United States Patent

Beane et al.

[15] **3,698,186**

[45] **Oct. 17, 1972**

[54] **AFTERBURNER COMBUSTION APPARATUS**

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[73] Assignee: **United Aircraft Corporation**, East Hartford, Conn.

[22] Filed: **Dec. 24, 1970**

[21] Appl. No.: **101,225**

[52] **U.S. Cl.** .....**60/39.72 R**, 60/39.74 R, 60/261

[51] **Int. Cl.**.....**F02k 3/10**

[58] **Field of Search** ..60/39.74 R, 39.72 R, 226, 261, 60/39.32, 262

[56] **References Cited**

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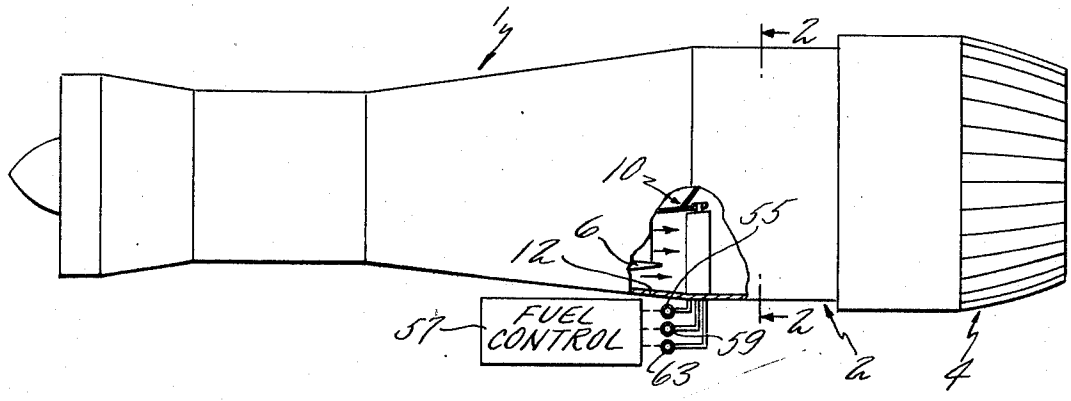
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Primary Examiner—Douglas Hart
Attorney—Jack N. McCarthy

[57] **ABSTRACT**

A power plant with an afterburner has a combustion apparatus therein which comprises a flameholder-spraybars extending radially into the afterburner at a plurality of locations. A third of the flameholder-spraybars are full length and extend to a center body, a third are of medium length and extend to the center of a hot exhaust, and a third are short and extend inwardly to a point rearwardly of a splitter separating the hot exhaust from a cooler fan duct air. The medium length flameholder-spraybars are divided into two fuel injection compartments and the full length flameholder-spraybars are divided into three fuel injection compartments. For primary zone burning fuel is admitted to the innermost compartment of each of the full length flameholder-spraybars; for secondary zone burning, the inner compartments of the medium length flameholder-spraybars and the middle compartments of the full length flameholder-spraybars then also have fuel directed thereto; and for tertiary zone burning, fuel is then also directed to the outermost compartment of each of the full length and medium length flameholder-spraybars and to the short length flameholder-spraybars.

