

(19)



(11)

EP 3 567 332 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

13.11.2019 Bulletin 2019/46

(51) Int Cl.:

F28F 9/02 ^(2006.01)

F28F 13/06 ^(2006.01)

F28F 13/12 ^(2006.01)

(21) Application number: **19173305.4**

(22) Date of filing: **08.05.2019**

(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

(72) Inventors:

- **ANDERSON, Corey D.**
East Hartford, Connecticut 06118 (US)
- **STYBORSKI, Jeremy**
East Hartford, Connecticut 06118 (US)
- **CURTIS, Lauryn M.**
Manchester, Connecticut 06042 (US)

(30) Priority: **08.05.2018 US 201815973709**

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

(74) Representative: **Dehns**

St. Bride's House
10 Salisbury Square
London EC4Y 8JD (GB)

(54) **SWIRLING FEED TUBE FOR HEAT EXCHANGER**

(57) In a featured embodiment, a heat exchanger assembly includes an inlet manifold defining an expanding area in a direction of flow; and an inlet in flow communication with the inlet manifold, the inlet including a wall for inducing a rotational inertia to flow entering the inlet manifold.

EP 3 567 332 A1

Description

BACKGROUND

[0001] A 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. Thermal gradients present in the sheet material create stresses that can be very high in certain locations. 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 a featured embodiment, a heat exchanger assembly includes an inlet manifold defining an expanding area in a direction of flow; and an inlet in flow communication with the inlet manifold, the inlet including a wall for inducing a rotational inertia to flow entering the inlet manifold.

[0005] In another embodiment according to the previous embodiment, the inlet comprises a constant cross-sectional area over an inlet length prior to the inlet manifold.

[0006] In another embodiment according to any of the previous embodiments, the inlet comprises a pipe and the wall comprises a plurality of walls spirally arranged within the inlet length.

[0007] In another embodiment according to any of the previous embodiments, the pipe is round and includes an inner surface and the plurality of walls are disposed transverse to the inner surface.

[0008] In another embodiment according to any of the previous embodiments, the plurality of walls include a height and the height is less than a width of the pipe.

[0009] In another embodiment according to any of the previous embodiments, the plurality of walls extend across a width of the pipe and define separate channels.

[0010] In another embodiment according to any of the previous embodiments, the plurality of walls are continuous for the entire inlet length.

[0011] In another embodiment according to any of the previous embodiments, the plurality of walls are intermittently arranged for at least a portion of the inlet length.

[0012] In another embodiment according to any of the previous embodiments, a density of walls is uniform for the entire inlet length.

[0013] In another embodiment according to any of the previous embodiments, a density of walls varies within the inlet length.

[0014] In another embodiment according to any of the previous embodiments, a distance between the plurality of walls in a direction parallel to a longitudinal axis and an angle of the walls relative to the longitudinal axis and a swirl induced into the inlet flow is determined by a combination of the distance between the plurality of walls and the angle.

[0015] In another embodiment according to any of the previous embodiments, at least one of the distance between the plurality of walls and angle of the plurality of walls varies over a length of the inlet.

[0016] In another featured embodiment, a heat exchanger assembly including an inlet manifold defining an increasing flow area. A plate fin heat exchanger plate includes a first end in flow communication with the inlet manifold and including a plurality of inlet openings arranged across an inlet width. An inlet communicating flow to the inlet manifold includes a means for inducing a spiral flow for spreading flow through the inlet manifold across the inlet width.

[0017] In another embodiment according to the previous embodiment, the inlet includes a uniform cross-sectional flow area over an inlet length.

[0018] In another embodiment according to any of the previous embodiments, inlet comprises a pipe and the means for introducing a spiral inertial comprises a plurality of walls spirally arranged and extending from an interior surface of the pipe within the inlet length.

[0019] In another embodiment according to any of the previous embodiments, the plurality of walls include a height from the inner surface and the height that is less than a width of the pipe.

[0020] In another embodiment according to any of the previous embodiments, the plurality of walls extend define separate channels within the inlet.

[0021] In another featured embodiment, a method of assembling a heat exchanger assembly includes forming an inlet manifold to include an expanding flow area, attaching the inlet manifold to a plate fin heat exchanger that includes a plurality of openings disposed across an inlet width. Forming an inlet to include a constant flow area and a spiral flow inducing means; and attaching the inlet to the inlet manifold for spreading flow entering the inlet manifold across inlet width.

[0022] In another embodiment according to the previous embodiment, the spiral flow inducing means comprises a plurality walls extending inward from an inner surface that are arranged in a spiral along an inlet length.

[0023] In another embodiment according to any of the previous embodiments, at least one of a distance between the plurality of walls in a direction common with a longitudinal axis of the inlet and an angle of the plurality

of walls relative to the longitudinal axis is defined to induce a defined swirl component into the flow entering the inlet manifold.

[0024] 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.

[0025] 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

[0026]

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

Figure 2 is a front view of an example plate fin heat exchanger.

Figure 3 is a schematic view of prior art heat exchanger inlet manifold.

Figure 4 is schematic view of an example inlet manifold embodiment.

Figure 5a is a cross-section of a portion of an example inlet pipe.

Figure 5b is a cross-section of another portion of the example inlet pipe.

Figure 5c is a cross-section of another portion of the example inlet pipe.

Figure 6 is a side view of an interior of the example inlet pipe.

Figure 7 is a schematic view of another example inlet pipe embodiment.

Figure 8 is a schematic view of yet another inlet pipe embodiment.

Figure 9 is a schematic view of still another example inlet pipe embodiment.

Figure 10a is a schematic view of another example inlet pipe embodiment.

Figure 10b is a schematic view of another example inlet pipe embodiment.

Figure 10c is a schematic view of another example inlet pipe embodiment.

Figure 11a is a cross-section through a portion of another example inlet pipe embodiment.

Figure 11b is a cross-section through another portion of the example inlet pipe embodiment.

Figure 11c is a cross-sectional of another portion of an example inlet pipe embodiment.

