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(54) **Tapered helical fuel distributor**

(57) A fuel distributor system for a turbomachine fuel injector can include a plurality of helical fuel flow channels (109) defined between a fuel distributor (107) and a shroud (105) that surrounds the fuel distributor. A wind axis of the helical flow channels is an axial axis of the fuel injector and each of the helical fuel flow channels includes an upstream opening (111) configured to be in fluid communication with a liquid fuel source and a downstream opening (115) configured to effuse fuel therefrom. Each of the plurality of helical fuel flow channels can reduce in flow area from the upstream opening to the downstream opening.

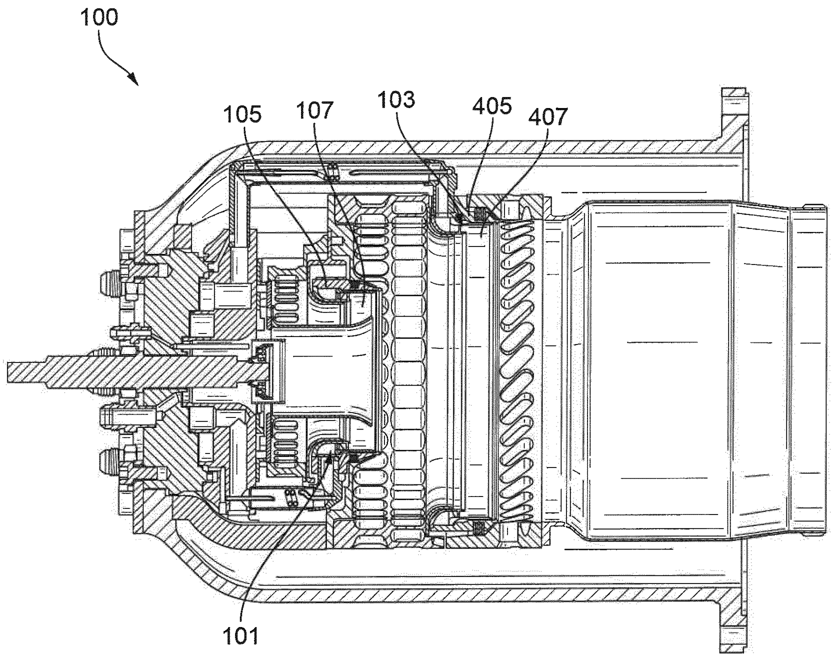

FIG. 1

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Description

BACKGROUND

1. Field

[0001] The present disclosure relates to turbomachines, more specifically to fuel nozzles for turbomachines (e.g., industrial turbomachines).

2. Description of Related Art

[0002] Large fuel nozzles, e.g., those for industrial engines, require large diameter fuel distributors for low emissions performance. Large diameter distributors require a large number of fuel distribution slots for adequate liquid fuel distribution. Slots are required to be large enough to avoid contamination. This leads to low pressure fuel injection which can be problematic as low fuel flows and can lead to streaky performance at high flows, for example.

[0003] Such conventional methods and systems have generally been considered satisfactory for their intended purpose. However, there is still a need in the art for improved fuel injector systems and components. The present disclosure provides a solution for this need.

SUMMARY

[0004] In accordance with at least one aspect of this disclosure, a fuel distributor system for a turbomachine fuel injector can include a plurality of helical fuel flow channels defined between a fuel distributor and a shroud that surrounds the fuel distributor. A wind axis of the helical flow channels is an axial axis of the fuel injector and each of the helical fuel flow channels include an upstream opening configured to be in fluid communication with a liquid fuel source and a downstream opening configured to effuse fuel therefrom. Each of the plurality of helical fuel flow channels can reduce in flow area from the upstream opening to the downstream opening.

[0005] The plurality of helical fuel flow channels can be defined on an outer diameter of the fuel distributor and are configured to be fluidly isolated from one another by the shroud. In certain embodiments, the upstream opening can include a transition area to widen the upstream openings to reduce pressure loss of fuel entering into the helical fuel flow channels.

[0006] A radial trough of each of the helical fuel flow channels can be reduced in depth from the upstream opening to the downstream opening. In certain embodiments, a radial peak height of each helical fuel flow channel can be constant from the upstream opening to the downstream opening.

[0007] In certain embodiments, each of the plurality of helical fuel flow channels change in flow area from the upstream opening to the downstream opening. For example, the change in flow area can include a change in a flow area shape instead of or in addition to a change in flow area size.

[0008] In accordance with at least one aspect of this disclosure, a fuel distributor for a turbomachine fuel injector can include a plurality of helical fuel flow channels as described above defined on an outer diameter thereof and configured to be fluidly isolated from one another by a shroud that surrounds the fuel distributor. The fuel distributor can be a primary fuel distributor or a secondary for distributor (e.g., for an industrial turbomachine fuel nozzle). In accordance with at least one aspect of this disclosure, a fuel injector for a turbomachine can include a fuel distributor system as described above for a turbomachine fuel injector.

