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(54) HEAT EXCHANGER LOW PRESSURE LOSS MANIFOLD

(57) A heat exchanger (10) includes a plurality of flow passages (18) in thermal contact with a cooling flow (24). The plurality of flow passages (18) include a first end and a second end. An inlet manifold (12) is at the first end of the plurality of flow passages (18). The inlet manifold (12) includes a plurality of independent splitter passages that communicate airflow (22) to the first end of the plurality of flow passages (18). An exhaust manifold (14) is at the second end of the plurality of flow passages (18).

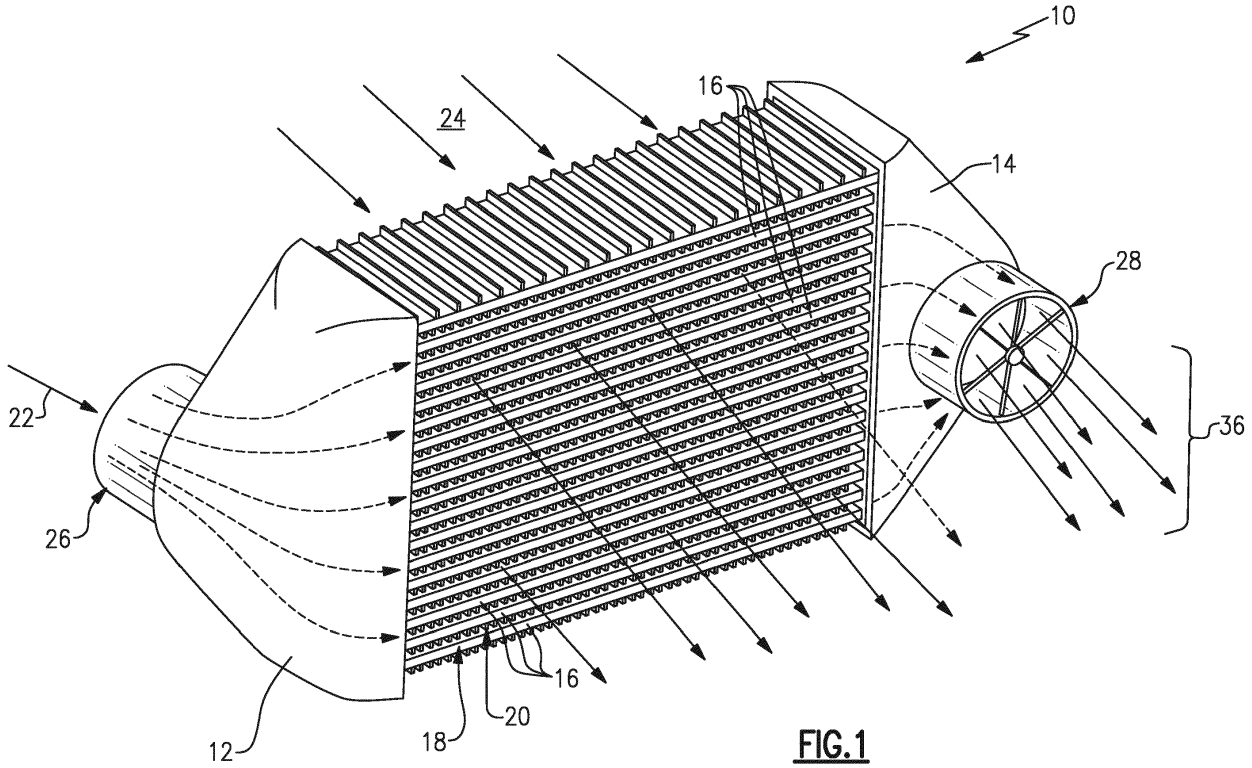

FIG.1

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Description

BACKGROUND

[0001] A heat exchanger includes inlet structures that distribute flow from a circular conduit into one or many smaller flow passages. High initial total pressure with the inlet manifold is desired to be maintained, with minimal loss, through the heat exchanger and out the exit manifold. Flow Velocity within the relative large spaces provided by the manifold are relatively low compared to airflow velocities desired within the smaller flow passages where thermal transfer occurs. Higher airflow velocities through the flow passages increase thermal transfer efficiencies. Pressure losses between the conduit, manifold and the smaller flow passages can be substantial and reduce airflow velocity and thereby thermal transfer efficiencies. Moreover, upon exiting the flow passages, the airflow expands into the larger space that generates further pressure losses. The combined pressure losses at the inlet and the outlet reduce thermal efficiencies and require structurally larger heat exchangers to accommodate increased demands.

[0002] Turbine engine manufactures utilize heat exchangers throughout the engine to cool and condition airflow for cooling and other operational needs. Turbine engine improvements 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 one aspect, a heat exchanger includes a plurality of flow passages in thermal contact with a cooling flow. The plurality of flow passages include a first end and a second end. An inlet manifold is at the first end of the plurality of flow passages. The inlet manifold includes a plurality of independent splitter passages that communicate airflow to the first end of the plurality of flow passages. An exhaust manifold is at the second end of the plurality of flow passages.

