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(54) **ANTI-COKING LIQUID FUEL INJECTOR ASSEMBLY FOR A COMBUSTOR**

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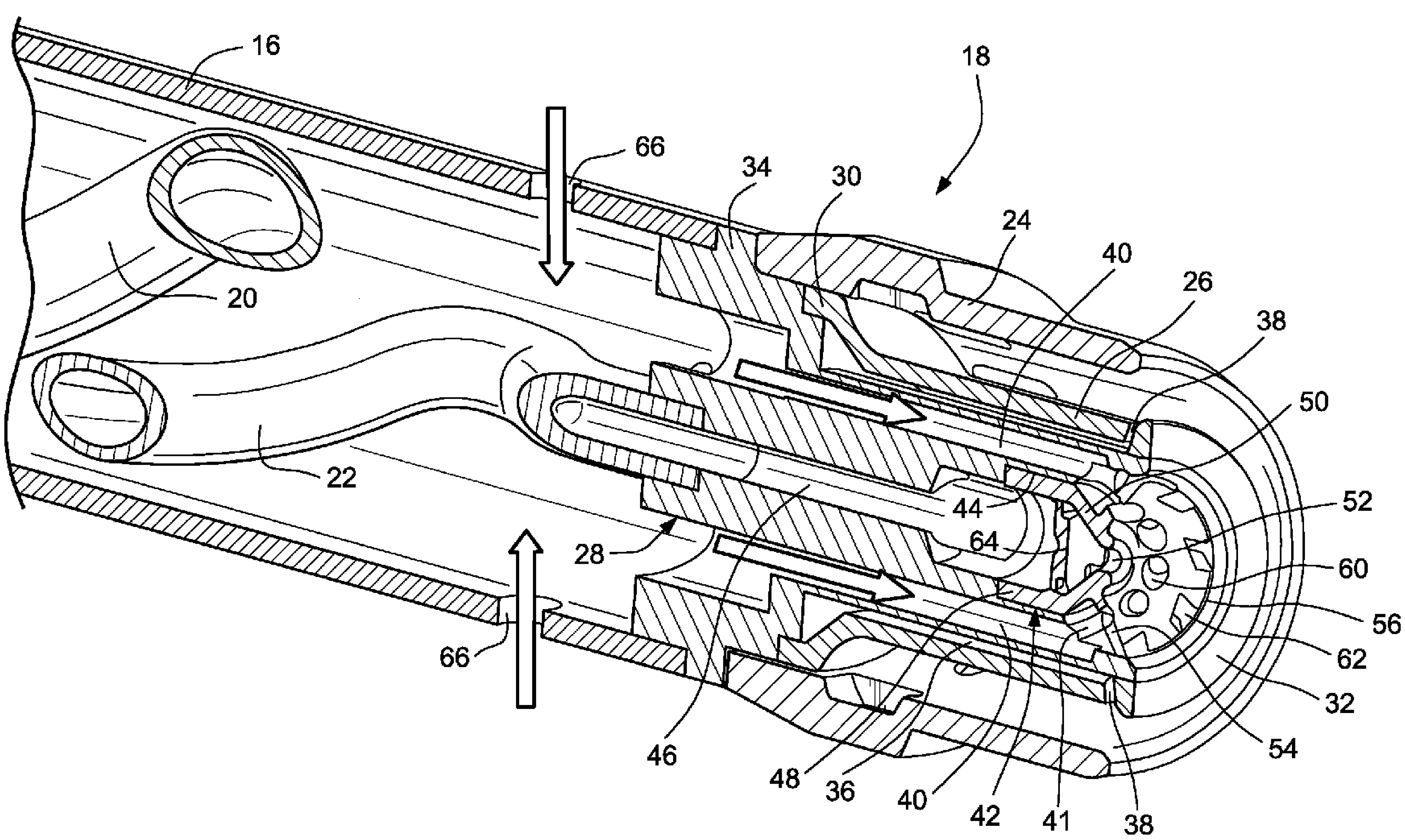
(57) **ABSTRACT**

A liquid fuel cartridge assembly for a gas turbine combustor comprising an elongated stem provided with a fuel injector tip at an aft end of said stem, said injector tip provided with a pilot fuel passage extending to a pilot fuel orifice; a plurality of air channels surrounding said pilot fuel passage and in communication with plural air holes; an annular main fuel passage surrounding said plurality of air channels and in communication with plural fuel exit holes; and a plurality of substantially radially oriented air supply holes in said stem upstream but proximate to a forward end of said tip in communication with said plurality of air channels.



