

(19)



(11)

EP 4 498 000 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
29.01.2025 Bulletin 2025/05

(51) International Patent Classification (IPC):
F23R 3/28 ^(2006.01) **F23R 3/14** ^(2006.01)
F23D 11/10 ^(2006.01)

(21) Application number: **24190964.7**

(52) Cooperative Patent Classification (CPC):
F23R 3/283; F23D 11/107; F23R 3/14;
F23D 2900/11101

(22) Date of filing: **25.07.2024**

(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 ME MK MT NL
NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

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(30) Priority: **25.07.2023 US 202318225796**

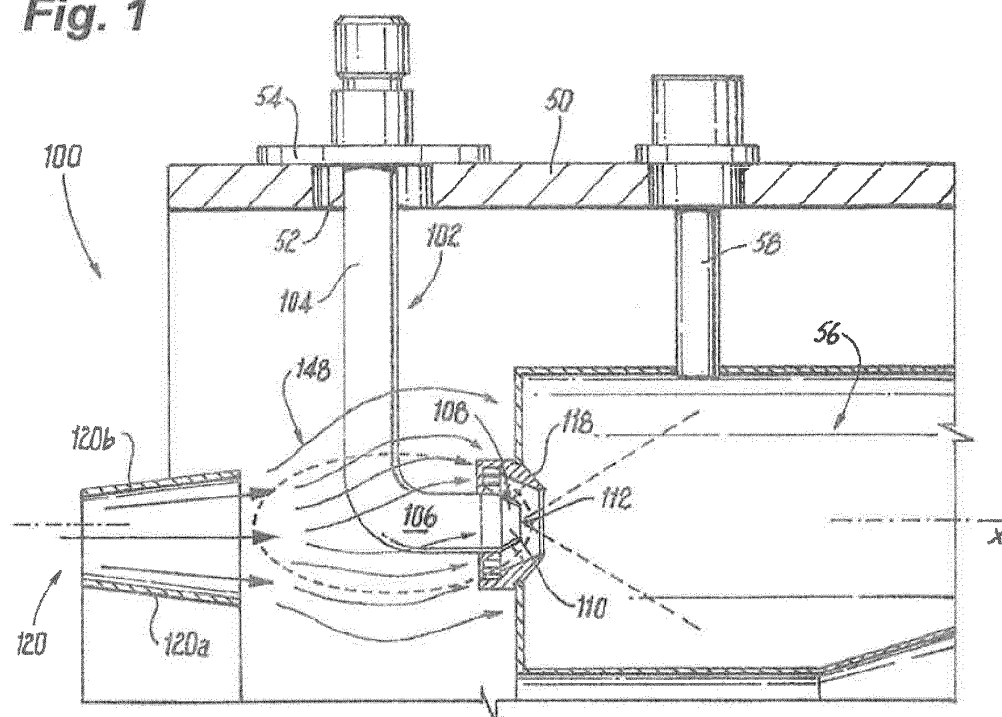
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(54) FLAT SPRAY FUEL INJECTORS

(57) A fuel injector assembly (100) has a fuel nozzle (102) including a radial feed arm with an elongated axially extending nozzle portion (106) having a central axis (X) extending therethrough, the elongated nozzle portion has a distal spray tip (108) with a frusto-conical outer surface (110) and a planar front surface (112), wherein a

primary pressure atomizer port (114) is centrally provided in the planar front surface of the distal spray tip and a set of circumferentially spaced apart secondary flat spray slots (116) are provided in the frusto-conical outer surface of the distal spray tip.

Fig. 1**EP 4 498 000 A1**

Description

BACKGROUND OF THE DISCLOSURE

1. Field of the Disclosure

[0001] This disclosure relates to fuel injectors, and more particularly, to flat spray fuel injectors for gas turbine engines.

2. Description of Related Art

[0002] There is a need for alternate injection styles for multi-circuit liquid fuel injectors for gas turbine engines. More specifically, there is a need for injecting fuel at operating conditions that may not be ideal for other traditional forms of injection, such as jet and prefilmer style injectors. Traditionally, complex fuel injector systems have been used for multi-circuit fuel injector systems. Due to the high temperatures within the environments of these systems, there is concern for the durability of such systems during long term use. For example, carbon growth on external faces or within the outlet features of such systems is an ongoing risk. Fuel passages must be thermally designed to prevent this carbon growth, or coking. Additionally, traditional systems also come with the risk of potential for streaky spray.

[0003] Atomized flat spray fuel injectors for use within a dome air swirler or swirl cups provide a simpler design than an array of multiple pressure atomizers which have traditionally been used. Atomized flat spray fuel injectors are more compact than prefilmer style injectors and require less air velocity to atomize. Additionally, the flat spray may be staged among alternate circuits for efficiency purpose, for example, droplet placement into the air stream. Atomized flat spray injectors provide for a variety of spray capabilities that are able to cover different combustor geometries. For example, spray capabilities include both axial angle coverage (e.g., pie shape) and conical angle coverage, which is an issue with traditional prefilmer style injectors.

[0004] Purposeful bias in fuel placement is created to account for a variety of combustor geometries. For example, targeted, atomized spray can be directed to an ignitor, such as a pilot. For example, atomized flat spray fuel injectors allow for individual metering of fuel prior to filming, resulting in multiple fuel patterns and minimal uniformity of fuel patterns. The non-uniform spray accounts for combustor geometries (e.g., bias in compressor diffuser discharge air profile resulting in non-uniform spray) and is particularly advantageous for large fuel injectors, such as ones used in lean combustion.

[0005] 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 injectors that cover various combustor geometries. The present disclosure provides a solution for this need.

SUMMARY

[0006] The subject disclosure is directed to a new and useful fuel injector assembly for a gas turbine engine. The fuel injector assembly has a fuel nozzle including a radial feed arm with an elongated axially extending nozzle portion having a central axis extending therethrough. The elongated nozzle portion has a distal spray tip with a frusto-conical outer surface and a planar front surface. A primary pressure atomizer port is centrally provided in the planar front surface of the distal spray tip and a set of circumferentially spaced apart secondary flat spray slots are provided in the frusto-conical outer surface of the distal spray tip. The secondary flat spray slots have non-uniform flow rates.

[0007] The primary pressure atomizer port is operatively associated with a primary pressure atomizer within the distal spray tip of the nozzle portion of the fuel nozzle. The primary pressure atomizer includes an atomizing tip portion which the primary pressure atomizer port extends through. The primary pressure atomizer further includes a fuel swirler surrounded by the atomizing tip portion. The fuel swirler has a front surface which abuts an inner wall of the atomizing tip portion. The fuel swirler has a plurality of offset slots and a main swirler. The fuel exits the plurality of offset slots and is directed into the main swirler by the inner wall of the primary pressure atomizer and through the primary pressure atomizer port.

