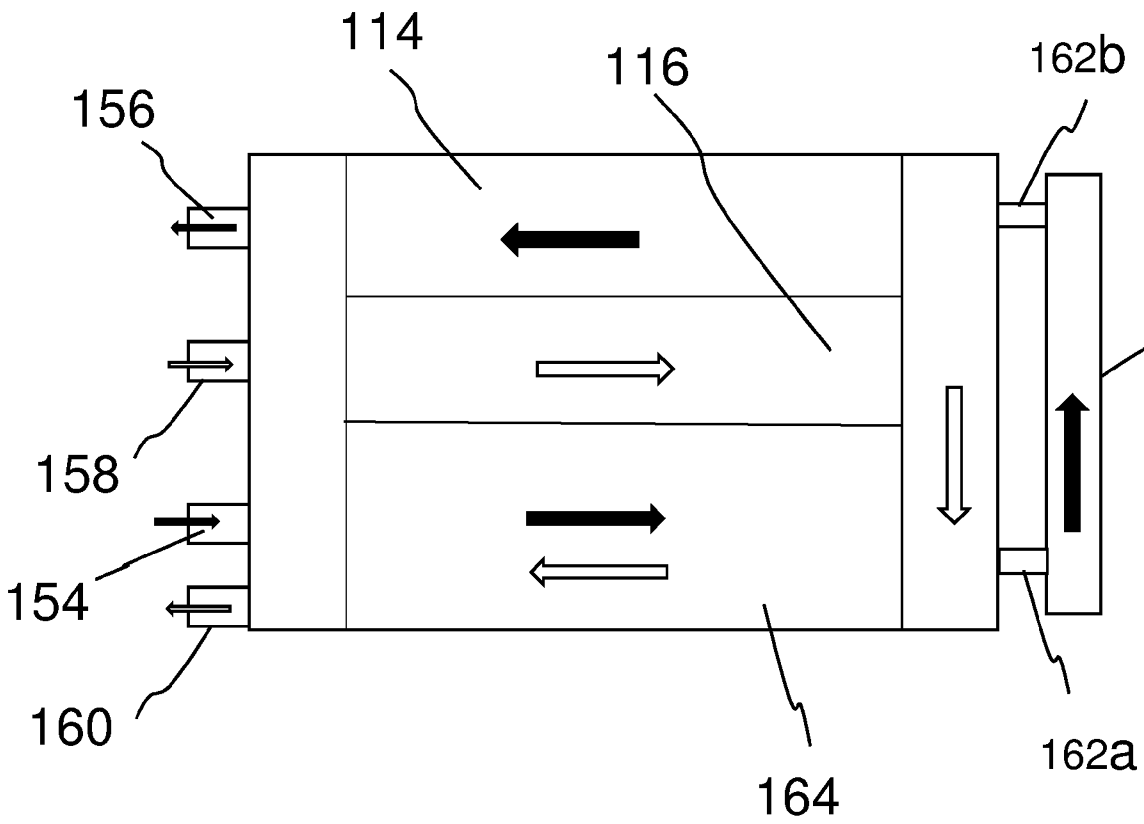

FIG. 28

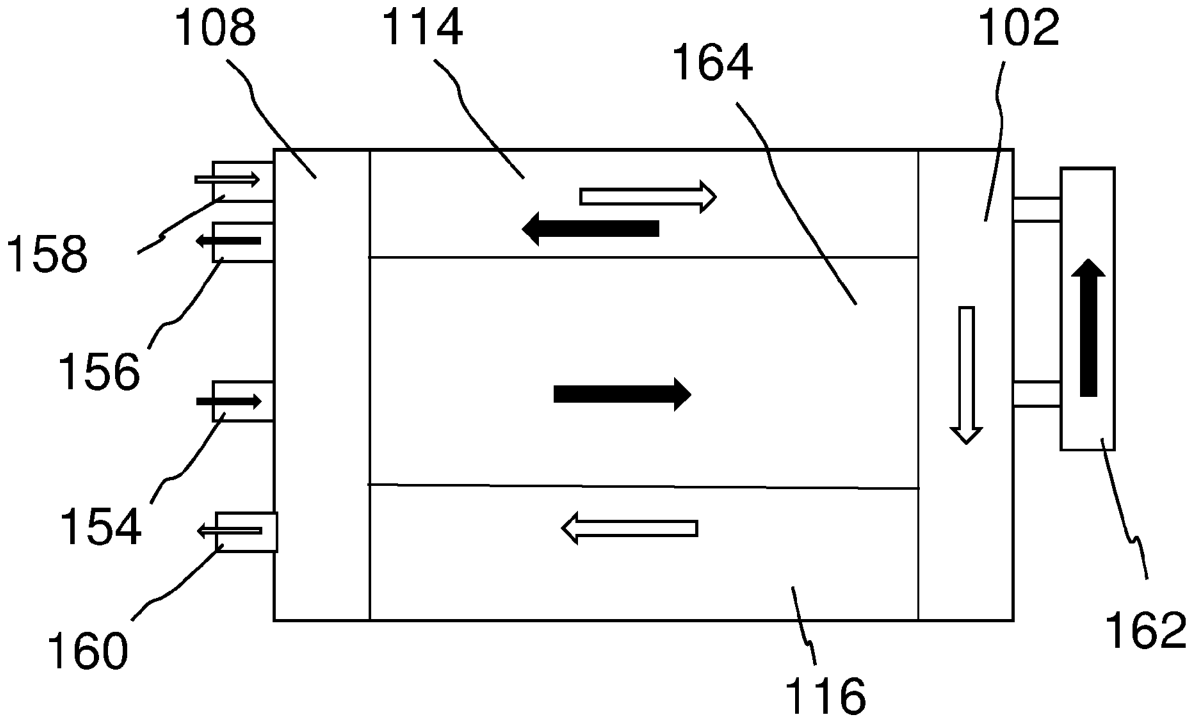
108
114
164
102
158
156
154
160
116
162

FIG. 29

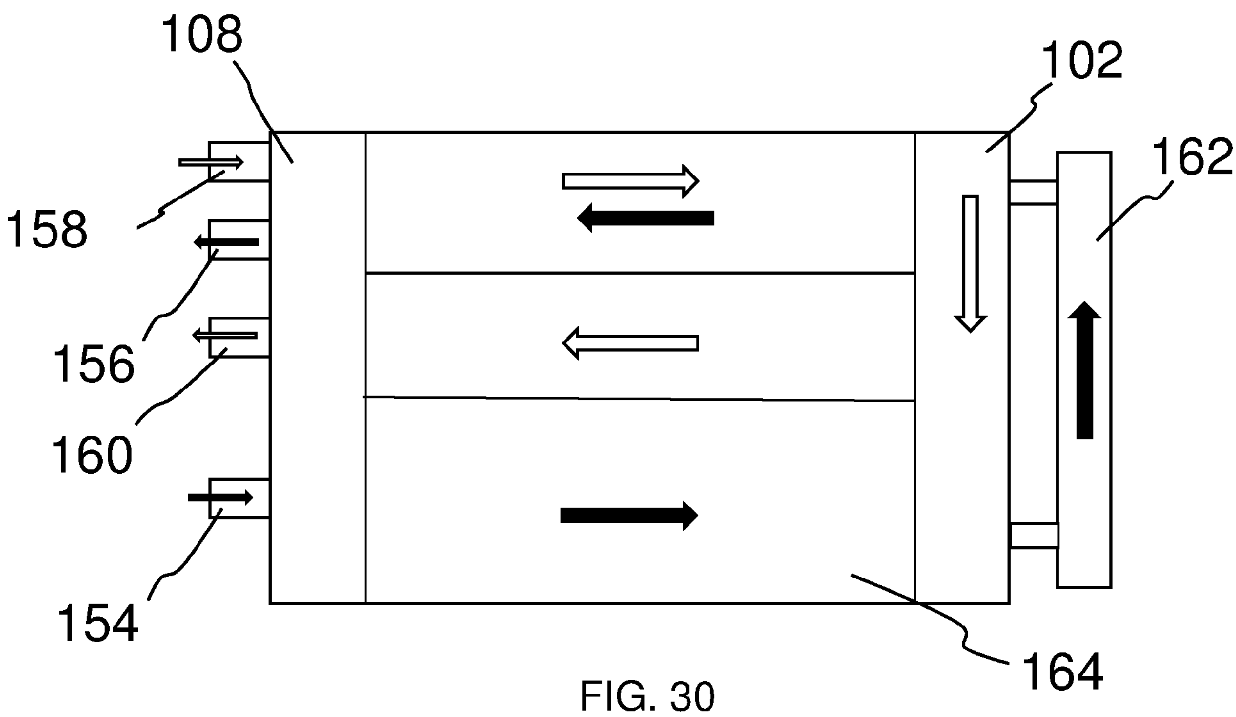
108
102
162
158
156
160
154
164

FIG. 30

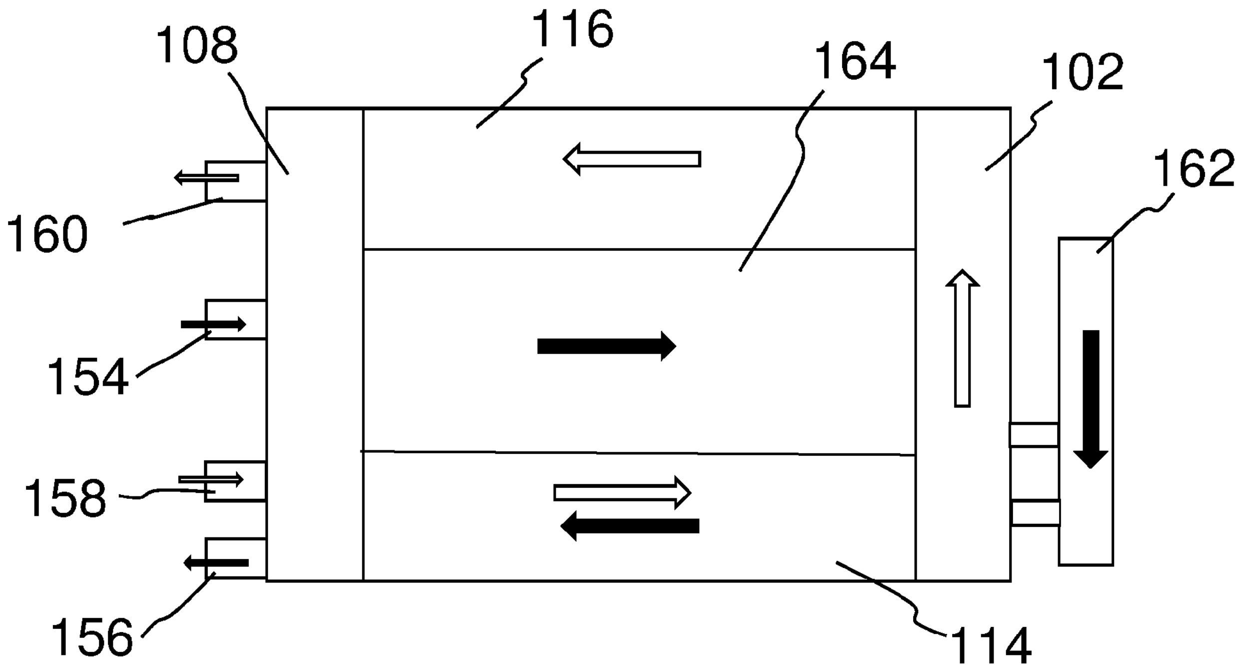
108
116
164
102
162
160
154
158
156
114

FIG. 31

