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

(11) EP 3 499 170 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
19.06.2019 Bulletin 2019/25

(21) Application number: **18209929.1**

(22) Date of filing: **03.12.2018**

(51) Int Cl.:
F28F 9/02 *(2006.01)* ***F28F 9/16*** *(2006.01)*
F28F 1/02 *(2006.01)* ***F28F 1/26*** *(2006.01)*
F28D 9/00 *(2006.01)* ***F28D 21/00*** *(2006.01)*

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

(30) Priority: **01.12.2017 US 201762593402 P**

(71) Applicant: **United Technologies Corporation**
Farmington, CT 06032 (US)

(72) Inventor: **McCAFFREY, Michael G.**
Windsor, CT Connecticut 06095 (US)

(74) Representative: **Dehns**
St. Brides House
10 Salisbury Square
London EC4Y 8JD (GB)

(54) HEAT EXCHANGER BELL MOUTH INLET

(57) A heat exchanger (10) includes at least one passage defining a flow path for airflow (28). A manifold (15; 20) includes a transition region (16; 22) including at least two rib portions defining a smoothly curved transition surface into the at least one passage.

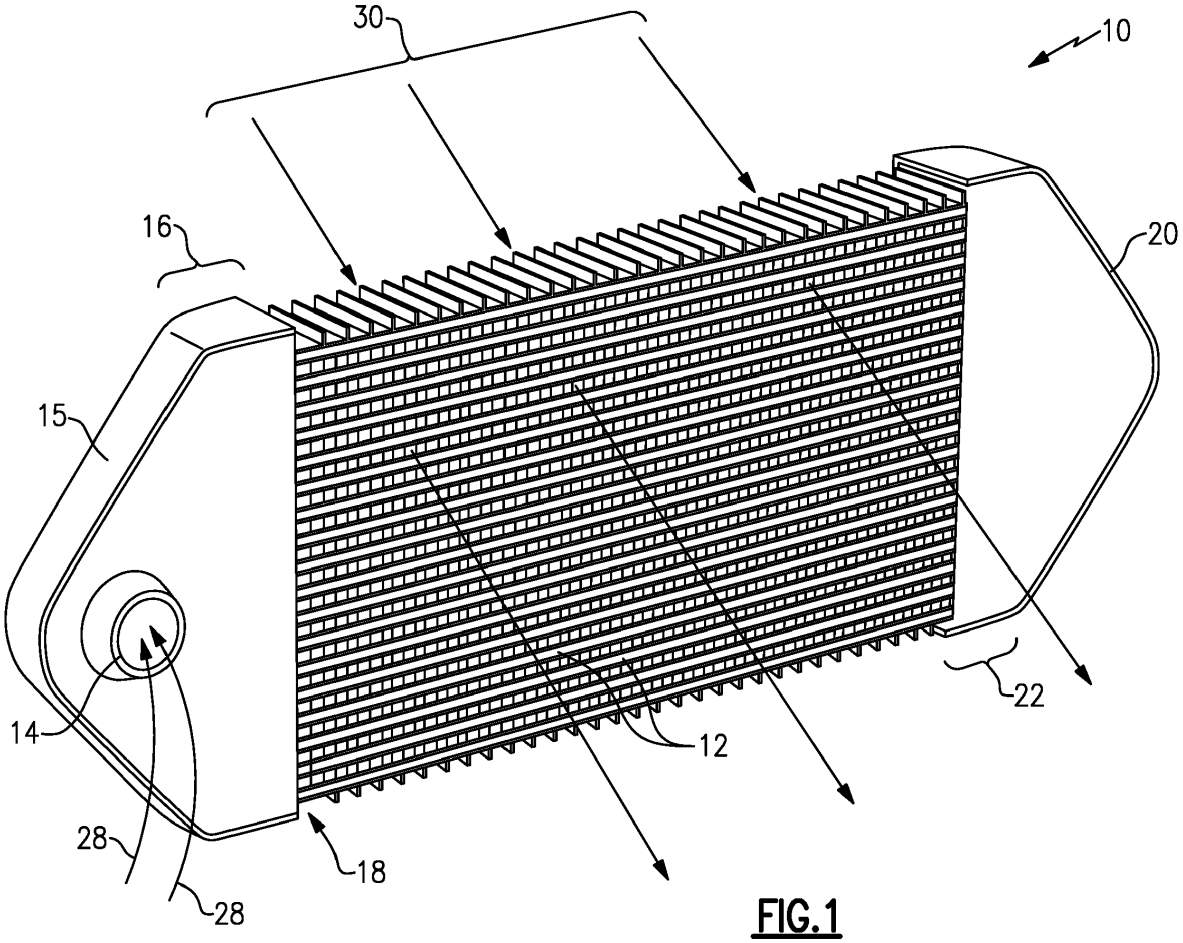

FIG.1

EP 3 499 170 A1

Description

BACKGROUND

[0001] A plate and fin heat exchanger includes alternating layers of passages formed by flat sheet metal material and corrugated preformed structures. The entire structure is brazed together to form a unitary brazed assembly. Inlet and outlet openings typically are blunt shaped and can create significant pressure losses as airflow transitions from large spaces within an inlet manifold into the much smaller passages defined by the preformed structures or plates. Similarly, airflow exiting the heat exchanger is subject to pressure losses due to undefined transition from the passages to an open area of a manifold.

[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 one aspect, a heat exchanger includes at least one passage defining a flow path for airflow. A manifold includes a transition region including at least two rib portions defining a smoothly curved transition surface into the at least one passage.

[0005] In an embodiment according to the above, the manifold includes a housing with an inlet opening and the transition region is adjacent the at least one passage.

[0006] In another embodiment according to any of the above, the at least two rib portions extend across the transition region of the manifold.

[0007] In another embodiment according to any of the above, the at least two rib portions include a support portion supporting the at least one passage.

[0008] In another embodiment according to any of the above, a plate defining the at least one passage, the plate abutted against the support portion of the at least two rib portions so as to continue the smoothly curved transition surface through the at least one passage.

[0009] In another embodiment according to any of the above, a seal disposed between the plate and the at least two rib portions.

[0010] In another embodiment according to any of the above, the plate includes a unitary part without joints.

[0011] In another embodiment according to any of the above, the smoothly curved transition surface includes a bell mouth shape.

[0012] In another embodiment according to any of the above, a plurality of passages for airflow and the manifold includes an inlet manifold at one end of the plurality of passages and an outlet manifold at an opposite end of the plurality of passages.