[0005] In an embodiment according to the above, each of the plurality of splitter passages include a flow area between an inlet of the inlet manifold and an outlet of the inlet manifold into the first end of the plurality of passages that are the same.

[0006] In another embodiment according to any of the above, a ratio between an area of the inlet and an area of the outlet of each of the plurality of splitter passages is between 1.5 and 5.

[0007] In another embodiment according to any of the above, the inlet includes a circular shape in cross-section and is divided into passage inlets of equal area that correspond with each of the plurality of splitter passages.

[0008] In another embodiment according to any of the above, each of the passage inlets are pie-shaped in cross-section.

[0009] In another embodiment according to any of the above, each of the passage inlets are circular shaped in cross-section.

[0010] In another embodiment according to any of the above, the outlet includes a rectangular shape in cross-section and is divided into passage outlets of equal area that correspond with the plurality of splitter passages.

[0011] In another embodiment according to any of the above, each of the passage outlets is in communication with more than one of the plurality of flow passages.

[0012] In another embodiment according to any of the above, each of the plurality of splitter passages includes a smooth curved passage without interruption between the inlet and the outlet.

[0013] In another embodiment according to any of the above, the exhaust manifold includes an inlet portion at the second end of the plurality of flow passages and an outlet portion. The exhaust manifold includes a plurality of exhaust passages defining separate flow passages between the inlet portion and the outlet portion.

[0014] In another embodiment according to any of the above, the inlet portion is divided into a plurality of rectangular inlets corresponding with the second end of the plurality of flow passages.

[0015] In another embodiment according to any of the above, each of the outlet portions includes a plurality of outlets having one of a pie-shaped cross-section and curvilinear shaped cross-section.

[0016] In another aspect, a method of forming a manifold for a heat exchanger includes creating a plurality of core sections that define a passageway between an inlet and an outlet. Each of the plurality of core sections define a common inlet area and outlet area for the passageway. A mold cavity is defined to receive the core sections that defines an outer shape of the manifold. The plurality of core sections is molded within the mold cavity to encase the core sections within a casting material. The core sections are removed from the casting material.

[0017] In an embodiment according to the above, each of the core sections defines an area ratio between the inlet and the outlet of between 1.5 and 5.

[0018] In another embodiment according to any of the above, the core sections define the inlet as one of a pie-shaped and a curvilinear shape in cross-section.

[0019] In another embodiment according to any of the above, each of the core sections define a smooth curved passage without interruption between the inlet and the outlet.

[0020] In another embodiment according to any of the above, the plurality of core sections together define a circular inlet in cross-section.

[0021] In another embodiment according to any of the above, the core defines a substantially rectangular outlet

in cross-section.

[0022] 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.

[0023] 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

[0024]

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

Figure 2 is a perspective view of an example plate of the example heat exchanger.

Figure 3 is a perspective view of an example intake manifold embodiment.

Figure 4 is a schematic cross section of a passage of the example intake manifold.

Figure 5 is a schematic view of an outlet for the example intake manifold.

Figure 6 is a schematic view of an inlet passage for the example intake manifold.

Figure 7 is a schematic view of an example exhaust manifold.

Figure 8 is a cross-sectional view of an inlet for the example heat exchanger.

Figure 9 is a cross-sectional view of an example outlet for the example heat exchanger.

Figure 10 is a cross-sectional view of another embodiment of an example inlet for the heat exchanger.

Figure 11 is a cross-sectional view of yet another example embodiment of an intake for the example intake manifold.

Figure 12 is perspective view of another example intake manifold embodiment.

Figure 13 is a perspective view of an outlet for the example intake manifold of Figure 12.

Figure 14 is a schematic view of a method of creating and casting an example intake manifold according to the disclosed embodiments.

DETAILED DESCRIPTION

[0025] Referring to Figures 1 and 2, a disclosed heat exchanger 10 includes an intake manifold 12 and an exhaust manifold 14. The intake manifold 12 is disposed on a first end 32 of a plurality of plates 16 with a limited number identified in Figure 1. The exhaust manifold 14 is disposed on a second end 34 of the plurality of plates 16. The intake manifold 12 defines an inlet 26 that communicates a first flow 22 to the first end 32 of the plates 16. Each of the plates 16 includes a first flow passage 18 between the first end 32 and the second end 34. The plates 16 also define a second flow path 20 for cooling airflow. The second flow path 20 is comprised of a plurality of fins 30 that extend upward from an outer surface of each of the plates 16.

[0026] Airflow 22 through the first flow passage 18 is placed in thermal contact with the cooling airflow 24 through the second flow path 20. The disclosed example plate 16 comprises a single unitary part that provides for thermal communication between the inlet flow 22 and the cooling airflow 24. It should be understood that it is within the contemplation of this disclosure that other plate configurations or other heat exchanger configurations could be utilized, benefit from this disclosure, and are within the contemplation of this disclosure.

