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(54) **SEGMENTED FINS FOR A CAST HEAT EXCHANGER**

(57) A heat exchanger (10) includes a plate portion (24) including a top surface (26), bottom surface (28), a leading edge (32), a trailing edge (32) and a plurality of internal passages (34) extending between an inlet (36) and an outlet (38). A plurality of fin portion rows (42) are included. A first row (48) of the plurality of fin portion rows (42) includes at least two discrete fin portions (46) and a second row (50, 52, 54) of the plurality of fin portion rows (42) includes fewer fin portions (56, 58, 40) than the first row (48). The first row (48) is closer to the inlet (36) than the second row (50, 52, 54). A cast plate (22) for a heat exchanger (10) and a method are also disclosed.

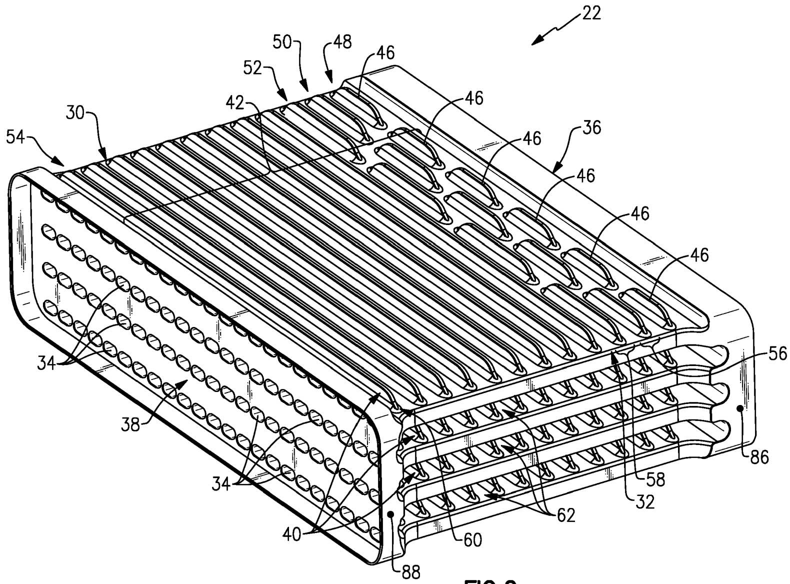

FIG.2

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Description

BACKGROUND

[0001] A plate fin heat exchanger includes adjacent flow paths that transfer heat from a hot flow to a cooling flow. The flow paths are defined by a combination of plates and fins that are arranged to transfer heat from one flow to another flow. The plates and fins are created from sheet metal material brazed together to define the different flow paths. Thermal gradients present in the sheet material create stresses that can be very high in certain locations. The stresses are typically largest in one corner where the hot side flow first meets the coldest portion of the cooling flow. In an opposite corner where the coldest hot side flow meets the hottest cold side flow the temperature difference is much less resulting in unbalanced stresses across the heat exchanger structure. Increasing temperatures and pressures can result in stresses on the structure that can exceed material and assembly capabilities.

[0002] Turbine engine manufactures utilize heat exchangers throughout the engine to cool and condition airflow for cooling and other operational needs. Improvements to turbine engines have enabled increases in operational temperatures and pressures. The increases in temperatures and pressures improve engine efficiency but also increase demands on all engine components including heat exchangers.

[0003] Turbine engine manufacturers continue to seek further improvements to engine performance including improvements to thermal, transfer and propulsive efficiencies.

SUMMARY

[0004] In an aspect of the present invention, a heat exchanger includes a plate portion including a top surface, bottom surface, a leading edge, a trailing edge and a plurality of internal passages extending between an inlet and an outlet. A plurality of fin portion rows are included. A first row of the plurality of fin portions includes at least two discrete fin portions and a second row of the plurality of in portions includes fewer fin portions than the first row. The first row is closer to the inlet than the second row.

[0005] In an embodiment, the internal passages extend substantially parallel to the leading and trailing edges.

[0006] In another embodiment according to any of the previous embodiments, the fin portion rows extend perpendicularly to the direction of the internal passages, from the leading edge to the trailing edge.

[0007] In another embodiment according to any of the previous embodiments, the plurality of fin portion rows includes a last row spaced furthest from the inlet that includes a continuous fin portion extending uninterrupted from the leading edge to the trailing edge.

[0008] In another embodiment according to any of the previous embodiments, a first group of discrete fin portions in the first row includes a first common length in a direction between the leading edge and the trailing edge.

[0009] In another embodiment according to any of the previous embodiments, second group of discrete fin portions are included in the second row. The second group of discrete fin portions includes a second common length that is larger than the first common length.

[0010] In another embodiment according to any of the previous embodiments, a third row is spaced further from the inlet than the first row and the second row. The third row includes a third group of discrete fin portion. The third group of discrete fin portions includes a third common length that is larger than either of the first common length and second common length.

[0011] In another embodiment according to any of the previous embodiments, the plurality of fin portion rows includes additional rows including groups of discrete fin portions disposed between the first row and a last row furthest from the inlet.

[0012] In another embodiment according to any of the previous embodiments, the plate portion includes a plurality of plate portions with corresponding pluralities of internal passages. The plurality of plate portions includes flow channels for cooling air flow with the plurality of fin portion rows extending into each of the flow channels.

[0013] In another embodiment according to any of the previous embodiments, each of the top surface and the bottom surface include the plurality of fin portion rows.

[0014] In another embodiment according to any of the previous embodiments, the plate portion and the fin portion rows include a single unitary cast item.

[0015] In another aspect of the present invention, a cast plate for a heat exchanger includes a plate portion including a top surface, bottom surface, a leading edge, a trailing edge and a plurality of internal passages extending between an inlet and an outlet. A plurality of fin portion rows are included. A first row of the plurality of fin portions includes at least two discrete fin portions. The plate portion and the plurality of fin portion rows include a single unitary uninterrupted cast item.