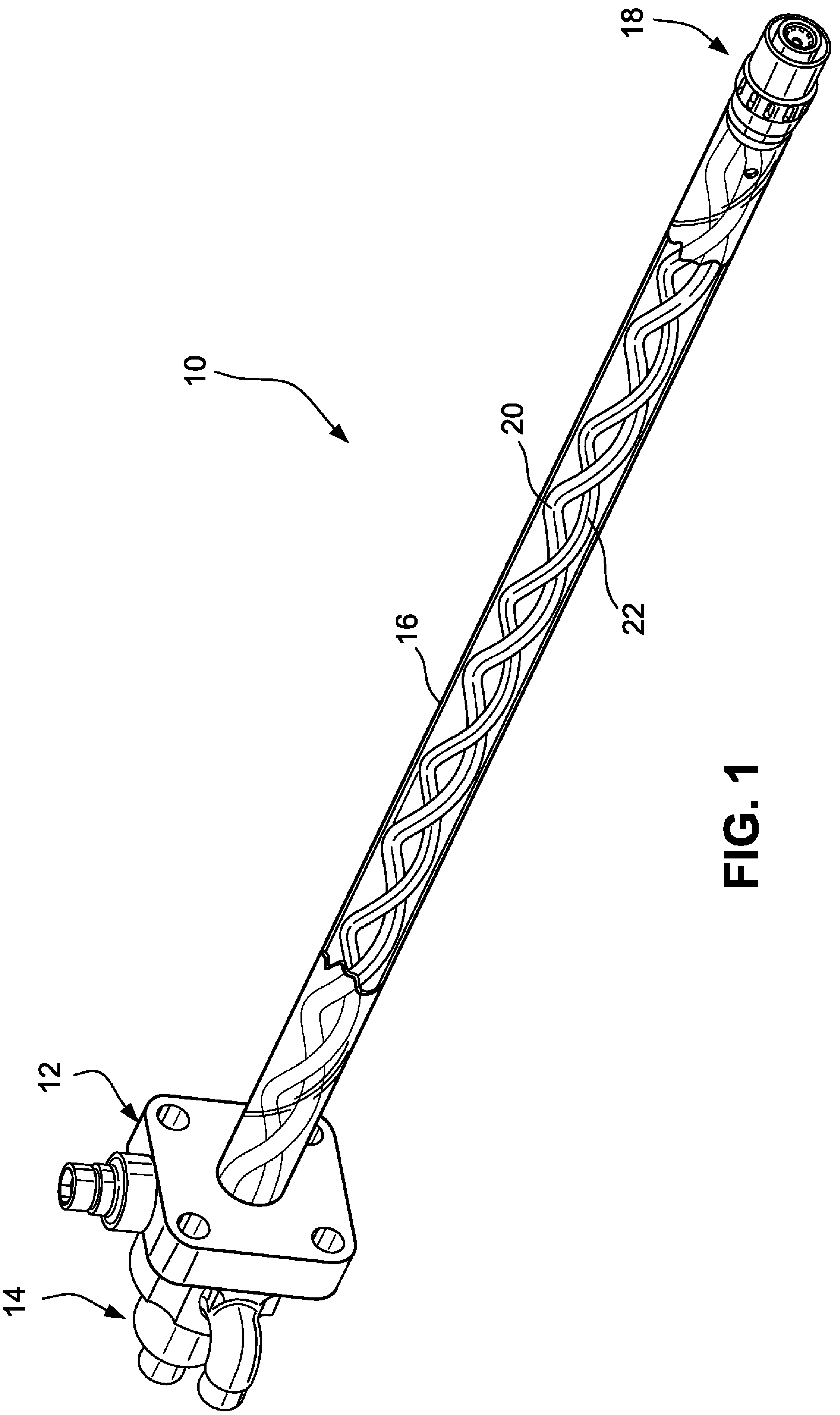


FIG. 1

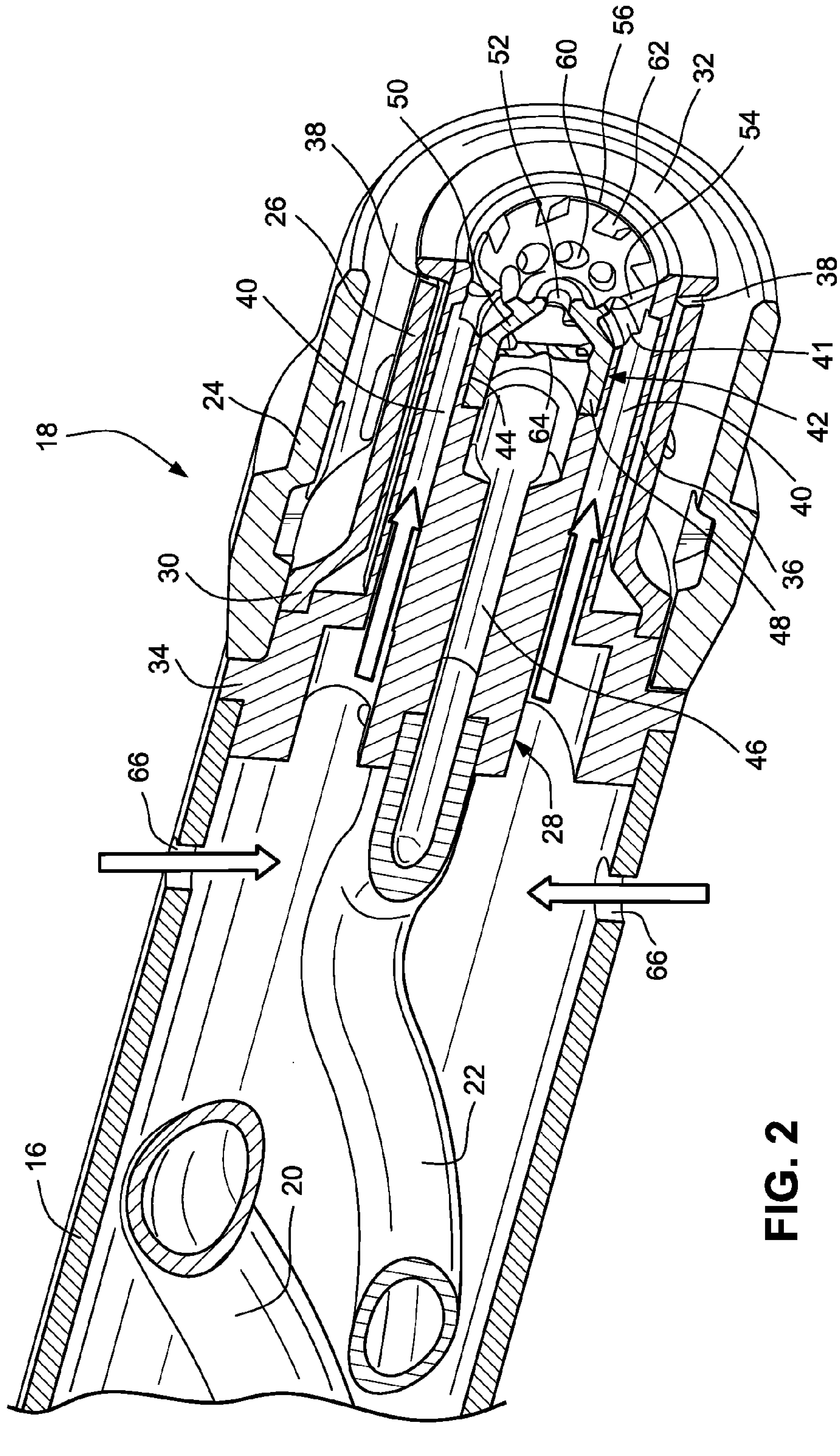

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FIG. 2

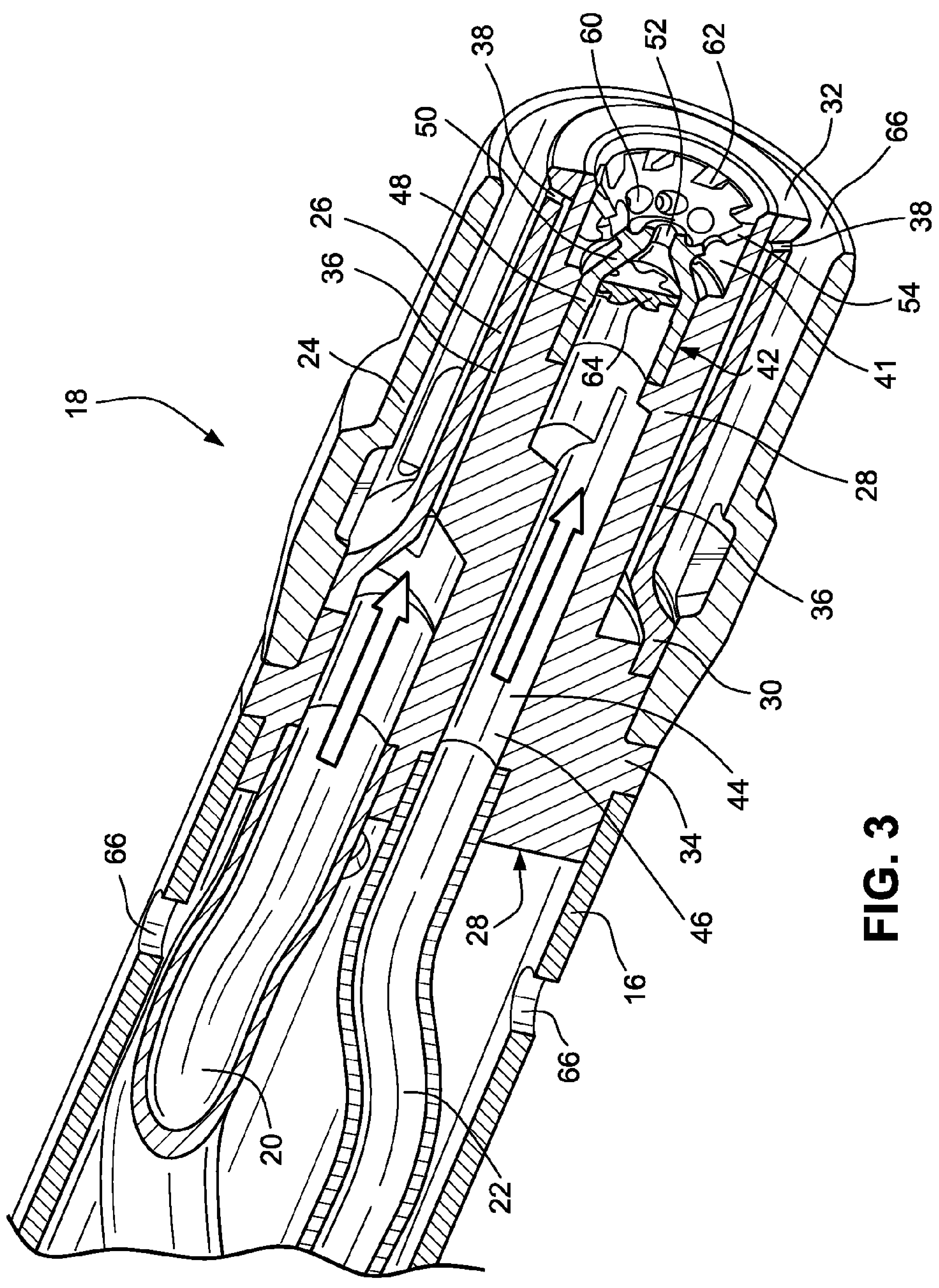
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FIG. 3

ANTI-COKING LIQUID FUEL INJECTOR ASSEMBLY FOR A COMBUSTOR

BACKGROUND OF THE INVENTION

[0001] This invention relates to gas turbine combustors and particularly to a liquid fuel cartridge designed to prevent formation of internal coke deposits about the fuel nozzle tip.

