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Marshall et al.

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[54] **PILOTED FLAMEHOLDER CONSTRUCTION**

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

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 741,159, June 27, 1968, abandoned.

[52] **U.S. Cl.** **60/39.72,** 60/224

[51] **Int. Cl.** **F02g 1/00**

[58] **Field of Search** 60/39.72, 39.74, 261, 39.65

[56] **References Cited**

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[57] **ABSTRACT**

A piloted flameholder construction having a plurality of combustion zones to which are supplied fuel and air to support combustion therewith. Combustion gases from at least one of the combustion zones are then supplied to a plurality of flame-holders thereby improving combustion efficiency and stability of the flameholders. This flameholder construction is particularly adaptable for use in a ducted fan gas turbine engine.

This application is reported as a Subject Invention under Government contract AF33(657)14903.

13 Claims, 5 Drawing Figures

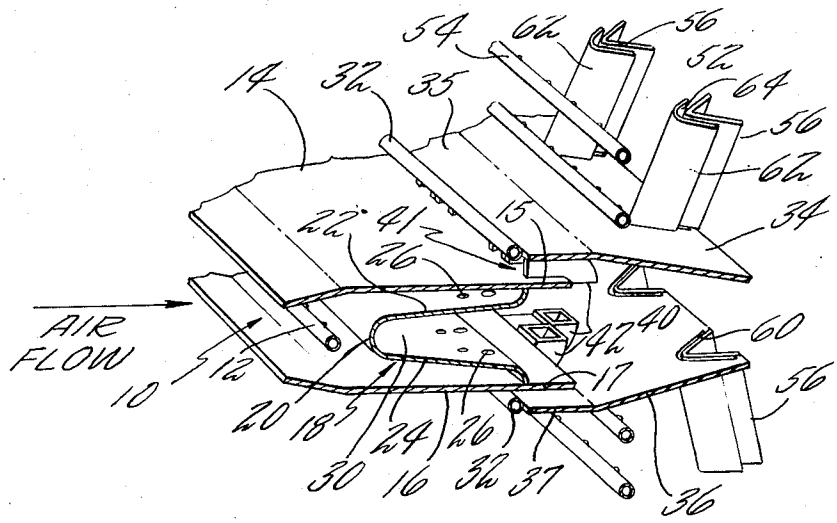

FIG. 1

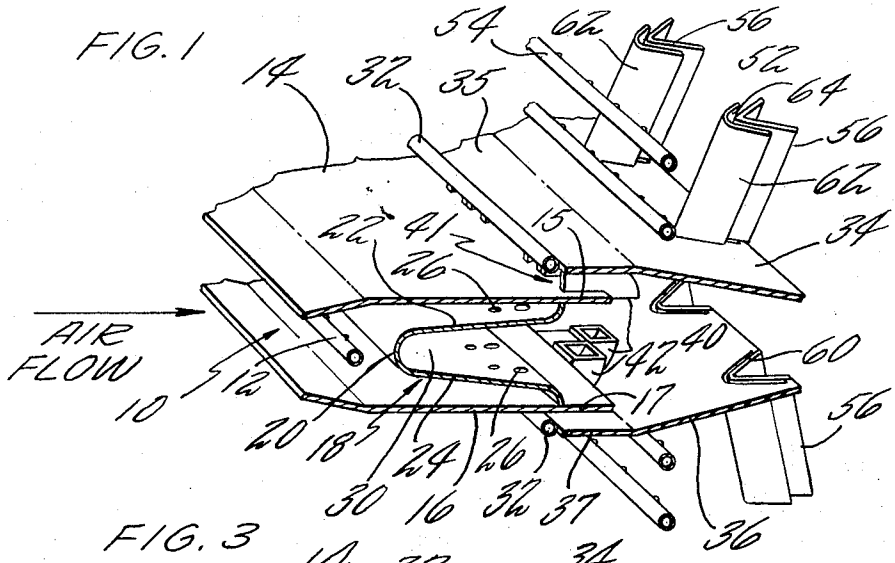

FIG. 3

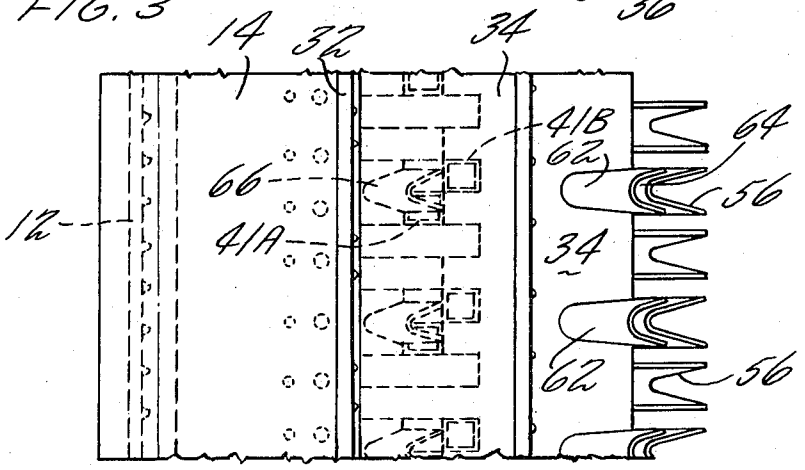

FIG. 2

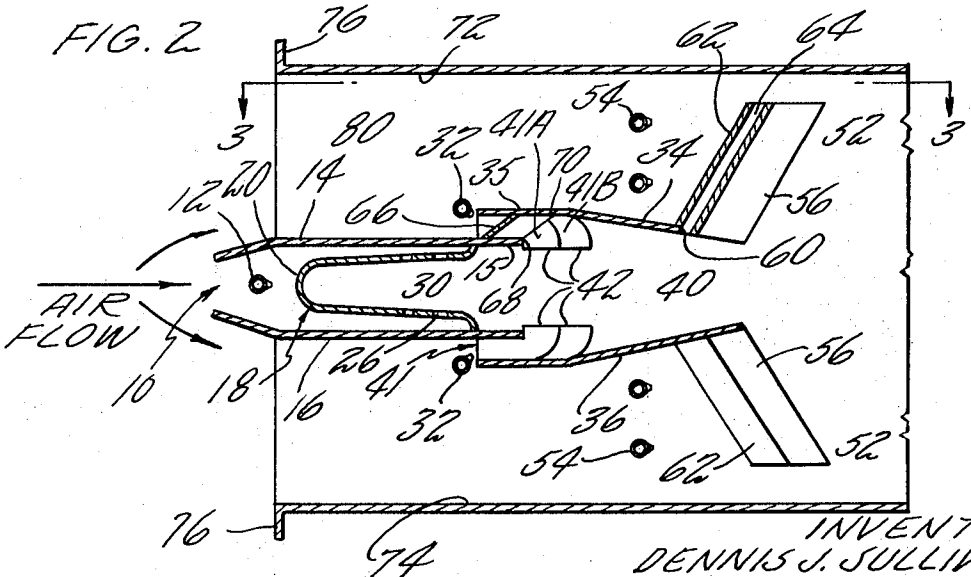

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FIG. 4

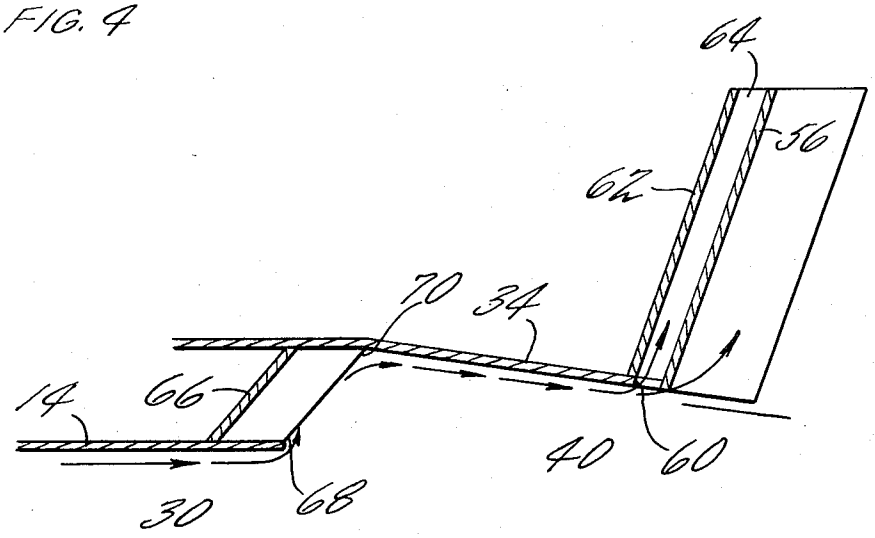
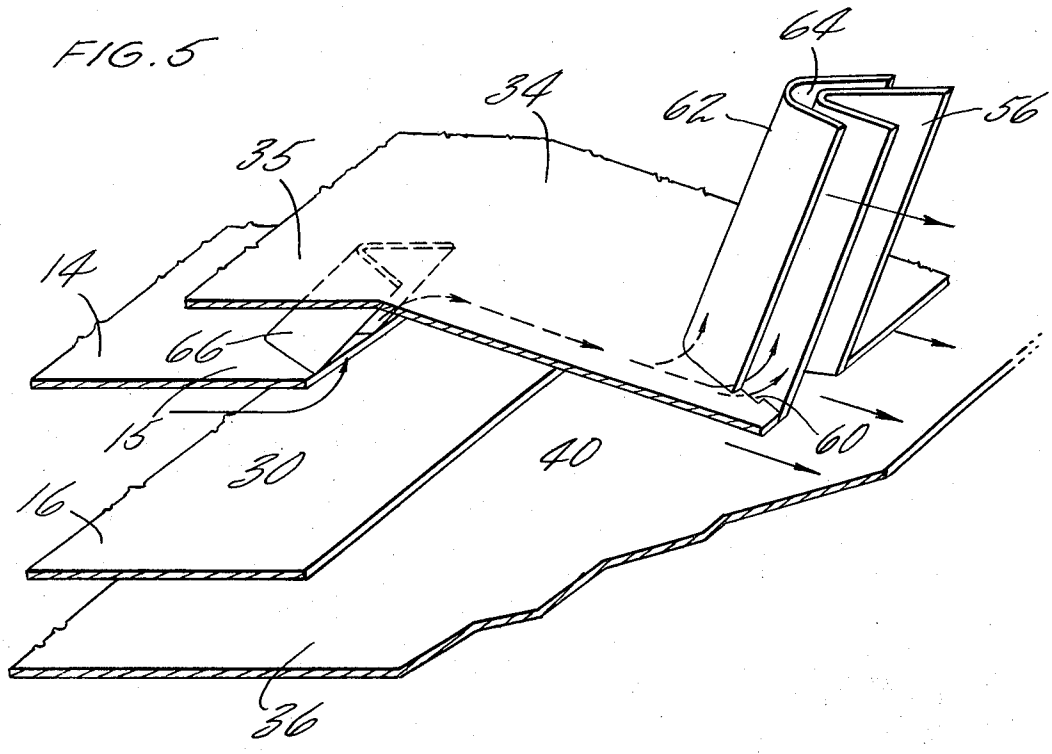


FIG. 5



PILOTED FLAMEHOLDER CONSTRUCTION

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of Application Ser. No. 741,159 filed June 27, 1968 for PILOTED FLAMEHOLDER CONSTRUCTION, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates to a piloted flameholder construction, one configuration thereof being particularly adapted for adding heat to the bypass air of a fan engine thereby increasing the overall thrust of the engine.

In a conventional turbojet gas turbine, air passes through an aligned compressor, burner and turbine and is then discharged to atmosphere through an exhaust outlet to generate thrust. Generally, a ducted fan engine adds the feature of taking a portion of engine air from a fan stage preceeding the low compressor and discharging it to atmosphere to generate thrust other than through the previously mentioned exhaust outlet. In the conventional ducted fan engine, this additional duct is of circular cross section and overlaps the engine to form an annular air passage therebetween. With the advent of higher thrust engines, interest has been generated in achieving a fan duct burner with performance characteristics satisfying requirements as regards combustion efficiency, operating range, high altitude operation, lean ignition properties and pressure loss.