[0016] In an embodiment according to the previous embodiment, the plate portion includes a plurality of plate portions with corresponding pluralities of internal passages. The plurality of plate portions include flow channels for cooling air flow between at least some of the plate portions and the plurality of fin portion rows extend into each of the flow channels.

[0017] In another embodiment according to any of the previous embodiments, the plurality of fin portion rows includes additional rows comprised of groups of discrete fin portions disposed between the first row and a last row furthest from the inlet.

[0018] In another embodiment according to any of the previous embodiments, each of the groups of discrete fin portions includes discrete fin portions of a common length and the common length for each of the groups of discrete fin portions increases with an increasing distance from the inlet.

[0019] In another embodiment according to any of the previous embodiments, the plurality of fin portion rows includes a last row spaced furthest from the inlet that includes a continuous fin portion extending uninterrupted from the leading edge to the trailing edge.

[0020] In another embodiment according to any of the previous embodiments, each of the plurality of fin portions includes tapered longitudinal ends.

[0021] In another aspect of the present invention, a method of building a heat exchanger includes forming a first core defining a plurality of internal passages through a plate portion. The core is inserted within a mold cavity that defines outer surfaces of the plate portion to include a top surface, bottom surface, a leading edge, a trailing edge and a plurality of fin portion rows. A first row includes at least two discrete fin portions. Cast material is introduced into the mold to form a single unitary heat exchanger plate without a joint between the plate portion and the plurality of fin portions. The heat exchanger plate is removed from the mold and removes the core from the plate portion.

[0022] In an embodiment according to the previous embodiment, the plate portion includes a plurality of plate portion defining flow channels between spaced apart plate portions and forming a second core to define a plurality of fin portions within the flow channels.

[0023] In another embodiment according to any of the previous embodiments, the mold cavity includes features for defining fin portions on a top surface of a top one of the plurality of plate portions and on a bottom surface of the plurality of plate portions and the second core includes features for defining the fin portions within the flow channels between intermediate ones of the plurality of plate portions.

[0024] In another embodiment according to any of the previous embodiments, the second core and the mold cavity define the plurality of fin portion rows to include additional rows comprised of groups of discrete fin portions disposed between the first row and a last row.

[0025] In another embodiment according to any of the previous embodiments, the second core and the mold cavity define the plurality of fin portion rows to include a last row spaced furthest from the inlet that includes a continuous fin portion extending uninterrupted from the leading edge to the trailing edge.

[0026] Although the different examples have the specific components shown in the illustrations, embodiments of this disclosure are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

[0027] These and other features disclosed herein can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

Figure 1 is a schematic view of an example heat exchanger embodiment.

Figure 2 is a perspective view of a plate assembly according to one example embodiment.

Figure 3 is a top view of a portion of the example plate assembly.

Figure 4 is a side view of the example plate assembly.

Figure 5 is a perspective view of another plate assembly embodiment.

Figure 6 is a schematic representation of a method of fabricating a cast plate heat exchanger.

DETAILED DESCRIPTION

[0029] Referring to Figure 1, a heat exchanger 10 includes an inlet manifold 12 and an outlet manifold 14 disposed on either side of a plate assembly 22. The plate assembly 22 is a single cast unitary part that includes plate portions 24 that define a plurality of internal passages 34 between inlets 36 and outlets 38. Fin portions 40 are disposed on each of the plate portions 24 and provide increased surface area for heat transfer between transverse flows 16, 20.

[0030] The incoming flow 16 is directed through the inlet manifold 12 and enters the plate assembly 22 through inlets 36 and flows through the internal passages 34. A cooling airflow 20 flows over the external surfaces of the plate assembly 22 to remove heat from the heated airflow 16. A cooled exhaust flow 18 exits through the outlet manifold 14. The plate assembly 22 includes a leading edge 30 where the cooling airflow 20 initially flows over surfaces of the plate portions 24 and through the plurality of fin portions 40 before being exhausted out past a trailing edge 32.

[0031] Heat exchanges encounter extremes in temperature differentials between the incoming hot airflow 16 and the cooling airflow 20. The thermal differentials vary throughout different regions of the plate assembly 22 such that heat exchanges typically encounter extreme stresses and strain due to the extreme thermal gradients.

[0032] The example plate assembly 22 includes features for reducing the thermal gradients based on the temperature of the incoming flow 16 and the cooling airflow 20. Specific features of the plate assembly 22 tailor the thermal differences to reduce the thermal gradients and includes structures that reduce stresses caused by extreme differences in temperature.

[0033] Referring to Figure 2 with continued reference to Figure 1, the example plate assembly 22 includes a plurality of plate portions 24 and a plurality of fin portions 40. The fin portions 40 are disposed on both a top surface 26 and a bottom surface 28 of each plate portion 24. The fin portions 40 are arranged in a plurality of rows 42 that extend perpendicular to the direction of the plurality of internal passages 34. Each of the plurality of rows 42 extend from the leading edge 30 to the trailing edge 32.

[0034] The greatest temperature differential in the plate assembly 22 during operation is at the inlet 36 where the incoming hot flow is at its greatest temperature before it has expelled heat into the plate assembly 22. Moreover, the cooling airflow 20 is at its lowest temperature at the leading edge 30 prior to absorbing any heat from the surface of the plate assembly 22. The plurality of rows 42 includes features that tailor heat transfer to the extremes of the incoming flows 16, 20 to reduce extremes in thermal gradients.

[0035] The example plate assembly 22 includes a first row 48 including a first group of discrete fin portions 46 that are aligned from the leading edge 30 to the trailing edge 32. Each of the plurality of discrete fin portions 46 are individual separate segments that are spaced apart longitudinally between the leading edge 30 and the trailing edge 32. The segmented fin portions 46 reduces a heat transfer surface area over which the cooling airflow 20 flows near the inlet 36. The reduced heat transfer surface area results in a reduction in heat transfer and a reduction in the differences in thermal gradient of the surface of the plate portions 24 relative to the temperature of air flowing through the passages 34 near the inlets 36.