15 Claims, 8 Drawing Figures



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SHEET 1 OF 2

FIG. 1

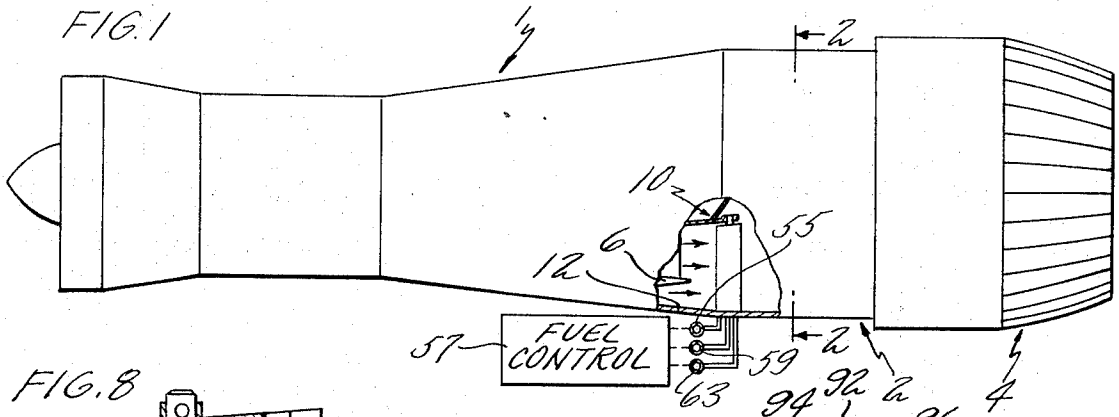


FIG. 8

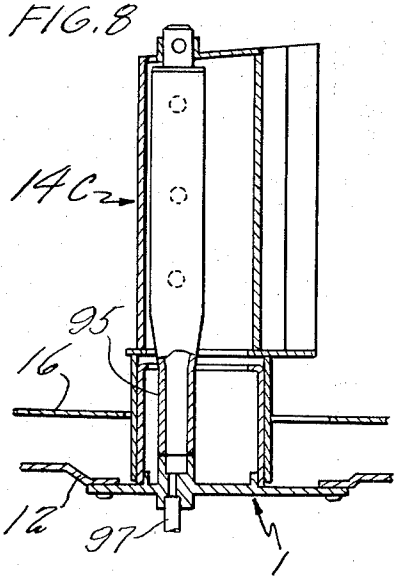


FIG. 7

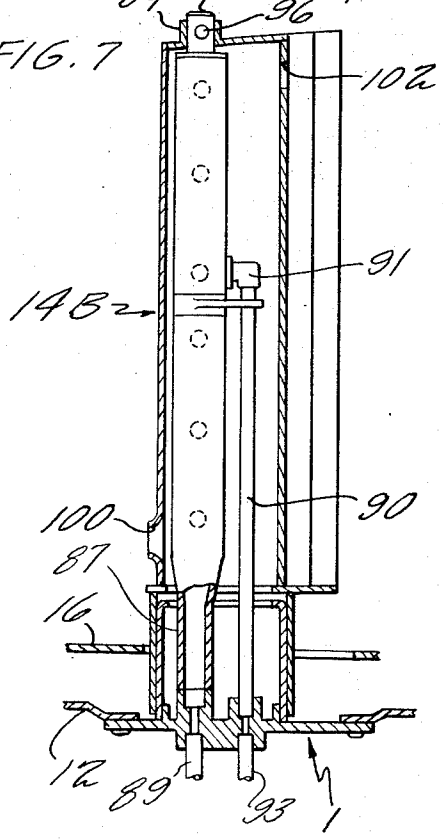
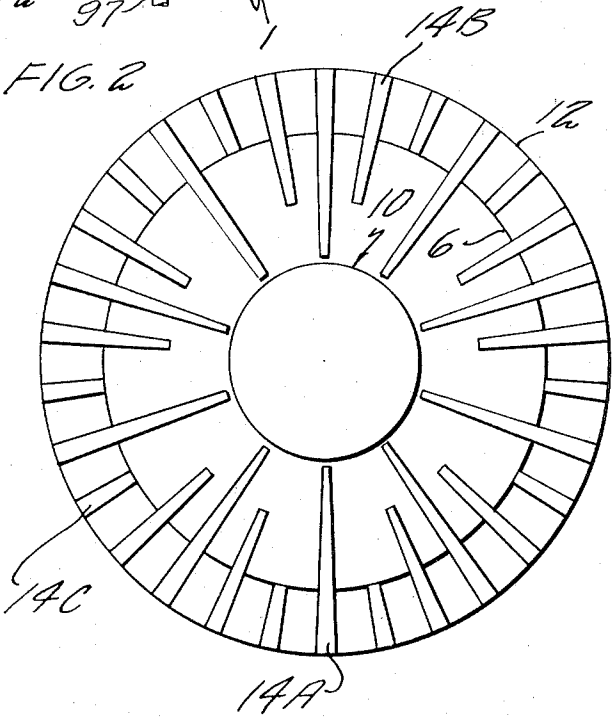