Normally, the inlet conditions of a duct burner are such that a duct burner encounters the relatively low air temperature of a main combustion burner and the relatively high Mach number flow of an afterburner. As a result, the requirements of a burner located in a bypass duct cannot be satisfied by using a conventional main burner or afterburner. In this type application a conventional afterburner system lacks the stability required for operation at relatively low inlet temperatures, the wide fuel air ratio range required, and the ability to propagate the flame across the entire duct without resultant adverse effects on combustion efficiency. A conventional main burner would suffer prohibitively high pressure losses in addition to having the disadvantages of the afterburner system.

SUMMARY OF THE INVENTION

It is a primary object of this invention to provide a piloted flameholder construction which is primarily adaptable for use in a ducted fan engine, the construction having favorable stability characteristics at relatively low inlet operating temperatures and pressures; capability of operating over a wide fuel air ratio range and low pressure loss; and improved flame propagation through the flameholders extending across the entire duct.

In a preferred arrangement of the present invention a plurality of combustion zones are employed. These combustion zones are normally annular and increase in cross-sectional area in a downstream direction. As herein illustrated, each of the combustion zones includes fuel supply means, air supply means and a pair of annular radially spaced walls, combustion normally occuring therebetween. In the present embodiment the gases of combustion from the first or pilot zone progress downstream to the next combustion zone, where additional air and fuel are added to intensify the temperature of the gases coming from the pilot or initial combustion zone, the gases generated by these zones being used with a plurality of flameholders hereinafter described.

In a preferred embodiment of the present invention, ram chutes are located at the sides of the second combustion zone. These ram chutes direct air which has flowed or bypassed the pilot combustion zone into the second combustion zone. The purpose of these chutes is to insure mixing of the second zone fuel and air mixture with the pilot zone combustion gases. It should be understood that as many combustion zones as desired may be employed, each zone being of substantially the same construction and including fuel supply means, air supply means, radially spaced annular walls and ram chute mixing means.

Positioned downstream of the pilot combustion zone, and downstream of the second combustion zone as herein illustrated, is a plurality of gutter-shaped flameholders. These flame-holders are positioned around the circumference of the duct and are supported from the radially spaced annular walls. The flame-holders are supported from the walls such that the inner annular wall supports the inwardly extending flameholders and the outer annular wall supports the outwardly extending flameholders, the flameholders thereby extending substantially across the entire duct. The construction of the flameholder and the attachment to the walls is novel in that at the point of attachment the walls are slotted thereby permitting the hot combustion gases from within the combustion zone annular walls to flow out and around the flameholders. The outward flow of these gases greatly increases the stability and combustion efficiency of the flame-holders. A further embodiment of the construction of the present invention is to position a plurality of heat shields forwardly or upstream of each of the flameholders. Each of the heat shields is of substantially the same shape as the flameholders and effectively forms a double-walled flameholder construction. Since the heat shields are spaced axially from the flameholders, a passageway therebetween is formed. This passageway is in communication with a combustion zone through the aforementioned slots in the walls, and thereby provides a means for preheating each of the flameholders. More specifically, the hot combustion gases heat the shield affording initial vaporization of fuel supplied to the flameholders from an upstream fuel supply means. Additionally, the temperature of the inner flameholders is raised; these raised temperatures also contributing to flame-holder stability and efficiency.

The construction of the present invention further provides for increased stability and flameholder efficiency by providing a plurality of transfer channels extending from the pilot combustion zone to the annular walls supporting the flameholders at a point upstream of the flameholders. The exits of these transfer channels are positioned around the circumference of the duct such that each exit is in substantial axial alignment with each flameholder. Therefore, hot gases are led by the transfer channels and issued therefrom as hot streaks over the end location of each of the flameholders with the hot gases flowing onto each of the flameholders from within the duct. This type construction

has been found to permit favorable flameholder stability and efficiency.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view showing the flameholder construction in longitudinal cross section.