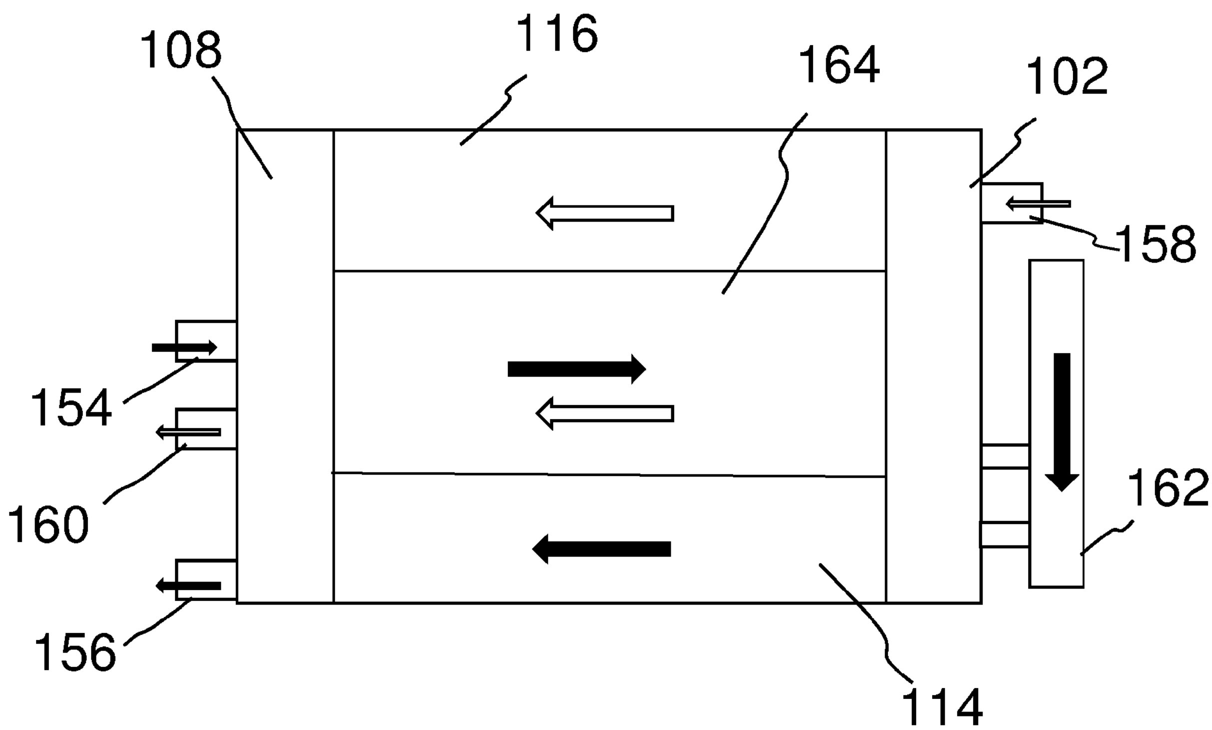
108
116
164
102
158
154
160
162
156
114

FIG. 32

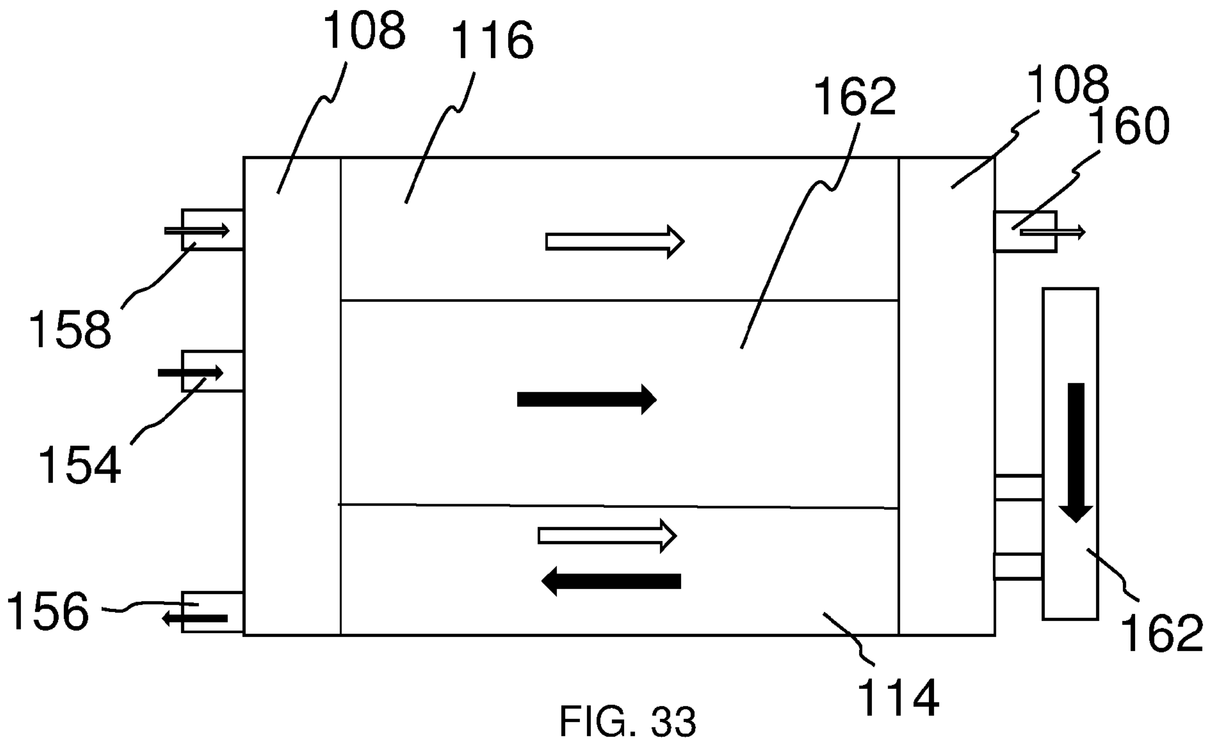
108
116
162
108
160
158
154
156
162
114

FIG. 33

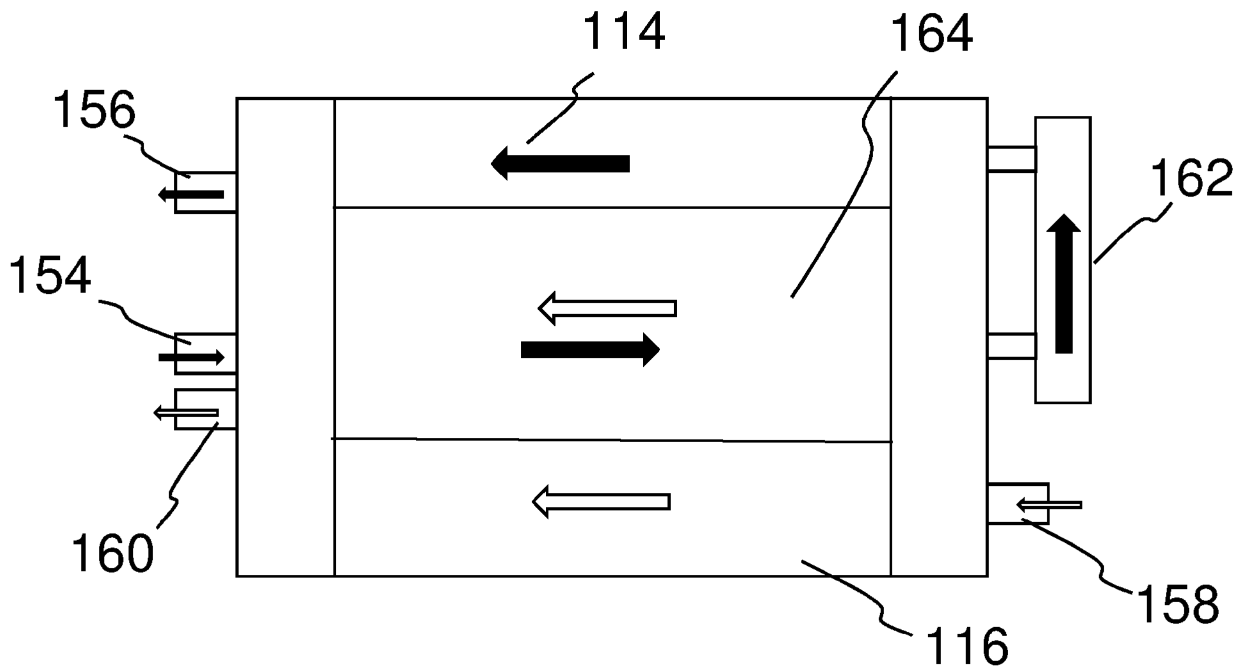
114
164
156
162
154
160
158
116

FIG. 34

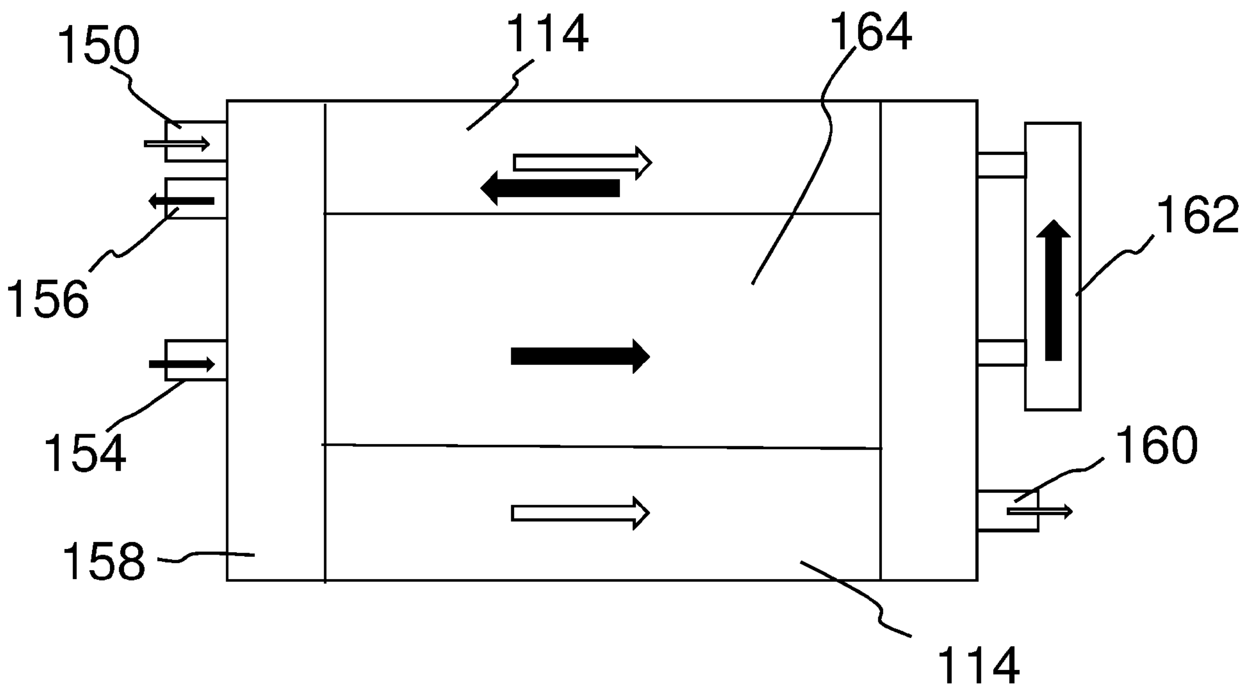

FIG. 35