[0013] In another aspect, a heat exchanger includes at least two plates defining a first flow passage. The at least two plates include an inlet region. The inlet region includes a smoothly curved transition region. A manifold includes an inlet opening and a transition region supporting the at least two plates.

[0014] In an embodiment according to the above, the plate includes a first end portion spaced apart from a second end portion. A cavity defines a first flow path between the first end portion and the second end portion. An outer surface portion defines a second flow path. The plate includes a single unitary part without a joint between any two portions.

[0015] In another embodiment according to any of the above, each of the first end portion and the second end portion include the smoothly curved transition region.

[0016] In another embodiment according to any of the above, the at least two plates includes a plurality of plates stacked atop each other and supported within the transition region of the manifold.

[0017] In another embodiment according to any of the above, the manifold includes a first manifold at an inlet end of the at least two plates and a second manifold at the outlet end of the at least two plates.

[0018] In another embodiment according to any of the above, the smoothly curved transition surface includes a bell mouth shape.

[0019] In yet another aspect, a method of assembling a heat exchanger includes defining a manifold to include a plurality of ribs extending across a transition region. Each of the plurality of ribs include a smoothly curved transition surface. A plate defining an airflow passage is inserted between two of the plurality of ribs to hold the plates within the transition region and define a smoothly curved transition surface into the airflow passage.

[0020] In an embodiment according to the above, inserting a seal between an end of the plate and at least two ribs.

[0021] In another embodiment according to any of the above, the manifold includes an inlet manifold and an outlet manifold and the method includes inserting the plate into both the inlet manifold to define an inlet transition surface into the airflow passage and the outlet manifold to define an outlet transition surface for airflow exiting the airflow passage.

[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 perspective view of an example heat exchanger embodiment.

Figure 2 is a cut away view of the example heat exchanger embodiment.

Figure 3 is a sectional cut away view of a portion of the example heat exchanger.

Figure 4 is a cross sectional view of a portion of the heat exchanger.

Figure 5 is a perspective view of an example plate embodiment.

Figure 6 is a perspective view of another example plate embodiment.

Figure 7 is a partial sectional view of a portion of another heat exchanger embodiment.

Figure 8 is a cross sectional view of the heat exchanger embodiment illustrated in Figure 7.

DETAILED DESCRIPTION

[0025] Referring to Figures 1 and 2, an example heat exchanger 10 includes an inlet manifold 15 and an outlet or exhaust manifold 20. The inlet manifold 15 includes an inlet 14 for a first airflow 28. The inlet manifold 15 and the outlet manifold 20 are disposed on the ends of a plurality of plates 12. The plates 12 define an airflow passage between the inlet 14 and an outlet 24. The plates 12 also define a plurality of passages for a cooling airflow 30 that passes through channels defined by the plurality of plates 12.

