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(54) ADAPTIVE HEAT EXCHANGER

(57) Disclosed is a heat exchanger comprising a first flow path (28) with an inlet (32), an outlet (34) and a first surface (36) and a second flow path (30) with an inlet (40), an outlet (42) and a second surface (44) wherein at least one of the first surface and the second surface has a portion consisting of a shape memory alloy which has a first shape at a first temperature, a second shape at a second temperature different than the first temperature, and returns to the first shape in response to a return to the first temperature.

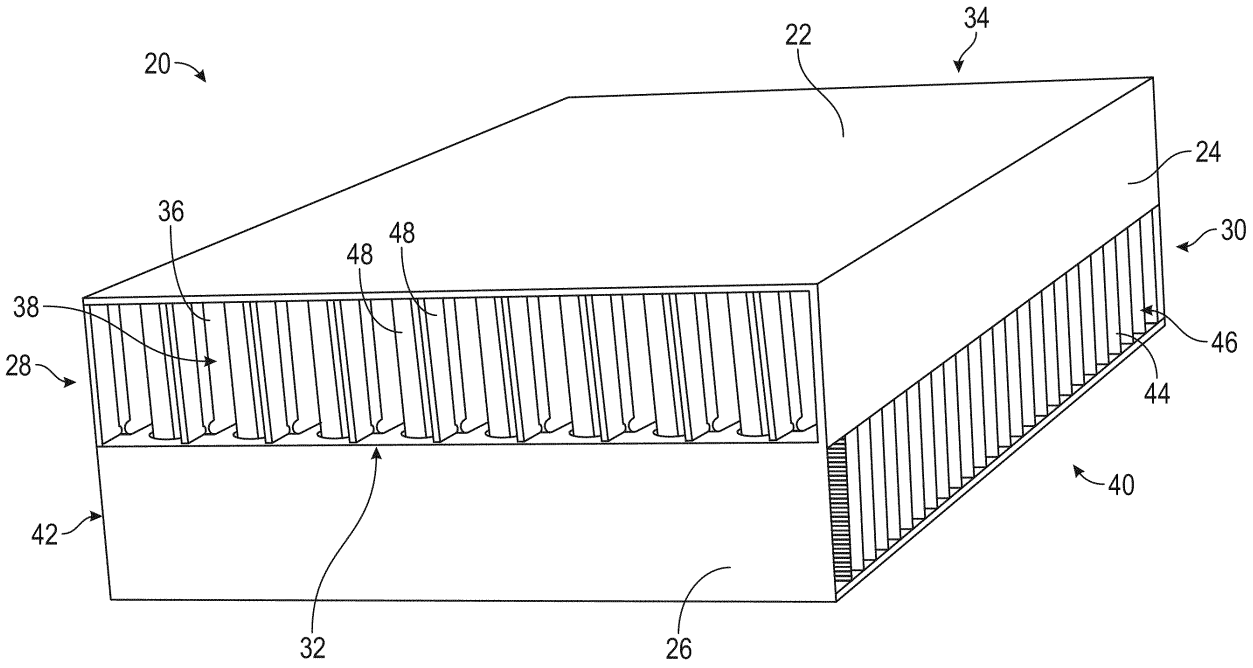

FIG. 1

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Description

BACKGROUND

[0001] Exemplary embodiments pertain to the art of heat exchangers.

[0002] One heat exchanger technology includes plate and fin technology. Plate and fin heat exchangers include layers of corrugated sheets separated by flat metal plates to create several finned chambers. A first fluid and a second fluid flow through alternating layers of the heat exchanger. Heat is exchanged between the first fluid and the second fluid at an interface between the fluids as the fluids flow through the heat exchanger. While currently available heat exchangers are adequate, improvements to efficiency are desired.

BRIEF DESCRIPTION

[0003] Disclosed is a heat exchanger comprising a first flow path with an inlet, an outlet and a first surface and a second flow path with an inlet, an outlet and a second surface wherein at least one of the first surface and the second surface has a portion consisting of a shape memory alloy which has a first shape at a first temperature, a second shape at a second temperature different than the first temperature, and returns to the first shape in response to a return to the first temperature.

[0004] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first surface and the second surface both have a portion consisting of a shape memory alloy.