[0008] In certain embodiments, a set of circumferentially spaced apart tertiary flat spray slots are provided in the frusto-conical outer surface rearward of the set of circumferentially spaced apart secondary flat spray slots. A primary fuel supply circuit extends through the fuel nozzle for supplying fuel to the primary pressure atomizer port. A secondary fuel supply circuit extends through the fuel nozzle for supplying fuel to the set of circumferentially spaced apart secondary flat spray slots. A tertiary fuel supply circuit extends through the fuel nozzle for supplying fuel to the set of circumferentially spaced apart tertiary flat spray slots.

[0009] In one embodiment, each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots is a splash plate style spray slot. In another embodiment, each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots is a pressure washer style spray slot. In certain embodiments, each flat spray slot in the set of circumferentially spaced apart tertiary flat spray slots is a splash plate style spray slot. In other embodiments, each flat spray slot in the set of circumferentially spaced apart tertiary flat spray slots is a pressure washer style spray slot.

[0010] In certain embodiments, the set of circumferentially spaced apart secondary flat spray slots includes at least three circumferentially spaced apart secondary flat spray slots. In certain embodiments, the set of circumferentially spaced apart tertiary flat spray slots includes at least three circumferentially spaced apart tertiary flat spray slots. In one embodiment, the set of circumferen-

tially spaced apart secondary flat spray slots and the set of circumferentially spaced apart tertiary flat spray slots can be axially aligned with one another relative to the central axis of the elongated nozzle portion. In another embodiment, the set of circumferentially spaced apart secondary flat spray slots and the set of circumferentially spaced apart tertiary flat spray slots can be axially offset from one another relative to the central axis of the elongated nozzle portion.

[0011] The fuel injector assembly further includes an air swirler operatively associated with the distal spray tip. In certain embodiments, the air swirler is a dome air swirler. In certain embodiments, the air swirler is an air swirler cup. The primary pressure atomizer port is adapted and configured to issue a conic fuel spray.

[0012] These and other features of the embodiments 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

[0013] 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 partial cross-sectional view of an engine casing of a gas turbine engine illustrating a fuel injector assembly of the subject disclosure, where an air swirler is shown in cross section, and the fuel injector assembly is shown in operation;

Fig. 2 is a perspective view in partial cross-section of the fuel injector assembly of Fig. 1 shown installed in a combustor chamber of a gas turbine engine, and showing a diffuser for guiding compressor airflow towards the air swirler to reduce sparse air feed in general, yet there remains uneven distribution of air flow around the injector and into the air swirler;

Fig. 3 is a front elevational view of a distal spray tip of an elongated nozzle portion of a nozzle of the fuel injector assembly of Fig. 1, showing a set of circumferentially spaced apart secondary flat spray slots surrounding a central axis, with fuel issuing therefrom;

Fig. 4 is an enlarged localized cross-sectional view of the injector assembly of Fig. 1, showing fuel issuing from the secondary flat spray slots and from a primary atomizer port;

Fig. 5 is a perspective in partial cross-section view taken along line 5-5 of Fig. 3, showing a primary fuel circuit and a secondary fuel circuit within the distal spray tip of the elongated nozzle portion;

Fig. 6 is a partial cross-sectional view of an engine casing of a gas turbine engine illustrating another embodiment of a fuel injector assembly of the subject

disclosure, where an air swirler is shown in cross section, illustrating the fuel injector assembly in operation;

Fig. 7 is a perspective view in partial cross-section of fuel injector assembly of Fig. 6 shown installed in a combustor chamber of a gas turbine engine, and showing a diffuser for guiding compressor airflow towards the air swirler to reduce sparse air feed in general, yet there remains uneven distribution of air flow around the injector and into the air swirler;

Fig. 8 is a front elevational view of a distal spray tip of an elongated nozzle portion of a nozzle of the fuel injector assembly of Fig. 6, showing a set of circumferentially spaced apart secondary flat spray slots and a set of circumferentially spaced apart tertiary flat spray slots surrounding a central axis, with fuel issuing therefrom;

Fig. 9 is an enlarged localized cross-sectional view of the injector assembly of Fig. 6 showing fuel issuing from the secondary flat spray slots, the tertiary flat spray slots, and the primary atomizer port;

Fig. 10 is a perspective in partial cross-sectional view of Fig. 8, showing a primary fuel circuit, a secondary fuel circuit, and a tertiary fuel circuit within the distal spray tip of the elongated nozzle portion, and illustrating splash plate style spray slots; and

Fig. 11 is a perspective in partial cross section view of Fig. 8, showing the primary fuel circuit, the secondary fuel circuit, and the tertiary fuel circuit within the distal spray tip of the elongated nozzle portion, illustrating pressure washer style spray slots.

DETAILED DESCRIPTION

[0014] Referring now to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure, there is shown in Fig. 1, an engine casing designated generally by reference numeral 50, which includes a fuel injector assembly 100 constructed in accordance with an embodiment of the subject disclosure that is designed to cover various combustor geometries and provide targeted flat spray.

[0015] Referring to Fig. 1, the fuel injector assembly 100 includes a fuel nozzle 102 having a radial feed arm 104 with an elongated axially extending nozzle portion 106, which has a central axis "X" extending therethrough. The fuel nozzle 102 is received within the engine casing 50 through an inlet hole 52 and is secured in place by an inlet fitting 54. The fuel nozzle 102 is supplied fuel from a fuel supply when in operation. As shown in Fig. 1, when in operation, fuel is sprayed out of the elongated nozzle portion 106 into an air swirler 118 and through to a combustion chamber 56.

[0016] With reference to Fig. 2, the elongated nozzle portion 106 has a distal spray tip 108 (e.g., as shown in Fig. 1) with a frusto-conical outer surface 110 and a planar front surface 112. A primary pressure atomizer port 114 is centrally provided in the planar front surface 112 of the

distal spray tip 108 and a set of circumferentially spaced apart secondary flat spray slots 116 (e.g., secondary flat spray slots 116a-116d, as shown in Fig. 3) are provided in the frusto-conical outer surface 110 of the distal spray tip 108. The secondary flat spray slots 116 have non-uniform flow rates (e.g., injection characteristic, such as angle, can vary for improvement with uneven air flow). In operation, the pressure atomizing port 114 meters the flow rate of exiting fuel into a conic spray pattern 144, as shown in Fig. 4, and the secondary flat spray slots 116a-116d create a flat spray pattern 146, as shown in Figs. 3 and 4.