[0027] Referring to Figures 3 and 4 with continued reference to Figures 1 and 2, the airflow 22 is of a hotter temperature and flows through the first flow passage 18 defined by the plate 16. Cooled flow 36 exits through the exhaust manifold outlet 28. Both the intake manifold 12 and the exhaust manifold 14 includes a plurality of separate splitter passages 38 defined within a housing 52 between an inlet that receives flow and an outlet that distributes a flow to the plurality of flow passages 18. In the case of the exhaust manifold, the exhaust manifold receives airflow from the first flow passage 18 defined within the plates 16 and transitions that flow into the circular outlet 28. In the case of the inlet manifold 12, the inlet flow 22 flows through a substantially circular inlet and is divided evenly to provide a smooth uniform flow path to each of the first flow passages 18. It should be understood that although the intake manifold 12 is described by way of example in this disclosure, that the same features are also applicable to the exhaust manifold 14.

[0028] Referring to Figures 3, 4, 5 and 6, the example intake manifold 12 includes the inlet 26 and an outlet 40. The outlet 40 distributes airflow to a plurality of first ends 32 of a corresponding plurality of the plates 16. The splitter passages 38 define a flow path between the inlet 26 and the outlet 40. The splitter passages 38 include smooth curved walls 50 reduce disruptions that may create turbulence and inefficient airflows. Each of the splitter passages 38 include smooth walls 50 along the curved passage without interruption between the inlet 26 and outlet 40. It should be understood, that surface treatments and/or surface features 55 may be added to the smooth walls 50, to assist the turning of the flow, within the passage 38. The smooth walls 50 may include surface features 55 that assist in turning of flow within the passage 38. The surface features 55 may include vortex generating structures such as dimples and local areas of increased roughness relative to the smooth walls 50. The surface features 55 can be utilized in regions of where flow might separate from the walls 50 and cause aerodynamic disturbances that reduce flowrate.

[0029] The inlet 26 is divided into a plurality of inlet portions 42 that include a cross sectional area 46. The

outlet 40 is divided into a plurality of outlet portions 44 that include an area 48. In one example embodiment, a ratio between the inlet area 46 and the outlet area 48 is within a range between 1.5 and 5. Each of the inlet portions 42 are of an equal area and disposed within the cross section of the inlet 26.

[0030] Referring to Figure 7, the disclosed exhaust manifold 14 is substantially the same as the intake manifold 12 except reversed such that airflow exiting through second ends 34 of the plurality of plates 16 enters a rectangular inlet portion and exits through the circular outlet 28. The splitter passages 38 include a common flow volume between the inlet 26 and the outlet 40. The exhaust manifold 14 includes exhaust passages 56 that, like passages 38, are of an equal flow area from the inlet portion to the outlet 28. The inlet portion is divided into a plurality of rectangular inlets 54. The outlet 28 is divided into a plurality of outlet portions 58 having a pie-shaped cross-section. The outlet portions 58 may also be of other curvilinear shapes in cross-section corresponding to each of the exhaust passages 56.

[0031] Referring to Figure 8 with continued reference to Figures 3-6, the example inlet 26 is a circular shape in cross section and is subdivided into six separate inlet portions 42. Each of the inlet portions 42 are of a substantially equal area and communicate independently with a corresponding passage 38. In this example, each of the inlet portions 42 are substantially pie shaped (or sector-shaped) in cross section and subdivide the circular cross section 26 of the inlet into six separate inlet portions 42 that communicate with different corresponding splitter passages 38.

[0032] Referring to Figure 9, the example outlet 40 includes a plurality of outlet portions 44 that are substantially rectangular. The rectangular orientation and cross sectional shape matches the inlet shape for the plate 16. It should be appreciated that other shapes of the outlet openings 44 could be utilized to correspond with shapes of the inlets to each of the plates 16. Moreover, it should be understood that each of the outlet portions 44 correspond with in at least one or several of the flow passages 18.

[0033] Referring to Figure 10, another example inlet 25 is shown and includes a plurality of inlet portions 41. In this example, the inlet 25 includes a circular cross section and includes a plurality of subdivided inlet portions 41. Each of the inlet portions 41 is a curvilinear shape that includes an irregularly curved shape. The different curvilinear shapes are provided to fit within the circular cross section of the inlet 25. Although example inlet portions 41 are schematically shown, other regular and irregularly shaped inlet portions 41 could be utilized and are within the contemplation of this disclosure. In this example, the inlet portions 41 are substantially identical in area while not identical in shape and provide smoothed shape to transition into each corresponding splitter passages 38.

[0034] Referring to Figure 11, another example inlet 27 is substantially circular and divided into rectangular inlet portions 43. Each of the rectangular inlet portions 43 correspond with one of the corresponding splitter passages 38.

