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(54) **Cross flow heat exchanger**

(57) A heat exchanger for a work vehicle is provided that comprises a tube layer (102) made of a plurality of elongate tubes (108) that are spaced apart by gaps (112) oriented parallel to each other in a first direction; a first fin layer (100) in the form of a corrugated sheet having a plurality of corrugations, wherein the plurality of corrugations of the first fin layer (100) facing the tube layer (102) define channels (106) for passing therethrough a fluid different from the first fluid; and a first fluid guide layer (200) formed of a planar sheet that extends across and encloses the plurality of corrugations of the first fin layer (100) over substantially an entire length of the plurality of corrugations.

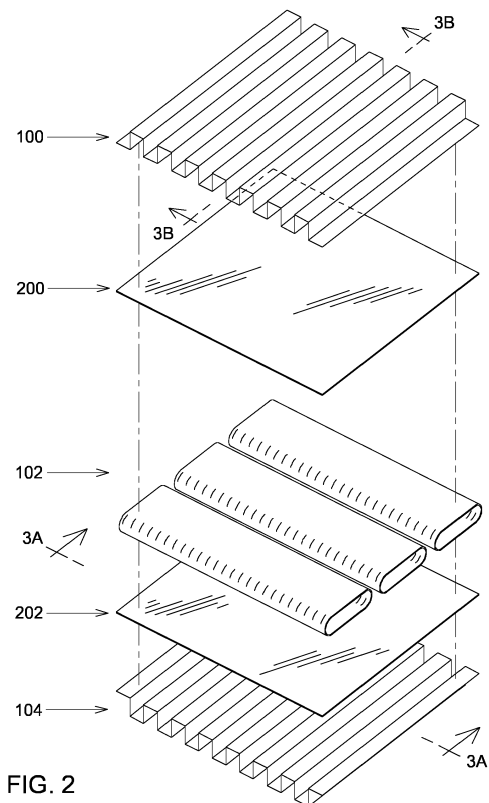


FIG. 2

Description

Field of the Invention

[0001] The invention pertains to heat exchangers. More particularly it relates to fluid to fluid (e.g. liquid to air) coolers for engine coolant, lubricating oil, or hydraulic fluid used in internal combustion engines, transmissions, and hydraulic circuits of work vehicles.

Background

[0002] Air cooled heat exchangers, particularly air cooled heat exchangers used in agricultural harvesters or other work vehicles, are subject to being plugged. During crop harvesting, agricultural harvesters generate contaminated air by the activity of crop cleaning fans, engine cooling fans, and the like. The contaminated air contains particulate matter (primarily plant matter) in sizes ranging from several inches in length to fine dust particles. This contaminated air surrounds the agricultural harvester almost as a cloud. It is difficult if not impossible to clean this air before it is used and reused in the various heat exchangers employed on the agricultural harvester. Similar problems exist for other work vehicles, such as road graders, bulldozers, tractors, backhoes, and excavators.

Summary of the Invention

[0003] A heat exchanger for a work vehicle is provided, comprising: a tube layer comprised of a plurality of elongate tubes, wherein the plurality of elongate tubes are spaced apart by gaps and are oriented parallel to each other in a first direction, wherein each of the plurality of elongate tubes defines a channel for passing a first fluid therethrough; a first fin layer in the form of a corrugated sheet having a plurality of corrugations, in which the plurality of corrugations of the first fin layer extend in a second direction transverse to the first direction, and wherein the first fin layer is disposed parallel to the tube layer and on a first side of the tube layer, and wherein each of the plurality of corrugations of the first fin layer facing the tube layer define an enclosed channel for passing there-through a fluid different from the first fluid; and a first fluid guide layer formed of a continuous, generally planar sheet that extends across and encloses the plurality of corrugations of the first fin layer over substantially an entire length of the plurality of corrugations.