[0017] With continued reference to Figs. 1 and 2, the fuel injector assembly 100 further includes an air swirler 118 operatively associated with the distal spray tip 108. A diffuser 120 is separate from, but operatively associated with the fuel injector assembly 100 for guiding compressor airflow towards the air swirler. The diffuser 120 has a radially inner wall 120a and a radially outer wall 120b, as best shown in Fig. 2. In operation, air flows through the diffuser 120 and surrounds the elongated nozzle portion 106 of the fuel nozzle 102 in an uneven pattern, as indicated by the directional flow arrows 148 in Fig. 1. The air flow around the elongated nozzle portion 106, e.g., as shown by the dotted circle in Fig. 1 and Fig. 6, surrounding the arrows 148, may have a concentrated air flow region around the center and creates dense and sparse air feed into air swirler 118. Fuel can be more efficiently placed into the high/low air flow regions by the independent calibration of particular injection sites (e.g., flat spray slots 116 & 136). For example, the secondary flat spray slots 116a and 116c may be higher fuel flow than the secondary flat spray slots 116b and 116d.

[0018] In certain embodiments, the air swirler 118 is an air swirler cup. In certain other embodiments, the air swirler 118 is a dome air swirler. Any other suitable type of air swirler is contemplated herein. In Figs. 1 and 2, the air swirler 118 is shown within a combustion chamber 56 of the gas turbine engine. It is envisioned that pilot fuel flow from the fuel nozzle 102 can be targeted, for example, directed at the ignitor 58 during engine start-up (e.g., as shown in Fig. 1).

[0019] With reference to Fig. 3, four secondary flat spray slots 116a-116d are shown spaced circumferentially around the central axis X. The four secondary flat spray slots 116a-116d can be spaced apart 90 degrees from each other (e.g., as shown in Fig. 3), or can include any other suitable arrangement. For example, there can be less than four secondary flat spray slots 116 or more than for secondary flat spray slots 116. They can have different arcs and angles than what is shown in Fig. 3. They can be longer or shorter in length and wider or narrower in width than what is shown in Fig. 3. Any suitable length, arc, width, and number of secondary flat spray slots 116 is contemplated herein. For example, certain secondary flat spray slots 116 may have a larger flow number and a wider angle resulting in one type of fuel flow pattern, while other secondary flat spray slots 116 may have a lower flow number and a narrower angle

resulting in a different fuel flow pattern.

[0020] With continued reference to Fig. 3, the secondary flat spray slots 116a-116d are embedded or otherwise formed within the frusto-conical outer surface 110. The secondary flat spray slots 116a-116d are shown with fuel being sprayed therethrough, resulting in the flat spray pattern 146. Each secondary flat spray slot 116a-116d, can be different as described above, to provide for different flow rates and flow patterns.

[0021] Referring to Fig. 4, the distal spray tip 108 is shown within the air swirler 118. The fuel injector assembly 100 is shown in operation and a fuel spray is shown coming from the pressure atomizer port 114 as well as from the secondary flat spray slots 116. The fuel coming from the pressure atomizer port is the conic spray pattern 144 and the fuel coming from the secondary flat spray slots 116a-116d is the flat spray pattern 146. The location of the secondary flat spray slots 116 around the central axis X (e.g., side versus top versus bottom locations) can each have unique performance characteristics. For example, top and/or bottom location spray slots may be a lower flow number and a narrower angle and side location spray slots may be a larger flow number and wider angle.

[0022] Referring now to Fig. 5, the primary pressure atomizer port 114 is operatively associated with a primary pressure atomizer 122 within the distal spray tip 108 of the nozzle portion 106 of the fuel nozzle 102. The primary pressure atomizer 122 is a common pressure atomizer used in the primary (e.g., pilot) fuel circuit 138. The primary pressure atomizer 122 includes an atomizing tip portion 124 which the primary pressure atomizer port 114 extends through. The primary pressure atomizer 122 further includes a fuel swirler 126 surrounded by the atomizing tip portion 124. The fuel swirler 126 has a front surface 128 which abuts an inner wall 130 of the atomizing tip portion 124. The fuel swirler 126 has a plurality of offset slots 132a, 132b, e.g., as best shown in Fig. 10, and a main swirler 134. The plurality of offset slots 132a, 132b aid in imparting centrifugal swirling. Any number of offset slots 132 is contemplated herein. The fuel exits the plurality of offset slots 132a, 132b and is directed into the main swirler 134 by the inner wall 130 of the primary pressure atomizer 122 and through the primary pressure atomizer port 114.

[0023] A primary fuel supply circuit 138 extends through the fuel nozzle 102 for supplying fuel to the primary pressure atomizer port 114. A secondary fuel supply circuit 140 extends through the fuel nozzle 102 for supplying fuel to the set of circumferentially spaced apart secondary flat spray slots 116. The primary fuel circuit 138 and secondary fuel circuit 140 are all supplied fuel independently and can each be staged on and/or off as best suits combustion performance (e.g., for power necessity, burn efficiency, emissions, etc.).

[0024] With continued reference to Figs. 4 and 5, in one embodiment, each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots 116 is a splash plate style spray slot (e.g., as shown by the

secondary flat spray slots of Fig. 5). In another embodiment, each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots 116 is a pressure washer style spray slot (e.g., a pressure washer style spray slot is shown in Fig. 11 for the tertiary flat spray slots 136). The secondary flat spray slots 116 can be any arrangement of pressure washer and or splash plate style slots. The pressure washer style spray slots may be created by a keyseat, a double angle shank, or thread mill style cutting tool. The splash plate style spray slots may be created by a keyseat style cutting tool.

[0025] Each of the secondary fuel circuits 140 include respective nominally central passages 143, e.g., as shown in Figs. 10, and 11, which are operatively connected to the secondary flat spray slots 116. The nominally central passages 143a of the washer pressure washer style spray slots, e.g., as shown in Fig 11) have an eccentric open area between the nominally central passage 143a and the secondary flat spray slots 116 to perform flow rate metering of exiting fuel and generates flat fuel spray. The nominally central passages 143b of the splash plate style spray slots, (e.g., as shown in Figs 10), can be covered completely or partially by the opposite side of the secondary flat spray slots 116. The nominally central passage 143b may partially intersect the opposite side of the secondary flat spray slots 116 without impacting the spray performance.