[0035] Referring to Figures 12 and 13, another example intake manifold 60 is shown and includes an inlet 62 that is subdivided into different inlet portions 66. The manifold 60 includes a housing 68 that defines a plurality of separate passages 74 that extend from the inlet 62 to the outlet 64. The passages 74 define a single unitary smoothly curved passage that reduces pressure losses. The inlet 62 includes separate inlet portions 66 and the outlet 64 includes separate outlet portions 72. The example housing 68 including the inlet 62 and the outlet 64 is a single unitary structure without seams or joints between different portions.

[0036] In this example, the outlet 64 includes flanges 70. The flanges 70 are attached to the intake manifold 60 and enable securement to the plates 16 or to supporting structures utilized to support the heat exchanger 60 in operation. The flanges 70 are shown as a separate feature from the housing 68, but also may be an integrally formed as a portion of the housing 68.

[0037] Referring to Figure 14, a method of creating one of the disclosed manifolds 12, 14 and 60 includes a casting operation where a core assembly 76 is utilized to define each of the individual flow splitter passages 38 (Figure 4). In this example, the core assembly 76 includes a plurality of passage defining structures 78A-F. Each of the passage defining structures 78A-F includes an inlet portion 80A-F and an outlet portion 82A-F.

[0038] The core assembly 76 is inserted into a mold 84 that defines a cavity 86. The cavity 86 defines outer surface features of a completed intake manifold. During operation, a casting material 88 is injected into the mold 84 and filled around the core assembly 76 to define the completed part. The cast part is then removed from the mold 84. The core assembly 76 is than removed according to known procedure and processes to provide a completed intake manifold 90. Additional finishing steps may be required to finalize the intake manifold 90 such as for example, polishing, machining, coating and other finishing processes as are known. Additionally, flange 70 may be added if not part of the cast manifold 90.

[0039] The example disclosed manifolds includes features to limit pressure losses and improve thermal transfer efficiencies. Moreover, each of the manifolds includes features that enable airflow velocities to be increased to improve thermal transfer efficiencies.

[0040] 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 plurality of flow passages (18) in thermal contact with a cooling flow (24), the plurality of flow passages (18) including a first end (32) and a second end (34);
   an inlet manifold (12; 60) at the first end (32) of the plurality of flow passages (18), the inlet manifold (12; 60) including a plurality of independent splitter passages (38; 74) that communicate airflow (22) to the first end (32) of the plurality of flow passages (18); and
   an exhaust manifold (14) at the second end (34) of the plurality of flow passages (18).

2. The heat exchanger (10) as recited in claim 1, wherein each of the plurality of splitter passages (38; 74) includes a flow volume between an inlet (25; 26; 27; 62) of the inlet manifold (12; 60) and an outlet (40; 64) of the inlet manifold (12; 60) into the first end (32) of the plurality of passages (18) that are the same.

3. The heat exchanger (10) as recited in claim 2, wherein a ratio between an area (46) of the inlet (25; 26; 27; 62) and an area (48) of an outlet (44) of each of the plurality of splitter passages (38; 74) is between 1.5 and 5.

4. The heat exchanger (10) as recited in claim 2 or 3, wherein the inlet (25; 26; 27; 62) comprises a circular shape in cross-section and is divided into passage inlets (41; 42; 43) of equal area that correspond with each of the plurality of splitter passages (38; 74).

5. The heat exchanger (10) as recited in claim 4, wherein each of the passage inlets (41; 42; 43) are pie-shaped or curvilinear-shaped in cross-section.

6. The heat exchanger (10) as recited in any of claims 2 to 5, wherein the outlet (40; 64) comprises a rectangular shape in cross-section and is divided into passage outlets (44; 72) of equal area that correspond with the plurality of splitter passages (38; 74).

7. The heat exchanger (10) as recited in claim 6, wherein each of the passage outlets (44; 72) is in communication with more than one of the plurality of flow passages (18).

8. The heat exchanger (10) as recited in any of claims 2 to 7, wherein each of the plurality of splitter passages (38; 74) comprises a smooth curved passage (50) without interruption between the inlet (25; 26; 27; 62) and the outlet (40; 64).

9. The heat exchanger (10) as recited in any preceding claim, wherein the exhaust manifold (14) includes an inlet portion at the second end (34) of the plurality of flow passages (18) and an outlet portion (28), and the exhaust manifold (14) includes a plurality of exhaust passages (56) between the inlet portion and the outlet portion (28).

10. The heat exchanger (10) as recited in claim 9, wherein the inlet portion is divided into a plurality of rectangular inlets (54) corresponding with the second end (34) of the plurality of flow passages (18).

11. The heat exchanger (10) as recited in claim 9 or 10, wherein the outlet portion (28) comprises a plurality of outlets (58) having a pie-shaped cross-section or a curvilinear shaped cross-section.