DETAILED DESCRIPTION

[0027] Referring to Figures 1 and 2, an example heat exchanger 10 includes an inlet manifold 12 that feeds hot airflow 18 to a plate fin heat exchanger 14. The plate

fin heat exchanger 14 includes an inlet end 32 attached to the inlet manifold 12 and an outlet end 34 attached to the outlet manifold 16. The hot flow 18 is communicated through an opening 30 of an inlet pipe 22 to the inlet manifold 12 and thereby to the plate fin heat exchanger 14. A cooling airflow 20 flows over the plate fin heat exchanger 14 and accepts heat from the hot flow 18. Outgoing hot flow 18 through the exhaust outlet manifold 16 is of a cooler temperature than the hot flow 18 into the inlet manifold 12.

[0028] The plate fin heat exchanger 14 includes a plurality of internal passages schematically shown at 26 and an outer surface including a plurality of fins 24. Each of the passages 26 is in communication with the inlet end 32 that includes a plurality of openings 36. The openings 36 are disposed across an inlet width 28 that is in communication with the inlet manifold 12.

[0029] Referring to Figure 3, a typical inlet manifold 112 receives flow from an inlet pipe 122. The flow projects into the manifold 112 and does not expand uniformly toward outer areas schematically indicated at 125. Instead, the flow concentrates within a center region 116 of the manifold and the corresponding center passages 126 within a heat exchanger 114. The non-uniform distribution of flow in to the heat exchanger 114 reduces heat transfer efficiency.

[0030] Referring to Figure 4, with continued reference to Figures 1 and 2, the disclosed example inlet manifold 12 includes a first area 40 near the inlet pipe 22 and a second area 42 near the inlet end 32. The first area 40 is much smaller than the second area 42. Accordingly, the inlet manifold 12 includes an expanding cross-sectional flow area in a direction towards the plate fin heat exchanger 14 inlet end 32. The rapidly increasing flow area within the inlet manifold 12 can cause distribution problems of flow entering from the inlet pipe 22. Flow entering from the inlet pipe 22 will proceed towards the center most passages of the plate fin heat exchanger 14 potentially leaving gaps of lower flow to areas indicated schematically at 25 near the inlet end 32.

[0031] The example inlet pipe 22 includes a means for distributing flow entering the inlet manifold 12 across the entire width 28 of the inlet end 32. In one disclosed example illustrated in Figure 4, the means for distributing flow includes a plurality of walls 38 on the inner surface of the inlet pipe 22 to induce a spiral flow to the incoming flow to uniformly distribute flow along the inlet width 28.

[0032] The example inlet pipe 22 includes an inlet length 44 with a substantially constant flow area. A plurality of walls 38 that define spiral channels 56 along the inner surface within the inlet pipe 22 at least for the inlet length 44. The walls 38 are provided within the inlet length 44, but may also extend throughout the entire inlet pipe 22. The walls 38 may also be provided only within the inlet length 44. The inlet length 44 is a length that is predetermined to provide sufficient turns to induce the desired spiral component to incoming hot flow 18. The walls 38 are twisted within the inlet pipe 22 to induce a spiral

flow component inlet manifold 12. The induced spiral flow components drive flow towards the extremes of the inlet width 28 schematically indicated at 25. The mixing and distributions provided by the swirling flows provide a more uniform distribution of the hot flow 18 into the plate fin heat exchanger 14.

[0033] Referring to Figures 5a, 5b and 5c, sections of the inlet pipe 22 are illustrated for the inlet length 44 and show the twist of one wall section 46 at different positions about the circumference of the inlet pipe 22. The wall section 46 spirally winds along the inner surface of the inlet pipe 22.

[0034] Each of the walls 46 extends a height 54 from the internal surface 48. In this example the height 54 is much less than a width 52 of the inlet pipe 22. The width 52 in the disclosed example inlet 22 is a diameter of the inlet 22. The example inlet 22 is a circular pipe including a circular inner surface 48. Each of the walls 46 extend the height 54 towards the center portion of the inlet 22. In this example each of the walls 46 are disposed transversally at an angle 50 normal to the inner surface 48. It should be appreciated that the walls 46 may be disposed at an angle other than normal to provide a desired flow component into the inlet manifold 12.

[0035] Referring to Figure 6 with continued reference to Figures 5a, 5b, and 5c, circumferential spacing between the walls 46 define channels 56 for the flow 18. The spiral round channels 56 induce a spiral swirling component into the flow that carries forward through the inlet manifold 12. The spiral component to the inlet hot flow 18 drives portions of the flow toward the sides of the inlet end 32 to more uniformly distribute flow into the heat exchanger plate 14.

[0036] Referring to Figure 7, an example inlet 22' includes the example walls 46 are spaced apart to define channels 58. In this example the walls 46 are spaced the distance 58 to provide a defined density along the inlet length 44. The density of walls 46 within the inlet length 44 is provided to define a desired amount of swirl into the inlet flow.

[0037] Referring to Figure 8 another example inlet 60 is disclosed includes spacing 64 that is greater than the spacing 58 described in the previous embodiment. The increased spacing 64 illustrates a different density of walls 62 within the inlet 22 to enable tuning specific flow parameters designed to spread incoming flow across the passages 36.

[0038] Referring to Figure 9 another example inlet 68 is disclosed and includes a plurality of walls 70 that are intermittent and includes spaces 72 therebetween. The spaces 72 demonstrate that walls 70 need not be uniform or constant throughout the entire inlet length 44. The inlet pipe 68 includes intermittent walls 70 that provide the desired inducement of swirl into the incoming flow.

[0039] Referring to Figures 10a, 10b and 10c, density is also be changed by varying an angle 90 of the walls 92. The angle 90 defines the length that an individual wall 92 needs to rotate 360 degrees about the interior

wall of the inlet pipe. The space 88 between the walls 92 is a function of the angle 90 and the number of walls 92 within a length 95 of the inlet cross section. The changing angle 90 enables tailoring a swirl rate of airflow through the inlet. In the disclosed examples shown in Figures 10a-c, the swirl rate is modified as function of the angle 90 and the number of walls 92 within the length 95 of the inlet. The steeper the angle 90, the more turns for the same length 95. Additionally, increasing or reducing the number of walls 92 also can be tailored to provide a desired swirl in the incoming flow.