[0036] A second row 50 from the inlet 36 includes a second group of discrete fin portions 56 that are spaced apart longitudinally between the leading edge and the trailing edge 32.

[0037] A third row 52 from the inlet 36 includes a third group of discrete fin portions 58 that are spaced apart longitudinally between the leading edge 30 and the trailing edge 32.

[0038] In this disclosed example, the plate assembly 22 includes three rows of segmented discrete fin portions and the remaining rows 42 of fin portions 40 up to the last row 54 furthest from the inlet 36 are continuous fins 60 that extend uninterrupted between the leading edge 30 and the trailing edge 32.

[0039] Referring to Figure 3 with continued reference to Figure 2, the first row 48 includes the plurality of the discrete fin portions 46 that each have a common width 66. Each of the fin portions 46 are also spaced a common distance 68. The width 66 and distance 68 tailor the available heat transfer surface area provided by the first row 48 nearest the inlet 36 to minimize heat transfer into the cooling flow 20. Minimizing heat transfer nearest the inlet 36 locally reduces the thermal gradient within the plate assembly 22. The width 66 and distance of the discrete fin portions 46 in the first row 48 is tailored to provide a heat transfer surface area determined to provide an acceptable thermal gradient based on expected temperatures of hot flow 16 and cooling flow 20.

[0040] The second row 50 includes the second group of discrete fin portions 56 that each have a second common width 70 and a second spacing 72 there between. The second row 50 includes an increased surface area as compared to the first row 48 that is tailored to maintain an acceptable thermal gradient in the plate assembly 22 within the region of the second row 50.

[0041] The third row 52 of discrete fin portions 58 that have a third common width 74 that are spaced apart a third distance 76. The width 74 and spacing 76 provides another increase in heat transfer surface area compared to each of the first row 48 and the second row 50.

[0042] In this disclosed example, there are three rows 48, 50, 52 of disecrete fin portions with the remainder of the fin portion rows 42 including continuous and interrupted fins 60. However, it is within the contemplation of this disclosure that additional rows of discrete fin portions could be utilized to further tailor operation of the heat exchanger based on expected operational temperatures and pressures.

[0043] A region 64 schematically shown in Figure 3 of the plate assembly 22 is at corner where the inlet 36 and the leading edge 30 meet. In this region 64, the hot flow 16 is at its greatest temperature and the cooling flow 20 is at its coolest temperature. The resulting interface between the two flows generates the highest thermal gradient within the plate assembly 22. The cooling airflow heats up in a direction indicated by arrow 90 and the hot airflow 16 cools down as it proceeds away from the inlet 36 in a direction indicated by arrow 92. The surface area provided by the rows 48, 50 and 52 of discrete fin portions 46, 56 and 58 accommodate the differences in temperatures within the region 64 to reduce stresses and strains on the plate assembly 22 by reducing the differences in thermal gradient encountered by the material comprising the plate assembly 22.

[0044] Although an example orientation of discrete fin portions 46, 56, and 58 is disclosed by way of example, other fin portion orientations could be utilized within the contemplation and scope of this disclosure.

[0045] Moreover, the different fin portions are provided relative to a high stress region such as the region 64 or a joint between the plate assembly and one of the inlet manifold 12 and the outlet manifold 14. The asymmetric orientation of fin portions provide benefits within a region disposed within a distance about 10% of the total length of the plate assembly. In another example the distance is within a region about 7% of the total length of the plate assembly. The asymmetric application of heat transfer augmentation features such as the discrete fin portions lower the amount of augmentation feature density by approximately 15%. Additionally, an increase in density up to 200% of the nominal on the external or internal core or joint features.

[0046] Referring to Figure 4 with continued reference to Figures 2 and 3, the example plate assembly is a quad plate assembly 22 and includes four plate portions 24, each including a top surface 26 and a bottom surface 28 and a fin portions extending therefrom. Each of the plate portions 24 include the first row 48, second row 50 and third row 52 on both the top surface 26 and the bottom surface 28. The stacked plate portions 24 form flow channels 62 there through within which the fin portions extend. Each of the fin portions are arranged such that they alternate and intermesh to define the flow channels 62 to provide the desired cooling airflow proximate the internal passages 34 within each of the plate portions 24.

[0047] In one disclosed example embodiment, the plate assembly 22 includes an upper plate 80, a lower plate 82 and intermediate plates 84. The upper and lower plates 80, 82 define the top and bottom surfaces of the plate assembly 22. The intermediate plate portions 24 define the flow channel 62 and include intermeshing fin portions that extend from each corresponding plate portion 24. Each of the plate portions 24 includes a common housing 86 disposed on an inlet side and a common outlet housing 88 that is integrated between the four plate portions 24. The example plate assembly 22 is a single unitary cast structure that includes common features utilized to define desired thermal gradients throughout the heat exchanger to reduce stresses and strains.

[0048] Referring to Figure 5, another example plate assembly embodiment 100 is shown and includes a single plate portion 24 including fin portions disposed on the top and bottom surfaces 26, 28. The example plate assembly 100 includes the first, second and third rows 48, 50 and 52 with corresponding groups of discrete fin portions 46, 56, 58. It should be understood that although a single plate 100 is shown and a plate assembly 22 with four plate portions 24 is shown in the previous figures by way of example, other numbers of plate portions 24 could be utilized and stacked to create a single unitary plate assembly with discrete fin portions provided to tailor thermal gradients within the structure during operation.

[0049] Referring to Figure 6 with continued reference to Figure 4, the example plate assembly is formed as a single cast item and formed utilizing a casting method schematically indicated at 115. A first core 102 is used to define the internal passages through each of the corresponding plate portions 24. A second core 104 is utilized to define the flow channel 62 between the plate portions 24.

[0050] The first core 102 and a second core 104 are formed using materials known and understood by those in the casting art. The cores 102 and 104 are placed within a mold 106 and a cast material 108 is injected into the mold 106 and cured. The cores 102 and 104 remain within the mold 106 and form the internal passages and the fins within the flow channel 62. The internal features of the cavity provided by the mold 106 define the fin portions of the top plate and bottom plate that provide the desired fin configuration of the discrete fin portions 46, 48, 58 to tailor the thermal gradient through the heat exchanger.

[0051] Once the material for the heat exchanger is cured, the cast part is removed from the mold 106, the cores 102 and 104 are removed using known techniques and the completed heat exchanger is ready for assembly and use.

[0052] Accordingly, the example heat exchanger plate assemblies provide a single cast unitary part that includes segmented fins to tailor thermal gradients in the heat exchanger to provide strain relief and improve operational life.

[0053] Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this disclosure. For that reason, the following claims should be studied to determine the scope and content of this disclosure.

Claims

1. A heat exchanger (10) comprising:

   a plate portion (24) including a top surface (26), bottom surface (28), a leading edge (30), a trailing edge (32) and a plurality of internal passages (34) extending between an inlet (36) and an outlet (38); and
   a plurality of fin portion rows (42), wherein a first row (48) of the plurality of fin portion rows (42) comprises at least two discrete fin portions (46) and a second row (50, 52, 54) of the plurality of fin portion rows (42) comprises fewer fin portions (56, 58, 40) than the first row (48), wherein the first row (48) is closer to the inlet (36) than the second row (50, 52, 54).

2. The heat exchanger as recited in claim 1, wherein the plurality of fin portion rows (42) includes a last row (54) spaced furthest from the inlet (36) that includes a continuous fin portion (60) extending uninterrupted from the leading edge (30) to the trailing edge (32).

3. The heat exchanger as recited in claim 1 or 2, wherein a first group of discrete fin portions (46) in the first row (48) includes a first common length (66) in a direction between the leading edge (30) and the trailing edge (32).

4. The heat exchanger as recited in claim 3, including second group of discrete fin portions (56) in the second row (50), wherein the second group of discrete fin portions (56) includes a second common length (70) that is larger than the first common length (66).

5. The heat exchanger as recited in claim 4, including a third row (52) spaced further from the inlet (36) than the first row (48) and the second row (50), the third row (52) including a third group of discrete fin portions (58), wherein the third group of discrete fin portions (58) includes a third common length (74) that is larger than either of the first common length (66) and second common length (70).

6. The heat exchanger as recited in any preceding claim, wherein the plurality of fin portion rows (42) includes additional rows (50, 52, 54) including groups of discrete fin portions (56, 58) disposed between the first row (48) and a last row (54) furthest from the inlet (36).

7. The heat exchanger as recited in any preceding claim, wherein the plate portion (24) comprises a plurality of plate portions (24) with corresponding pluralities of internal passages (34), the plurality of plate portions (24) including flow channels (62) for cooling air flow (20) with the plurality of fin portion rows (42) extending into each of the flow channels (62).

8. The heat exchanger as recited in any preceding claim, wherein each of the top surface (26) and the bottom surface (28) include the plurality of fin portion rows (42).

9. The heat exchanger as recited in any preceding claim, wherein the plate portion (24) and the fin portion rows (42) comprise a single unitary cast item.

10. A cast plate (22) for a heat exchanger (10) comprising:

a plate portion (24) including a top surface (26), bottom surface (28), a leading edge (30), a trailing edge (32) and a plurality of internal passages (34) extending between an inlet (36) and an outlet (38); and
a plurality of fin portion rows (42), wherein a first row (48) of the plurality of fin portion rows (42) comprises at least two discrete fin portions (46), wherein the plate portion (24) and the plurality of fin portion rows (42) comprise a single unitary uninterrupted cast item.

11. The cast plate for heat exchanger as recited in claim 10, wherein the plate portion (24) comprises a plurality of plate portions (24) with corresponding pluralities of internal passages (34), the plurality of plate portions (24) including flow channels (62) for cooling air flow (20) between at least some of the plate portions (24) and the plurality of fin portion rows (42) extending into each of the flow channels (62), and/or the plurality of fin portion rows (42) includes a last row (54) spaced furthest from the inlet (36) that includes a continuous fin portion (60) extending uninterrupted from the leading edge (30) to the trailing edge (32).

12. The cast plate for heat exchanger as recited in claim 10 or 11, wherein the plurality of fin portion rows (42) includes additional rows (50, 52, 54) comprised of groups of discrete fin portions (56, 58) disposed between the first row (48) and a last row (54) furthest from the inlet (36), and, optionally, each of the groups of discrete fin portions (56, 58) includes discrete fin portions (56, 58) of a common length (70, 74) and the common length (70, 74) for each of the groups of discrete fin portions (56, 58) increases with an increasing distance from the inlet (36).

13. The cast plate for a heat exchanger as recited in claim 10, 11 or 12, wherein each fin portion (40, 42, 56, 58) includes tapered longitudinal ends.

14. A method of building a heat exchanger (10) comprising:

forming a first core (102) defining a plurality of internal passages (34) through a plate portion (24);
inserting the core (102) within a cavity of a mold (106) that defines outer surfaces of the plate portion (24) to include a top surface (26), bottom surface (28), a leading edge (30), a trailing edge (32) and a plurality of fin portion rows (42), wherein a first row (48) comprises at least two discrete fin portions (46);
introducing cast material (108) into the mold (106) to form a single unitary heat exchanger plate (100) without a joint between the plate portion (24) and the plurality of fin portion rows (42); and
removing the heat exchanger plate (100) from the mold (106) and removing the core (102) from the plate portion (24).

15. The method as recited in claim 14, wherein the plate portion (24) comprises a plurality of plate portions (24) defining flow channels (62) between spaced apart plate portions (24) and further comprising forming a second core (104) to define a plurality of fin portions (40, 46, 56, 58) within the flow channels (62), and, optionally, wherein the mold cavity includes features for defining fin portions (40) on a top surface (26) of a top one of the plurality of plate portions (24) and on a bottom surface (28) of the plurality of plate portions (24) and the second core (104) includes features for defining the fin portions (40, 46, 56, 58) within the flow channels (62) between intermediate ones of the plurality of plate portions (24), and/or wherein the second core (104) and the mold cavity define the plurality of fin portion rows (42) to include additional rows comprised of groups of discrete fin portions (56, 58) disposed between the first row (48) and a last row (54), and/or wherein the second core (104) and the mold cavity define the plurality of fin portion rows (42) to include a last row (54) spaced furthest from the inlet (36) that includes a continuous fin portion (60) extending uninterrupted from the leading edge (30) to the trailing edge (32).

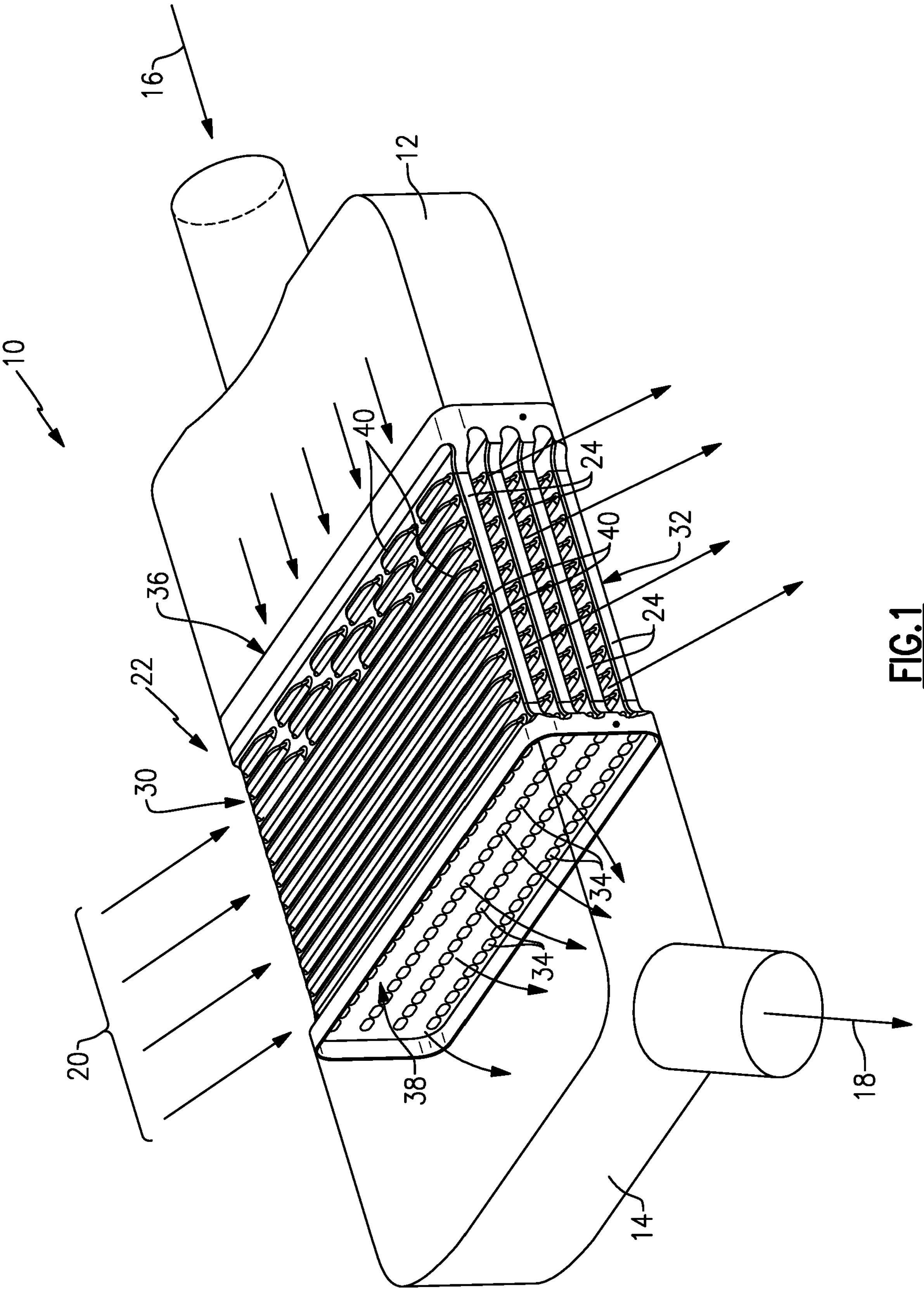

FIG.1

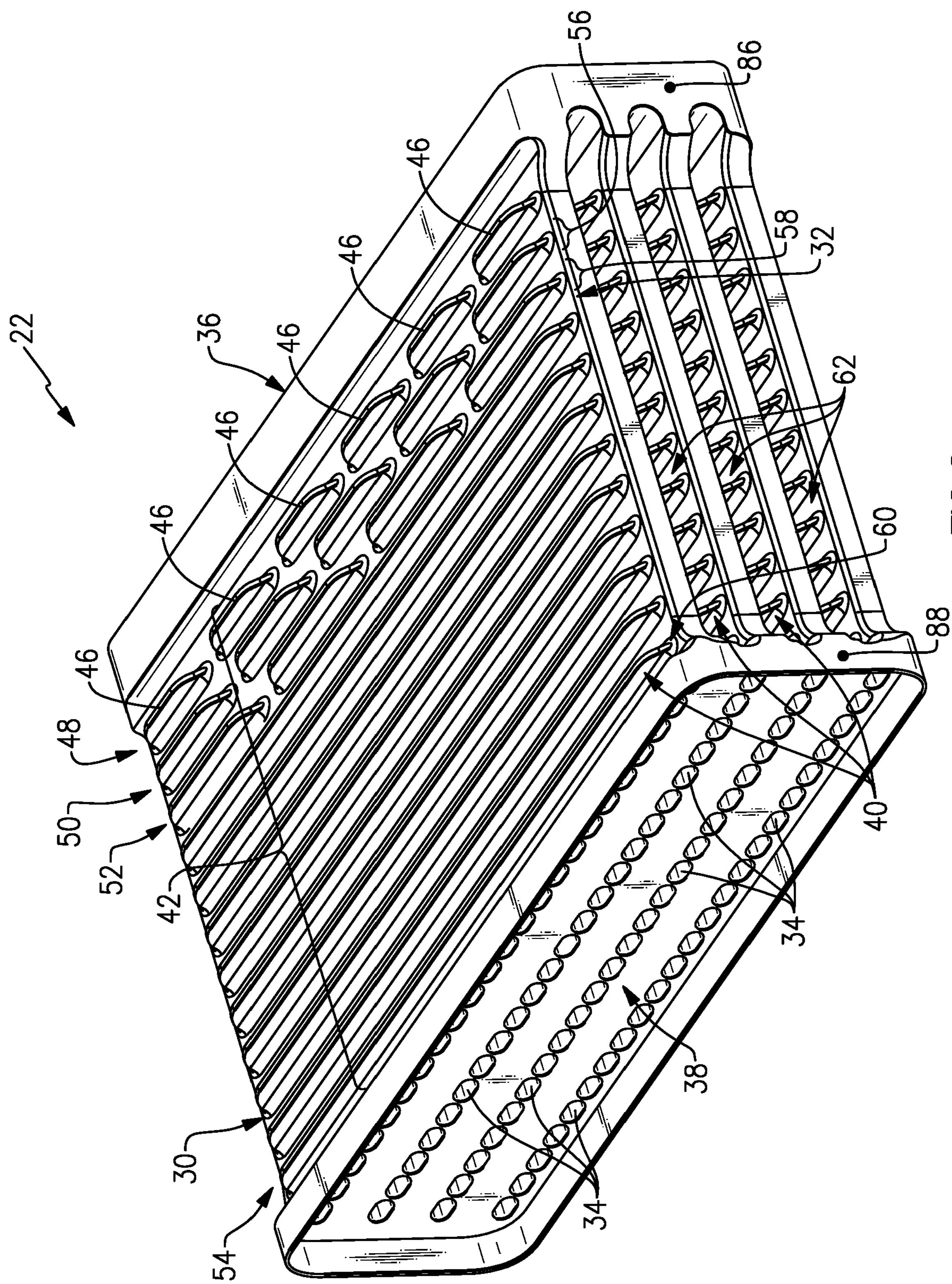
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FIG.2

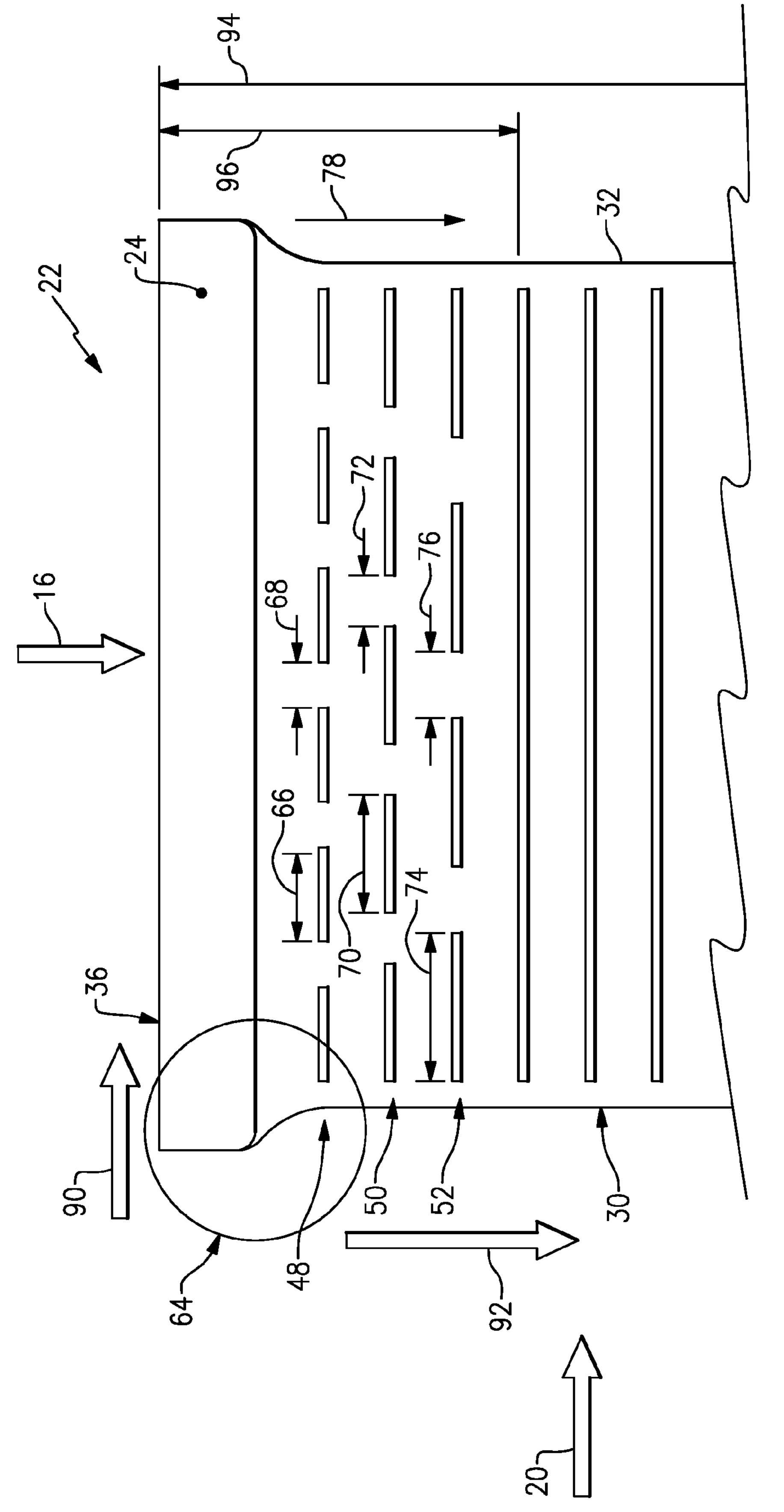

FIG.3

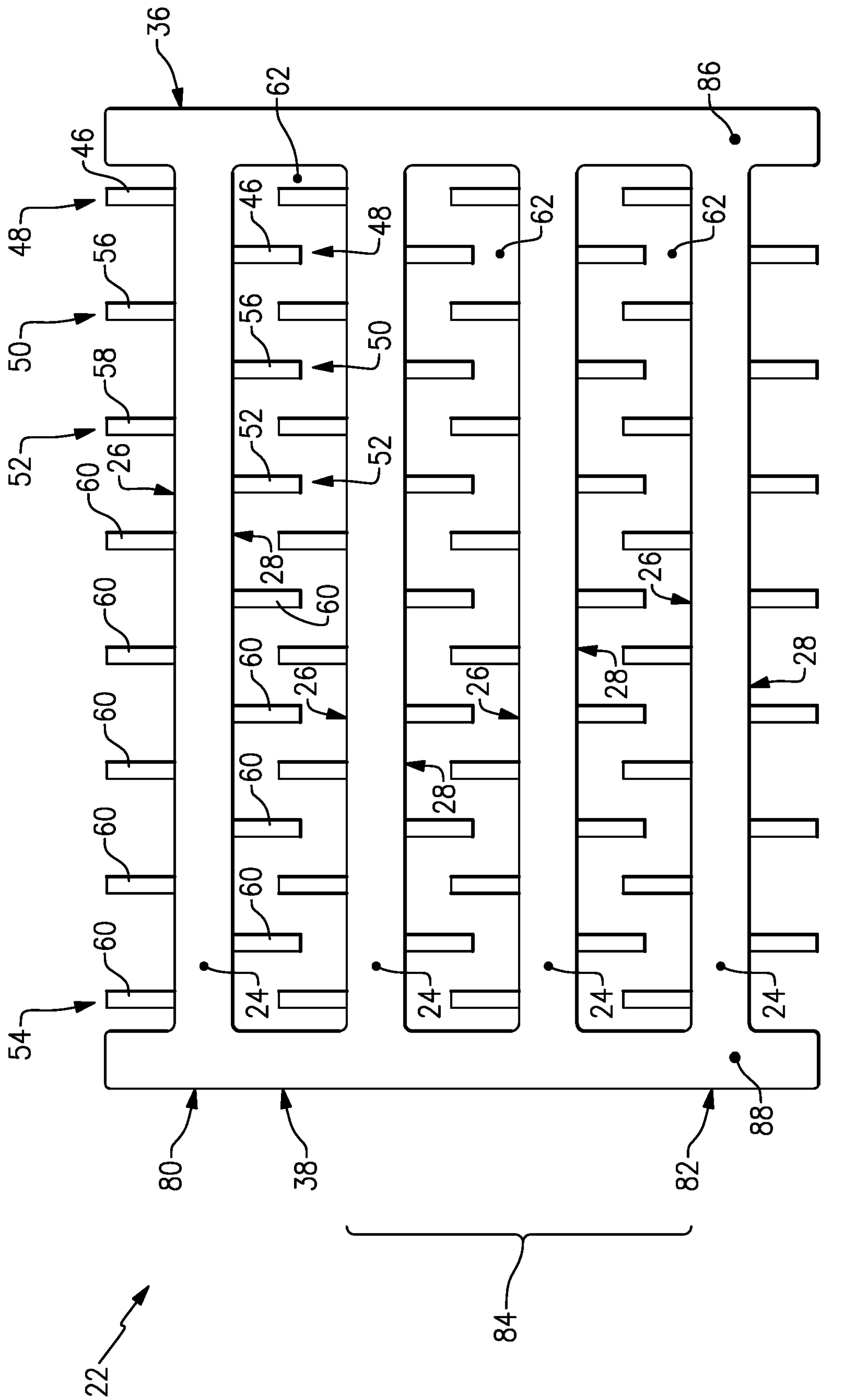

FIG.4

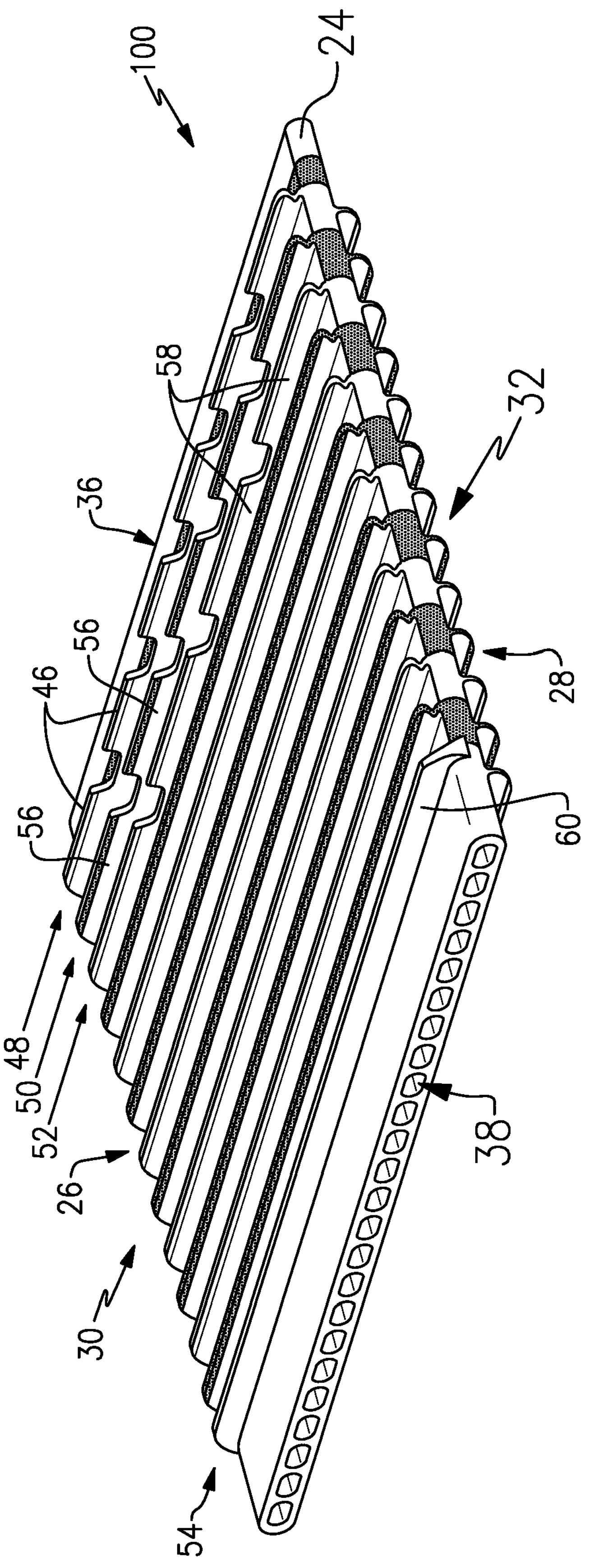

FIG.5

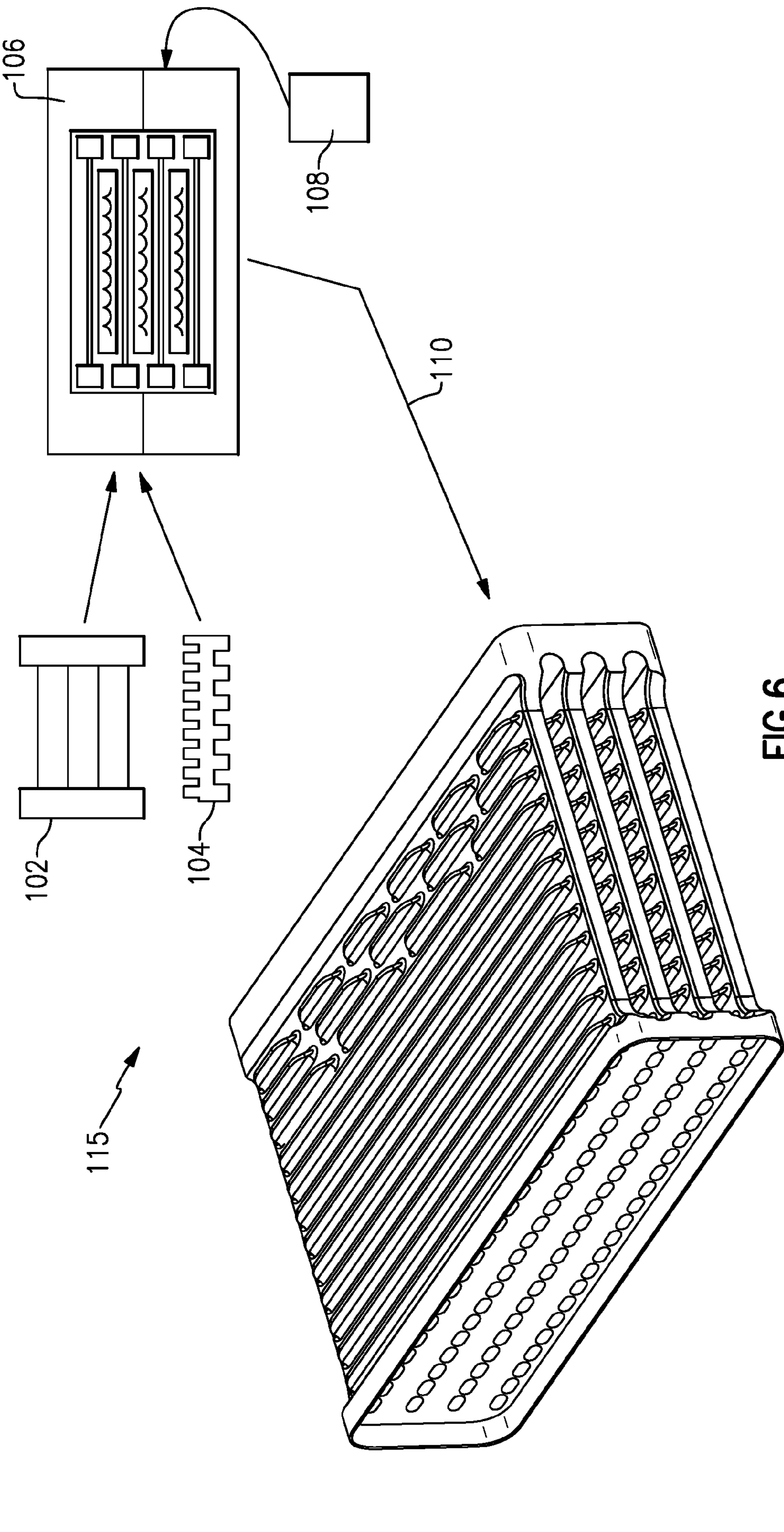

FIG.6