[0009] These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

Fig. 1 is a cross-sectional view of an embodiment of a fuel injector nozzle in accordance with this disclosure;
Fig. 2 is a partial cross-sectional view of a portion of the embodiment of Fig. 1;
Fig. 3A is a perspective view of an embodiment of a fuel distributor in accordance with this disclosure;
Fig. 3B is a cross-sectional view of the embodiment of Fig. 3A;
Fig. 3C is a partial cross-sectional view of the embodiment of Fig. 3A;
Fig. 3D is a partial cross-sectional view of the embodiment of Fig. 3A, showing taper geometry overlaid;
Fig. 4A is a perspective view of an embodiment of a fuel distributor in accordance with this disclosure;
Fig. 4B is a partial side elevation view of the embodiment of Fig. 4A; and
Fig. 4C is a partial cross-sectional view of the embodiment of Fig. 4A.

DETAILED DESCRIPTION

[0011] Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, an illustrative view of an embodiment of a fuel injector in accordance with the disclosure is shown in Fig. 1 and is designated generally by reference character 100. Other embodiments and/or aspects of this disclosure are shown in Figs. 2-4C. The systems and methods described herein can be used to improve fuel distribution in turbomachine fuel injectors.

[0012] Referring to Fig. 1, an embodiment of a fuel injector 100 is shown having a first fuel distributor 101 system (e.g., which can be referred to as a primary fuel distributor system) and a second fuel distributor 103 (e.g., which can be referred to as a secondary fuel distributor system). Each fuel distributor system 101, 103 can include an annular body referred to as a fuel distributor and a second body surrounding the fuel distributor, which is referred to as a shroud (which can also be annular).

[0013] Referring to Fig. 2, a zoomed cross-sectional view of a portion of a fuel distributor system 101 having a shroud 105 surrounding a fuel distributor 107. A plurality of helical fuel flow channels 109 (e.g., as described further below) are defined between the fuel distributor 107 and the shroud 105 that surrounds the fuel distributor 107. A wind axis of the helical flow channels 109 is an axial axis (e.g., a central axis) of the fuel injector 100.

[0014] Each of the helical fuel flow channels 109 include an upstream opening 111 configured to be in fluid communication with a liquid fuel source (e.g., through inlet 113) and a downstream opening 115 configured to effuse fuel therefrom. Each of the plurality of helical fuel flow channels 109 can reduce in flow area from the upstream opening 111 to the downstream opening 115.

[0015] Referring additionally to Figs. 3A-3C, the plurality of helical fuel flow channels 109 can be defined on an outer diameter 117 of the fuel distributor. In such embodiments, the helical fuel flow channels 109 are configured to be fluidly isolated from one another by the shroud 105. In certain embodiments, the helical fuel flow channels 109 can be defined on an inner diameter 121 of the shroud 105 and can be fluidly isolated by the fuel distributor 107. In certain embodiments, the upstream opening 111 can include a transition area 119 to widen the upstream openings 111, e.g., to reduce pressure loss of fuel entering into the helical fuel flow channels 109.

[0016] Referring additionally to Fig. 3D, a radial trough 123 of each of the helical fuel flow channels 109 can be reduced in depth from the upstream opening 111 to the downstream opening 115. This can be a linear decrease as a function of length, e.g., as shown by the linear taper line in Fig. 3D. In certain embodiments as shown, a radial peak height 125 of each helical fuel flow channel 109 can be constant (e.g., as shown by the horizontal line in Fig. 3D) from the upstream opening 111 to the downstream opening 115. Any other suitable decrease or flow area change (e.g., via geometric changes to the cross-sectional flow area of the channels 109) is contemplated herein. For example, the radial troughs 123 can be held constant in depth and the peak height 125 can be tapered (e.g., via a shroud having a conical inner diameter).

[0017] Referring additionally to Figs. 4A-4C, the second fuel distributor system 103 can include a fuel distributor 407 and a shroud 405 (e.g., as shown in Fig. 1). The fuel distributor 407 and/or shroud 405 can be similar to the fuel distributor 107 and/or the shroud 105, respectively, as described above. In the embodiment shown, the diameter of the annular body that makes up fuel distributor 407 and shroud 405 are larger than the first fuel distributor system.

[0018] Embodiments of the fuel distributor 107, 407 can be press fit to the shroud 105, 405 and/or attached in any other suitable manner. The channels 109 can be formed in any suitable means (e.g., cutting, additive manufacturing). The fuel injector nozzle 100 can be configured for use as an industrial turbomachine fuel nozzle. In accordance with at least one aspect of this disclosure, a fuel injector for a turbomachine can include a fuel distributor system as described above for a turbomachine fuel injector.