[0026] The inlet manifold 15 includes a transition region 16 defining an opening or series of openings 18 at the end of the manifold 15 that receives the plates 12 and where airflow schematically indicated at 28 is dispersed and transitions into the airflow passages defined by the plates 12. The outlet manifold 20 includes a similar transition region 22 where airflow exiting the passages defined within the plates 12 transition towards the outlet 24.

[0027] The example heat exchanger 10 is an air to air heat exchanger where a hot airflow indicated at 28 is injected through the inlet 14 and flows through passages within the plates 12 towards the exhaust manifold 20. Airflow exhausted through the outlet 24 as is indicated at 32 is cooled to a desired temperature. A cooling airflow schematically indicated at 30 flows through the passages defined between the plates 12 by channels between fins. The airflow through the inlet 14 is desired to maintain a desired pressure and avoid excessive pressure losses. Accordingly, the transition region 16 includes features to improve flow into the cooling passages in a more controlled and less turbulent manner to reduce pressure losses that can degrade thermal transfer efficiencies. By controlling transition of airflow into the passages defined by the plates 12, the pressure losses produced through this transition region can be significantly reduced.

[0028] Referring to Figure 3 with continued references to Figures 1 and 2, the example intake manifold 15 is shown in an enlarged cross sectional view. The example intake manifold 10 includes a plurality of ribs 36 that extend from a first wall 34 shown in Figure 3 to a second wall not shown in Figure 3. Each of the ribs 36 include a smoothly curved transition surface 40. The ribs 36 further include a support portion 42. Each of the plates 12 are supported between two of the ribs 36 such that the smoothly curved transition surface indicated at 40 is disposed above and below each intake passage of each plate 12. The smooth surfaces 40 define a bell mouth shape forward of the inlet to the plate 12 that improves flow properties into the flow passage.

[0029] In this example, the plate 12 defines a first flow passage 44 through the plate 12 and a second flow passage 46 that flows over an outer surface of the plate 12 between fins 56. As appreciated, the fins 56 cooperate with fins 56 in an adjacent plate 12 to define channels through which the cooling airflow 30 flows.

[0030] Referring to Figures 4 and 5 with continued reference to Figure 3, each of the plates 26 are trapped between at least two of the ribs 36. In the cross section illustrated in Figure 4, a first plate 26A is trapped between rib 36A and 36B. A portion of a second plate 26B is also illustrated and trapped between the rib 36B and 36C.

[0031] The example plate 26 is shown in perspective view includes a first end 52 and a second end 54. The first end 52 defines an inlet 48 that leads to the first flow passage 44. The outer surface includes the fins 56 that define the second airflow passage 46 for the cooling airflow that flows perpendicular to the hot airflow communicated through the intake manifold 15. A seal 50 is disposed between each of the plates 26A, 26B and 26C and the corresponding ribs 36A, 36B and 36C.

[0032] Each of the ribs includes the support portion 42 that accepts the first end portion 52 of a corresponding plate 26. By defining the ribs 36 within the intake manifold transition region 16 and providing the ribs 36 with the smooth curved transition portions 40, the bell mouth is created forward of the inlet to the plates 26 to provide a more uniform and smooth transition of airflow from the manifold into each of the corresponding first passages 44.

[0033] Referring to Figures 6, 7 and 8, another example heat exchanger 60 is illustrated and includes a plurality of plates 64 that are stacked atop each other and that are in communication with a transition region 66 of an intake manifold 62. Each of the plates 64 includes fins 70 that are disposed within the cooling air flow. As appreciated, the example manifold is shown by way of an example and only the intake manifold 62 is illustrated. A corresponding exhaust manifold would be provided at the exit end of each of the plurality of plates 64 in a similar

arrangement to that of the intake manifold 62.

[0034] In this example, each of the plates 64 include a bell mouth surface 68. The bell mouth surfaces 68 mate to one another to define a smoothly curved surface that transitions airflow into the air passages through the plates 64. In this embodiment, the manifold 62 is not required to have a plurality of ribs. Instead, each of the plates 64 include features that define the bell mouth shape that provide the smooth transition of airflow from the manifold into the airflow passage defined through the plates.

[0035] In the disclosed example embodiments, the plates 26 and 64 are one piece unitary structures that are cast as a one piece item that do not include joints between any of the portions. The unitary structure of the plate eliminates the need for welded or brazed joints that can cause problems during operation or that may be susceptible to mechanical strains and stresses caused by extreme thermal gradients.

[0036] The example heat exchanger manifold includes features that tailor airflow and transition that airflow through the plates to enable higher pressure capabilities that in turn increase the overall efficiency of the heat exchanger to enable use and higher temperature and pressure applications.