[0040] An inlet 82 shown in Figure 10a includes walls 92 that are a distance 88a apart and disposed at an angle 90a relative to a longitudinal axis A. The angle 90a and number of walls 92 for the length 95 defines a density that is tailored to induce a predefined swirl into the flow exiting the inlet 82. The example angle, in one disclosed embodiment, is less than 90 degrees and more than 45 degrees. The distance 88a is a function of the angle 90a of the walls 92 in the defined length 95.

[0041] Another inlet 84 shown in Figure 10b includes walls 92 that disposed at an angle 90b combined with a number of walls 92 that provides a spacing 88b that is less than the spacing 88a shown in Figure 10a. The angle 90a remains the same, but increasing the number of walls 92 decrease in the spacing 88b to provide increased swirl for the same length 95.

[0042] A further inlet 86 shown in Figure 10c includes an angle 90b that is not as steep as the previous angle 90a. The number of walls 92 is reduced and therefore the distance 88c is greater than either that shown in Figures 10a and 10b. The different angle 90b with a reduced number of walls 92 provides a larger spacing 88c to induce the desired defined swirl in the inlet flow. The swirl provided by the walls 92 of the inlet 86 can have any number of variation of the walls 92 and angles 90 to provide different spacings 88 to induce different swirl in flows exiting the inlet tube.

[0043] Referring to Figures 11a, 11b, and 11c, another example inlet 76 is disclosed and includes a plurality walls 78 defining a corresponding plurality of closed passages 80 that spirally wind along the inlet length 44. The plurality of separate passages 80 induce swirl components into the incoming airflow to uniformly spread and distribute airflow along the inlet end 32 of the plate fin heat exchanger 14.

[0044] Accordingly, the disclosed inlet pipe induces flow characteristics that aid in more uniformly distributing the hot airflow throughout the passages of the heat exchanger.

[0045] 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 assembly comprising:
- an inlet manifold defining an expanding area in a direction of flow; and
an inlet in flow communication with the inlet manifold, the inlet including a wall for inducing a rotational inertia to flow entering the inlet manifold.
- 2.** The heat exchanger assembly as recited in claim 1 wherein the inlet comprises a constant cross-sectional area over an inlet length prior to the inlet manifold.
- 3.** The heat exchanger assembly as recited in claim 1 or 2, wherein the inlet comprises a pipe and the wall comprises a plurality of walls spirally arranged within the inlet length.
- 4.** The heat exchanger assembly as recited in claim 3, wherein the pipe is round and includes an inner surface and the plurality of walls are disposed transverse to the inner surface.
- 5.** The heat exchanger assembly as recited in claim 3 or 4, wherein the plurality of walls include a height and the height is less than a width of the pipe.
- 6.** The heat exchanger assembly as recited in any one of claims 3-5, wherein the plurality of walls extend across a width of the pipe and define separate channels.
- 7.** The heat exchanger assembly as recited in any one of claims 3-6, wherein the plurality of walls are continuous for the entire inlet length.
- 8.** The heat exchanger assembly as recited in any one of claims 3-7, wherein the plurality of walls are intermittently arranged for at least a portion of the inlet length.
- 9.** The heat exchanger assembly as recited in any one of claims 3-8, wherein a density of walls is uniform for the entire inlet length, or wherein a density of walls varies within the inlet length.
- 10.** The heat exchanger assembly as recited in any one of claims 3-9, including a distance between the plurality of walls in a direction parallel to a longitudinal axis and an angle of the walls relative to the longitudinal axis and a swirl induced into the inlet flow is determined by a combination of the distance between the plurality of walls and the angle, wherein, optionally, at least one of the distance between the plurality of walls and angle of the plurality of walls varies over a length of the inlet.

10. A heat exchanger assembly comprising:

an inlet manifold defining an increasing flow area;
a plate fin heat exchanger plate including a first end in flow communication with the inlet manifold and including a plurality of inlet openings arranged across an inlet width;
an inlet communicating flow to the inlet manifold including a means for inducing a spiral flow for spreading flow through the inlet manifold across the inlet width.

11. The heat exchanger assembly as recited in claim 10, wherein the inlet includes a uniform cross-sectional flow area over an inlet length.