[0004] The heat exchanger may further comprise a second fin layer in the form of a corrugated sheet having a plurality of corrugations, in which the plurality of corrugations of the second fin layer extend in the second direction, and wherein the second fin layer is disposed parallel to the tube layer and on a second side of the tube layer that is opposite to the first side of the tube layer, and wherein the plurality of corrugations of the second fin layer facing the tube layer define channels for passing

therethrough a fluid different from the first fluid; and a second fluid guide layer formed of a continuous, generally planar sheet that extends across and encloses the plurality of corrugations of the second fin layer over substantially an entire length of the plurality of corrugations.

[0005] The first fluid guide layer may extend across and enclose the gaps over substantially the entire length of the gaps.

[0006] The first fin layer may comprise metal and the first fluid guide layer may comprise metal, and the first fin layer may be bonded to a first side of the first fluid guide layer by a process selected from a group comprising soldering, brazing, and welding.

[0007] The tube layer may comprise metal and the tube layer may be bonded to a second side of the first fluid guide layer by a process selected from a group comprising soldering, brazing, and welding.

[0008] In one arrangement, none of the channels has an interior region that is in fluid communication with an interior region of any of the plurality of elongate tubes.

[0009] The channels may be rectangular or square in cross-section.

Brief Description of the Drawings

[0010]

Figure 1A is a side view of a prior art heat exchanger. Figure 1B is a front view of the prior art heat exchanger of Figure 1A.

Figure 2 is an exploded perspective view of a heat exchanger in accordance with the present invention. Figure 3A is a fragmentary cross-sectional view of the assembled heat exchanger arrangement of Figure 2 taken at section line 3A-3A.

Figure 3B is a fragmentary cross-sectional view of the assembled heat exchanger arrangement of Figure 2 taken at section line 3B-3B.

Detailed Description

[0011] In Figures 1A and 1B, a prior art cross flow heat exchanger (hereinafter "heat exchanger") is shown comprising a first fin layer 100, a tube layer 102, and a second fin layer 104.

[0012] The first fin layer 100 is formed as a corrugated sheet from a thin sheet of thermally conductive metal, such as copper, brass, aluminum or other light metal alloy. In the illustrated example, the corrugations are in the form of a square wave in cross-section.

[0013] The first fin layer 100 is bonded to the tube layer 102 by soldering, brazing, welding, or other metal-to-metal attachment means that permit heat transfer from the tube layer 102 to the first fin layer 100.

[0014] By providing the first fin layer 100 as a repeating wave, a series of enclosed channels 106 are formed for channeling a flow of air along the surface of the tube layer 102. This intimate contact of the air in the enclosed chan-

nels 106 enhances the exchange of heat from the tube layer 102 to the first fin layer 100.

[0015] The tube layer 102 is formed of individual elongate tubes 108 that are arranged in side-by-side relation. The elongate tubes 108 are formed of a thermally conductive metal, typically copper, brass, aluminum or other light metal alloy. The elongate tubes 108 have flat walls disposed parallel to and bonded to the coplanar and flat bottom surfaces 110 of the first fin layer 100. A gap 112 is provided between each pair of adjacent elongate tubes 108. This provides for some airflow between the curved end walls 114 of the elongate tubes 108 and thus provides additional heat transfer from the curved end walls 114 to the flow of air passing through the enclosed channels 106.

[0016] The elongate tubes 108 extend in a direction perpendicular to the longitudinal extent of the enclosed channels 106. In this manner, air flowing down the enclosed channels 106 can branch at each gap 112 and flow around the curved end walls 114 of the elongate tubes 108.

[0017] The second fin layer 104 is identical in construction and operation to the first fin layer 100, but it is disposed on the opposite side of the tube layer 102 than the first fin layer 100.

[0018] This type of prior art heat exchanger is very effective when dealing with clean, processed air. In vehicles that work in the field, such as dump trucks, front loaders, excavators, tractors, and particularly agricultural harvesters, the large amount of contaminants in the air, and particularly longer and more elongate fibrous contaminants such as chaff, leaves, husks, and the like, can plug these heat exchangers. The heat exchangers are plugged by contaminants traveling with the cooling airflow through the enclosed channels 106. When these contaminants reach a branch at each gap 112, they tend to fill the gaps 112 and plug them.