[0026] Referring to Fig. 6, the system as described above with respect to Fig. 1 is shown including all of the features described above with respect to Figs. 1-5. In Fig. 6, the fuel injector assembly further includes a set of circumferentially spaced apart tertiary flat spray slots 136 provided in the frusto-conical outer surface 110 rearward of the set of circumferentially spaced apart secondary flat spray slots 116. The tertiary flat spray slots 136 have non-uniform flow rates (e.g., injection characteristic, such as angle, can vary for improvement with uneven air flow) In Fig. 6, the fuel injector is shown in operation as described above with respect to Fig. 1. Fuel is sprayed out of the elongated nozzle portion 106 into an air swirler 118 and into the combustion chamber 56.

[0027] Referring to Fig. 7, the elongated nozzle portion 106 includes the distal spray tip 108 (e.g., as shown in Fig. 6) with the frusto-conical outer surface 110 and the planar front surface 112. The primary pressure atomizer port 114 is centrally provided in the planar front surface 112 of the distal spray tip 108 and a set of circumferentially spaced apart secondary flat spray slots 116 and circumferentially spaced tertiary flat spray slots 136 (e.g., three tertiary spray slots 136a-136c as shown in Fig. 8) are provided in the frusto-conical outer surface 110 of the distal spray tip 108. In operation, the pressure atomizing port 114 meters the flow rate of exiting fuel into a conic spray pattern 144, e.g., as shown in Fig. 9, and the secondary flat spray slots 116 and tertiary flat spray slots 136 create a flat spray pattern 146, as shown in Figs. 8 and 9.

[0028] Referring to Fig. 8, three secondary flat spray

slots 116a-116c are shown spaced circumferentially around the central axis X and three tertiary flat spray slots 136a-136c are shown rearward of the secondary flat spray slots 116a-116c and circumferentially spaced around the central axis X. The three secondary flat spray slots 116a-116c and the tertiary flat spray slots 136a-136c can be spaced apart 120 degrees from each other, e.g., as shown in Fig 8, or they can include any other suitable arrangement. For example, there can be less than three secondary flat spray slots 116 and/or tertiary flat spray slots 136 or more than three secondary flat spray slots 116 and/or tertiary flat spray slots 136. They can have different arcs and angles than what is shown in Fig. 8. They can be longer or shorter in length and wider or narrower in width than what is shown in Fig. 8. Any suitable length, arc, width, and number of secondary flat spray slots 116 and/or tertiary flat spray slots 136 is contemplated herein.

[0029] In one embodiment, the set of circumferentially spaced apart secondary flat spray slots 116a-116c and the set of circumferentially spaced apart tertiary flat spray slots 136a-136c can be axially aligned with one another relative to the central axis X of the elongated nozzle portion 106. For example, each of the secondary flat spray slots 116a-116c can be spaced apart 120 degrees from each other and each of the tertiary flat spray slots 136 can be rearward of the secondary flat spray slots 116a-116c and can also be spaced 120 degrees apart from each other.

[0030] In another embodiment shown in Fig. 8, the set of circumferentially spaced apart secondary flat spray slots 116a-116c and the set of circumferentially spaced apart tertiary flat spray slots 136a-136c can be axially offset from one another relative to the central axis X of the elongated nozzle portion 106. For example, the secondary flat spray slots 116a-116c can be spaced apart 120 degrees from one another around the central axis and the tertiary flat spray slots 136a-136c can be rearward of the secondary flat spray slots 116a-116c and spaced apart from each other 240 degrees from each other.

[0031] With continued reference to Fig. 8, the secondary flat spray slots 116a-116c and tertiary flat spray slots 136a-136c are embedded within the frusto-conical outer surface 110. The secondary flat spray slots 116a-116c and tertiary flat spray slots 136a-136c are shown with fuel being sprayed therethrough, resulting in the flat spray pattern 146. Each secondary flat spray slot 116a-116c and tertiary flat spray slot 136a-136c, can be different as described above, to provide for different flow rates and flow patterns.

[0032] Referring now to Fig. 9, the distal spray tip 108 is shown within the air swirler 118. The fuel injector assembly 100 is shown in operation and a fuel spray is shown coming from the pressure atomizer port 114 as well as from the secondary flat spray slots 116 and the tertiary flat spray slots 136. The fuel coming from the pressure atomizer port is the conic spray pattern 144 and the fuel coming from the secondary flat spray slots 116 and the

tertiary flat spray slots 136 is the flat spray pattern 146. The location of the secondary flat spray slots 116 and the tertiary flat spray slots 136 around the central axis X (e.g., side versus top versus bottom locations) can each have unique performance characteristics. For example, top and/or bottom location spray slots may be a lower flow number and a narrower angle and side location spray slots may be a larger flow number and wider angle.

[0033] Referring to Figs. 10 and 11, a primary fuel supply circuit 138 extends through the fuel nozzle 102 for supplying fuel to the primary pressure atomizer port 114. A secondary fuel supply circuit 140 extends through the fuel nozzle 102 for supplying fuel to the set of circumferentially spaced apart secondary flat spray slots 116. A tertiary fuel supply circuit 142 extends through the fuel nozzle 102 for supplying fuel to the set of circumferentially spaced apart tertiary flat spray slots 136. The primary fuel circuit 138, secondary fuel circuit 140, and tertiary fuel circuit 142 are all supplied independently and can each be staged on and/or off as best suits combustion performance, e.g., for power necessity, burn efficiency, emissions, etc.).

[0034] In one embodiment, each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots 116 is a splash plate style spray slot. In another embodiment, each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots 116 is a pressure washer style spray slot. In certain embodiments, each flat spray slot in the set of circumferentially spaced apart tertiary flat spray slots 136 is a splash plate style spray slot. In other embodiments, each flat spray slot in the set of circumferentially spaced apart tertiary flat spray slots 136 is a pressure washer style spray slot. As shown in Fig. 10, the tertiary flat spray slots 136 are of the flat spray style slot. As shown in Fig. 11, the tertiary flat spray slots 136 are of the pressure washer style spray slot.

[0035] The secondary flat spray slots 116 and tertiary flat spray slots 136 can be any arrangement of washer and/or splash plate style slots. The pressure washer style spray slots may be created by a keyseat, a double angle shank, or thread mill style cutting tool. The splash plate style spray slots may be created by a keyseat style cutting tool.

[0036] With continued reference to Figs. 10 and 11, each of the secondary fuel circuits 140 and tertiary fuel circuits 142 include respective nominally central passages 143, e.g., as shown in Figs. 9 and 10, which are operatively connected to the secondary flat spray slots 116 and the tertiary flat spray slots 136. The nominally central passages 143a of the washer pressure washer style spray slots have an eccentric open area between the nominally central passage 143a and the secondary flat spray slots 116 and/or the tertiary flat spray slots 136 to perform flow rate metering of exiting fuel and generates flat fuel spray. The nominally central passages 143b of the splash plate style spray slots can be covered completely or partially by the opposite side of the secondary

flat spray slots 116 and/or the tertiary flat spray slots 136. The nominally central passage 143b may partially intersect the opposite side of the secondary flat spray slots 116 and/or the tertiary flat spray slots 136 without impacting the spray performance.