[0005] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape is planar with the first surface and the second shape projects into the flow path.

[0006] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape is planar with the first surface and the second shape reduces the size of the flow path.

[0007] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the portion consisting of a shape memory alloy is fabricated using additive manufacturing.

[0008] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape puts the first surface in the flow path and the second shape puts the first surface on the side of the flow path.

[0009] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape is planar with the first surface and the second shape closes the flow path.

[0010] Also disclosed is a heat exchanger including a first flow path with an inlet, an outlet and a first set of fins and a second flow path with an inlet, an outlet and a second set of fins wherein at least one of the first set of fins and the second set of fins has a portion consisting of a shape memory alloy which has a first shape at a first temperature, a second shape at a second temperature different than the first temperature, and returns to the first shape in response to a return to the first temperature.

[0011] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first set of fins and the second set of fins both have a portion consisting of a shape memory alloy.

[0012] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape is planar with the fins in the first set fins and the second shape projects into the flow path.

[0013] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the portion consisting of a shape memory alloy is fabricated using additive manufacturing.

[0014] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape is planar with the fins in the first set of fins and the second shape reduces the size of the first flow path.

[0015] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape puts the first set of fins in the first flow path and the second shape puts the first set of fins on the side of the first flow path.

[0016] In addition to one or more of the features described above, or as an alternative to any of the foregoing embodiments, the first shape is planar with the first set of fins and the second shape closes the flow path.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

FIG. 1 is a perspective view of a heat exchanger; and

FIGS. 2A-B, FIGS. 3A-B, and FIGS. 4A-B show exemplary changes in fin shape.

DETAILED DESCRIPTION

[0018] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0019] FIG. 1 is a perspective view of heat exchanger 20. Heat exchanger 20 includes housing 22, a first layer 24, a second layer 26, a first flow path 28, a second flow path 30, inlet 32, outlet 34, fins 36, passages 38, inlet 40, outlet 42, fins 44, and passages 46.

[0020] Heat exchanger 20 includes housing 22 that forms a body of heat exchanger 20. Heat exchanger 20

is shown as including two layers, first layer 24 and second layer 26 but this is not limiting and heat exchanger 20 may include additional layers. Two layers are shown merely for simplicity and clarity. First layer 24 includes first flow path 28 and second layer 26 includes second flow path 30. First flow path 28 extends in a first direction through heat exchanger 20 and second flow path 30 extends in a second direction through heat exchanger 20 that is perpendicular to the first direction. In alternate embodiments, first flow path 28 and second flow path 30 can extend in parallel directions.

[0021] First flow path 28 has inlet 32 and outlet 34. Inlet 32 is positioned on a first end of first flow path 28 and outlet 34 is positioned on a second end of first flow path 28. A fluid enters first flow path 28 through inlet 32 and exits first flow path 28 through outlet 34. First flow path 28 further includes first surfaces such as fins 36 that are walls that extend from inlet 32 to outlet 34. Fins 36 form passages 38 in first flow path 28. Passages 38 are open channels that extend from inlet 32 to outlet 34 through which the fluid in first flow path 28 flows.

[0022] Second flow path 30 has inlet 40 and outlet 42. Inlet 40 is positioned on a first end of second flow path 30 and outlet 42 is positioned on a second end of second flow path 30. A fluid enters second flow path 30 through inlet 40 and exits second flow path 30 through outlet 42. Second flow path 30 further includes second surfaces such as fins 44 that are walls that extend from inlet 40 to outlet 42. Fins 44 form passages 46 in second flow path 30. Passages 46 are open channels that extend from inlet 40 to outlet 42 through which the fluid in second flow path 30 flows.

[0023] A cold fluid can flow through passages 38 of first flow path 28 while a hot fluid flows through passages 46 of second flow path 30. As the hot fluid flows through passages 46 of second flow path 30 it will flow across fins 44 and heat will transfer out of the hot fluid and into fins 44. The heat from fins 44 in second flow path 30 will then transfer through housing 22 of heat exchanger 20 and into fins 36 in first flow path 28. The cold fluid flowing through passages 38 of first flow path 28 can then absorb heat from fins 36. The cold fluid that has absorbed heat from fins 36 can then exit passages 38, removing the heat from heat exchanger 20. In this manner, the hot fluid flowing through second flow path 30 will be cooled as it flows through heat exchanger 20 and the cold fluid flowing through the first flow path 28 will be heated as it flows through heat exchanger 20.