[0002] The formation of coke deposits at the tip of a fuel injector nozzle can interfere with the desired fuel/air mixture delivered to the combustion chamber throughout the various stages of combustion, and thus negatively impact on the reduction of oxides of nitrogen (NOx)required by exhaust emissions regulations.

[0003] One attempt to solve the coke formation problem is described in U.S. Pat. No. 6,715,292. A coke-resistant fuel injector for a low-emission combustor is formed with a pressure-atomizing core nozzle and an airblast secondary injector. The airblast portion includes inner and outer air passages for injecting co-annular, co-swirling streams into the combustor can. An air distribution baffle extends radially across the inner air passage to divide the inner airstream into a substream and a plurality of air jets. The presence of the air baffle and co-swirling inner and outer air streams is said to promote superior fuel-air mixing which promotes clean burning and resists coke formation.

BRIEF DESCRIPTION OF THE INVENTION

[0004] The present invention provides a liquid fuel cartridge (LFC) that utilizes an internal heat shield and purge air to prevent internal coking formation and overheating of the LFC tip.

[0005] In a first exemplary but nonlimiting embodiment, there is provided a liquid fuel cartridge assembly for a gas turbine combustor comprising an elongated stem provided with a fuel injector tip at an aft end of said stem, said injector tip provided with a pilot fuel passage extending to a pilot fuel orifice; a plurality of air channels surrounding said pilot fuel passage and in communication with plural air exit openings; an annular main fuel passage surrounding said plurality of air channels and in communication with plural fuel exit holes; and a plurality of substantially radially oriented air supply holes in said stem upstream but proximate to a forward end of said tip in communication with said plurality of air channels.

[0006] In another aspect, the invention provides a liquid fuel cartridge assembly for a combustor of a gas turbine comprising an elongated, hollow stem provided with a fuel injector tip at an aft end of said stem, said injector tip provided with a pilot fuel passage centered within said tip along a longitudinal axis of said tip and extending to a pilot fuel orifice; a plurality of air channels surrounding said pilot fuel passage and in communication with plural air exit openings within said fuel injector tip; an annular main fuel passage surrounding said plurality of air channels and in communication with plural fuel exit openings radially outward of said plural air exit holes; a plurality of substantially radially oriented air supply holes in said stem upstream of said tip in communication with said plurality of air channels; and wherein said stem encloses a first pilot fuel supply pipe in fluid communication with said pilot fuel passage and a second main fuel supply pipe in fluid communication with said annular main fuel passage that are intertwined along a length portion of said hollow stem.

[0007] In still another aspect, there is provided a liquid fuel cartridge assembly for a combustor of a gas turbine comprising an elongated stem provided with a fuel injector tip at an aft end of said stem, said stem enclosing main fuel and pilot fuel supply pipes, said injector tip provided with a pilot fuel passage centered within said tip along a longitudinal axis of said tip; a plurality of air channels surrounding said pilot fuel passage; an annular main fuel passage surrounding said plurality of purge/cooling air channels; and a plurality of substantially radially oriented air supply holes in said stem upstream and adjacent said fuel injector tip in communication with said plurality of air channels; wherein said injector tip is comprised of an outer sleeve, a concentrically-arranged inner sleeve and a concentrically-arranged center core; said pilot fuel passage and said plurality of air channels formed in said center core; and said annular main fuel passage formed in a radial space between said first-inner sleeve and said center core.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a perspective view of a liquid fuel cartridge in accordance with an exemplary but nonlimiting embodiment of the invention;

[0009] FIG. **2** is a partial perspective view of the tip portion of the liquid fuel cartridge shown in FIG. **1**, sectioned to show the internal air cooling channels; and

[0010] FIG. **3** is a partial perspective view of the tip portion of the liquid fuel cartridge shown in FIG. **1**, sectioned to show the internal fuel supply channels.