[0037] The embodiments of the present disclosure, as described above and shown in the drawings, provide for improvement in the art to which they pertain.

Claims

1. A fuel injector assembly (100) for a gas turbine engine, comprising:
 - a fuel nozzle (102) including a radial feed arm (104) with an elongated axially extending nozzle portion (106) having a central axis (X) extending there-through, the elongated nozzle portion having a distal spray tip (108) with a frusto-conical outer surface (110) and a planar front surface (112), wherein a primary pressure atomizer port (114) is centrally provided in the planar front surface of the distal spray tip and a set of circumferentially spaced apart secondary flat spray slots (116) are provided in the frusto-conical outer surface of the distal spray tip.
2. The fuel injector assembly of claim 1, wherein the primary pressure atomizer port (114) is operatively associated with a primary pressure atomizer (122) within the distal spray tip (108) of the nozzle portion of the fuel nozzle, wherein the primary pressure atomizer includes an atomizing tip portion (124) which the primary pressure atomizer port extends through, and a fuel swirler (126) surrounded by the atomizing tip portion; and optionally:
 - wherein the fuel swirler has a front surface (128) which abuts an inner wall (130) of the atomizing tip portion, wherein the fuel swirler has a plurality of offset slots (132n) and a main swirler (134), and wherein fuel exits the plurality of offset slots and is directed into the main swirler by the inner wall of the primary pressure atomizer and through the primary pressure atomizer port.
3. The fuel injector assembly of Claim 1 or 2, wherein a set of circumferentially spaced apart tertiary flat spray slots (136) are provided in the frusto-conical outer surface (110) rearward of the set of circumferentially spaced apart secondary flat spray slots (116).
4. The fuel injector assembly of Claim 1, 2 or 3, wherein a primary fuel supply circuit extends through the fuel nozzle (102) for supplying fuel to the primary pressure atomizer port (114); and/or wherein a secondary fuel supply circuit extends through the fuel nozzle for supplying fuel to the set of circumferentially spaced apart secondary flat spray slots (116).

5. The fuel injector assembly of Claim 3 or 4, wherein a tertiary fuel supply circuit extends through the fuel nozzle (102) for supplying fuel to the set of circumferentially spaced apart tertiary flat spray slots (136). 5
6. The fuel injector assembly of Claim 3, 4 or 5, wherein the each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots (116) is a splash plate style spray slot; and/or wherein the each flat spray slot in the set of circumferentially spaced apart tertiary flat spray slots (136) is a splash plate style spray slot. 10
7. The fuel injector assembly of any of claims 3 to 6, wherein the each flat spray slot in the set of circumferentially spaced apart secondary flat spray slots (116) is a pressure washer style spray slot; and/or wherein the each flat spray slot in the set of circumferentially spaced apart tertiary flat spray slots (136) is a pressure washer style spray slot. 15 20
8. The fuel injector assembly of any preceding Claim, wherein the set of circumferentially spaced apart secondary flat spray slots (116) includes at least three circumferentially spaced apart secondary flat spray slots. 25
9. The fuel injector assembly of any of Claims 3 to 8, wherein the set of circumferentially spaced apart tertiary flat spray slots (136) includes at least three circumferentially spaced apart tertiary flat spray slots. 30
10. The fuel injector assembly of any of Claims 3 to 9, wherein the set of circumferentially spaced apart secondary flat spray slots (116) and the set of circumferentially spaced apart tertiary flat spray slots (136) are axially aligned with one another relative to the central axis (X) of the elongated nozzle portion (106). 35 40
11. The fuel injector assembly of any of Claims 3 to 10, wherein the set of circumferentially spaced apart secondary flat spray slots (116) and the set of circumferentially spaced apart tertiary flat spray slots (136) are axially offset from one another relative to the central axis (X) of the elongated nozzle portion (106). 45
12. The fuel injector assembly of any of Claims 3 to 11, further comprising an air swirler (118) operatively associated with the distal spray tip (106). 50
13. The fuel injector assembly of any preceding claim, wherein the secondary flat spray slots (116) have non-uniform flow rates. 55
14. The fuel injector assembly of Claim 12 or 13, wherein the air swirler (118) is a dome air swirler; or wherein the air swirler (118) is an air swirler cup.
15. The fuel injector assembly of any preceding Claim, wherein the primary pressure atomizer port (114) is adapted and configured to issue a conic fuel spray.