FIG. 2



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FIG. 3

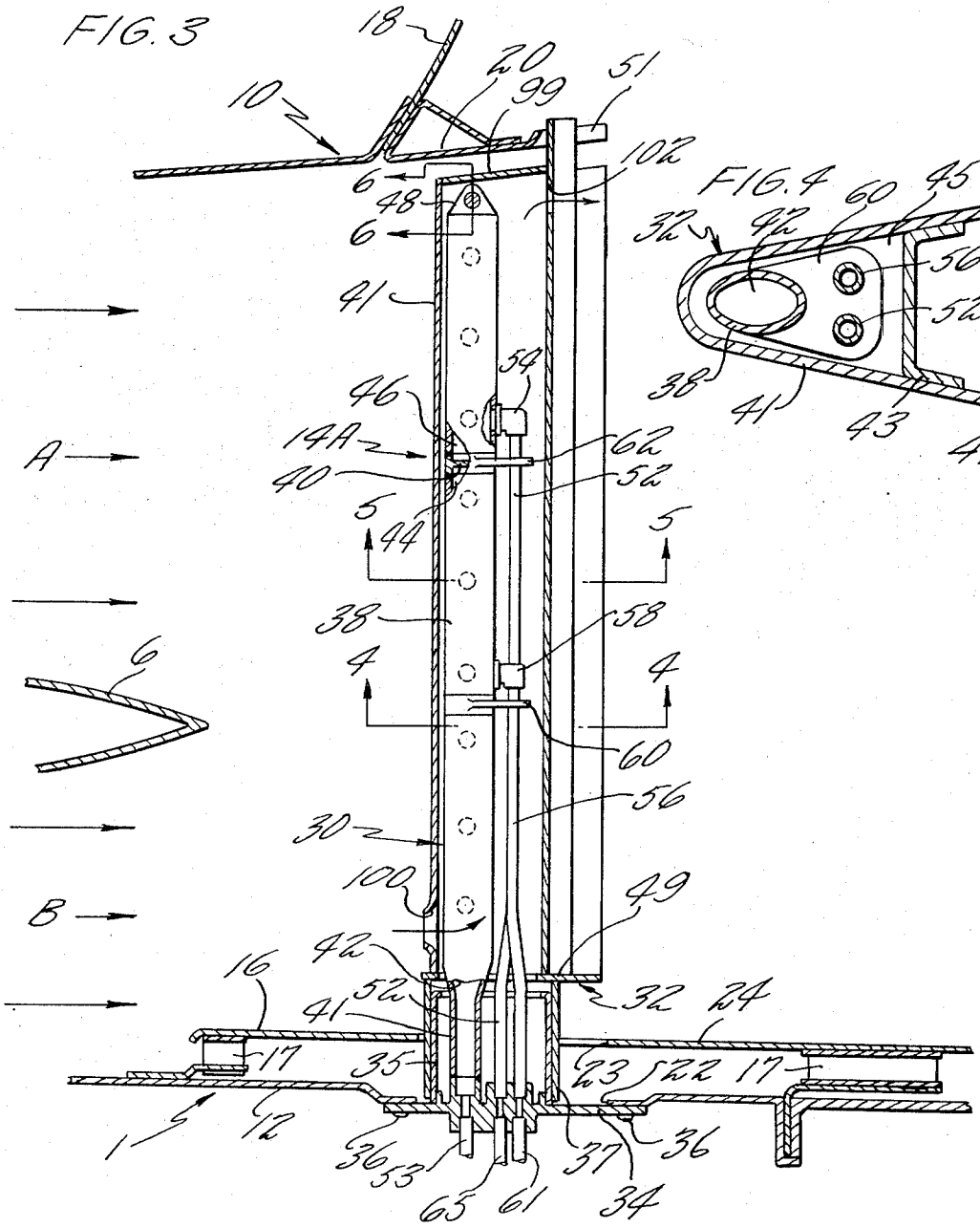


FIG. 4

FIG. 6

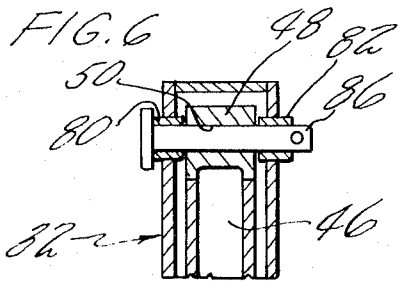
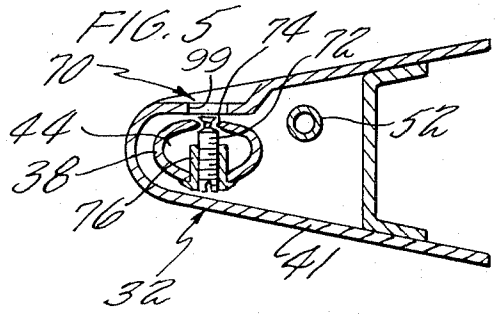


FIG. 5



AFTERBURNER COMBUSTION APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to flameholders for gas turbine engines and is located in the afterburner of a fan engine. An afterburner including a flameholding arrangement for a bypass gas turbine engine is shown in U.S. Pat. No. 3,485,045.