DETAILED DESCRIPTION OF THE INVENTION

[0011] FIG. **1** illustrates a liquid fuel cartridge or injector **10** for use in gas turbine engines. The cartridge **10** is provided at a forward end with conventional mounting hardware **12** for securing the cartridge to the forward end or cap assembly (not shown) of a combustor, along with conventional fuel supply fixtures **14**. A hollow stem or tube **16** extends from the mounting hardware **12** to an aft end fitted with an injector tip **18**.

[0012] Liquid fuel is supplied to the tip **18** by means of intertwined conduits or helix pipes **20**, **22** (see also FIG. **2**) connected to the fixtures **14**. Stem or tube **16** is shown as translucent merely to make visible the pipes **20**, **22**. Pipe **20** supplies the main fuel to the tip **18**, while pipe **22** supplies pilot fuel to the tip. The pipes **20**, **22** may be made from any stainless steel or other materials, having required manufacturability and mechanical properties. The intertwined arrangement of pipes **20**, **22** allows for differential thermal expansion without having to design the attachment hardware and/or nozzle tip to accommodate differential expansion of the pipes.

[0013] As best seen in FIG. **2**, the injector tip **18** is comprised of an outer, substantially-cylindrical sleeve **24**, a concentrically-arranged inner sleeve **26** and a concentrically-arranged center core **28**. The first inner sleeve **26** is joined to the outer sleeve **24** at a forward, outwardly flared end **30**, and to the center core **28** at an aft flanged end **32**. The center core **28** is formed with a forward radial flange **34** sandwiched between the forward end of the outer sleeve **24** and the aft edge of the stem or tube **16**. The securements mentioned above may be implemented in any suitable known manner, such as by welding, brazing, etc.

[0014] The radial space between the inner sleeve **26** and the center core **28** forms an annular main fuel channel **36**, and the aft tip of the inner sleeve **26** is formed with slanted fuel exit orifices **38** arranged about the flanged end **32**. The center core **28** is formed with a circumferentially arranged plurality of axially-extending cooling channels **40** in the radially outer region of the center core that open into an annular space **41** formed by adjacent-tapered portions **50**, **54** (described below) of a nozzle insert **42**. The nozzle insert **42** is received in a counterbore **44** formed in the center of the core **28**. The counterbore **44** extends in an aft direction from, and is contiguous with, the bore **46** which forms the pilot fuel passage. The nozzle insert **42** includes an axially-extending cylindrical section **48** received in the counterbore **44** and an inwardly-tapered portion **50** leading to a single, centered pilot fuel exit orifice **52**. The nozzle insert then extends outwardly via tapered portion **54** to an edge **56**. The outwardly-tapered portion **54** includes annular rows or arrays of openings in the form of holes and optional slots **60**, **62**, respectively described in further detail below. A swirler element **64** is located within the nozzle insert, upstream of the exit orifice **52**, where the cylindrical section **48** joins the inwardly tapered portion **50**. The swirler element swirls the pilot fuel prior to its exit via the orifice **52**, thus promoting better mixing with air downstream of the nozzle tip.

[0015] FIG. 2 is cut away to especially illustrate the cooling/purge air flow path through the nozzle tip **18**. Specifically, cooling/purge air is supplied to the stem or tube **16** by means of a circumferential array of holes **66** located close to the forward end of the tip **18**. The cooling/purge air flows through the circumferentially arranged plurality of axially-extending cooling channels **40** formed in the radially outer region of the center core **28** and into the annular space **41**. The air exits through the annular rows of holes and optional slots **60**, **62** in the nozzle insert **42**. The rows of holes and optional slots **60**, **62**, respectively, may be formed of different shape (e.g., round, oval, square, oblong, etc.), swirl angles and inclination angles. In addition, the holes and optional slots in the respective rows may be angled or slanted in the same direction, or alternatively, in opposite directions to provide counter-swirling streams to effect better mixing with the fuel exiting the pilot fuel exit orifice **52**. It will be understood that the row of holes **60** could be used without peripheral slots **62** and, conversely, the peripheral slots **62** could be used without the holes **60**. In addition, more than one row of holes **60** could be provided, with or without the peripheral slots **62**.