[0037] 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:

   at least one passage (44) defining a flow path for airflow (28); and
   a manifold (15;20) including a transition region (16;22) including at least two rib portions (36) defining a smoothly curved transition surface (40) into the at least one passage (44).

2. The heat exchanger (10) as recited in claim 1, wherein the manifold (15) includes a housing with an inlet opening (14) and the transition region (16) is adjacent the at least one passage (44).

3. The heat exchanger (10) as recited in claim 1 or 2, wherein the at least two rib portions (36) extend across the transition region (16;22) of the manifold (15;20).

4. The heat exchanger (10) as recited in any preceding claim, wherein the at least two rib portions (36) include a support portion (42) supporting the at least one passage (44).

5. The heat exchanger (10) as recited in claim 4, including a plate (12;26) defining the at least one passage (44), the plate (12;26) abutted against the support portion (42) of the at least two rib portions (36) so as to continue the smoothly curved transition surface (40) through the at least one passage (44).

6. The heat exchanger (10) as recited in claim 5, including a seal (50) disposed between the plate (12;26) and the at least two rib portions (36).

7. The heat exchanger (10) as recited in claim 5 or 6, wherein the plate (12;26) comprises a unitary part without joints.

8. The heat exchanger (10) as recited in any preceding claim, including a plurality of passages (44) for airflow and the manifold (15;20) comprises an inlet manifold (15) at one end of the plurality of passages (44) and an outlet manifold (20) at an opposite end of the plurality of passages (44).

9. A heat exchanger (60) comprising:

   at least two plates (64) defining a first flow passage, the at least two plates (64) including an inlet region comprising a smoothly curved transition surface (68); and
   a manifold (62) including an inlet opening and a transition region (66) supporting the at least two plates (64).

10. The heat exchanger (60) as recited in claim 9, wherein each plate (64) comprises a first end portion spaced apart from a second end portion, a cavity defining a first flow path between the first end portion and the second end portion, and an outer surface portion defining a second flow path, and the plate (64) comprises a single unitary part without a joint between any two portions, wherein each of the first end portion and the second end portion optionally includes the smoothly curved transition surface (68).

11. The heat exchanger (60) as recited in claim 9 or 10, wherein:

    the at least two plates (64) comprises a plurality of plates (64) stacked atop each other and supported within the transition region (66) of the manifold (62); and/or
    the manifold (62) comprises a first manifold (62) at an inlet end of the at least two plates (64) and a second manifold at an outlet end of the at least two plates (64).

12. The heat exchanger (60) as recited in any preceding claim, wherein the smoothly curved transition surface (40,68) comprises a bell mouth shape.

13. A method of assembling a heat exchanger (10) comprising:

defining a manifold (15;20) to include a plurality of ribs (36) extending across a transition region (16;22), each of the plurality of ribs (36) including a smoothly curved transition surface (40); and
inserting a plate (12;26) defining an airflow passage (44) between two of the plurality of ribs (36) to hold the plates (12;26) within the transition region (16;22) and define a smoothly curved transition surface (40) into the airflow passage (44).

14. The method as recited in claim 13, including inserting a seal (50) between an end of the plate (12; 26) and at least two ribs (36).

15. The method as recited in claim 13 or 14, wherein the manifold (15; 20) comprises an inlet manifold (15) and an outlet manifold (20) and the method includes inserting the plate (12; 26) into both the inlet manifold (15) to define an inlet transition surface (40) into the airflow passage (44) and the outlet manifold (20) to define an outlet transition surface for airflow (32) exiting the airflow passage (44).