Fig. 1

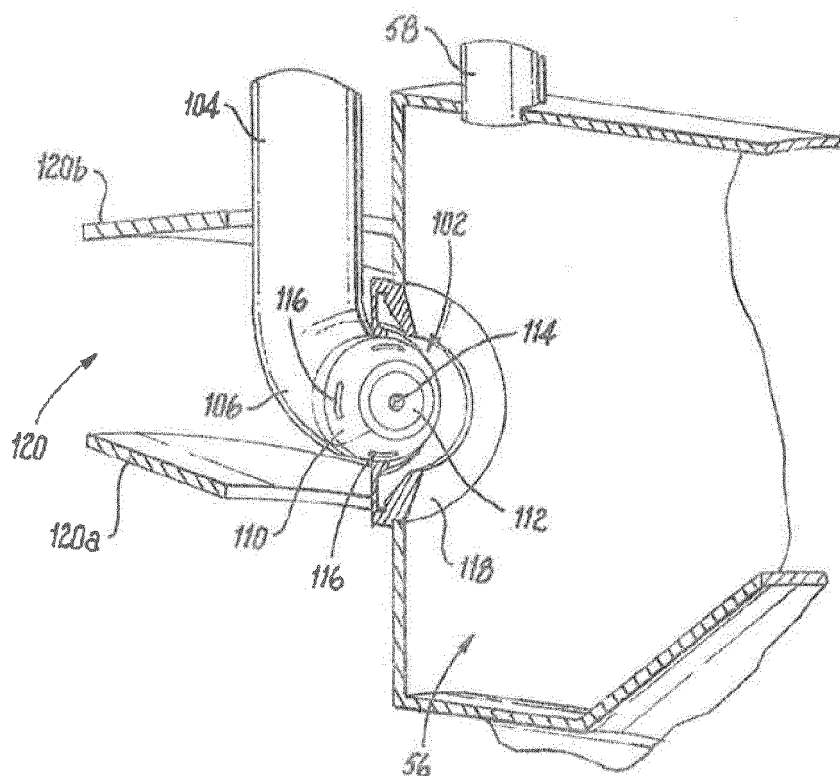
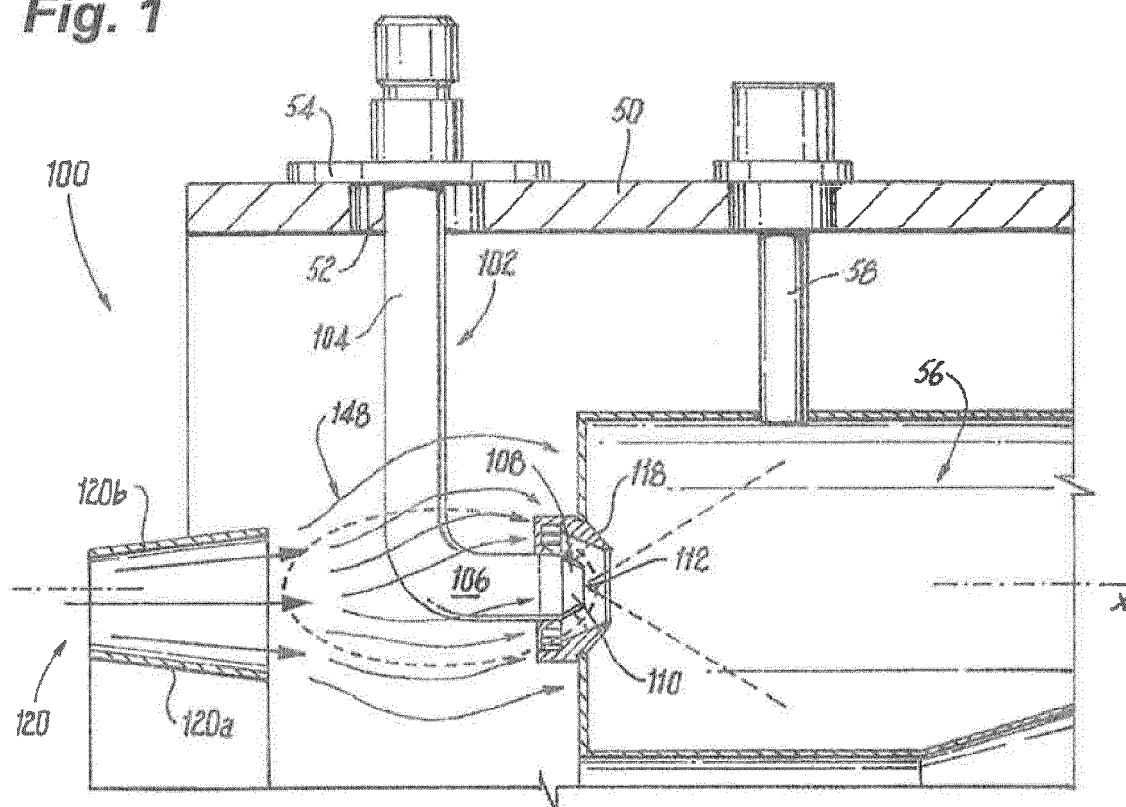