[0016] FIG. 3 is cut away to more clearly illustrate the liquid fuel flow path through the nozzle tip **18**. The pilot fuel helix pipe **22** is received in the center core **28**, in communication with the bore **44** such that pilot fuel flows through the center core **28** and exits the pilot fuel nozzle orifice **52**. Before exiting the orifice **52**, the pilot fuel flows through the swirler **64**. The main fuel helix pipe **20** is connected to the forward end of the injector tip **18**, and supplies main fuel to the annular channel **36**. The main fuel exits the holes **38**, into a passive air space **66** between the outer sleeve **24** and the inner sleeve **26**.

[0017] From the above construction, it will be appreciated that the main fuel channel **36** is insulated on opposite radial sides by purge/cooling air flowing through the channels **40** (radially inside), and passive air in the radial space between the outer sleeve **24** and the inner sleeve **26** (radially outside). The outer sleeve **24** also serves as a heat shield for the liquid fuel. The purge/cooling air entry ports **66** are located close to the tip **18** and thus provide cooler purge air than if supplied axially through the stem **16**. The purge air flowing through the channels **40** also prevents overheating of the pilot fuel flowing through the center bore **46**. The annular space **41** formed by the inwardly-tapered portion **50** and outwardly-tapered portion **54** of nozzle insert **42** enables the purge air to exit the annular arrays of holes and optional slots **60**, **62** in a swirling and/or counter-swirling manner to thereby prevent or at least minimize coke formation at the tip of the nozzle insert **42**. The purge air discharge about the pilot fuel orifice exit **52** also provides for quasi-premix purged gas combustion with reduced NOx emissions.

[0018] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

What is claimed is:

1. A liquid fuel cartridge assembly for a gas turbine combustor comprising:

an elongated stem provided with a fuel injector tip at an aft end of said stem, said injector tip provided with a pilot fuel passage extending to a pilot fuel orifice; a plurality of air channels surrounding said pilot fuel passage and in communication with plural air exit openings; an annular main fuel passage surrounding said plurality of air channels and in communication with plural fuel exit holes; and a plurality of substantially radially oriented air supply holes in said stem upstream but proximate to a forward end of said tip in communication with said plurality of air channels.

2. The liquid fuel cartridge assembly of claim **1** wherein a nozzle insert is located within said tip and is provided with said pilot fuel orifice.

3. The liquid fuel cartridge assembly of claim **2** wherein said nozzle insert is further provided with said plural air exit openings.

4. The liquid fuel cartridge assembly of claim **3** wherein said nozzle insert includes a first inwardly-tapered portion extending to said pilot fuel orifice, and a second outwardly-tapered portion downstream of said pilot fuel orifice, wherein said plural air exit openings are located in said second outwardly-tapered portion.

5. The liquid fuel cartridge assembly of claim **1** wherein said injector tip is comprised of an outer sleeve, a concentrically-arranged inner sleeve and a concentrically-arranged center core; said pilot fuel passage and said plurality of air channels is formed in said center core; wherein said annular main fuel passage is formed in a radial space between said first inner sleeve and said center core.

6. The liquid fuel cartridge assembly of claim **5** wherein said inner sleeve is formed at its aft end with an annular ring, and wherein a plurality of circumferentially-spaced main fuel orifices in communication with said annular main fuel passage are located on an upstream side of said annular ring.

7. The liquid fuel cartridge assembly of claim **3** wherein said plural air exit openings comprise at least one annular row of holes or an annular row of slots slanted in a circumferential direction.

8. The liquid fuel cartridge assembly of claim **1** wherein a swirler is located within said nozzle insert, upstream and adjacent said first inwardly-tapered portion.

9. The liquid fuel cartridge assembly of claim **7** wherein said plural air exit openings comprise a radially inner row of holes and a radially outer row of slots, and further wherein the holes in said at least one annular row of holes and the slots in said radially outer row of slots are slanted in opposite-circumferential directions.