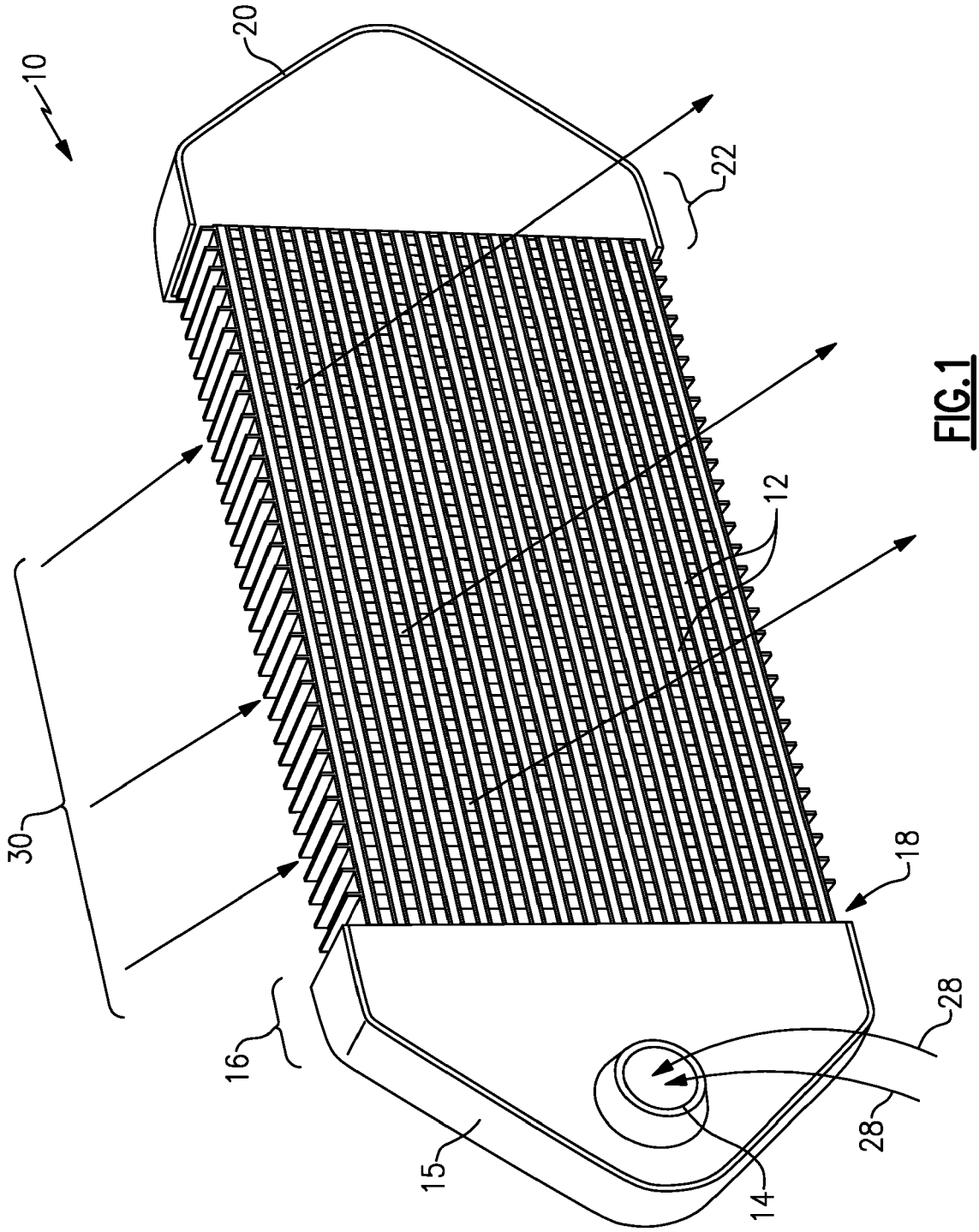

FIG.1

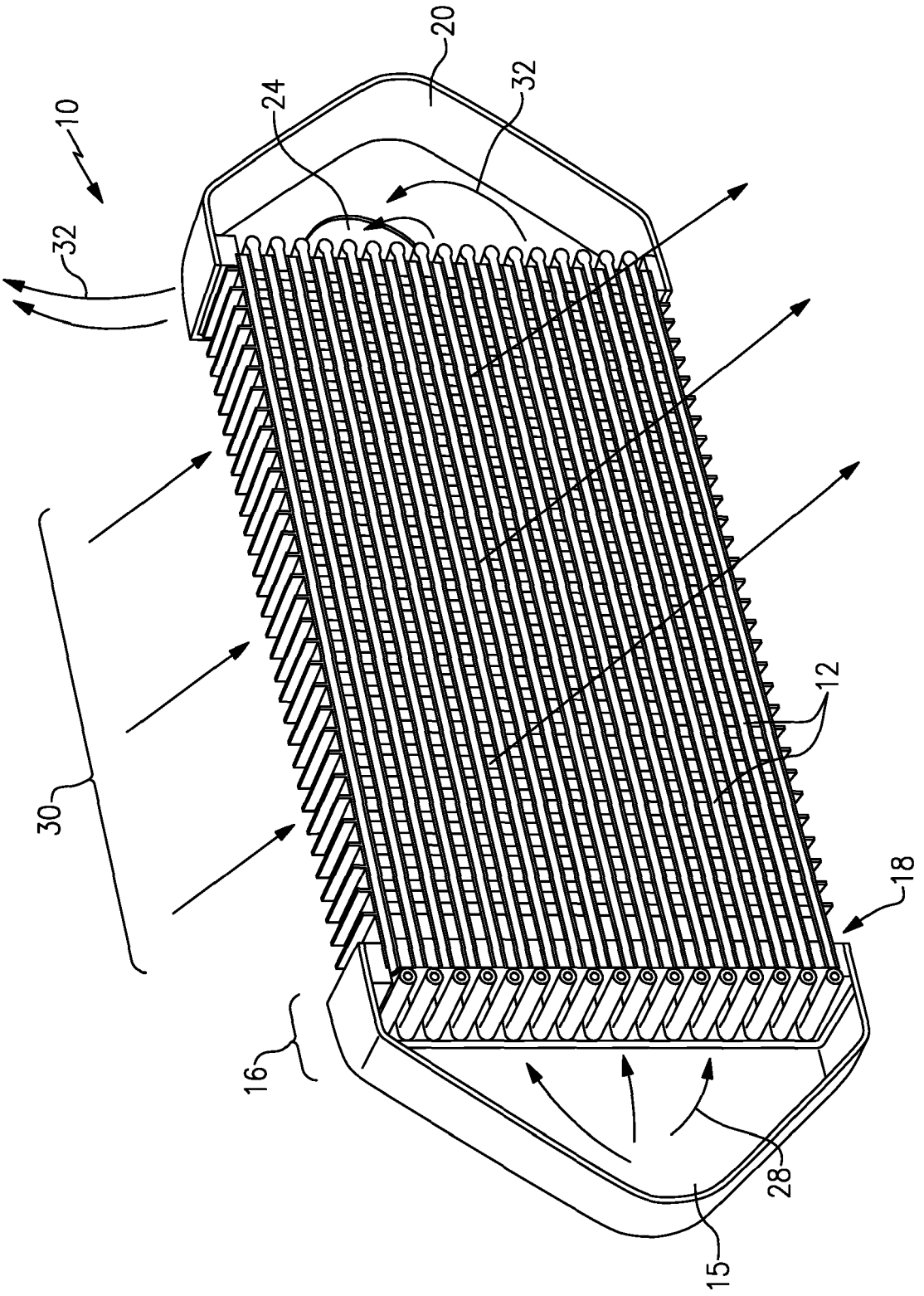

FIG.2

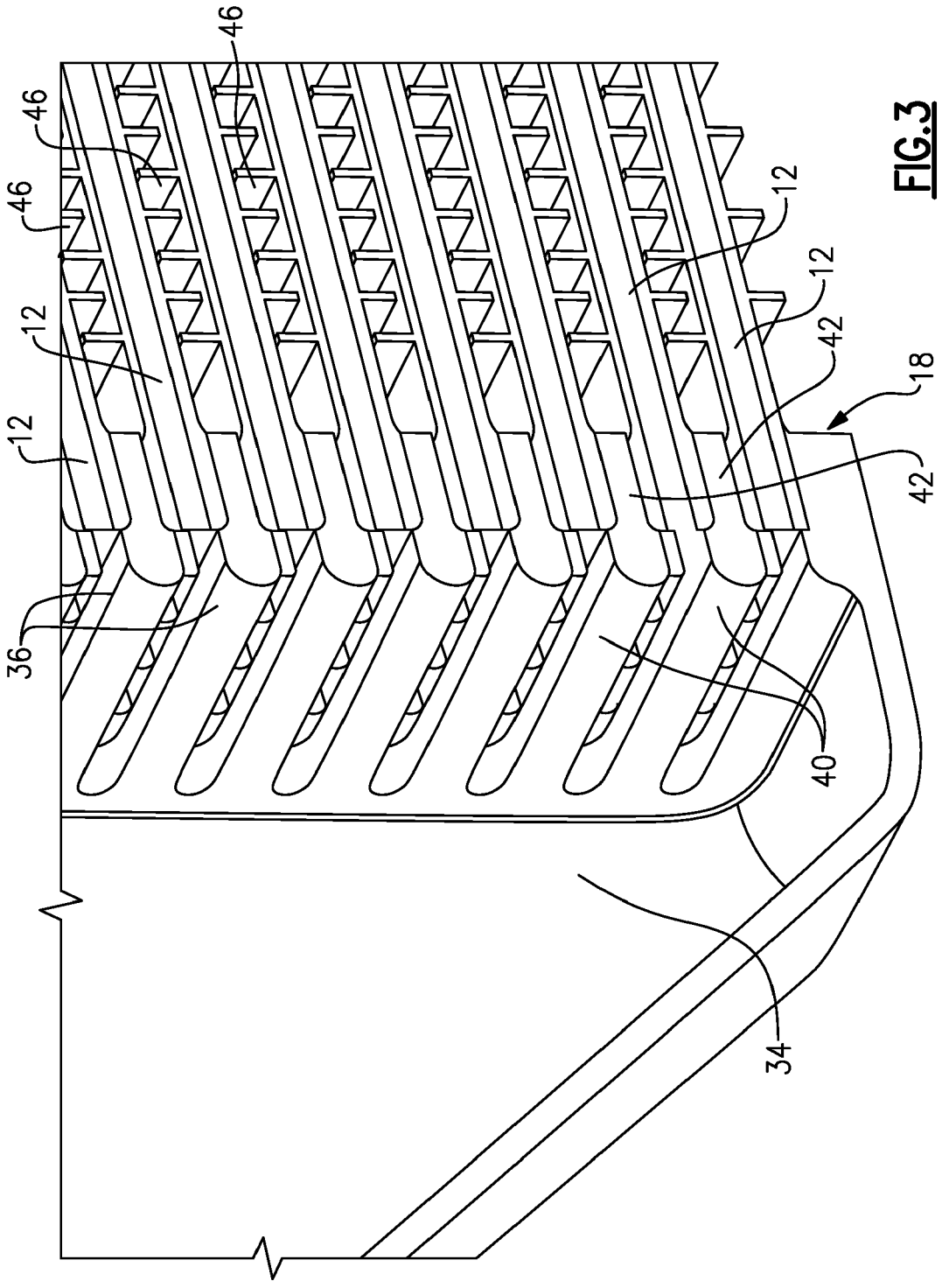

FIG.3

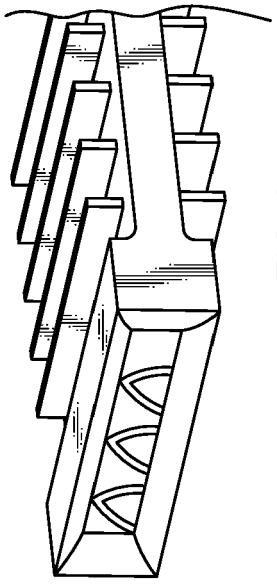

FIG.6

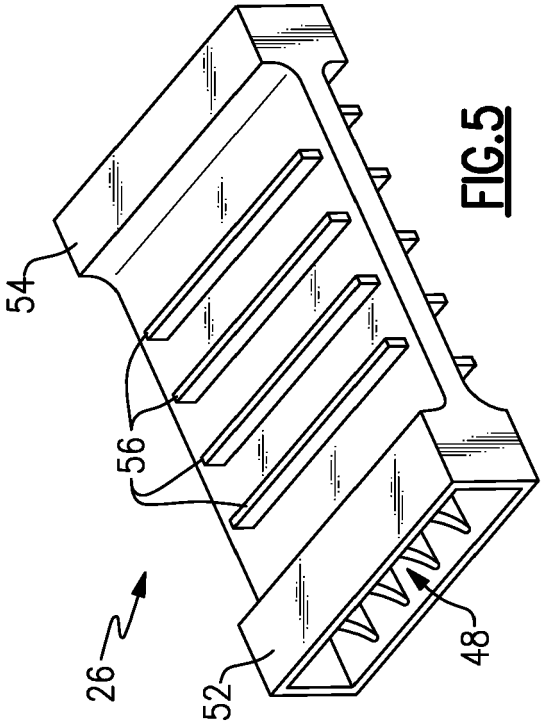

FIG.5

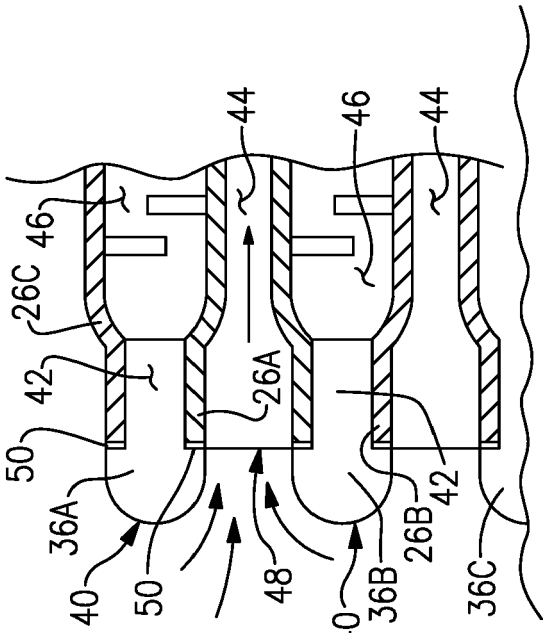

FIG.4

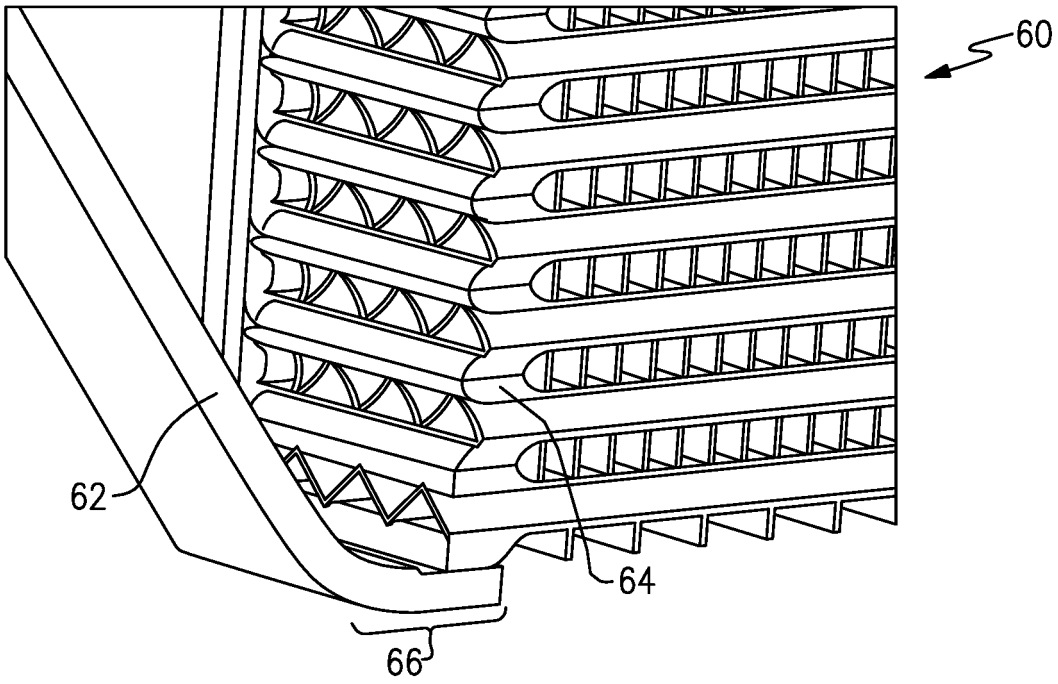

FIG.7

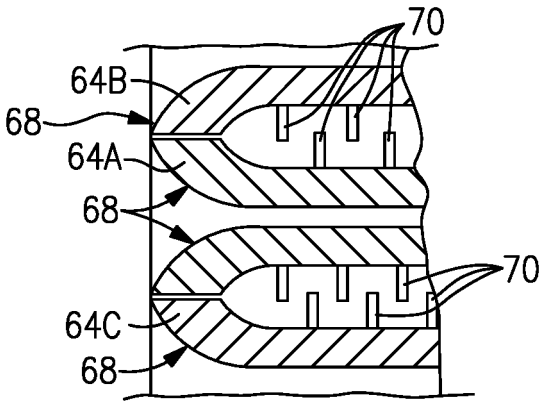

FIG.8

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 18 20 9929