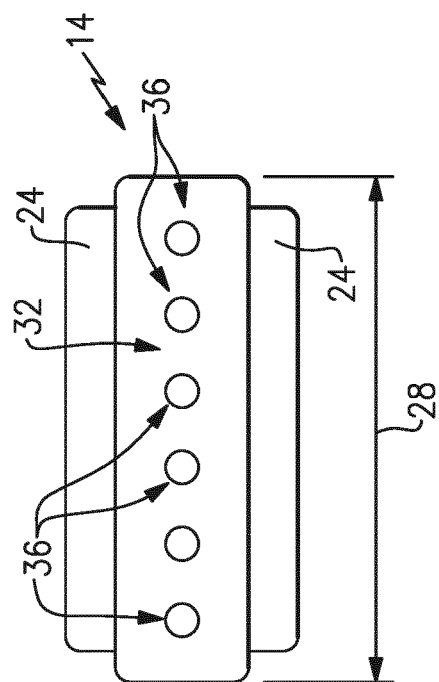
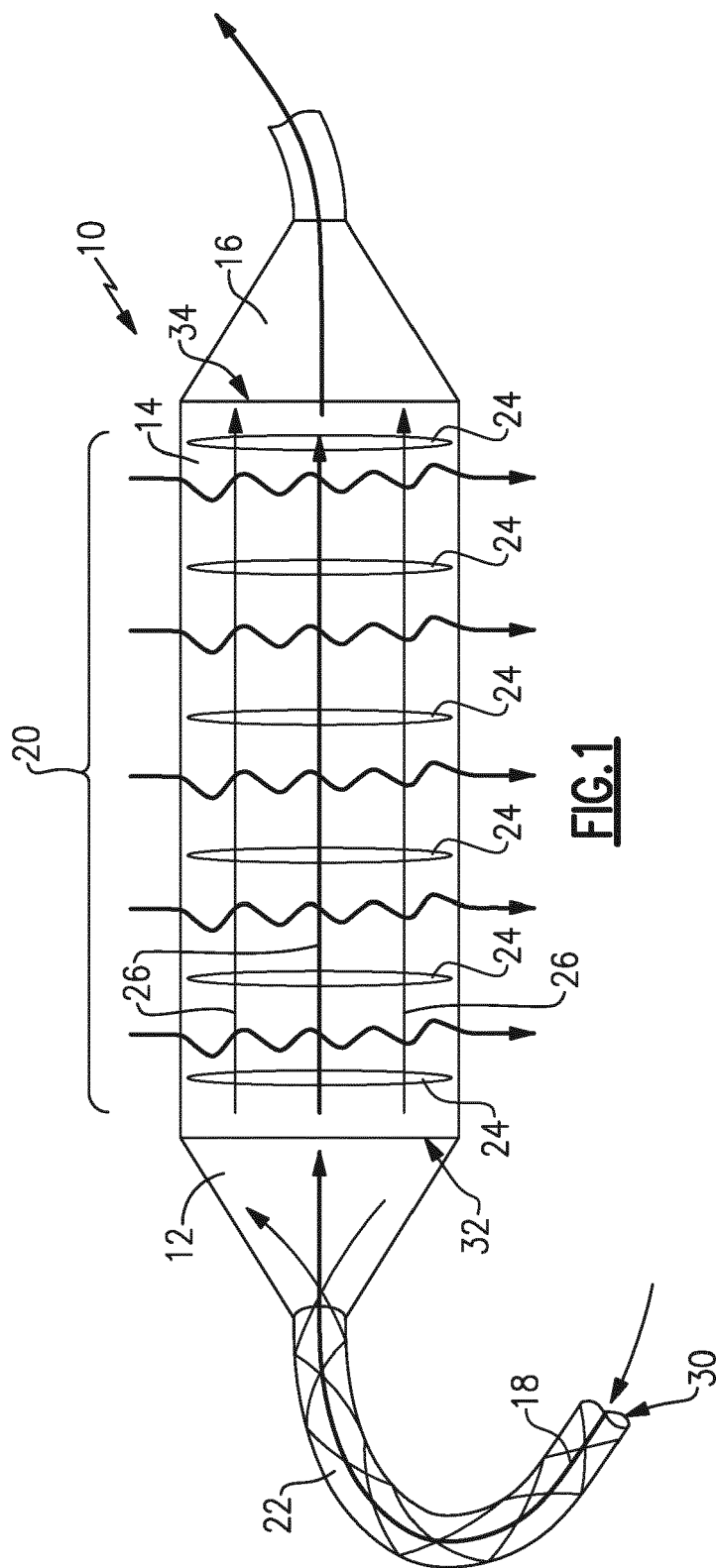
12. The heat exchanger assembly as recited in claim 10 or 11, wherein inlet comprises a pipe and the means for introducing a spiral inertial comprises a plurality of walls spirally arranged and extending from an interior surface of the pipe within the inlet length, wherein, optionally, the plurality of walls include a height from the inner surface and the height that is less than a width of the pipe, wherein, optionally, the plurality of walls extend define separate channels within the inlet.

13. A method of assembling a heat exchanger assembly comprising:

forming an inlet manifold to include an expanding flow area;
attaching the inlet manifold to a plate fin heat exchanger that includes a plurality of openings disposed across an inlet width;
forming an inlet to include a constant flow area and a spiral flow inducing means; and
attaching the inlet to the inlet manifold for spreading flow entering the inlet manifold across inlet width.

14. The method as recited in claim 13, wherein the spiral flow inducing means comprises a plurality of walls extending inward from an inner surface that are arranged in a spiral along an inlet length.

15. The method as recited in claim 14, wherein at least one of a distance between the plurality of walls in a direction common with a longitudinal axis of the inlet and an angle of the plurality of walls relative to the longitudinal axis is defined to induce a defined swirl component into the flow entering the inlet manifold.