10. A liquid fuel cartridge assembly for a combustor of a gas turbine comprising:

an elongated, hollow stem provided with a fuel injector tip at an aft end of said stem, said fuel injector tip provided with a pilot fuel passage centered within said tip along a longitudinal axis of said tip and extending to a pilot fuel orifice; a plurality of air channels surrounding said pilot fuel passage and in communication with plural air exit openings within said fuel injector tip; an annular main fuel passage surrounding said plurality of air channels and in communication with plural fuel exit holes radially outward of said plural air exit openings; a plurality of substantially radially oriented air supply holes in said stem upstream of said tip in communication with said plurality of air channels; and

wherein said stem encloses a first pilot fuel supply pipe in fluid communication with said pilot fuel passage and a second main fuel supply pipe in fluid communication with said annular main fuel passage that are intertwined along a length portion of said hollow stem.

11. The liquid fuel cartridge assembly of claim **10** wherein a nozzle insert is located within said tip and is provided with a said pilot fuel orifice, and said plural air exit holes.

12. The liquid fuel cartridge assembly of claim **11** wherein said nozzle insert comprises a first inwardly-tapered portion extending to said pilot fuel orifice and a second outwardly-tapered portion downstream of said pilot fuel orifice, wherein said plural air exit openings are located in said second outwardly-tapered portion.

13. The liquid fuel cartridge assembly of claim **12** wherein said plural air exit openings comprise at least one radially inner, annular row of holes and a radially outer, annular row of slots, and further wherein holes in said at least one row of holes and/or slots in said annular row of slots are slanted in a circumferential direction.

14. The liquid fuel cartridge assembly of claim **12** wherein an annular air chamber is formed between said first inwardly-tapered portion and said second outwardly-slanted portion, externally of said nozzle insert.

15. A liquid fuel cartridge assembly for a combustor of a gas turbine comprising:

an elongated stem provided with a fuel injector tip at an aft end of said stem said stem enclosing main fuel and pilot fuel supply pipes, said injector tip provided with a pilot fuel passage centered within said tip along a longitudinal axis of said tip; a plurality of air channels surrounding said pilot fuel passage; an annular main fuel passage surrounding said plurality of purge/cooling air channels; and a plurality of substantially radially oriented air supply holes in said stem upstream and adjacent said fuel injector tip in communication with said plurality of air channels; wherein said injector tip is comprised of an outer sleeve, a concentrically-arranged inner sleeve and a concentrically-arranged center core; said pilot fuel passage and said plurality of air channels formed in said center core; and said annular main fuel passage formed in a radial space between said first-inner sleeve and said center core.

16. The liquid fuel cartridge assembly of claim **15** wherein a nozzle insert is located within said tip, said nozzle insert provided with said pilot fuel orifice and plural air exit openings in communication with said plurality of air channels, and a swirler upstream of said pilot fuel orifice.

17. The liquid fuel cartridge assembly of claim **16** wherein said nozzle insert includes a first inwardly-tapered portion extending to said pilot fuel orifice, and a second outwardly-tapered portion downstream of said pilot fuel orifice, wherein said plural air exit openings are located in said second outwardly-tapered portion.

18. The liquid fuel cartridge assembly of claim **17** wherein said plural air exit openings comprise at least one radially inner annular row of holes and a radially outer annular row of slots, and further wherein the holes in said at least one radially inner annular row of holes, or the slots in said radially outer row of slots, are slanted in a circumferential direction.

19. The liquid fuel cartridge assembly of claim **17** wherein said plural air exit openings comprise at least one radially inner annular row of holes and a radially outer row of slots, and further wherein the holes in said at least one annular row of holes, and the slots in said radially outer row of slots, are slanted in opposite-circumferential directions.

20. The liquid fuel cartridge assembly of claim **15** wherein said inner sleeve is formed at its aft end with an annular ring, and wherein a plurality of circumferentially-spaced main fuel orifices in communication with said annular main fuel passage are located on an upstream side of said annular ring.

* * * * *