FIG. 2 is a longitudinal cross section of the flameholder construction.

FIG. 3 is a view taken along the line 3—3 of FIG. 2.

FIG. 4 is an enlarged view of a portion of FIG. 2. showing the positioning of a channel and flameholder along with a general flow path.

FIG. 5 is an enlarged perspective view of a portion of the invention showing the positioning of the channel with respect to its cooperating flameholder.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, the construction of the present invention is clearly illustrated. As shown, the construction includes three combustion zones, the first combustion zone being pilot combustion zone **30** and includes any conventional fuel supply means **12** in the burner inlet section **10** located upstream of the pilot combustion zone **30.** Additionally, the inlet section **10** includes a pair of annular radially spaced walls **14** and **16,** wall **14** constituting the inner annular wall and wall **16** constituting the outer annular wall. Walls **14** and **16** are arranged such that at their leading edges the radial spacing therebetween is relatively small so that the air flowing into inlet section **10** is only a small percentage of the total airflow, the remainder of the air flowing around the outer surfaces of walls **14** and **16.**

Positioned in the radial space between walls **14** and **16** and in the burner inlet section **10** is fuel supply means **12.** As illustrated, the pilot combustion zone **30** is formed by a pilot body **18** which is supported from walls **14** and **16** and includes a nose portion **20** at its leading edge. As a result of the shape of the leading edge of the pilot body **18** and the pilot nose **20,** combustion within the pilot zone **30** occurs in a protected region. Also pilot body **18** includes two radially spaced walls **22** and **24,** each wall having a plurality of openings **26.**

It is through these latter openings **26** that a pre-mixed fuel-air mixture passes from the inlet section **10** into pilot zone **30,** these openings are the primary means of metering the airflow to the pilot zone **30.** After being burned in the pilot zone **30** these hot gases flow downstream into the second zone **40.** Combustion zone **40** is constructed in much the same manner as pilot combustion zone **30** in that it includes fuel supply means **32** positioned downstream of pilot zone **30** and surrounding the walls **14** and **16** respectively. Combustion zone **40** as pilot zone **30** also includes a pair of annular radially spaced walls **34** and **36.**

The walls **34** and **36** are arranged such that wall **34** is the inner annular wall of combustion zone **40,** the leading portion **35** thereof overlapping the downstream portion **15** of inner wall **14** of pilot zone **30.** Similarly, wall **36** is the outer annular wall of zone **40** and its leading portion **37** overlaps the downstream portion **17** of wall **16.** In each instance portion **35** is spaced radially from portion **15** and portion **37** from portion **17** so that two annuli exist between the pilot combustion zone **30** and the second combustion zone **40.** Within each annulus is positioned a plurality of scoops **41,** each of the scoops facing forwardly to receive air which has flowed around the inlet. As shown, fuel supply means **32** are positioned at the inlet of each of the scoops, it therefore being clear that scoops **41** insure a proper mixing of the incoming fuel and air mixture with the combustion gases exiting from the pilot zone **30.** To insure this proper mixing the exists **42** of the scoops **41** are arranged such that they face either inwardly or outwardly. In the construction illustrated herein, the inwardly facing exits are attached and supported from the outer annular wall **36** and the outwardly facing exits are attached and supported from the inner annular wall **34.** With respect to the combustion zone **40,** the scoops all face inwardly thereto. To further enhance mixing, either short scoops **41A** or long scoops **41B** may be employed, this being more clearly illustrated in FIG. **3.** It should be noted that either all long, all short, or any combination thereof may be used.