[0024] Heat exchangers are typically designed for a specific condition and are oversized for most other conditions. The resulting fluid flow resistance reduces the efficiency of the system overall by having greater fluid flow resistance than necessary during the majority of the operating conditions. The efficiency of the overall system can be improved by employing an adaptive heat exchanger which increases the surface area for heat exchange when needed. As disclosed herein at least a portion of the surface of the flow path of the heat exchanger, such as the fins, alter shape in response to temperature, thus providing an adaptive heat exchanger. In some embodiments the fins adapt to lay on the bottom or top of the flow path and then can adapt again to extend across the flow path. FIGS. 2A and 2B show fins altering shape to lay on the bottom of the flow path. FIG. 2A shows fins 36 positioned in the flow path 28 to form passages 38. In response to a change in temperature fins 36 may change shape to lay on a side of flow path 28, thereby decreasing fluid flow resistance.

[0025] In some embodiments a surface of the flow path, such as the fins, alters shape to have a projection which extends into the flow path and increase turbulence of the fluid flowing through the flow path. The fins can further alter shape to remove the projection from the flow path. FIGS. 3A and 3B shows fins having projections that extend into the flow path altering shape to remove the projections from the flow path. In FIG. 3A fins 36 have projections 37 protruding into the passages 38 that are part of flow path 28. In FIG. 3B projections 37 have altered shape to be removed from the flow path 28 and be planar with the remainder of the fin. The projections 37 are shown in FIG. 3B to be additional to the fin. In some embodiments projections 37 may be integral to the fin and leave an opening when protruding into the flow path.

[0026] FIG. 4A and 4B show an embodiment in which fins 36 have portions 39 which can alter shape in response to a change in temperature to reduce the size of the flow path by closing off a portion of the flow path. In some embodiments the portions 39 can close the flow path to fluid flow.

[0027] The fins can alter shape due to at least a portion of the fin consisting of a shape memory alloy. For example, in embodiments such as those shown in FIGS. 2A and 2B, the portion of the fin that connects to the housing 22 or is adjacent to housing 22 is a shape memory alloy which changes shape at the desired temperature, allowing the fin to change position. Alternatively, the entire fin may consist of a shape memory alloy.

[0028] Similarly, the fin in the embodiment shown in FIGS. 3A and 3B has a portion which consists of a shape memory alloy and allows the projection to move into and out of the flow path. It is further contemplated that the entire projection may consist of a shape memory alloy.

[0029] While fins are used as an example throughout the description this should not be construed as limiting as any surface of the heat exchanger that forms part of the flow path may comprise a portion consisting of a shape memory alloy.

[0030] Exemplary shape memory alloys include nickel-titanium alloy, copper-aluminum-nickel, copper-tin, copper-zinc-X, indium-titanium, nickel-aluminum, iron-platinum, manganese-copper, and iron-manganese-silicon.

[0031] The heat exchanger, the fins or both can be made using additive manufacturing. Exemplary methods include laser powder-bed fusion.

[0032] The shape memory alloy portion of the fin must be trained to have two-way shape memory. Two-way

shape memory is developed through thermomechanical cyclic training. Developing two-way shape memory allows the shape memory alloy to have a different shape depending on temperature. This is in contrast to a shape memory alloy without two-way shape memory which may change shape in response to a temperature change but does not revert to the previous shape once the original temperature is re-established.

[0033] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, element components, and/or groups thereof.

[0034] While the present disclosure has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made without departing from the scope of the invention as defined by the claims. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present disclosure without departing from the scope of the claims. Therefore, it is intended that the present disclosure not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this present disclosure, but that the present disclosure will include all embodiments falling within the scope of the claims.

Claims

1. A heat exchanger comprising a first flow path (28) with an inlet (32), an outlet (34) and a first surface (36) and a second flow path (30) with an inlet (40), an outlet (42) and a second surface (44) wherein at least one of the first surface and the second surface has a portion consisting of a shape memory alloy which has a first shape at a first temperature, a second shape at a second temperature different than the first temperature, and returns to the first shape in response to a return to the first temperature.