12. A method of forming a manifold (12; 14; 60) for a heat exchanger (10) comprising:

    creating a plurality of core sections (78A-F) that define a passageway (38; 56; 74) between an inlet (25; 26; 27; 62) and an outlet (28; 40; 64), wherein an inlet area for each of the plurality of core sections (78A-F) are the same and an outlet area for each of the pluralilty of core sections (78A-F) are the same;
    defining a mold cavity (86) to receive the core sections (78A-F) that defines an outer shape of the manifold (12; 14; 60);
    molding the plurality of core sections (78A-F) within the mold cavity (86) to encase the core sections (78A-F) within a casting material (88); and
    removing the core sections (78A-F) from the casting material (88).

13. The method as recited in claim 12, wherein each of the core sections (78A-F) defines an area ratio between the inlet (25; 26; 27; 62) and the outlet (28; 40; 64) of between 1.5 and 5.

14. The method as recited in claim 12 or 13, wherein:

    the core sections (78A-F) define the inlet (25; 26; 27; 62) as pie-shaped or a curvilinear shape in cross-section; and/or
    each of the core sections (78A-F) define a smooth curved passage (50) without interruption between the inlet (25; 26; 27; 62) and the outlet (28; 40; 64).

15. The method as recited in any of claims 12 to 14, wherein:

    the plurality of core sections (78A-F) together define a circular inlet (25; 26; 27; 62) in cross-section; and/or

the plurality of core sections (78A-F) together define a substantially rectangular outlet in cross-section.