Downstream of combustion zone **40** is the third combustion zone **52.** Combustion zone **52** includes fuel supply means **54** and also a plurality of flameholders **56.** Flameholders **56** are positioned downstream of fuel supply means **54,** and are supported from the annular walls comprising the second combustion zone **40** at the downstream ends of these walls. The flameholders **56** are arranged such that they extend radially from walls **34** and **36,** the flameholders supported from inner annular wall **34** extending radially inward while the flameholders supported from the outer annular wall **36** extending radially outward. The flameholder supports may be rods or any other type of fixture desired. With this type arrangement it is possible to realize stable burning across an entire duct or opening. This can more clearly be seen in FIG. **2.**

To improve the stability and the combustion efficiency of the flameholders the present invention provides a number of unique features. As illustrated in the present embodiment, gases from the pilot zone **30** move downstream and are mixed with the air and fuel entering the second combustion zone **40** the heat and temper thereby being intensified. To utilize these hot combustion gases which have been generated in the first two combustion zones, the annular walls **34** and **36** are slotted around their entire circumference, as at **60** to permit passage of these gases to the flame-holders **56.** In the present embodiment flameholders **56,** which are gutter-type flameholders which are substantially U-shaped in cross section with the apex of the U facing upstream, are positioned over slots **60** such that the generated combustion gases may pass along and radially out the upstream and downstream sides of the flameholders **56.** A flameholder support could include integral fingers projecting from its open end of the U to its flameholder. To further enhance the performance characteristics of the flame-holders **56,** a plurality of heat shields **62** positioned forwardly of and axially spaced from each of the flameholders **56** may be employed. Each of the heat shields **62** is substantially the same shape as its associated flameholder, so effectively the construction is a double-walled construction with a passageway **64** therebetween.

FIG. **3** illustrates an additional feature which also improves the performance characteristics of flameholders **56.** A plurality of transfer channels **66** are employed, one end **68** of each of the channels being in communication with the gases generated in the two combustion

zones and each of the other ends **70** being arranged around the circumference of annular walls **34** and **36.** These transfer channels are located between the downstream portion **15** of inner wall **14** and the leading edge portion **35** of wall **34** and between the downstream portion **17** of wall **16** and the leading portion **37** of wall **36.** The ends **68** of the channels **66** can be considered the inlet ends of the channels and the ends **70** of the channels can be considered the exit ends of the channels, in that gases generated flow outwardly from end **68** to end **70** to the inside of walls **34** and **36** where they then flow downstream. The exits **70** of transfer channels **66** are further arranged such that each exit **70** is substantially axially aligned with each of the flameholders **56.** Therefore, as the hot combustion gases issued from the exits **70,** they do so as hot streaks which travel along walls **34** and **36** and onto each of the flameholders **56.**

In FIG. **2** the present invention is illustrated as being positioned in an annular duct **80,** concentric wall **72** being the inner wall of duct **80** and concentric wall **74** being the outer wall of duct **80.** Each wall has similar flange means **76** for attachment to an engine (not shown).

it is to be understood that the invention is not limited to the specific embodiments herein illustrated and described but may be used in other ways without departure from its spirit as defined by the following claims.

We claim:

1. A piloted flameholder construction including a plurality of combustion zones, each zone having means for supplying fuel and air thereto for combustion, wherein the improvement comprises:

supporting a plurality of flameholders rearwardly of at least the first combustion zone; and

means for supplying hot combustion gases from at least one of the combustion zones to a point forwardly of each of the flameholders, each of these points being in substantially axial alignment with each of the flameholders, the combustion gases exiting from each of these points as a hot streak and being directed at and onto each of the flameholders.

2. A flameholder construction as in claim **1,** wherein:

the combustion zones include a pair of annular radially spaced walls each of the flameholders being supported from at least one of these pairs of walls, and the flameholders extend radially inwardly and outwardly from these walls.

3. A flameholder construction as in claim **2,** wherein:

the means for supplying hot combustion gases includes a plurality of transfer channels extending from at least one combustion zone to a point forwardly of the flameholders, each of the channels having an exit which is substantially axially aligned with a flameholder.