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 20 2004 011489 U1 (AUTOKUEHLER GMBH & CO KG [DE]) 8 December 2005 (2005-12-08) * the whole document *	1-15	INV. F28F9/02 F28F9/16 F28F1/02 F28F1/26 F28D9/00 F28D21/00
X	WO 2006/102736 A1 (DANA CANADA CORP [CA]; MARTIN MICHAEL A [CA]; WU ALAN K [CA]) 5 October 2006 (2006-10-05) * the whole document *	1-15	
A	WO 2014/176194 A1 (CATERPILLAR INC [US]) 30 October 2014 (2014-10-30) * the whole document *	1-5, 7-13,15	
A	DE 10 2004 012358 A1 (PORSCHE AG [DE]) 29 September 2005 (2005-09-29) * the whole document *	1-3,8,9, 12	

TECHNICAL FIELDS SEARCHED (IPC)

F28F
F28D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	6 May 2019	Bloch, Gregor

CATEGORY OF CITED DOCUMENTS

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

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

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 20 9929

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

06-05-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 202004011489 U1	08-12-2005	NONE	
WO 2006102736 A1	05-10-2006	CA 2503424 A1	01-10-2006
		CN 101184972 A	21-05-2008
		EP 1869389 A1	26-12-2007
		WO 2006102736 A1	05-10-2006
WO 2014176194 A1	30-10-2014	CN 104110997 A	22-10-2014
		WO 2014176194 A1	30-10-2014
DE 102004012358 A1	29-09-2005	DE 102004012358 A1	29-09-2005
		EP 1574802 A2	14-09-2005

EPO FORM P0459

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