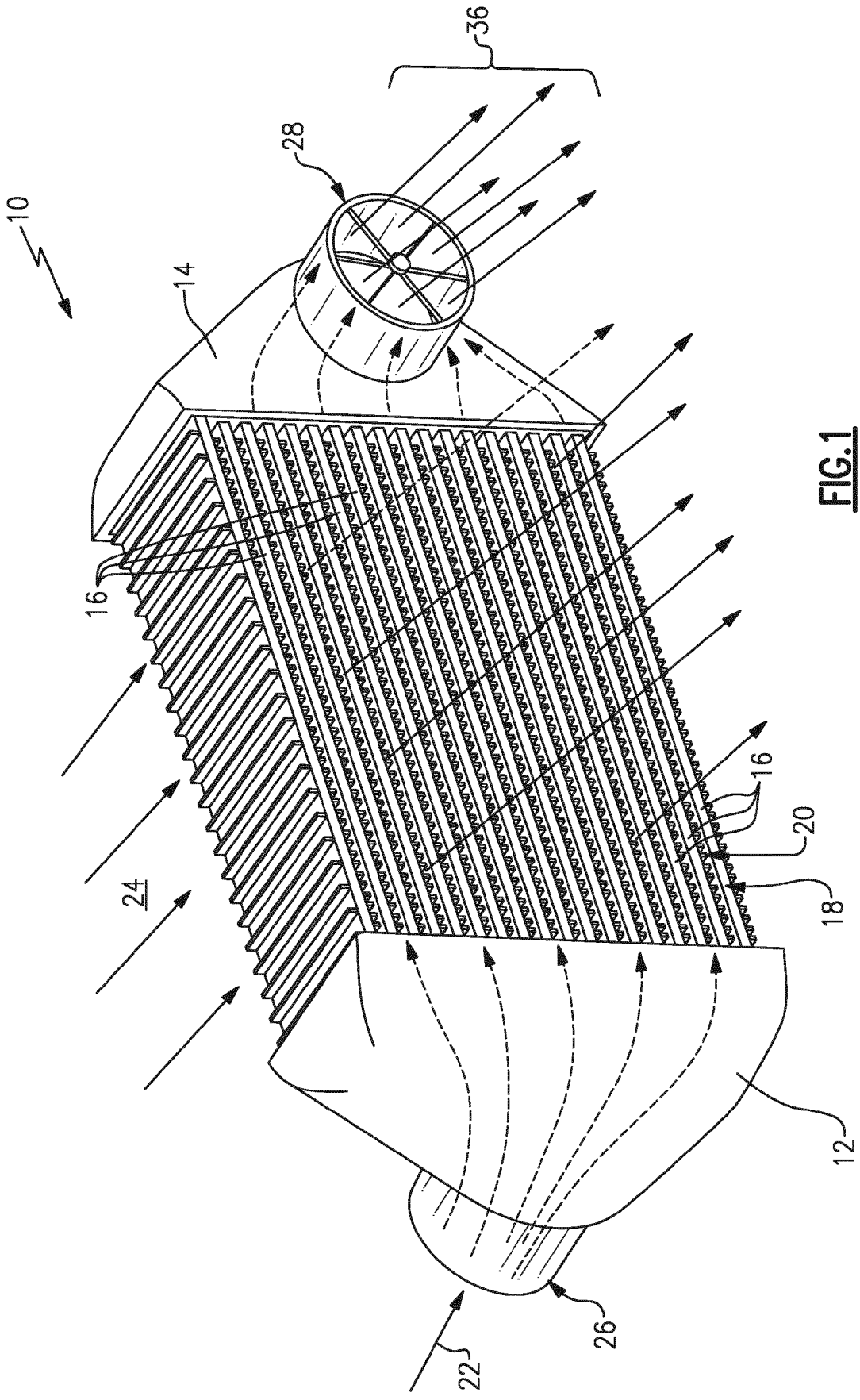


FIG.1

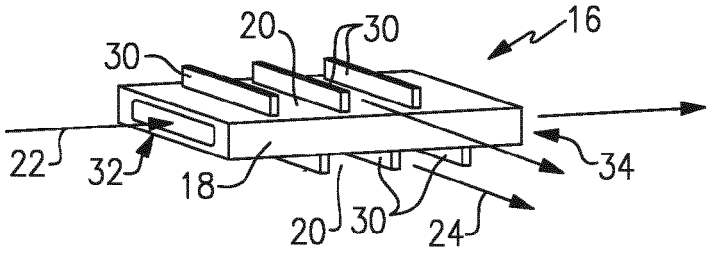


FIG.2

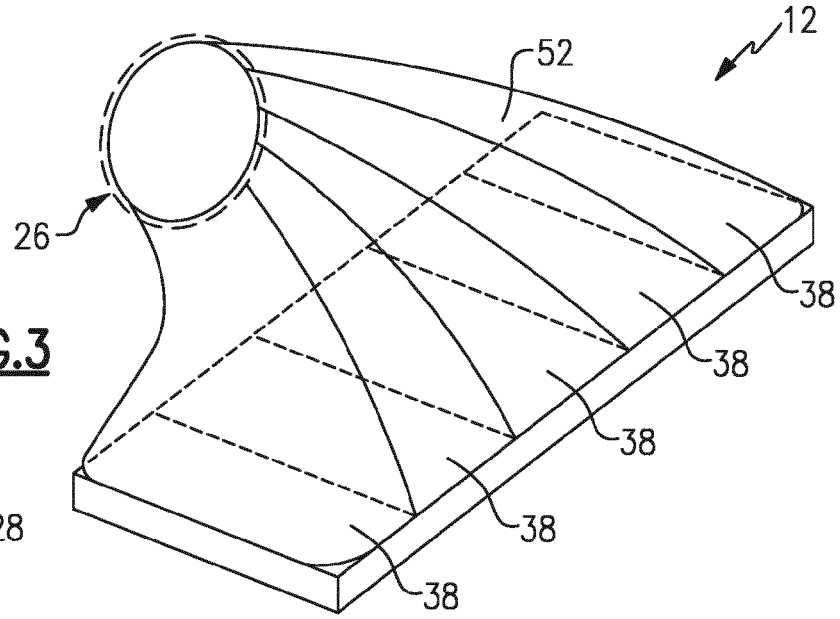


FIG.3

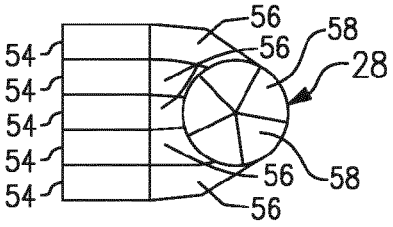


FIG.7

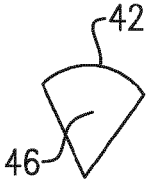


FIG.6

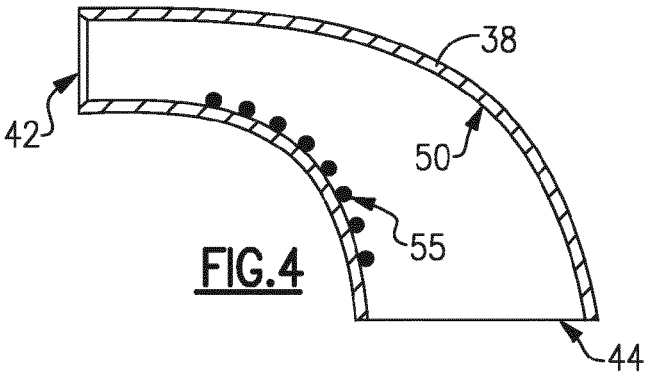
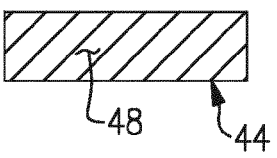