Fig. 2

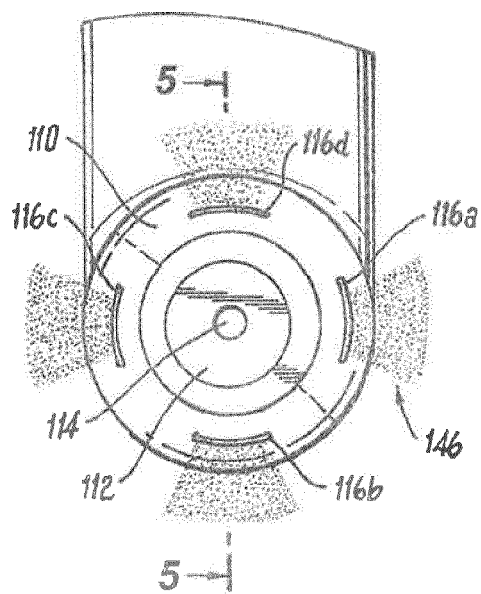


Fig. 3

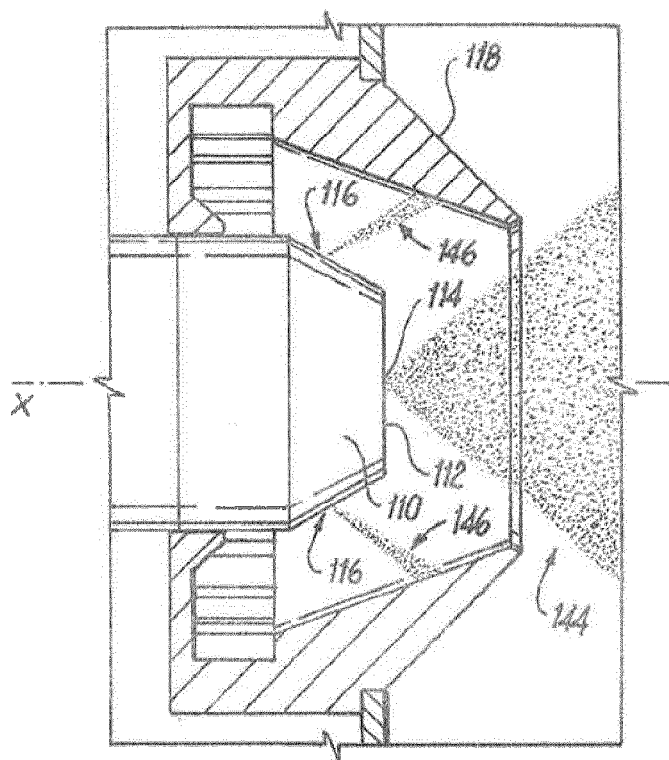


Fig. 4

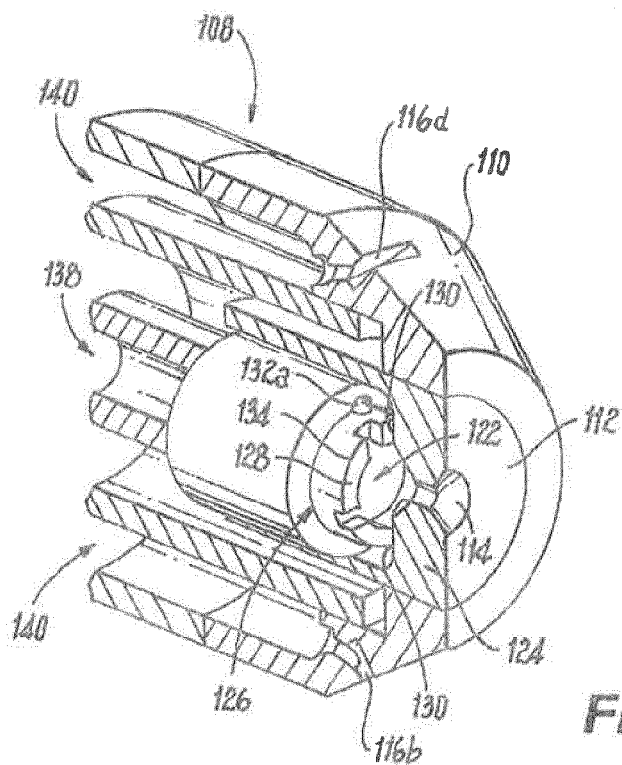


Fig. 5

Fig. 6

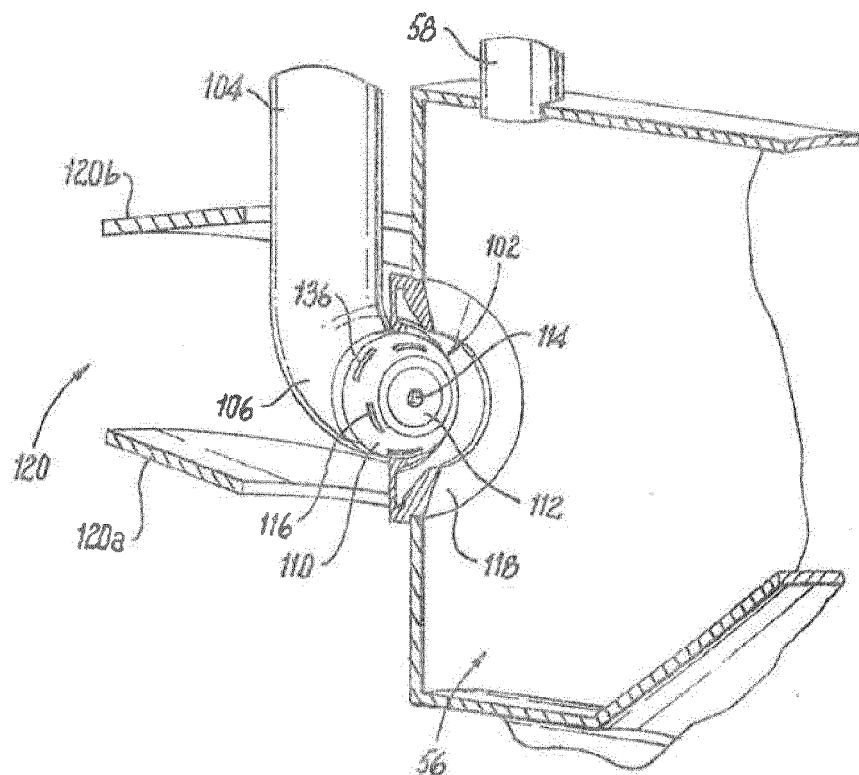
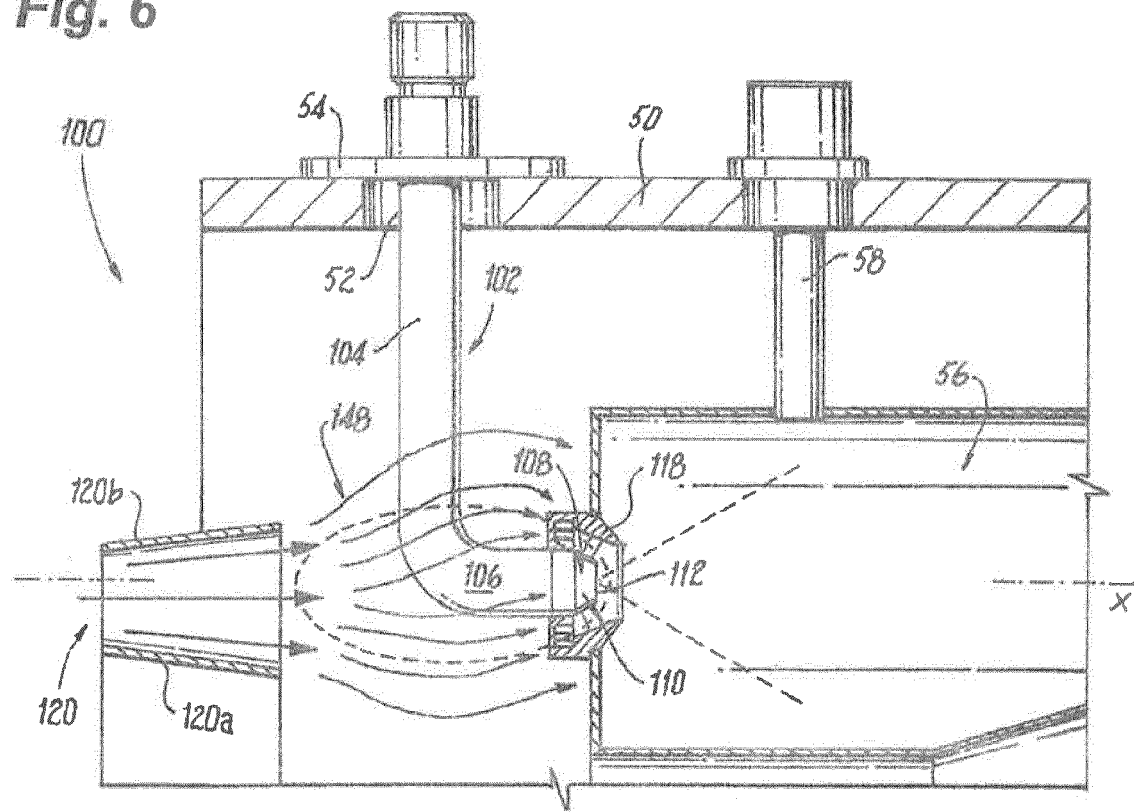
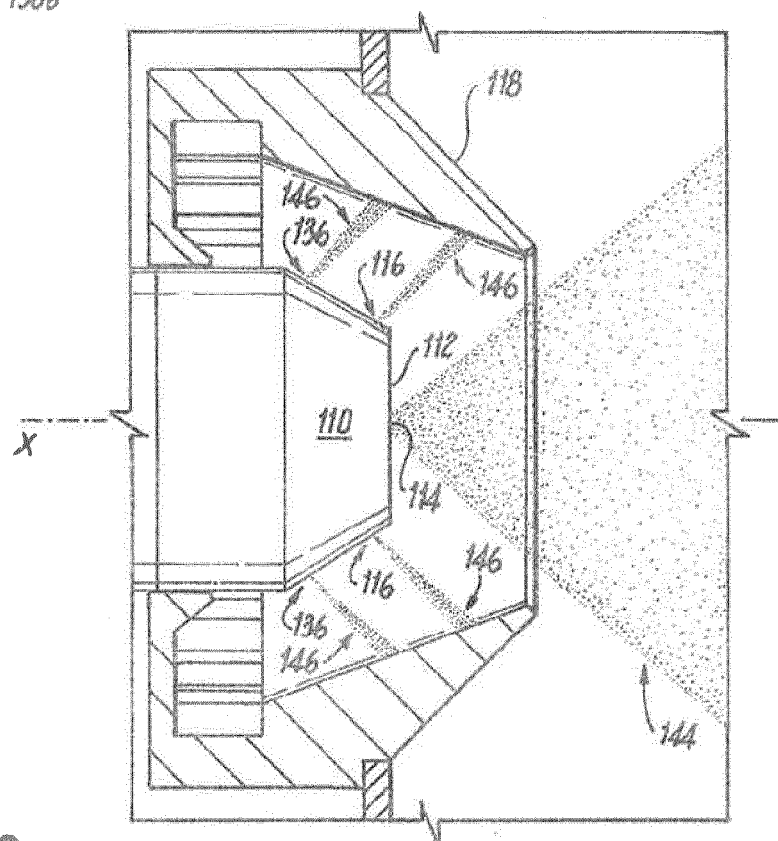
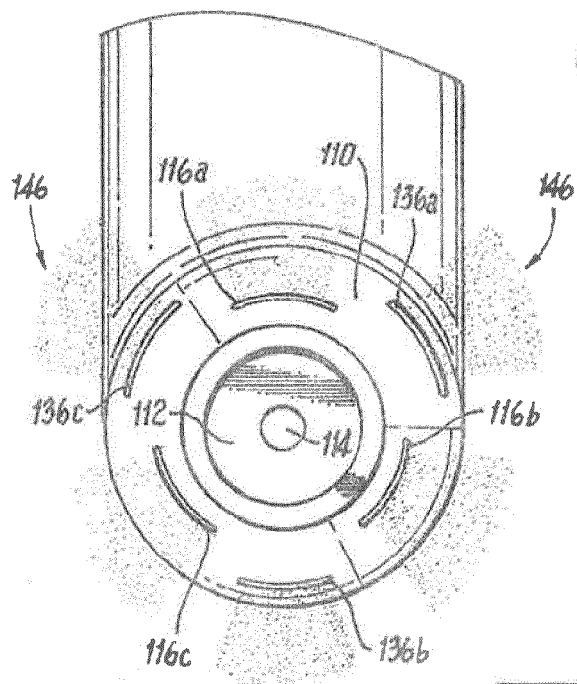