[0019] Embodiments of the fuel flow channels 109 can create resistance which allows flow to distribute evenly around the entire circumference of the distributor 107, 407. Changing length and/or flow areas and/or shapes allow control of pressure drop to achieve a desired fuel flow. Tapering the flow channels 109 and/or controlling their length are some parameters that can control fuel flow resistance/distribution not available from convention holes or straight slot. In embodiments, e.g., on very large diameter, channels 109 can be reduced in length (and/or how many winds or how much of a wind around the circumference the channel is defined) to maintain a large number of small channels to encourage film creation while maintaining control over flow resistance at high power.

[0020] Embodiments of a fuel injector nozzle can include two distributors that have large diameter for liquid fuel, e.g., 15.24 cm (6"(and larger (such as 15.24 cm (6") for primary and 20.32 cm (8") for secondary). A large area flow channel is valuable in situations where there is a risk of flow blockage due to foreign matter or due contaminant deposition by the flowing media. In a fuel distributor, fuel distribution is determined by flow area distribution which is usually governed by the number of flow channels. Using a large number of helical channels 109, channel lengths can be long to provide flow resistance which can be used to uniformly divide the liquid flow among the channels 109 even in situations with very large diameters. Any suitable number of flow channels 109 and/or characteristics thereof is contemplated herein to achieve a desired flow distribution.

[0021] In embodiments, the openings 115 can be cause fuel to effuse at a high tangential angle enabling neighboring flows to merge into a film immediately upon exit. Resistance can also be controlled by variable channel depth, for example to utilize more channels of a given exit area spaced more closely together, the inlet area and shape can be manipulated to permit less resistance at the inlet and more toward the exit.

[0022] As described above, embodiments utilize a large number of helical fuel channels to distribute the fuel about a large diameter. The fuel can be injected at very high tangential velocities to encourage merging of the discrete jets into a tangential film before mixing which a large quantity of co swirling air. The helical channels can be modified by varying the shape or depth from beginning to end to control the total pressure drop across the channels. The length of the channels 109 can also be controlled to obtain a specific pressure loss before the fuel exit. Embodiments provide for flow accurate flow resistance to help provide uniform fuel distribution even at relatively large fuel nozzle flow exit diameters.

[0023] Any suitable combination(s) of any disclosed embodiments and/or any suitable portion(s) thereof is contemplated therein as appreciated by those having ordinary skill in the art.

[0024] The embodiments of the present disclosure, as described above and shown in the drawings, provide for improvement in the art to which they pertain. While the subject disclosure includes reference to certain embodiments, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the scope of the subject disclosure.

Claims

1. A fuel distributor system (101) for a turbomachine fuel injector (100), comprising:

   a plurality of helical fuel flow channels (109) defined between a fuel distributor (107) and a shroud (105) that surrounds the fuel distributor,
   wherein a wind axis of the helical flow channels is an axial axis of the fuel injector,
   wherein each of the helical fuel flow channels includes an upstream opening (111) configured to be in fluid communication with a liquid fuel source and a downstream opening (115) configured to effuse fuel therefrom, and
   wherein each of the plurality of helical fuel flow channels reduces in flow area from the upstream opening to the downstream opening.

2. The system of claim 1, wherein the plurality of helical fuel flow channels (109) are defined on an outer diameter (117) of the fuel distributor (107) and are configured to be fluidly isolated from one another by the shroud.

3. The system of claim 2, wherein a radial trough of each of the helical fuel flow channels is reduced in depth from the upstream opening to the downstream opening.

4. The system of claim 3, wherein a radial peak height of each helical fuel flow channel is constant from the upstream opening to the downstream opening.

5. The system of claim 4, wherein the upstream opening includes a transition area (119) to widen the upstream openings to reduce pressure loss of fuel entering into the helical fuel flow channels.

6. A fuel distributor for a turbomachine fuel injector, comprising:

   a plurality of helical fuel flow channels (109) defined on an outer diameter thereof and configured to be fluidly isolated from one another by a shroud (105) that surrounds the fuel distributor (107),
   wherein a wind axis of the helical flow channels is an axial axis of the fuel injector,
   wherein each of the helical fuel flow channels includes an upstream opening (111) configured to be in fluid communication with a liquid fuel source and a downstream opening (115) configured to effuse fuel therefrom, and
   wherein each of the plurality of helical fuel flow channels reduces in flow area from the upstream opening to the downstream opening.

7. The distributor of claim 6, wherein a radial trough of each of the helical fuel flow channels is reduced in depth from the upstream opening to the downstream opening.

8. The distributor of claim 7, wherein a radial peak height of each helical fuel flow channel is constant from the upstream opening to the downstream opening.

9. The distributor of claim 8, wherein the upstream opening includes a transition area (119) to widen the upstream openings to reduce pressure loss of fuel entering into the helical fuel flow channels.

10. The distributor of claim 9, wherein the fuel distributor is a primary fuel distributor or a secondary fuel distributor.