[0019] Worse, once the gaps 112 are plugged at any point, they tend to gather other, smaller particles until the enclosed channels 106 are completely filled, thereby providing a complete blockage of air flow through the enclosed channel 106.

[0020] Even worse, once an enclosed channel 106 is blocked or partially blocked by contaminants, the increase in pressure in the blocked or partially blocked enclosed channel 106 will cause the airflow to bypass the blockage, spread out, pass through adjacent gaps 112 and be directed into adjacent enclosed channels 106. This will laterally spread contaminants entering the blocked or partially blocked enclosed channel 106 into adjacent enclosed channels 106, and adjacent gaps 112. This process causes a blockage in a single enclosed channel 106 to propagate laterally and grow in size. This is due to the interconnected nature of the enclosed channels 106. The enclosed channels 106 are interconnected by air flowing laterally (i.e. perpendicular to the longitudinal extent of the enclosed channels 106) down the length of the gaps 112 and into adjacent enclosed chan-

nels 106.

[0021] Because these contaminants are wrapped around the curved end walls 114 of the elongate tubes 108 they cannot be reached and cleaned by long rods or blasts of air that are forced down the enclosed channels 106. The contaminants remain trapped in these gaps 112 even after such cleaning, and the efficiency of the heat exchanger is substantially reduced.

[0022] The new arrangement of Figure 2 overcomes these problems with heat flow and cleaning by closing the gaps 112. In Figure 2, the first fin layer 100, the tube layer 102, and the second fin layer 104 are arranged with respect to each other as provided in the prior art discussed above. The first fin layer 100 and the tube layer 102 are separated by the addition of a fluid guide layer 200. The tube layer 102 and the second fin layer 104 are separated by the addition of a fluid guide layer 202. The function of the fluid guide layer 200 and the fluid guide layer 202 is to reduce or eliminate the airflow passing into the gaps 112. The fluid guide layer 200 and the fluid guide layer 202 prevent the airflow from being deflected into the gaps 112 and thereby preventing contaminants to pass into the gaps 112. In this manner, contaminants cannot wrap around the curved end walls 114 of each of the elongate tubes 108, accumulate, and eventually create a plug that cannot easily be removed.

[0023] The fluid guide layer 200 and the fluid guide layer 202 are in the form of thin, planar sheets. The fluid guide layer 200 and the fluid guide layer 202 are formed of a thermally conductive metal, such as copper, brass, aluminum or other light metal alloy. As in the prior art arrangement of Figure 1A and Figure 1B, the elongate tubes 108 have flat walls disposed parallel to and bonded to the coplanar and flat bottom surfaces 110 of the first fin layer 100 and the second fin layer 104. In the embodiment of Figure 2, however, the fluid guide layer 200 and the fluid guide layer 202 are bonded between the first fin layer 100 and the tube layer 102, and between the second fin layer 104 and the tube layer 102, respectively.

[0024] The heat exchanger is formed in the manner suggested by Figure 2. The tube layer 102 is assembled by arranging the elongate tubes 108 in a regular orientation with the gap 112 between each tube. The first fin layer 100 and the second fin layer 104 are formed from sheets into the corrugated arrangement shown in Figure 2. Once these layers are formed, the fluid guide layer 200 is disposed between the first fin layer 100 and the tube layer 102, and the fluid guide layer 202 is disposed between the tube layer 102 and the second fin layer 104. The layers are then brought together and are mechanically bonded, preferably by soldering, brazing, or welding the now-abutting layers together.

[0025] When this assembly process is complete the heat exchanger has the appearance shown in Figure 3A and Figure 3B. As best shown in Figure 3A, the fluid guide layer 200 encloses the open bottom of each enclosed channel 106, extending substantially the entire length of each enclosed channel 106 and preventing air from pass-

ing out of the enclosed channel 106 and into the gaps 112 between the elongate tubes 108. As best shown in Figure 3B, the fluid guide layer 200 and the fluid guide layer 202 enclose opposing sides of the gap 112, extending substantially the entire length of each elongate tube 108. In this manner, air with entrained contaminants is prevented from entering the gaps 112 and traveling laterally through the gaps 112 and into adjacent enclosed channels 106.

[0026] A further advantage to this arrangement is that the fluid guide layer 200 and the fluid guide layer 202 form a continuous smooth bottom to each of their respective enclosed channels 106. This reduces irregularities in the cross-section of each enclosed channel 106 and thus reduces the possibility of contaminants becoming entrapped in any of the enclosed channels 106.

[0027] What has been illustrated and described herein is a cross flow heat exchanger, with a first fluid (e.g. liquid) flow in the elongate tubes 108 traveling transverse to a second fluid (e.g. gas or air) flow in the enclosed channels 106. Typically, manifolds are coupled to the open ends of the enclosed channels 106 and the elongate tubes 108 to distribute (at their inlet ends) and to gather (at their outlet ends) the fluid flow. Such manifolds are of conventional arrangement and have not been illustrated herein for convenience since they do not form a part of the invention.

[0028] The arrangements illustrated and described herein are merely examples of one way to create the invention. Someone skilled in the art of this invention would readily see other ways to create the invention that would fall within the scope of the claims. It is the claims that define the scope of the invention.

[0029] For example, the corrugated pattern, shown here as a square wave may have a different cross sectional pattern, such as a sine wave, saw tooth wave, trapezoidal wave, or other repeating pattern. The particular pattern will depend upon the particular cooling requirements, sheet thickness, and cross-sectional area of the enclosed channels 106.

[0030] As another example, the elongate tubes 108 shown herein have opposing flat sides and rounded ends (the "ends" in this context meaning the portion of the elongate tubes 108 that face into and define the gap 112). The elongate tubes 108 could have a variety of other cross-sectional shapes, such as a circle, a square, rectangle, or an oval, as just a few examples.

[0031] As another example, if the fluid guide layer 200 encloses one side of the gaps 112 over their entire length and the second fluid guide layer 202 encloses the other side of the gaps 112 over their entire length, the gaps 112 themselves can form an additional fluid flow channel for the fluid passing through the elongate tubes 108 by keeping the fluid passing through the gaps 112 separate from the fluid passing through the enclosed channels 106.

[0032] As another example, the arrangements illustrated herein shows two fluid guide layers 200, 202 separat-

ing two fin layers 100, 104 from both sides of the tube layer 102. For reasons of space and economy of construction, only a single fluid guide layer 200 and a single fin layer need to be used.

[0033] As another example, the arrangements discussed herein refer to the fluid passing through the first fin layer 100 and the second fin layer 104 as air (a gas). Alternatively, the fluid passing to the first fin layer 100 and the second fin layer 104 may be a liquid.

Claims

1. A heat exchanger for a work vehicle, comprising:

a tube layer (102) comprised of a plurality of elongate tubes (108), wherein the plurality of elongate tubes (108) are spaced apart by gaps (112) and are oriented parallel to each other in a first direction, wherein each of the plurality of elongate tubes (108) defines a channel for passing a first fluid therethrough;

a first fin layer (100) in a form of a corrugated sheet having a plurality of corrugations, in which the plurality of corrugations of the first fin layer (100) extend in a second direction transverse to the first direction, and wherein the first fin layer (100) is disposed parallel to the tube layer (102) and on a first side of the tube layer (102), and wherein each of the plurality of corrugations of the first fin layer (100) facing the tube layer (102) define an enclosed channel (106) for passing therethrough a fluid different from the first fluid; and

a first fluid guide layer (200) formed of a continuous, generally planar sheet that extends across and encloses the plurality of corrugations of the first fin layer (100) over substantially an entire length of the plurality of corrugations.

2. The heat exchanger of Claim 1, further comprising a second fin layer (104) in a form of a corrugated sheet having a plurality of corrugations, in which the plurality of corrugations of the second fin layer (104) extend in the second direction, and wherein the second fin layer (104) is disposed parallel to the tube layer (102) and on a second side of the tube layer (102) that is opposite to the first side of the tube layer (102), and wherein the plurality of corrugations of the second fin layer (104) facing the tube layer (102) define channels (106) for passing therethrough a fluid different from the first fluid; and a second fluid guide layer (202) formed of a continuous, generally planar sheet that extends across and encloses the plurality of corrugations of the second fin layer (104) over substantially an entire length of the plurality of corrugations.

3. The heat exchanger of Claim 1, wherein the first fluid guide layer (200) extends across and encloses the gaps (112) over substantially an entire length of the gaps (112).
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4. The heat exchanger Claim 1, wherein the first fin layer (100) comprises metal and the first fluid guide layer (200) comprises metal, and wherein the first fin layer (100) is bonded to a first side of the first fluid guide layer (200) by a process selected from a group comprising soldering, brazing, and welding.
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5. The heat exchanger of Claim 4, wherein the tube layer (102) comprises metal and wherein the tube layer (102) is bonded to a second side of the first fluid guide layer (200) by a process selected from a group comprising soldering, brazing, and welding.
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6. The heat exchanger of Claim 1, wherein none of the channels (106) has an interior region that is in fluid communication with an interior region of any of the plurality of elongate tubes (108).
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7. The heat exchanger of Claim 1, wherein the channels (106) are rectangular in cross section.
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8. The heat exchanger of Claim 7, wherein the channels (106) are square in cross-section.
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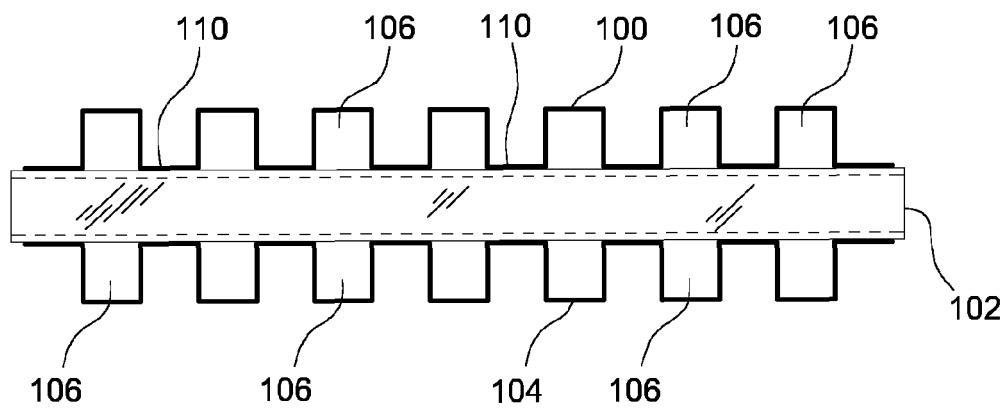


FIG. 1A
(Prior art)

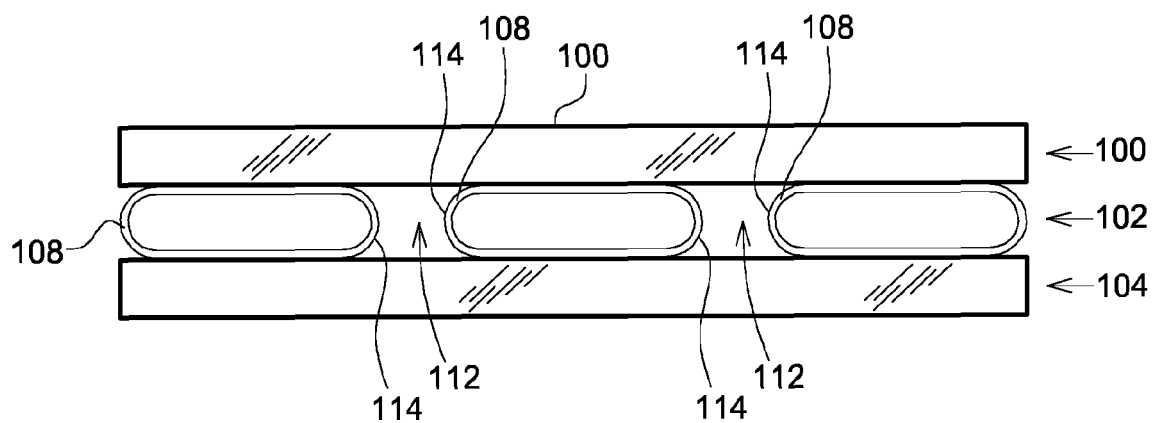


FIG. 1B
(Prior art)

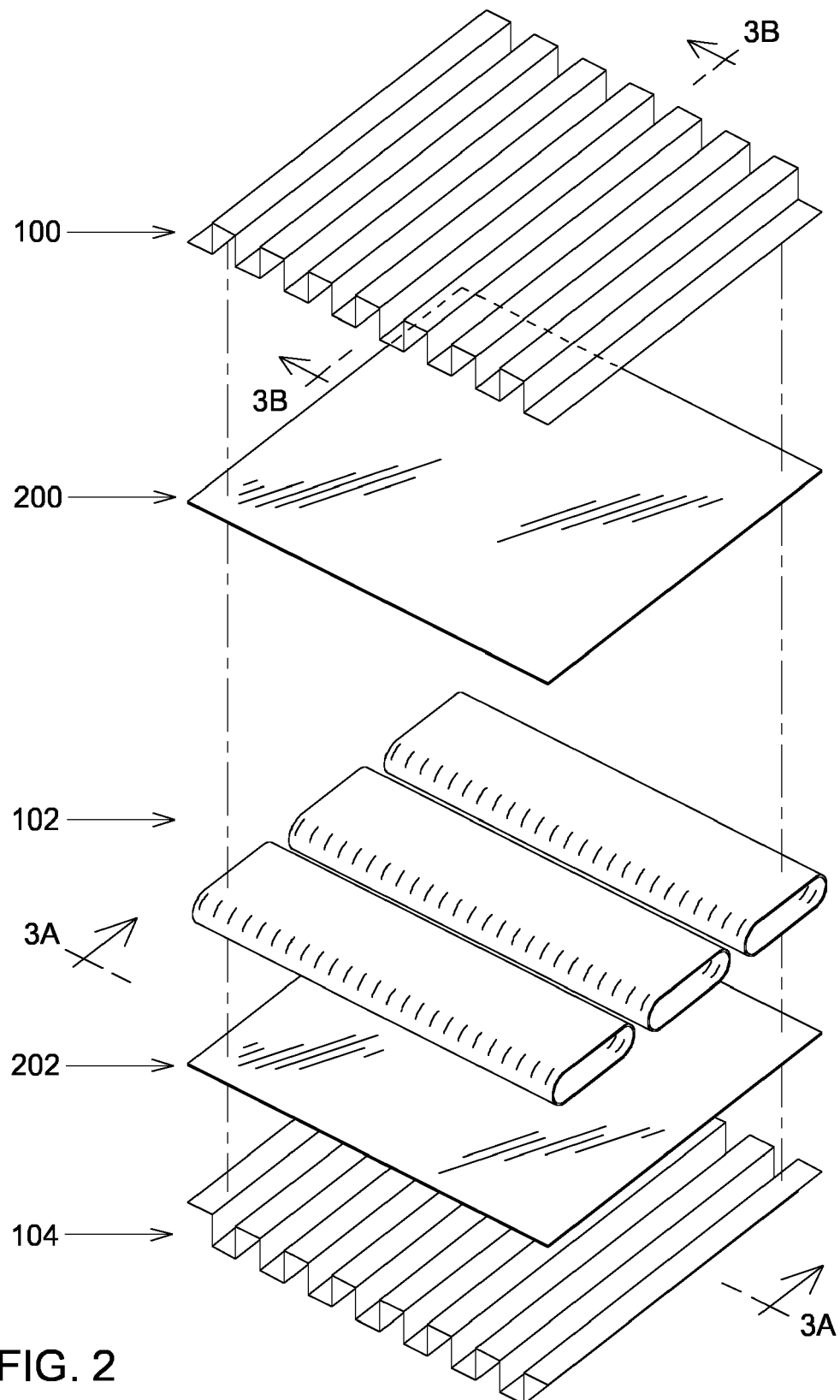


FIG. 2

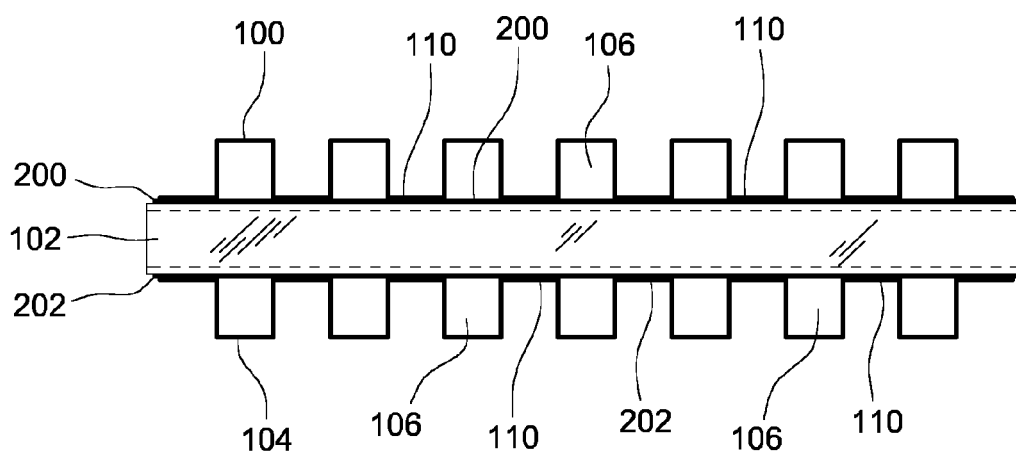


FIG. 3A

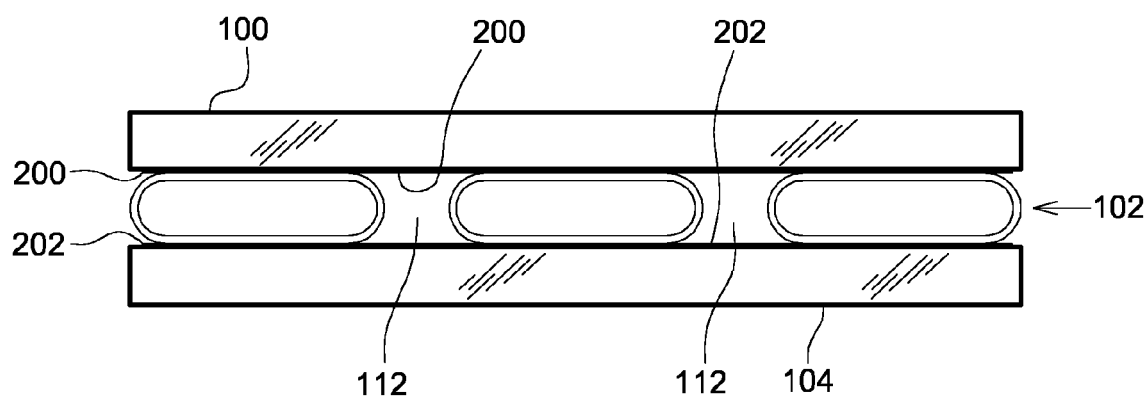


FIG. 3B



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Application Number
EP 14 19 3031

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 May 2015	Examiner Vassoille, Bruno
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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