Fig. 7



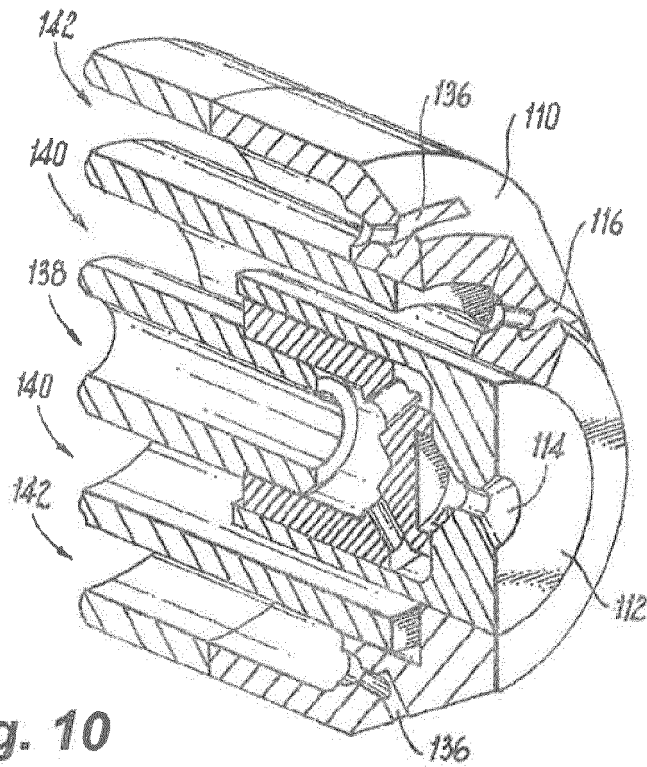


Fig. 10

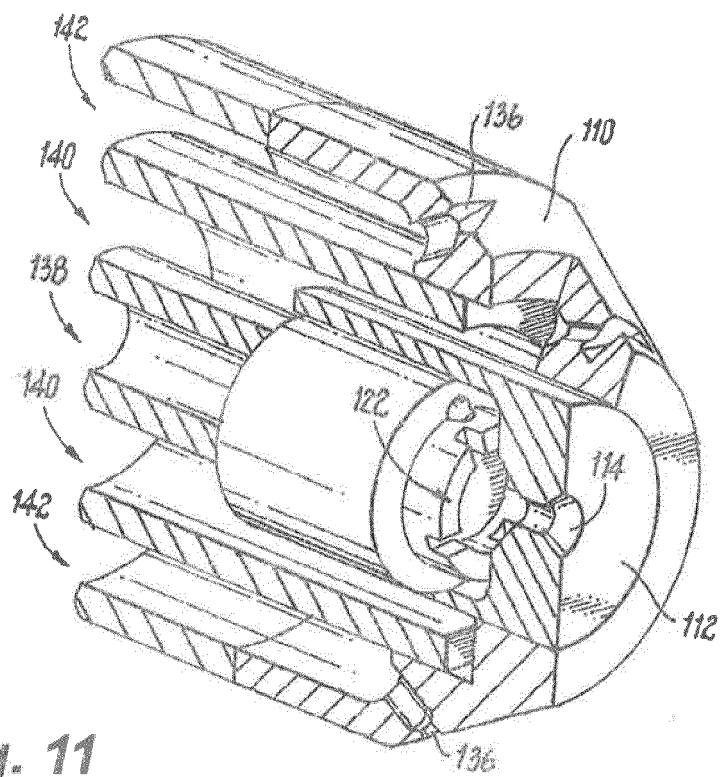


Fig. 11



EUROPEAN SEARCH REPORT

Application Number

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