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 18 8220

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP H05 10694 A (SHOWA ALUMINUM CORP) 19 January 1993 (1993-01-19) * paragraph [0010] - paragraph [0014] *	1-15	INV. F28D1/04 F28D7/00 F28D7/10
A	US 2022/080801 A1 (CAO LANBAO [CN] ET AL) 17 March 2022 (2022-03-17) * figure 1 *	1-15	
A	KR 101 580 233 B1 (HALLA CLIMATE CONTROL CORP [KR]) 24 December 2015 (2015-12-24) * figure 1b *	1-15	
A	EP 1 788 333 A1 (FORD GLOBAL TECH LLC [US]) 23 May 2007 (2007-05-23) * figure 5 *	1-15	
A	US 2005/217839 A1 (PAPAPANU STEVEN J [US]) 6 October 2005 (2005-10-06) * figure 1 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28D

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	10 January 2023	Bain, David

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 18 8220

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

10-01-2023

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
JP H0510694	A	19-01-1993	NONE		
US 2022080801	A1	17-03-2022	CN 110345668	A	18-10-2019
			EP 3901537	A1	27-10-2021
			JP 2022515470	A	18-02-2022
			US 2022080801	A1	17-03-2022
			WO 2020140882	A1	09-07-2020
KR 101580233	B1	24-12-2015	NONE		
EP 1788333	A1	23-05-2007	NONE		
US 2005217839	A1	06-10-2005	NONE		

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82