11. A fuel injector for a turbomachine, comprising:
    a fuel distributor system as claimed in any of claims 1 to 6.

12. A fuel distributor system for a turbomachine fuel injector, comprising:

    a plurality of helical fuel flow channels (109) defined between a fuel distributor (107) and a shroud (105) that surrounds the fuel distributor,
    wherein a wind axis of the helical flow channels is an axial axis of the fuel injector,
    wherein each of the helical fuel flow channels includes an upstream opening (111) configured to be in fluid communication with a liquid fuel

source and a downstream opening (115) configured to effuse fuel therefrom, and
wherein each of the plurality of helical fuel flow channels changes in flow area from the upstream opening to the downstream opening.

13. The system of claim 12, wherein the change in flow area includes a change in a flow area shape.

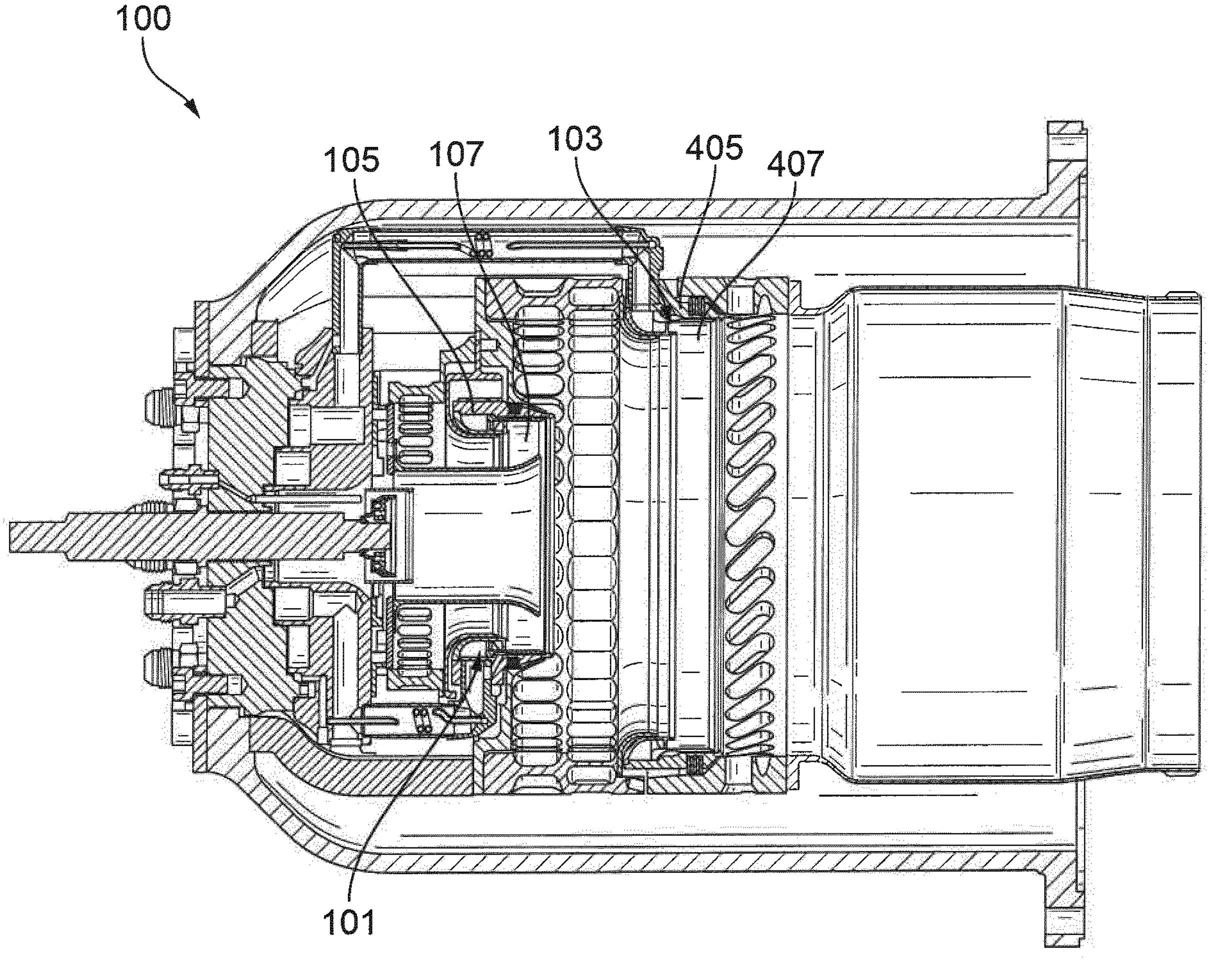

FIG. 1

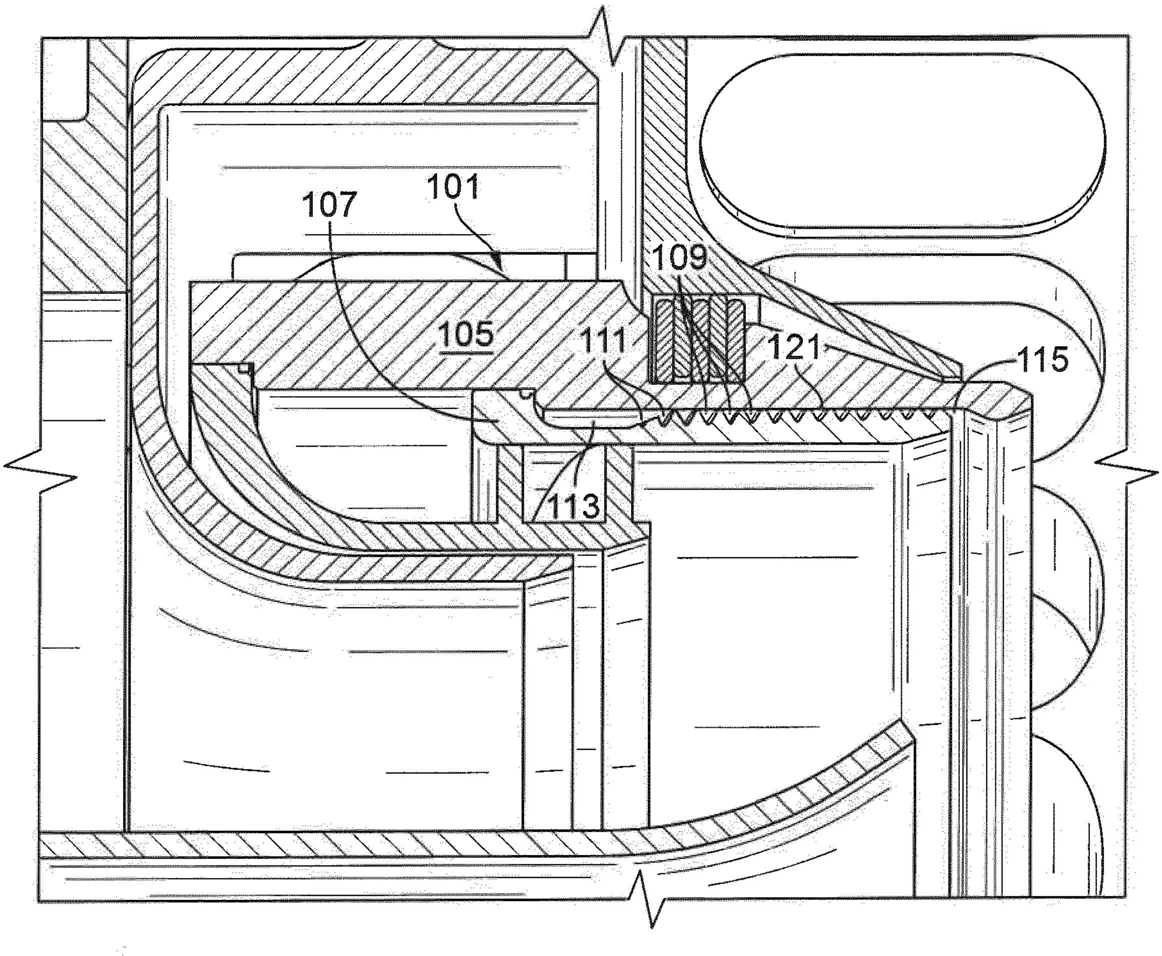

FIG. 2

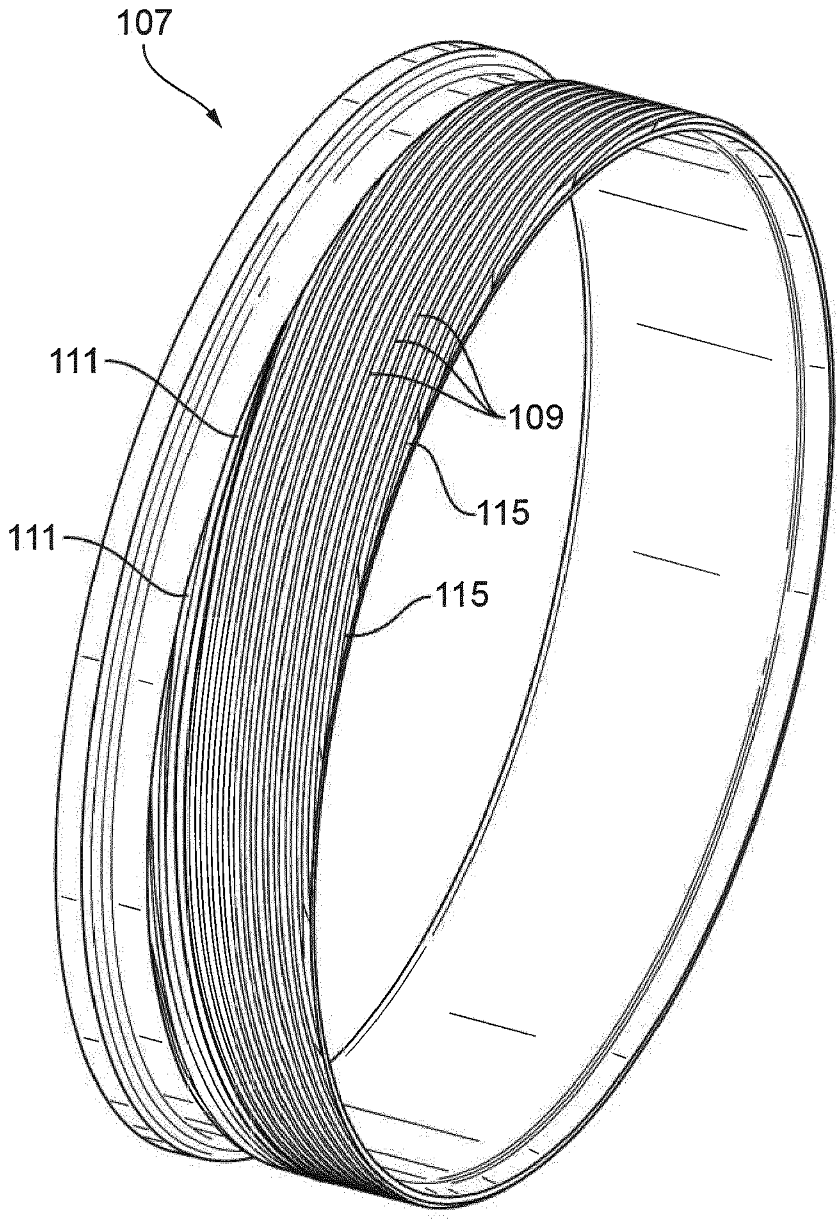

FIG. 3A

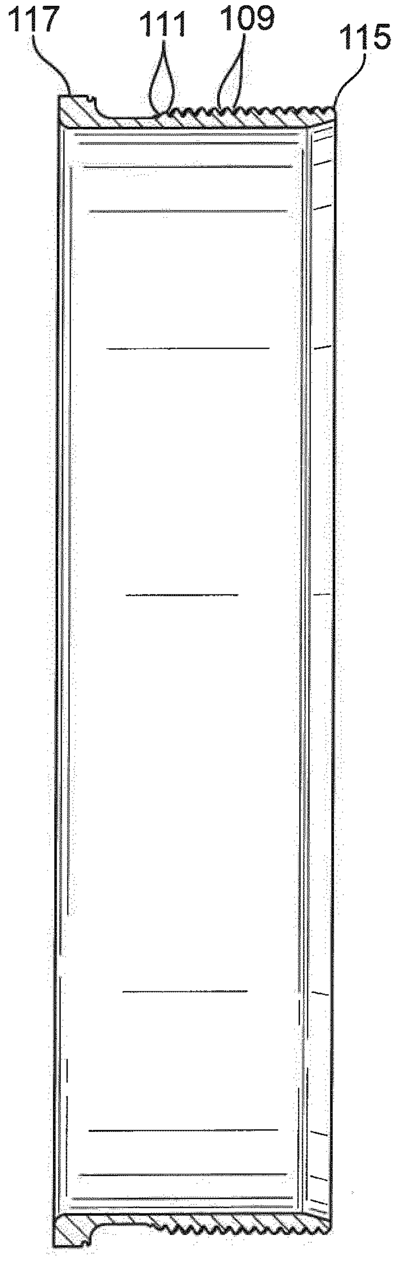

FIG. 3B

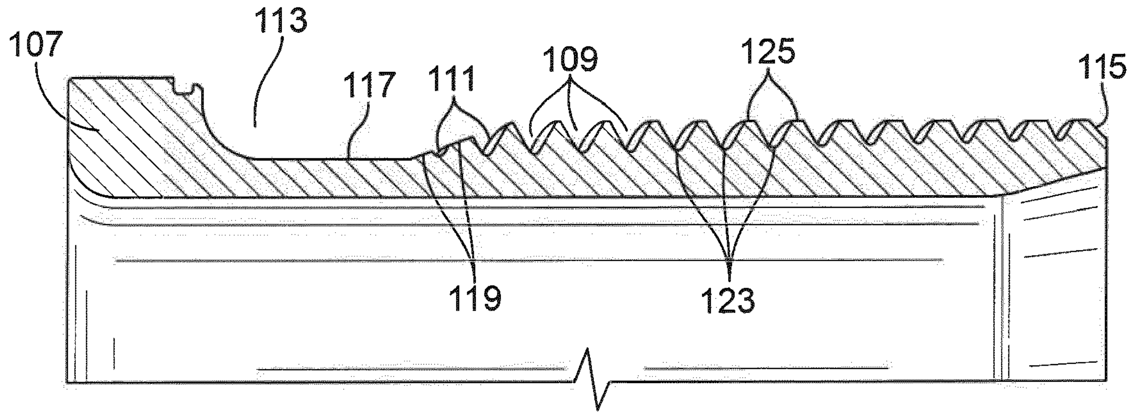

FIG. 3C

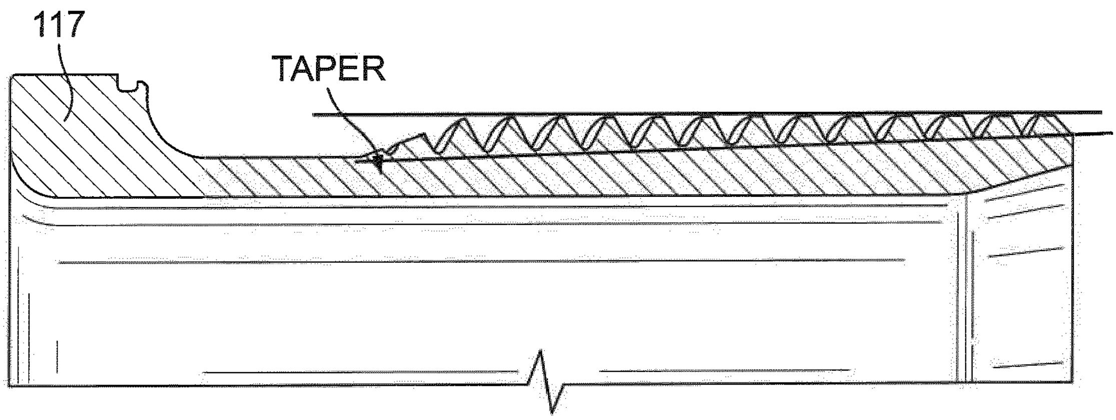