SUMMARY OF INVENTION

A primary object of the present invention is to provide an afterburner combustion apparatus having combined flameholder-spraybars extending radially inwardly from the outer casing of an engine, said flameholder-spraybars acting as cantilevered beams. This close coupling of spraybars within flameholders eliminates the need for a separate heat shield.

In accordance with the present invention, each flameholder-spraybar is separately removable and replaceable. The absence of circumferential flameholders connected to said radial flameholders prevents distortion and buckling due to the transport hoop.

In accordance with a further aspect of the present invention, cooling is obtained by having air flow from the cooler fan air section into the interior of the flameholder and over the cooperating spraybar to a discharge. This operates efficiently since the fan air is at a high pressure and the hot exhaust is at a lower pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view of a fan engine showing the location of the flameholder-spraybars in the afterburner.

FIG. 2 is a schematic view taken along the line 2—2 of FIG. 1 showing the position of the different lengths of flameholder-spraybars.

FIG. 3 is an enlarged view, partially in section, of the full length flameholder-spraybar shown in FIG. 1.

FIG. 4 is a cross-sectional view taken along the line 4—4 of FIG. 3.

FIG. 5 is a view taken along the line 5—5 of FIG. 3 showing a fuel nozzle.

FIG. 6 is a view taken along the line 6—6 of FIG. 3.

FIG. 7 is an enlarged view, partially in section, of the medium length flameholder-spraybar.

FIG. 8 is an enlarged view, partially in section, of the short flameholder-spraybar.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The power plant shown in FIG. 1 comprises a conventional fan engine 1 with an afterburner 2 and nozzle 4. Turbine engine exhaust flows from the engine at A between the rear end of the splitter 6 and the tail cone 10. Fan air flows from the outer fan duct at B between the splitter 6 and the outer casing 12. Both of these flows, then enter the flameholder-spraybars arranged as a plurality of radially extending composite members fixed to the outer casing 12 and extending toward the tail cone. A cooling liner 16 extends around the inner surface of the outer casing 12 and is fixed thereto by a plurality of spacing members 17 along its length. Flow from the outer fan duct passes between the liner 16 and outer casing 12.

As shown in FIG. 2, there are thirty flameholder-spraybars, ten of them are full length flameholder-spraybars 14A, ten of them are medium length flameholder-spraybars 14B, extending about two-thirds of the length of the full length flameholder-spraybars, and ten of them are short length flameholder-spraybars 14C extending about one-third of the length of the full length flameholder-spraybar. The short flameholder-spraybars 14C extend in length approximately to the circumference of the rear end of the splitter 6 which separates the fan air and turbine engine exhaust. The medium spraybars, 14B, extend to a point midstream of the distance between the rear end of the splitter 6 and tail cone 10. The full length flameholder-spraybars 14A extend approximately to a circular flange 20 which extends rearwardly from a rear surface 18 of the tail cone 10 and are guided therein in a manner to be hereinafter described.

Since the flameholder-spraybars 14A, 14B and 14C are similar in construction, except for the length, the full length flameholder-spraybar 14A will be described fully and the other flameholder-spraybars 14B and 14C will be described as they differ from it. Each flameholder-spraybar is removable through an opening 22 in the outer casing 12 and an axially aligned similar fixed opening 23 in the cooling liner 16. The full length flameholder-spraybar 14A comprises two main parts, the spraybar assembly 30 and the flameholder assembly 32.

The spraybar assembly 30 comprises a cover plate 34 which covers the opening 22 in the outer casing 12 and is removably attached thereto by bolts 36. This cover plate 34 has a thickened center portion with passages therethrough which provide for the connection of the fuel lines mounted externally of the outer casing 12 and the fuel transfer lines within said outer casing 12. A guide member 35 is fixed around the thickened center portion of the cover plate 34 and extends inwardly through the opening 23 of the cooling line 16 a short distance for receiving a mating end 37 of the flameholder assembly 32.