FIG.4

FIG.5



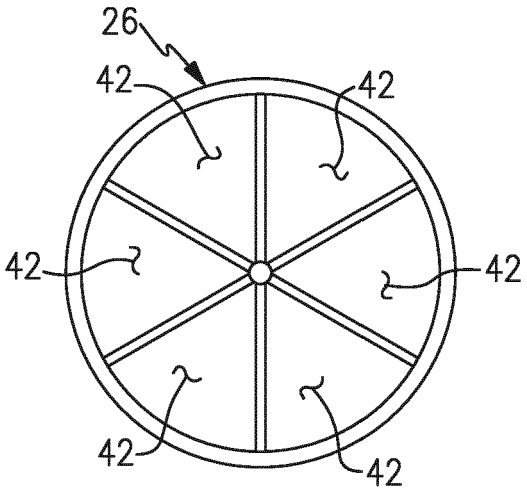


FIG.8

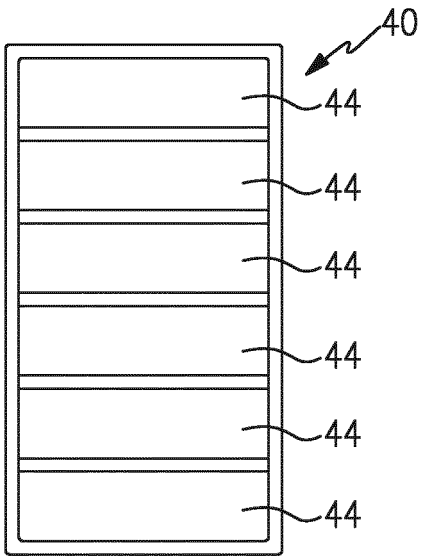


FIG.9

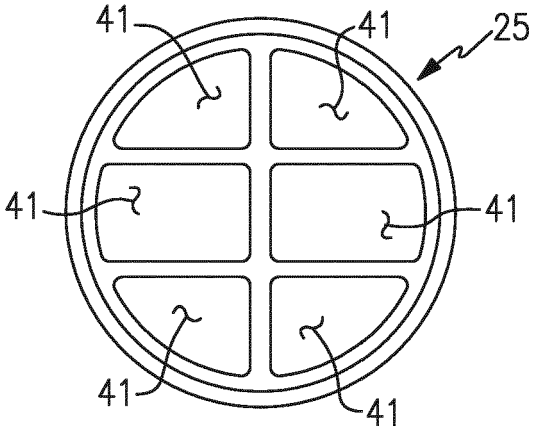


FIG.10

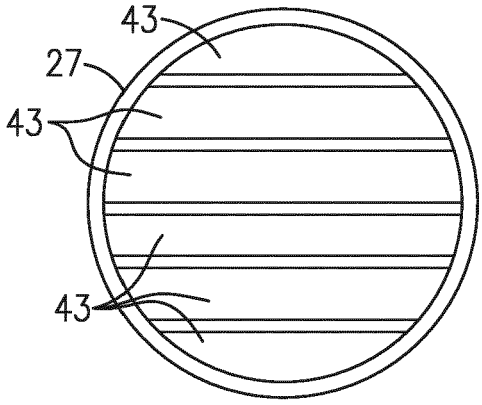


FIG.11

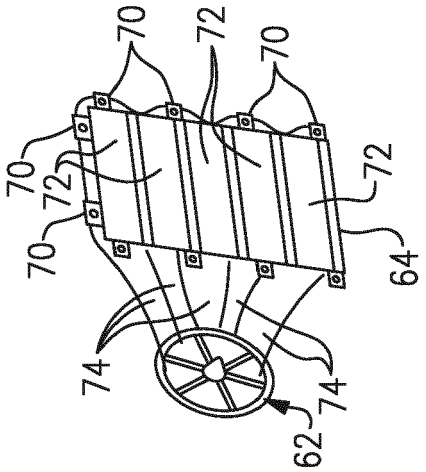

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FIG.13

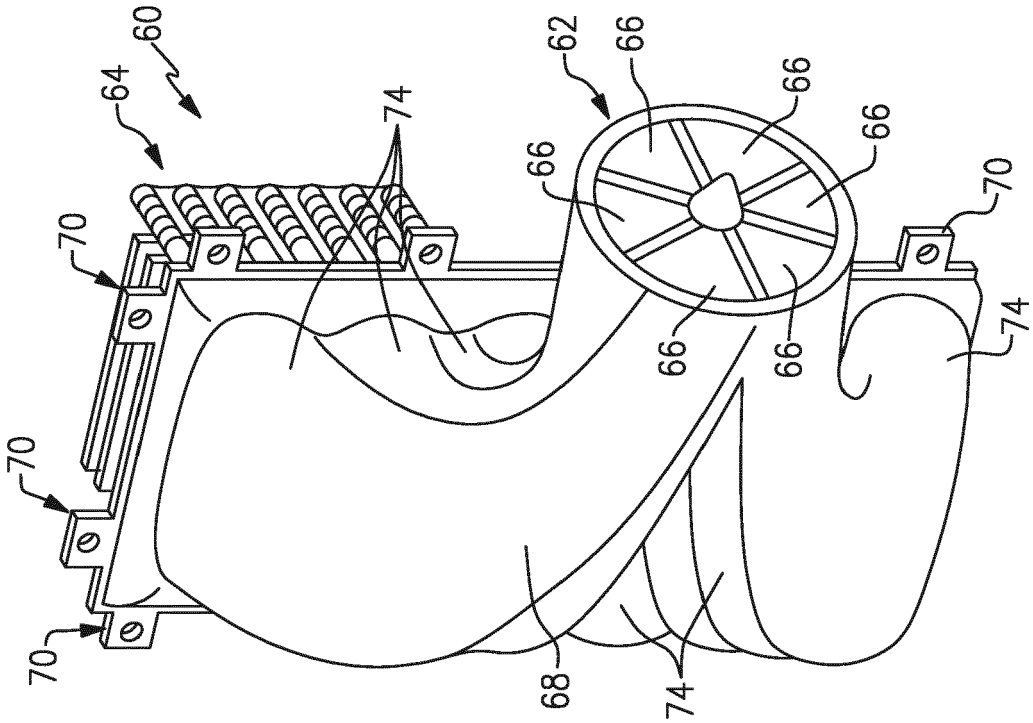
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FIG.12