FIG. 3D

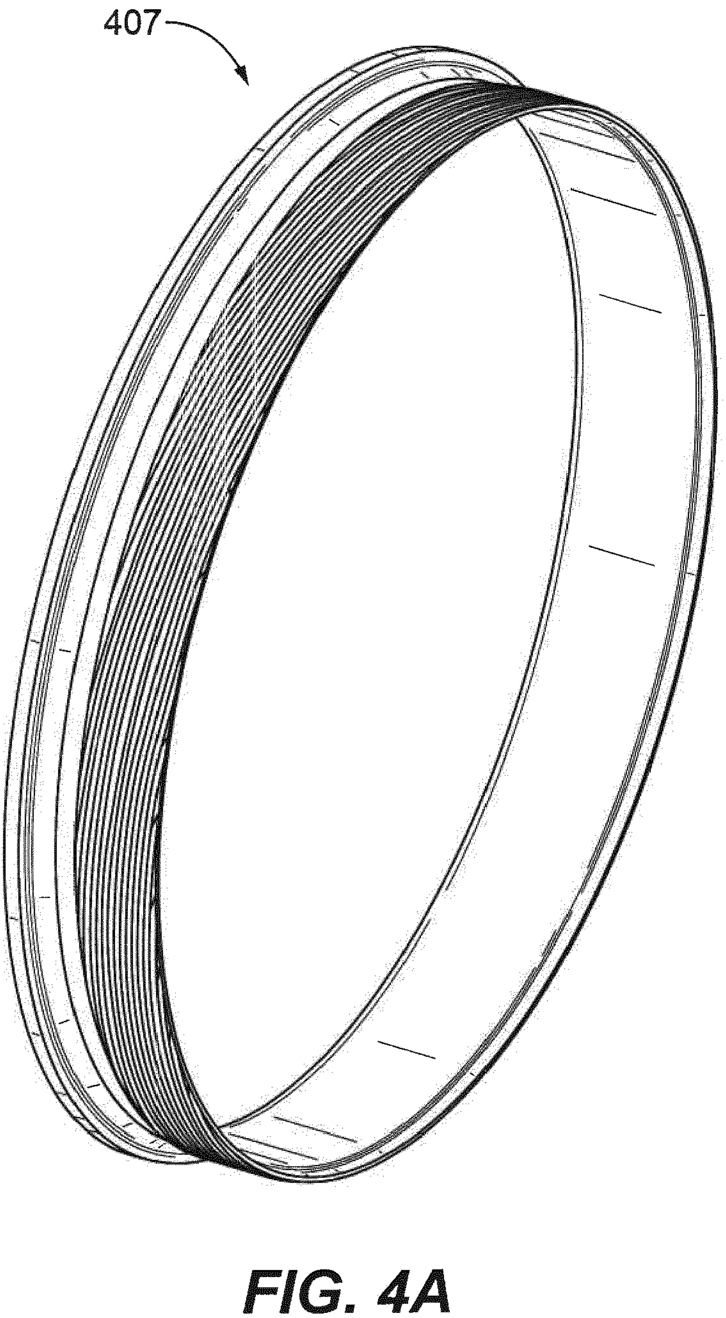

FIG. 4A

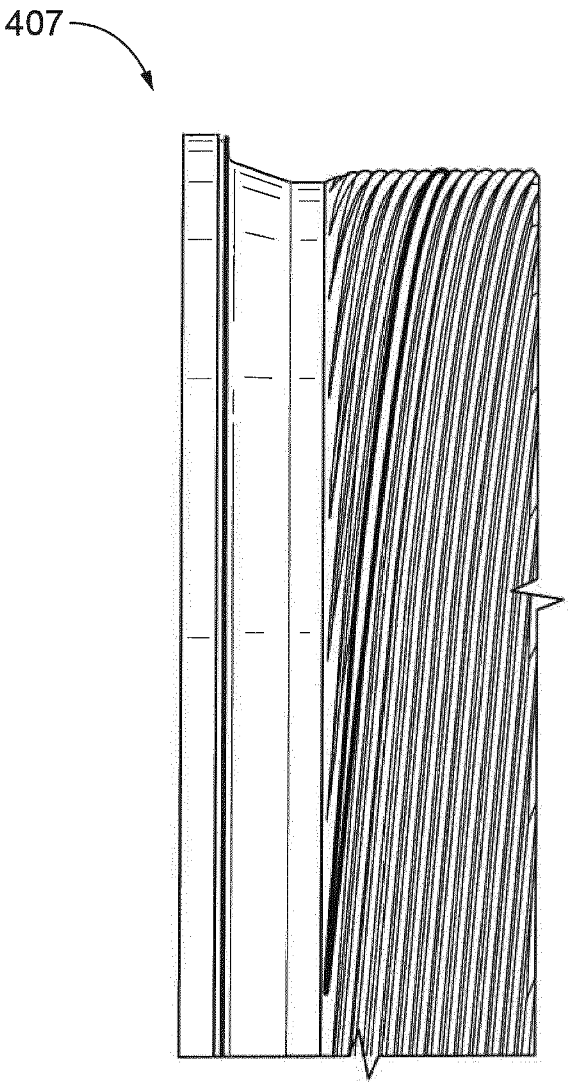

FIG. 4B

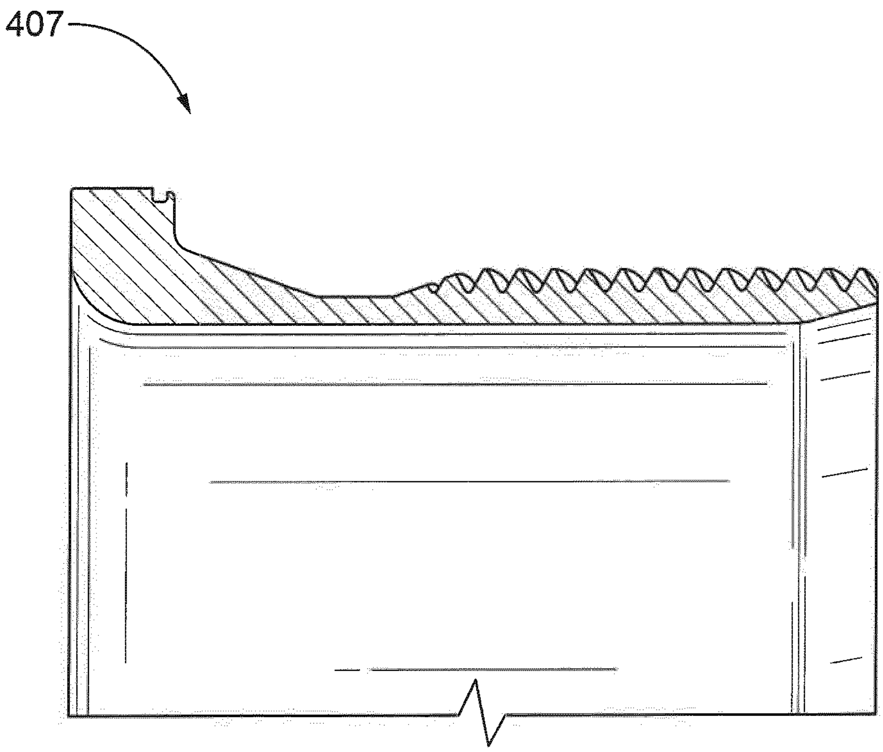

FIG. 4C

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EUROPEAN SEARCH REPORT

Application Number
EP 18 21 3120

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	EP 3 156 732 A1 (DELAVAN INC [US]) 19 April 2017 (2017-04-19) * abstract; paragraph [0012] - paragraph [0022]; figures 1-4 * -----	1-13	INV. F23R3/28 F23R3/36
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A	US 2009/050714 A1 (KOJOVIC ALEKSANDAR [CA] ET AL) 26 February 2009 (2009-02-26) * abstract; figures 1-3 * -----	1-13	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	14 January 2019	Munteh, Louis

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82