A spraybar 38 extends inwardly from the thickened portion of the cover plate 34. The spraybar 38 is a hollow member with two partitions 40 therein dividing it into three compartments 42, 44 and 46. Compartment 42 extends for approximately the first one-third of the length of the spraybar 38, compartment 44 extends for approximately the second one-third of its length, and compartment 46 extends for the last remaining one-third of its length. The inner end of the spraybar is closed by a boss member 48 having an opening 50 therethrough for a purpose to be hereinafter described. The outer end of the compartment 42 is connected by a conduit section 41 to one of the three passageways in the thickened center portion of the cover plate 34. The other end of this passageway is connected to a conduit 53 which is in turn connected to an annular manifold 55. Fuel is directed to the manifold 55 from the fuel control 57.

A fuel line 52 extends inwardly from the thickened portion of the cover plate 34 and is connected at its inner end to the interior of the compartment 46 adjacent partition 40 by a right angle connector 54. The outer end of the fuel line 52 is connected around one of the other passageways in the thickened center portion

of the cover plate 34. The other end of this passageway is connected to a conduit 65 which is in turn connected to an annular manifold 59. Fuel is directed to the manifold 59 from the fuel control 57.

A fuel line 56 extends inwardly from the thickened portion of the cover plate 34 and is connected at its inner end to the interior of the compartment 44 adjacent partition 40 by a right angle connector 58. The outer end of the fuel line 56 is connected around one of the other passageways in the thickened center portion of the cover plate 34. The other end of this passageway is connected to a conduit 61 which is in turn connected to an annular manifold 63. Fuel is directed to the manifold 63 from the fuel control 57. The fuel lines 52 and 56 are connected to the spraybar 38 along their lengths adjacent connector 58 by rearwardly extending flange 60. A similar support 62 supports fuel line 52 adjacent connector 54.

Each compartment contains three fuel nozzles 70 which spray fuel at 90° to the axis of the spraybar 38. Each fuel nozzle 70 comprises a stem 72 and an opening 74 in the side of the spraybar 38 which acts as a valve seat. A contoured end of the stem 42 coacts with the opening 74 to provide a variable nozzle opening. The stem 72 can be adjusted to obtain the opening desired for afterburner operation. The stem can be adjusted axially since it is threadably mounted in a boss 76 fixed to the spraybar 38. In each of the figures, the position of the fuel nozzle is shown by a small dotted circle.

The flameholder assembly 32 comprises a combination heat shield and flameholder which is positioned over the spraybar assembly. The outer end of said flameholder assembly has a mating guide member 37 which is formed to slidably engage guide member 35 on the cover plate 34. When these are properly positioned, two bushings 80 and 82 at the inner end of the flameholder assembly have openings therein which are aligned with the opening 50 in the boss member 48 mentioned hereinbefore. A pin member 86 therethrough maintains the flameholder-spraybars in their proper relationship.

The flameholder assembly 32 is formed by a V-shaped member 41 with a flat U-shaped member 43 fixed adjacent the rear end thereof forming a long closed compartment 45 and rearwardly open trough 47. A plate 49 covers the outer end of the compartment 45. The V-shaped member 41 has an opening 100 adjacent its outer end in its forwardly facing portion to receive air from the outer fan duct. A second opening 102 is located in the U-shaped member 43 adjacent its inner end so that the cooling air entering opening 100 can flow from the compartment 45. The flat U-shaped member 43 extends at the inner end of the flameholder assembly into an opening 51 in the circular flange 20 of the tail cone 10 to provide for proper spacing and support of the full length flameholder-spraybars 14A. The sides of the opening 51 are made so as to slidably engage the outer side of the U-shaped member. This permits unrestricted radial growth of the flameholder-spraybars.

FIG. 7 shows the medium length flameholder-spraybar 14B and it comprises only two compartments with one fuel line 90 necessary. The outer end of the outer compartment is connected by a conduit section 87 to one of the passageways in the thickened center portion of its cooperating cover plate. It is noted that the cover plate for the medium length flameholder-spraybar has only two passageways therein. The other end of this passageway is connected to a conduit 89 which is in turn connected to the annular manifold 55.

The fuel line 90 extends inwardly from the thickened portion of the cover plate and is connected at its inner end to the interior of the outer compartment adjacent partition 40 by a right angle connector 91. The other end of the fuel line 90 is connected around the other passageway in the thickened center portion of the cover plate. The other end of this passageway is connected to a conduit 93 which is in turn connected to the annular manifold 63.