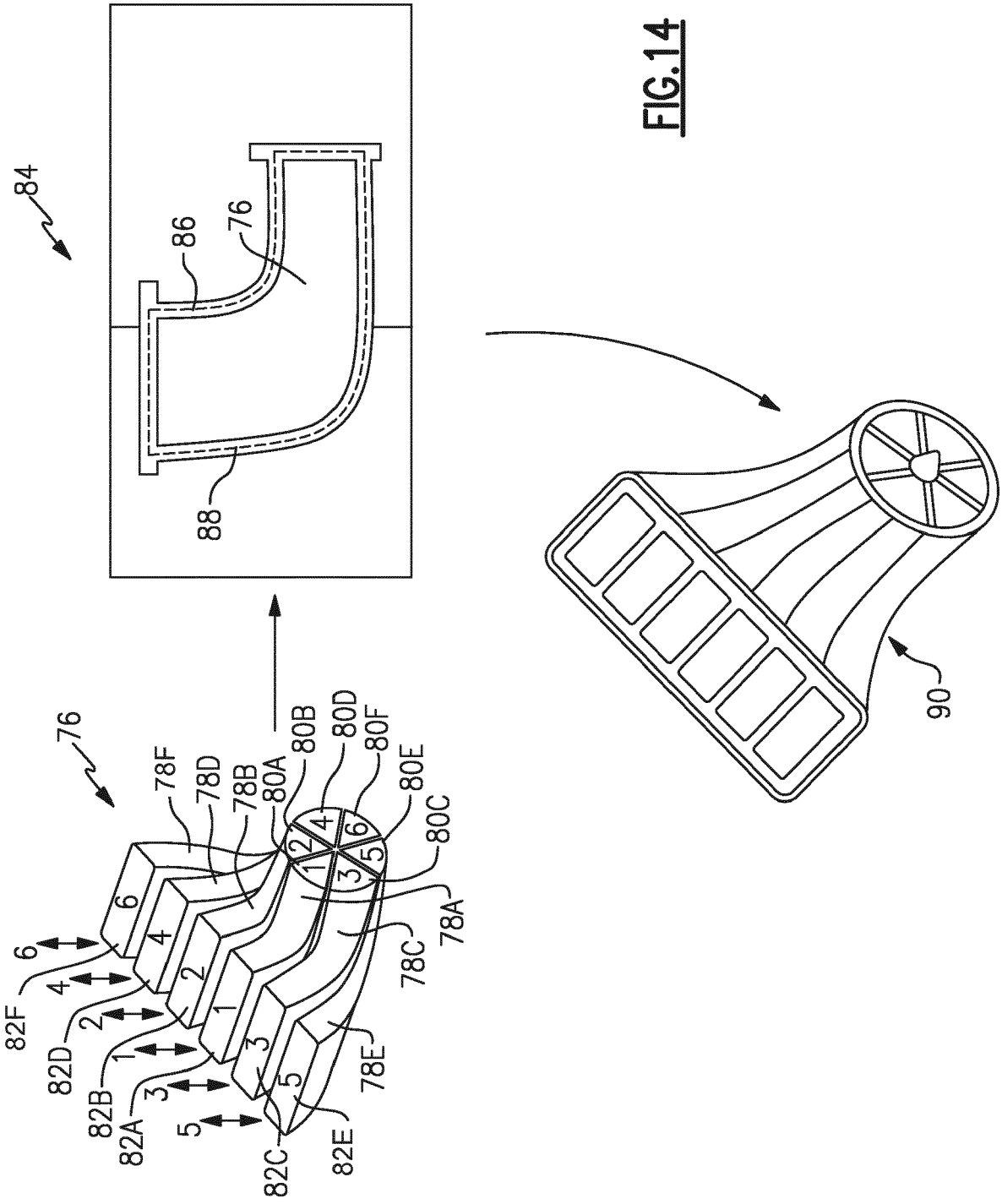
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FIG.14

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EUROPEAN SEARCH REPORT

Application Number
EP 18 20 9933

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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A	* paragraph [0012] - paragraph [0023]; figures 1-8 *	12-15	F28D1/053
X	WO 99/11421 A1 (TRANSPRO INC [US]) 11 March 1999 (1999-03-11) * page 8, line 18 - page 10, line 17; figures 8-10 *	12-15	
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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	10 April 2019	Jessen, Flemming

CATEGORY OF CITED DOCUMENTS

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10-04-2019

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