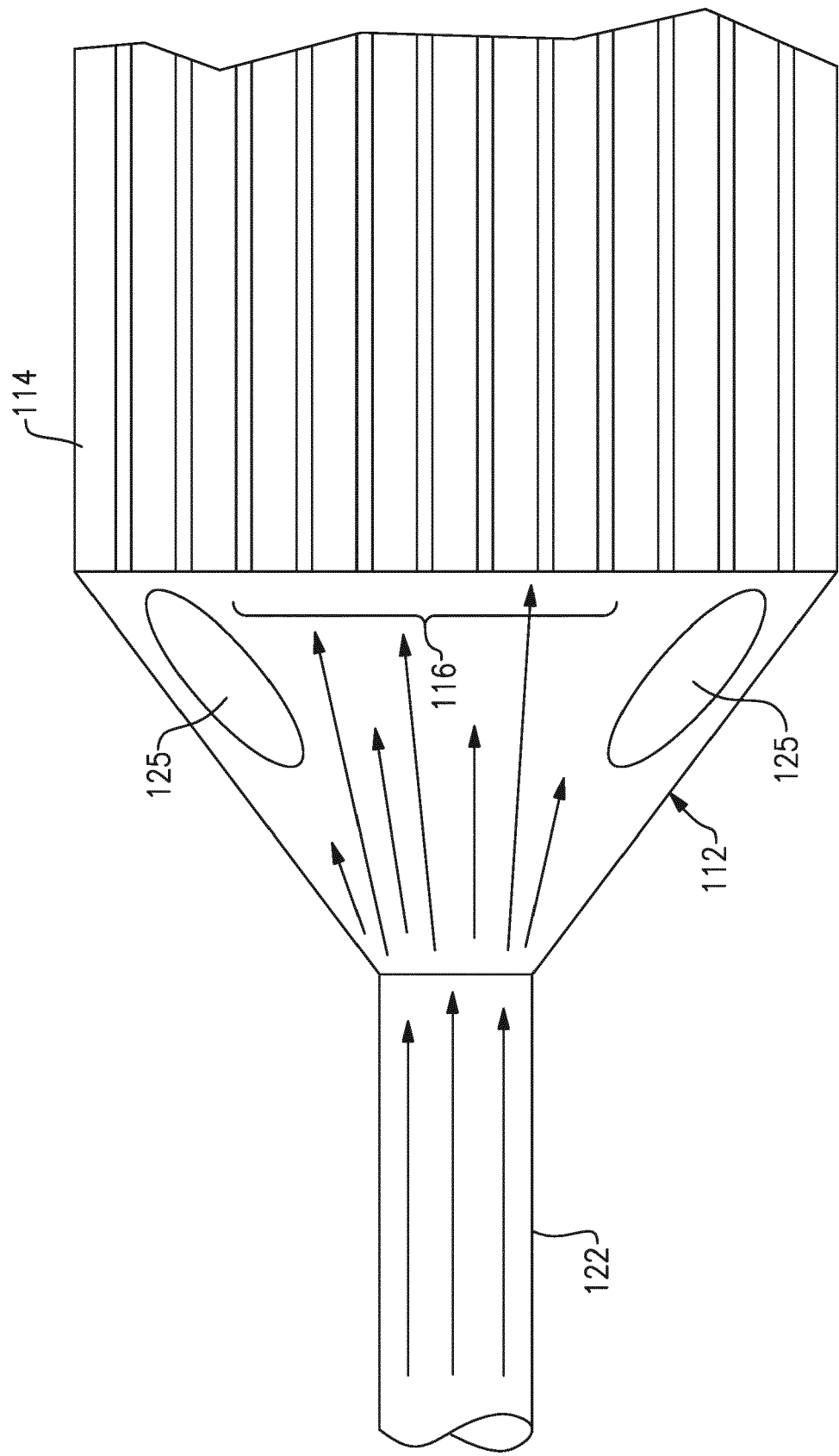


FIG.3

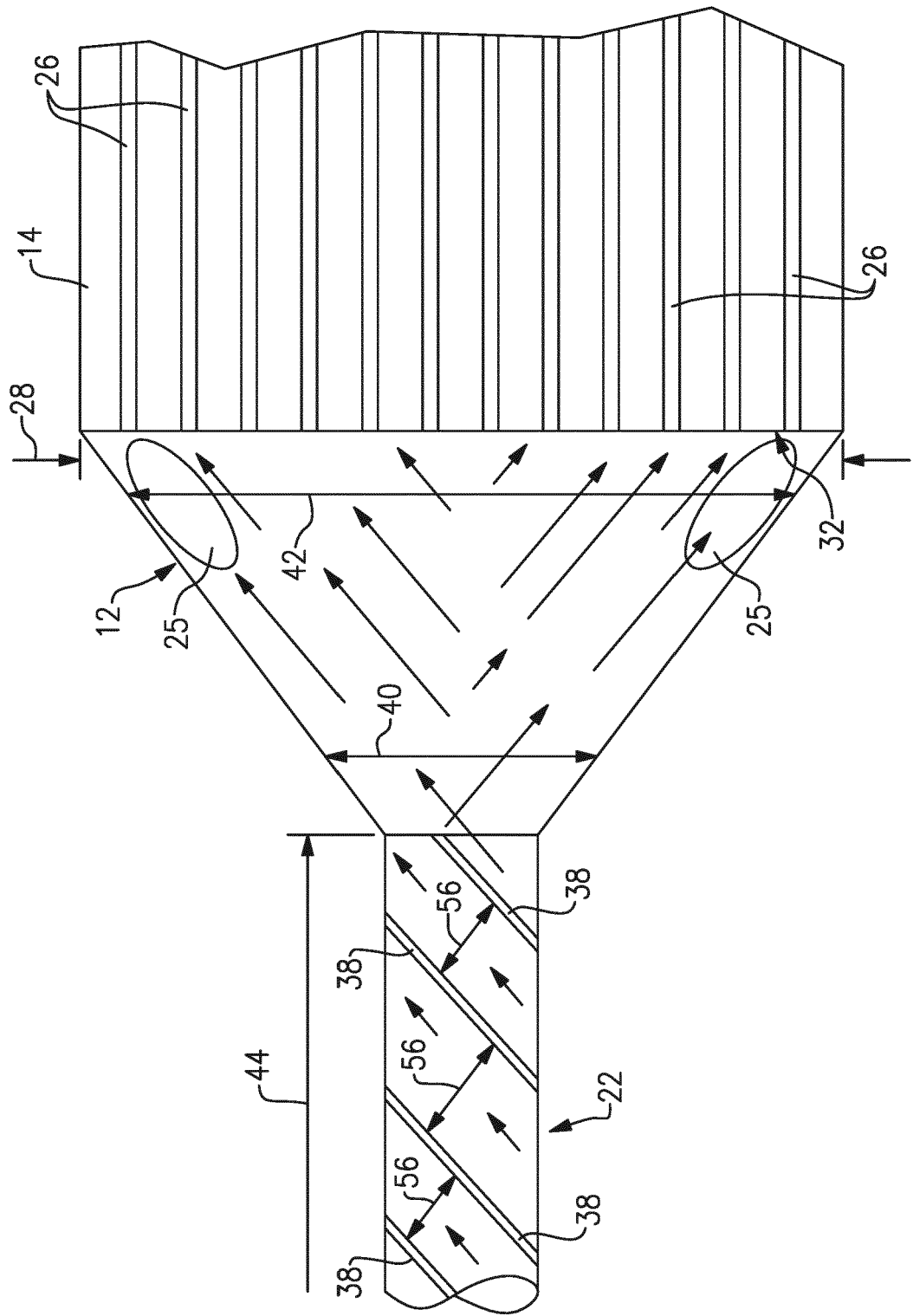
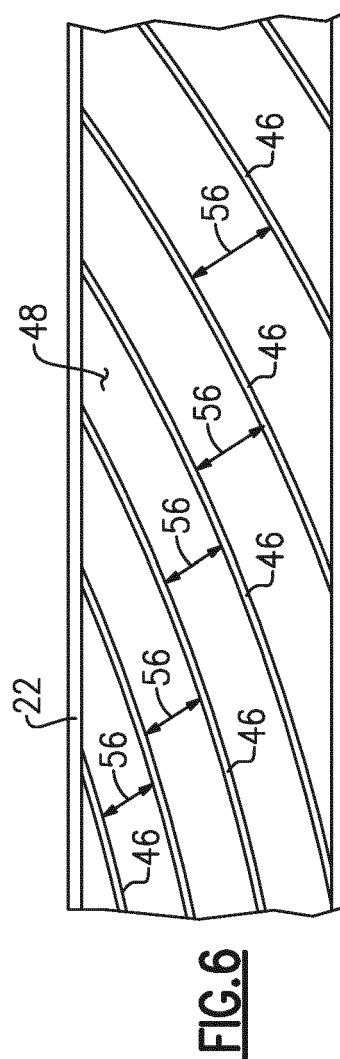
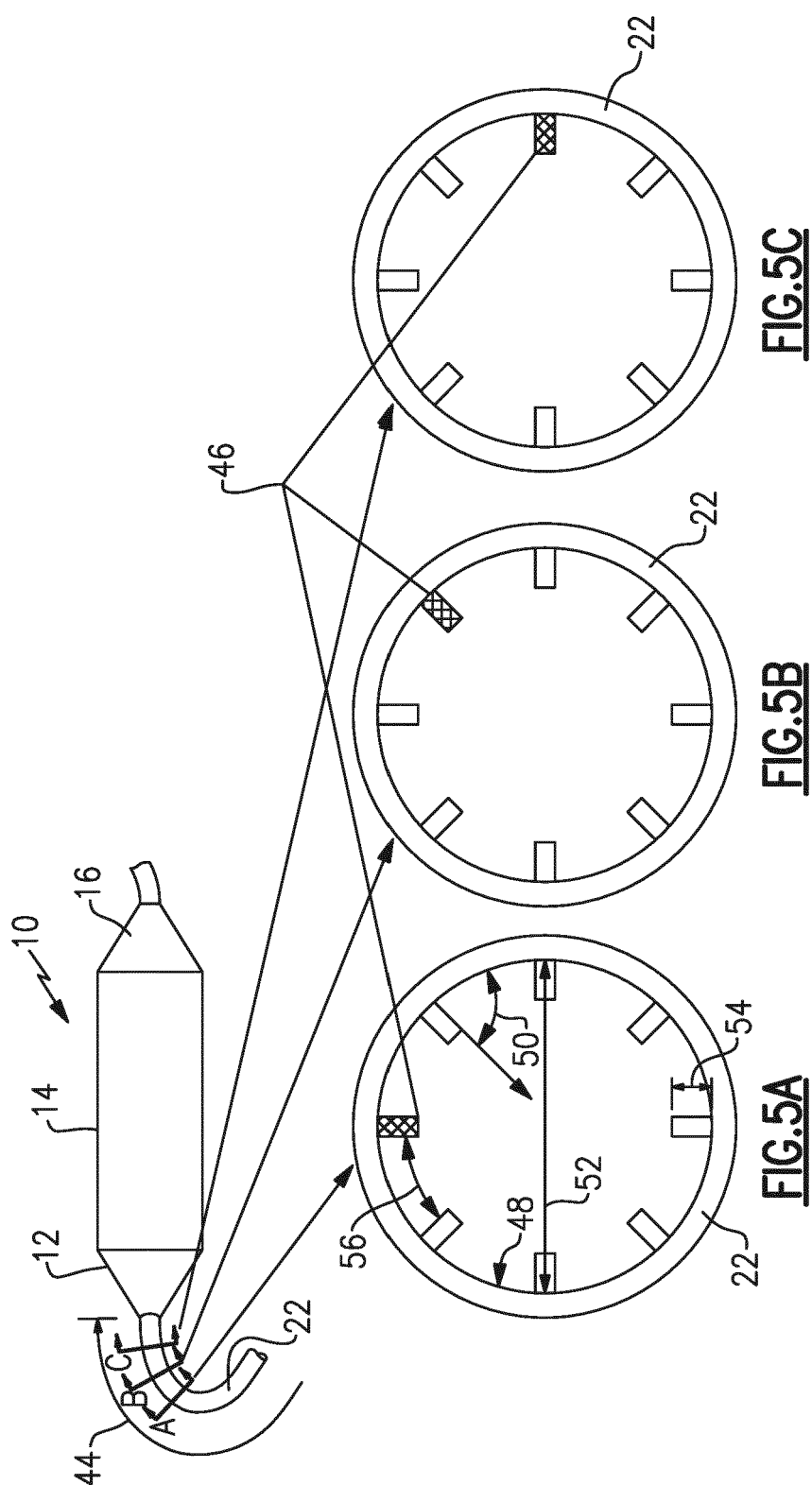