2. The heat exchanger of claim 1, wherein the first surface and the second surface both have a portion consisting of a shape memory alloy.

3. The heat exchanger of claim 1, wherein the first shape is planar with the first surface and the second shape projects into the flow path.

4. The heat exchanger of claim 1, wherein the first shape is planar with the first surface and the second shape reduces the size of the flow path.

5. The heat exchanger of claim 1, wherein the first shape puts the first surface in the flow path and the second shape puts the first surface on the side of the flow path.

6. The heat exchanger of claim 1, wherein the first shape is planar with the first surface and the second shape closes the flow path.

7. The heat exchanger of any preceding claim, wherein the portion consisting of a shape memory alloy is fabricated using additive manufacturing.

8. A heat exchanger comprising:

   a first flow path (28) with an inlet (30), an outlet (32) and a first set of fins (34), and
   a second flow path (30) with an inlet (40), an outlet (42) and a second set of fins (34),
   wherein at least one of the first set of fins and the second set of fins has a portion consisting of a shape memory alloy which has a first shape at a first temperature, a second shape at a second temperature different than the first temperature, and returns to the first shape in response to a return to the first temperature.

9. The heat exchanger of claim 8, wherein the first set of fins and the second set of fins both have a portion consisting of a shape memory alloy.

10. The heat exchanger of claim 8 or 9, wherein the first shape is planar with the fins in the first set fins and the second shape projects into the flow path.

11. The heat exchanger of claim 8 or 9, wherein the first shape is planar with the fins in the first set of fins and the second shape reduces the size of the first flow path.

12. The heat exchanger of claim 8 or 9, the first shape puts the first set of fins in the first flow path and the second shape puts the first set of fins on the side of the first flow path.

13. The heat exchanger of claim 8 or 9, wherein the first shape is planar with the first set of fins and the second shape closes the flow path.

14. The heat exchanger of any of claims 8 to 13, wherein the portion consisting of a shape memory alloy is fabricated using additive manufacturing.