4. A piloted flameholder construction including a plurality of combustion zones, each zone having means for supplying fuel and air thereto for supporting combustion at each zone, wherein the improvement comprises:

a first combustion zone including a first pair of radially spaced annular walls, the upstream ends of the spaced walls constituting the burner system inlet, this first combustion zone including a protected region bounded by a second pair of radially spaced annular walls inside the first pair of walls, means for permitting a predetermined amount of air to pass into this pilot combustion zone, the remainder of the airflow passing around the inlet of the burner system;

a second combustion zone downstream of the first combustion zone including a third pair of radially spaced annular walls, the third pair of annular walls being radially spaced from the first pair of walls;

a plurality of scoops positioned between the two pairs of annular walls, each of the scoops having exit locations directed either inwardly or outwardly, the inlets of the scoops facing forwardly to receive the air flowing past the first combustion zone;

a plurality of transfer channels extending between the first combustion zone and the second combustion zone, the transfer chennels permitting passage of hot combustion gases from the first combustion zone to the exit of each of the transfer channels; and

a third combustion zone downstream of the second combustion zone including a plurality of gutter-shaped flameholders, each of the flameholders being substantially in axial alignment and downstream thereof of the exits of each of the transfer channels, a hot gas streak issuing from the exit of each of the transfer channels and being directed at each of the flameholders.

5. A flameholder construction as in claim **4** wherein:

the third pair of walls support the flameholders, the walls being slotted at the point of support of each of the flameholders to permit passage of hot combustion gases from the second combustion zone along each of the flameholders.

6. A flameholder construction as in claim **5** wherein:

a plurality of heat shields of substantially the same cross section as each of the flameholders is spaced axially therefrom and at the leading edge of each of the flameholders, the hot combustion gases from the second combustion zone being passed through the slots between each of the heat shields and flameholders and around the flameholders.

7. A flameholder construction as in claim **6** wherein:

the heat shields and the flameholders are substantially U-shaped, and the apex of the U of the heat shield and flameholder is facing upsteam.

8. A flameholder construction as in claim **5** wherein:

the flameholders supported from the inner annular wall extend radially inward therefrom and the flameholders supported from the outer annular wall extend radially outward therefrom.

9. A piloted flameholder construction for use with a ducted fan gas turbine engine, the flameholder being positioned in the relatively cool fan gas stream and including a plurality of combustion zones, each of the zones having means for supplying fuel and air thereto for supporting combustion in each zone, wherein the improvement comprises:

an outer concentric wall including means for connecting the wall to the engine;

an inner concentric wall spaced radially inward therefrom and also including means for connecting the wall to the engine, the two walls forming a duct therebetween within which the plurality of combustion zones are positioned, the combustion zones being arranged so that each successive downstream zone can accommodate a greater amount of flow than the zone immediately upstream;

one of the combustion zones also including a pair of annular radially spaced walls, the flameholders being supported from both of the walls, the flameholders extending radially inwardly and outwardly from the wall thereby extending substantially across the entire duct; and

means for supplying hot combustion gases from at least one of the combustion zones to a point forwardly of each of the flameholders, each of these points being in substantially axial alignment with each of the flameholders, the combustion gases exiting from each of these points as a hot streak and being directed at and onto the base of each of the flameholders.

10. A flameholder construction as in claim **9** wherein:

there are three combustion zones and the flameholders are positioned downstream of the second combustion zone and the third combustion zone includes means for conducting hot combustion gases around each of the flameholders thereby heating each of the flameholders.

11. A piloted flameholder construction as in claim **10** wherein:

each of the flameholders are gutter-shaped and a heat shield of substantially the same construction is positioned forwardly of each of the flameholders, each of the heat shields and flameholders thereby having a space therebetween, this space being in communication with one of the preceeding combustion zones thereby permitting a flow of hot combustion gases between the heat shields and the flameholders.

12. A piloted flameholder as in claim **11** wherein:

the heat shields and the flameholders are substantially U-shaped, and the apex of the U of the heat shield and flameholder is facing upstream.

13. A piloted flameholder construction as in claim **10** wherein:

the means for supplying the hot combustion gases includes a plurality of transfer channels each of the channels extending from the second combustion zone to a point forwardly of each of the flameholders.

* * * * *