The inner end of the flameholder assembly is attached in a different manner than that of the full length flameholder-spraybar 14A. In the medium length construction, a projection 92 extends into a bushing member 94 with a pin 96 being placed through aligned openings therein. A cooling arrangement similar to that shown in FIG. 3 for the full length flameholder-spraybar is incorporated in the medium length flameholder-spraybar.

The short flameholder-spraybar 14C of FIG. 8 has a similar arrangement at its inner end to that in FIG. 7 for connecting the spraybar assembly and the flameholder assembly. It is noted that this section does not have the cooling flow through the flameholder assembly. This short flameholder-spraybar comprises only one compartment which is similar to the outer compartments of the other spraybars. This compartment is connected by conduit section 95 to the one passageway in the thickened center portion of its cooperating cover plate. It is noted that the cover plate for the short length flameholder-spraybar has only one passageway therein. The other end of this passageway is connected to a conduit 97 which is in turn connected to the annular manifold 55.

It can be seen that the outer compartments of the full length and medium length flameholder-spraybars are connected to the same manifold 55 as the single compartment of the short length flameholder-spraybar so that when fuel is directed to the annular manifold 55 fuel is then delivered to all of the compartments of all of the flameholder-spraybars which are located downstream of the outer fan duct. The center compartment of the full length flameholder-spraybars and the inner compartment of the medium length flameholder-spraybars are connected to the same manifold 63 so that when fuel is directed to the annular manifold 63 fuel is then delivered to all of the compartments of the full length and medium length flameholder-spraybars which are located downstream of the outer portion of the turbine engine hot exhaust flow. The inner compartments of the full length flameholder-spraybars are connected to the annular manifold 59 so that when fuel is delivered to the annular manifold 59 fuel is then delivered to all of the compartments of the full length flameholder-spraybars which are located downstream of the inner portion of the turbine engine hot exhaust flow.

When fuel is admitted to the annular manifold 59 a primary zone of afterburning is obtained. When the fuel control then supplies fuel to the annular manifold

63 a secondary zone is brought in, and when fuel is directed to the annular manifold 55 a tertiary zone is brought in.

We claim:

1. In a combustion chamber having an inlet and outlet a plurality of flameholder-spraybars, said flemholder-spraybars extending radially into said combustion chamber at a plurality of locations, each flameholder-spraybar comprising a spraybar assembly which is fixedly mounted to said combustion chamber, a flameholder assembly being positioned over each spraybar assembly and fixed thereto, a plurality of fuel nozzles located along the length of each spraybar assembly, an opening in each flameholder assembly opposite each nozzle to permit fuel exiting from the nozzle to be directed therethrough into the combustion chamber, said flameholder-spraybars being of different lengths around said combustion chamber, some spraybars are full length and extend across the full radius of the inlet of the combustion chamber while others extend for substantially two-thirds of said length and one-third of said length.

2. An apparatus as set forth in claim 3 wherein said inlet is annular and the full length spraybars are guided at their inner end by a center body structure positioned in the combustion chamber.

3. In a combustion chamber having an inlet and outlet a plurality of flameholder-spraybars, said flameholder-spraybars extending radially into said combustion chamber at a plurality of locations, each flameholder-spraybar comprising a spraybar assembly which is fixedly mounted to said combustion chamber, a flameholder assembly being positioned over each spraybar assembly and fixed thereto, a plurality of fuel nozzles located along the length of each spraybar assembly, an opening in each flameholder assembly opposite each nozzle to permit fuel exiting from the nozzle to be directed therethrough into the combustion chamber, said flameholder-spraybars being of at least two different lengths around said combustion chamber, said longer of said flameholder-spraybars having its spraybar divided into compartments, the outer compartment being the length of the shorter spraybars, each extra inner compartment having conduit means for directing fuel thereto.

4. A flameholder-spraybar assembly adapted to be positioned in a combustion chamber having a wall and a forward end and an after end and including:

1. a fuel spraybar comprising a hollow tube member adapted to extend into said combustion chamber, and having:
   a. first aperture means extending through the hollow tube member for fuel flow therethrough,
2. means to support one end of said spraybar with respect to said combustion chamber wall,
3. a flameholder of gutter-shaped cross-section and being of selected shape and length to be sleeved over said spraybar in scabbard fashion and having its closed end projecting in a forward direction, and having:
   a. second aperture means oriented to communicate with said first aperture means for fuel flow to said combustion chamber,
4. slip joint means supporting one end of the flameholder with respect to said one end of said spraybar,
5. means to connect the other end of the flameholder to the other end of the spraybar.