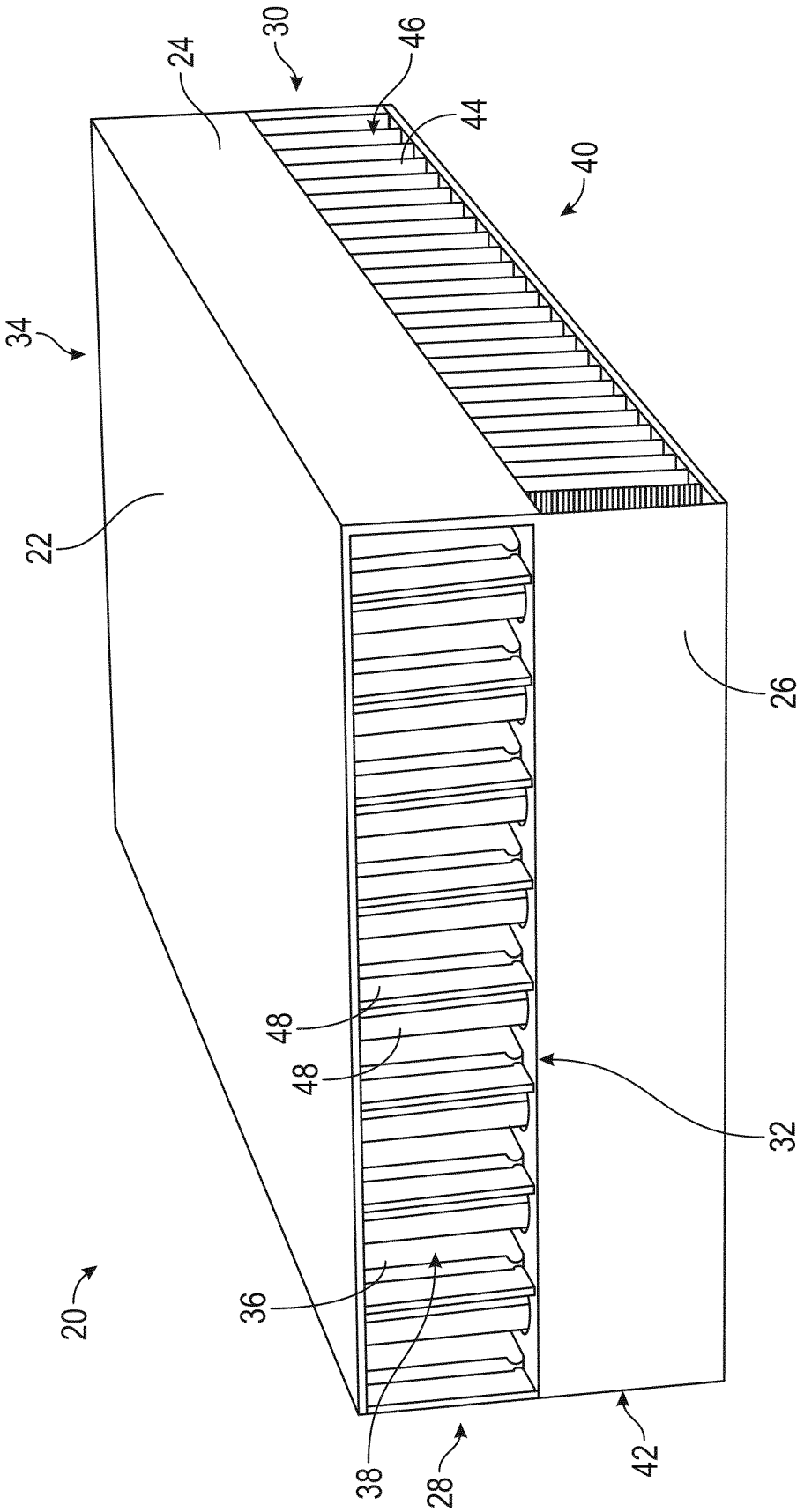

FIG. 1

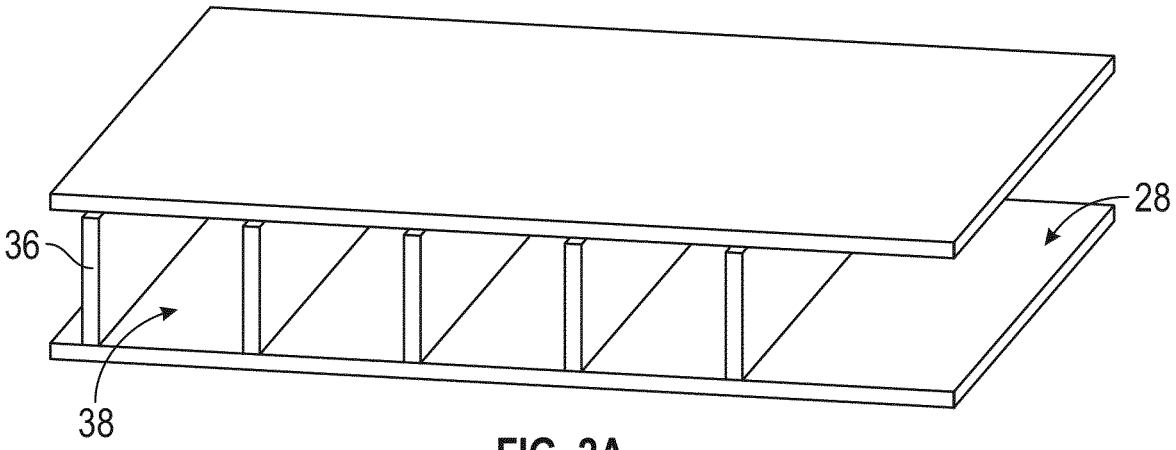

FIG. 2A

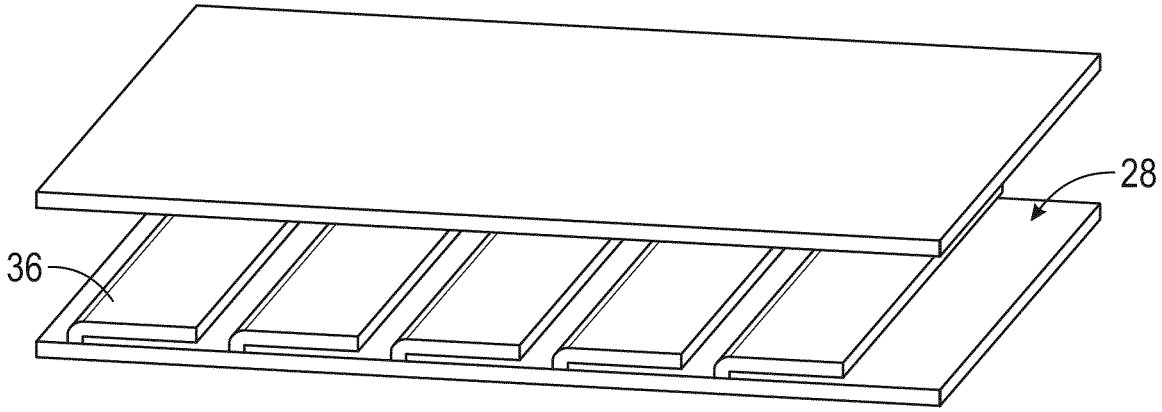

FIG. 2B

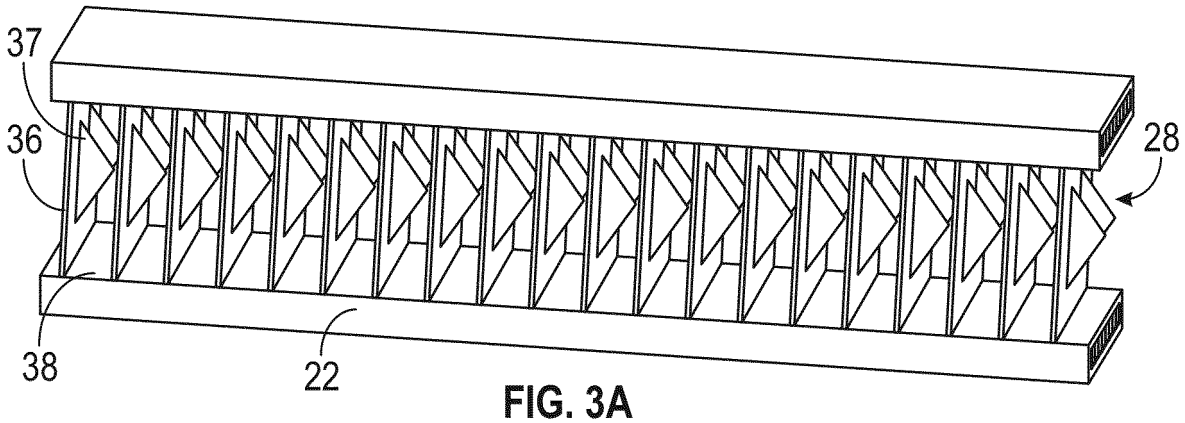

FIG. 3A

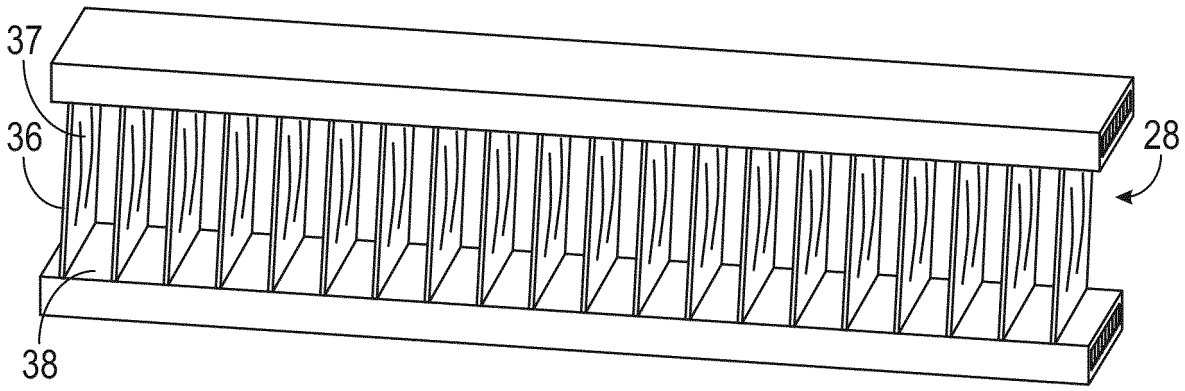

FIG. 3B

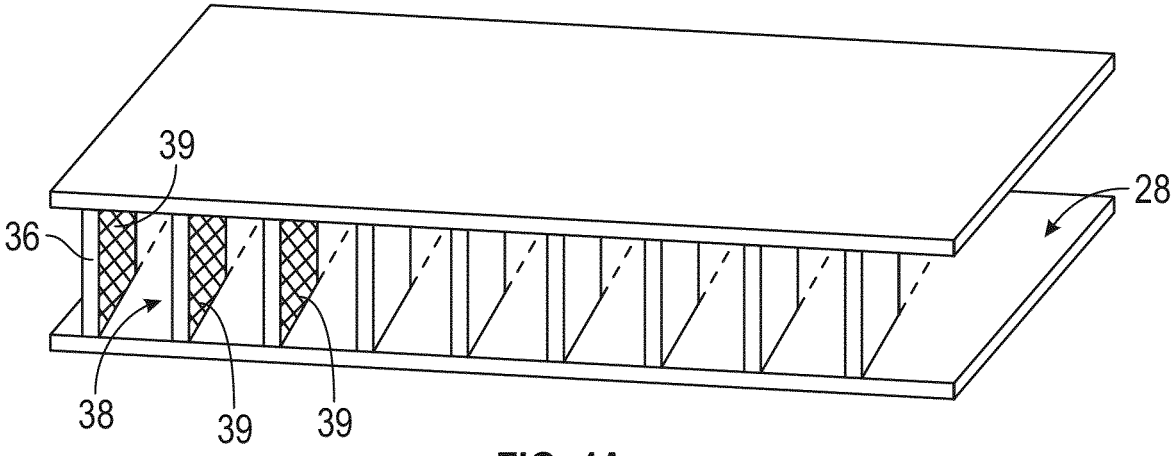

FIG. 4A

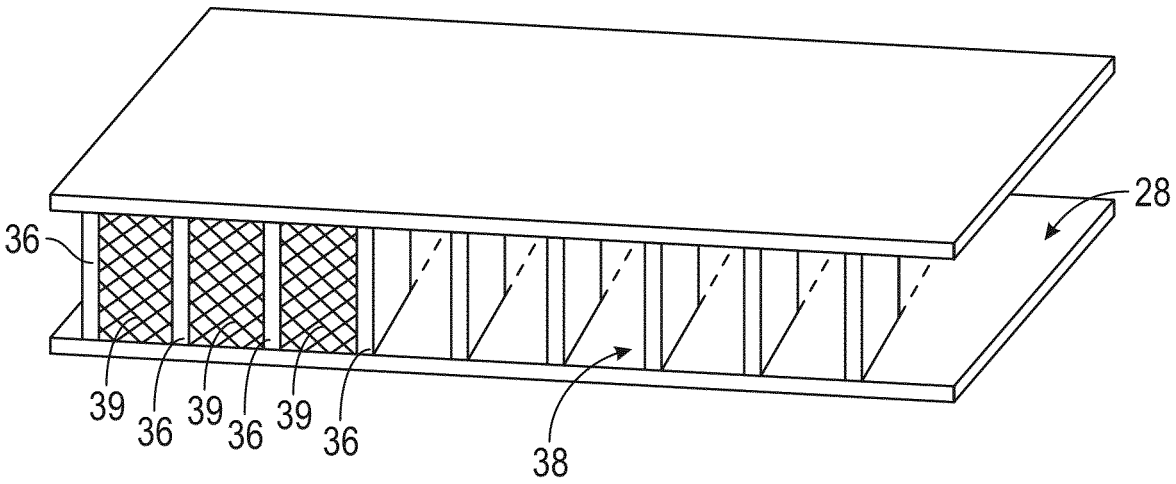

FIG. 4B

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EUROPEAN SEARCH REPORT

Application Number
EP 21 21 6164

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 April 2022	Jessen, Flemming

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 21 6164

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