FIG. 4



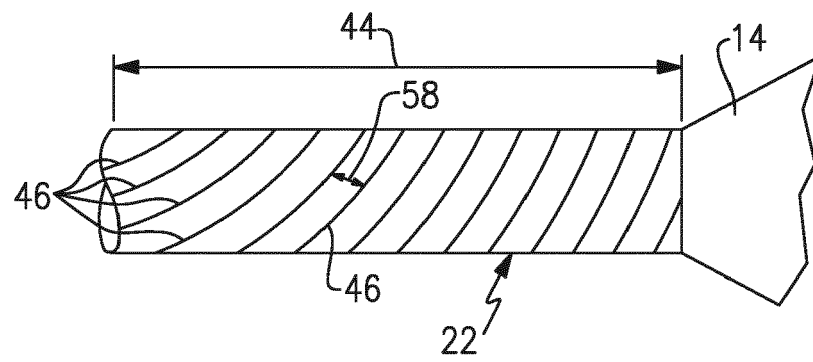


FIG. 7

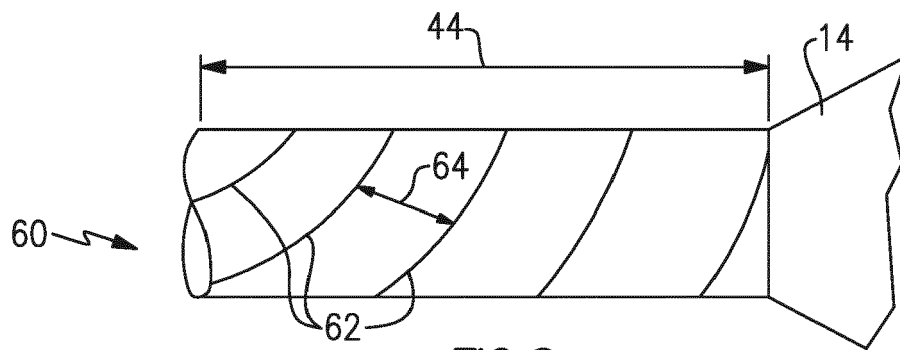


FIG. 8

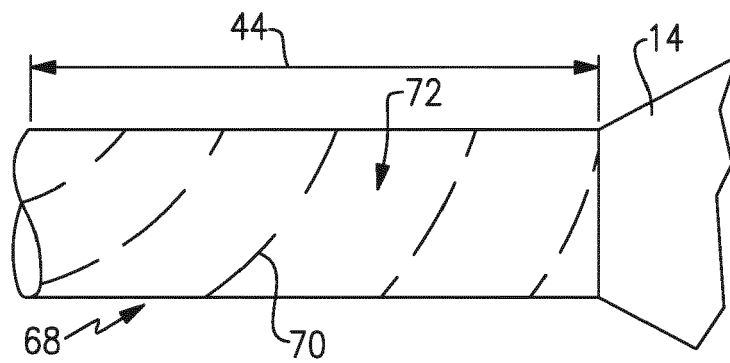
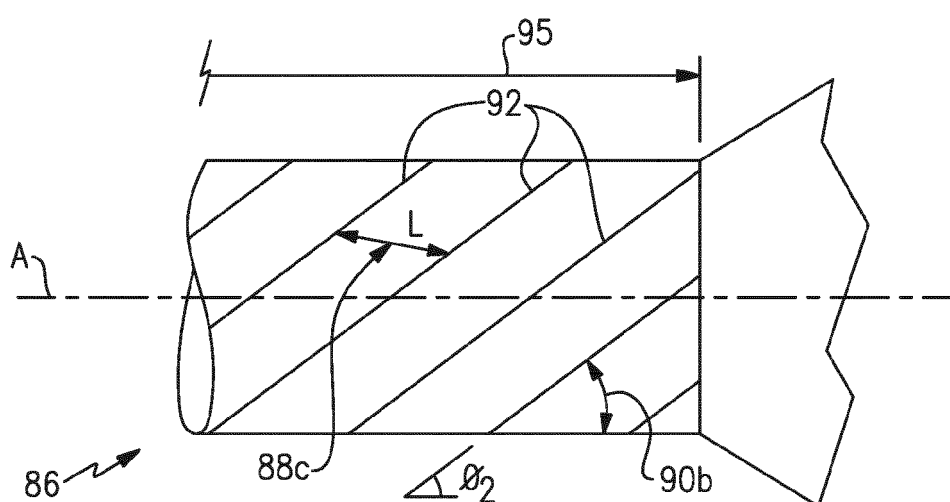
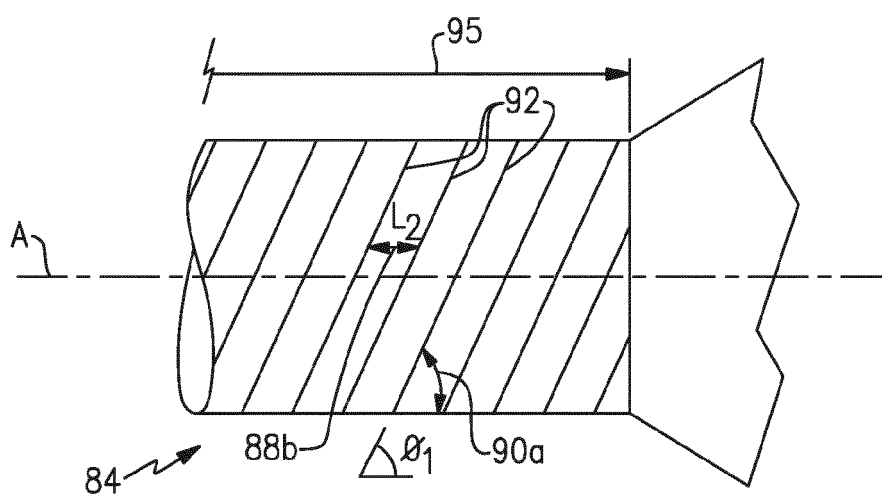
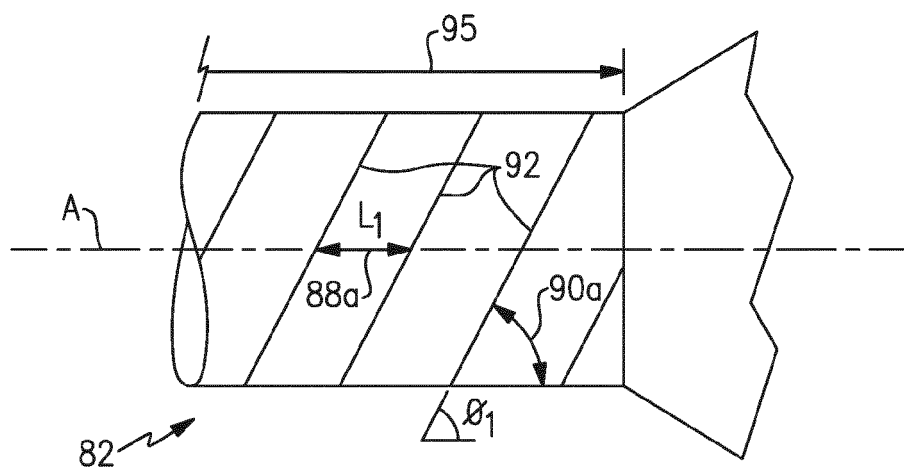
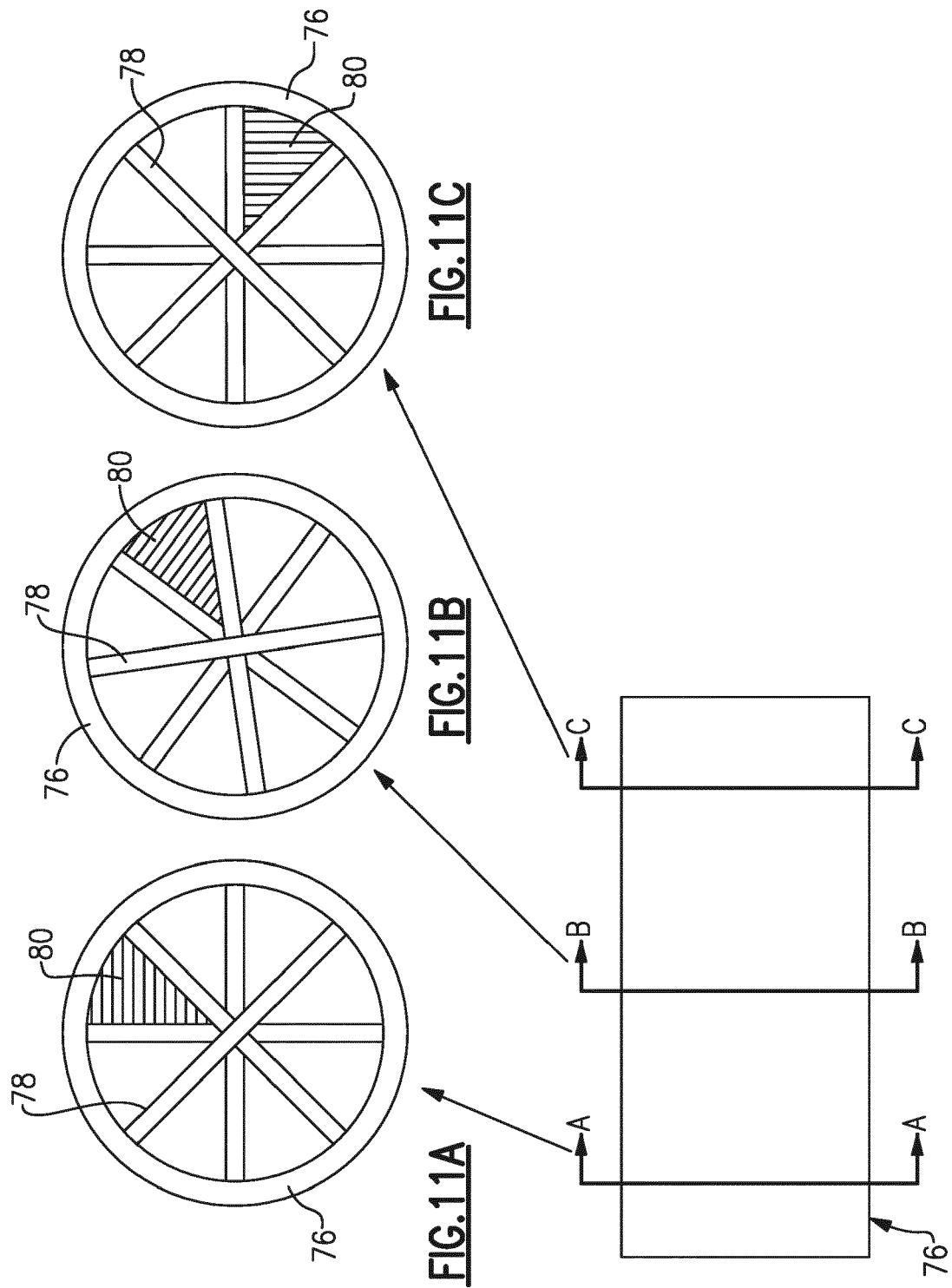


FIG. 9







EUROPEAN SEARCH REPORT

Application Number
EP 19 17 3305

5

10

15

20

25

30

35

40

45

50

55

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 10 2005 042315 A1 (BEHR GMBH & CO KG [DE]) 8 March 2007 (2007-03-08) * paragraph [0021]; figures 4,7,11 * * paragraph [0028] * * paragraph [0039] * * paragraph [0042] *	1-15	INV. F28F9/02 F28F13/06 F28F13/12
X	EP 2 998 684 A1 (MAHLE INT GMBH [DE]) 23 March 2016 (2016-03-23) * figure 2 *	1,2	
			TECHNICAL FIELDS SEARCHED (IPC)
			F28F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 23 July 2019	Examiner Bain, David
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			

 1
EPO FORM 1503 03.02 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 17 3305

5

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.

23-07-2019

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102005042315 A1	08-03-2007	DE 102005042315 A1	08-03-2007
		EP 1926964 A1	04-06-2008
		WO 2007028463 A1	15-03-2007

EP 2998684 A1	23-03-2016	DE 102014219078 A1	24-03-2016
		EP 2998684 A1	23-03-2016
		JP 2016070654 A	09-05-2016
		US 2016084128 A1	24-03-2016

15

20

25

30

35

40

45

50

55

EPO FORM P0459

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