5. Apparatus according to claim 10 and including an inner combustion chamber wall forming an annular section, means to position said other end of said flameholder with respect to said inner combustion chamber wall.

6. Apparatus according to claim 4 wherein said flameholder has its open end closed by a closure member forming a long closed compartment therein, an opening in the closed forward part of its outer portion so as to receive flow from the outer part of the combustion chamber, an exhaust opening at its inner portion to exhaust flow at the inner part of the combustion chamber.

7. A flameholder-spraybar assembly as set forth in claim 4 wherein said first aperture means comprises a fuel nozzle means.

8. In combination, a combustion chamber between inner and outer walls positioned concentrically about an axis:

1. a plurality of flameholder-spraybar assemblies extending radially across said combustion chamber and positioned in spaced circumferential positions therearound and with the flameholder-spraybar assemblies being of different lengths selected so as to form a flameholder-spraybar assembly pattern circumferentially about said combustion chamber,
2. each of said flameholder-spraybar assemblies comprising:
   a. a spraybar comprising a hollow tube member adapted to extend into a combustion chamber and having:
      1. aperture means extending through the wall of the hollow tube member and oriented to communicate with the combustion chamber,
   b. means to connect one end of said spraybar to the combustion chamber outer wall,
   c. a flameholder of gutter-shaped cross-section and being of selected shape and length to be sleeved over said spraybar in scabbard fashion and having its closed end projecting in a forward direction,
   d. slip joint means supporting one end of the flameholder with respect to said one end of said spraybar,
   e. means to connect the other end of the flameholder to the other end of the spraybar so that with said last-named means removed, said flameholder may be sleeved free of said slip joint means and off of said spraybar.

9. Apparatus according to claim 8 and wherein said spraybar apertures are oriented to extend substantially transversely of the combustion chamber and wherein said flameholders include a plurality of apertures positioned and sized so that a flameholder aperture is positioned adjacent each spraybar aperture so that fuel from the interior of the spraybar will pass through both the spraybar and the flameholder apertures in passing into the combustion chamber.

10. In combination, in an engine, a combustion chamber, said chamber having an inwardly facing wall, said chamber having an inlet and outlet, a plurality of flameholder-spraybars, said flameholder-spraybars extending radially into said combustion chamber from said wall at a plurality of locations, each flame-holder-

spraybar comprising a spraybar assembly which is fixedly mounted with respect to said combustion chamber, each spraybar assembly comprising a spraybar extending radially into the combustion chamber, a flameholder assembly being mounted over each spraybar and supported by the spraybar assembly, a plurality of fuel nozzles located along the length of each spraybar, an opening in each flameholder assembly spaced from each nozzle to permit fuel exiting from the nozzle to be directed therethrough into the combustion chamber.

11. A combination as set forth in claim **10** wherein each spraybar assembly has a plate member fixed to each spraybar which is removably attached with respect to said combustion chamber, an opening in each plate member connects the interior of its attached spraybar to the exterior of said plate member, means are provided for directing a fuel to the interior of each spraybar, each flameholder-spraybar being removable as a unit.

12. A combination as set forth in claim **10** wherein said inlet is divided by a splitter located radially inwardly from said inwardly facing wall forming two inlet sections, said outer annular inlet section having cool gas pass therethrough while the inner inlet section has relatively hot gases pass therethrough.

13. A combination as set forth in claim **12** wherein some spraybars extend radially inward to the radius of said splitter, and some spraybars extend radially inward across said outer annular inlet section and into said inner inlet section.

14. A combination as set forth in claim **13** wherein the spraybars which extend into said inner inlet section have a plurality of compartments therein, one compartment extends inwardly approximately to the radius of said splitter, a second compartment is located inwardly of said splitter extending further inwardly of said combustion chamber, means for directing fuel directly to said inner compartment.

15. A combination as set forth in claim **14** wherein means are provided to direct fuel to only the inner compartments of the spraybars at a given time, and means are provided to direct fuel to the outer compartments of the spraybars and the spraybars which extend only to the splitter at another given time.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,698,186 Dated October 17, 1972

Inventor(s) David J. Beane and John H. Gastler

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 2, Column 5, line 23, change "3" to --1--

Claim 4, Column 6, line 3, change "10" to --4--

Signed and sealed this 13th day of March 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents