This invention relates to the supporting of combustion and more particularly to the igniting and supporting of combustion in a cold gas stream of the type encountered in a ducted fan engine.

Experience with modern powerplants such as modern aircraft engines requires that ignition occur and that combustion be supported in a cold airstream which carries atomized fuel of the type having poor low temperature vaporization characteristics. This problem is encountered, for example, in afterburning ducted fan engines and in ducted ramjets where providing ignition and sustaining combustion with an ordinary flameholder in the low temperature stream is very difficult. Experience has shown that even when flameholders of high blockage are used the flame blow out limit confines operation to low velocity and high pressure, and within a narrow fuel-air ratio band. Special secondary fuels can be used to produce a piloted flameholder in the cold airstream area but this practice brings about the attendant problems and dangers of handling two types of fuels in flight, one of which is the less stable pilot fuel.

It is an object of this invention to teach a flameholder construction which uses a single and conventional fuel yet provides a piloted flameholder.

It is a further object of this invention to teach a flameholder construction in which ignition means are provided to cause ignition and combustion in a heated gas stream, which combustion causes a flamespread flow to a flameholder located in a cold airstream so as to ignite the cold air-fuel mixture and cause combustion thereof to be supported in the relatively stagnant area downstream of the cold air flameholder.

It is still a further object of this invention to provide a flameholder construction, which is preferably one piece, and which carries a connecting or attaching flange at its forward end and which attaches to the downstream end of a duct such as a splitter duct in a ducted fan engine, which duct serves as the sole support for the flameholder unit and positions the flameholder unit such that flameholder rings project into the gas passage external of and internal of the supporting duct.

It is still a further object of this invention to teach a flameholder construction of the type usable in a ducted fan engine which is supported solely by the engine splitter duct and which carries flameholder rings which are positioned to intercept the heated gas-fuel mixture flowing on one side of the splitter duct and the cold gas-fuel mixture flowing on the other side of the splitter duct and further carries a flameholder ring positioned downstream of and in substantially axial alignment with the downstream end of the splitter duct so that the last mentioned ring intercepts both the heated gas-fuel mixture and the cold gas-fuel mixture and serves, by means of inclined flame-spreaders or interconnectors to ignite and support combustion behind the flameholder rings located in the cold airstream, in pilot flameholder fashion.

Other objects and advantages will be apparent from the specification and claims, and from the accompanying drawings which illustrate an embodiment of the invention.

Fig. 1 is an external showing of a typical ducted fan engine of the type used in modern aircraft and is partially broken away to illustrate this invention.

Fig. 2 is an enlarged showing of the flameholder construction taught herein in its environment.

Fig. 3 is an enlarged and fragmentary showing of the flameholder and the splitter duct and the attachment means therebetween.

Fig. 4 is a view taken along line 4-4 of Fig. 3.

For purposes of illustration, our flameholder will be described in the environment of a modern aircraft ducted fan engine but it should be borne in mind that its use extends to any powerplant in which ignition must occur and combustion must be supported in both a hot gas passage and a cold gas passage, for example, a ducted ramjet engine.

Referring to Fig. 1, we see a ducted fan engine 10 of the type described in U.S. Patent Nos. 2,458,600 and 2,610,465 and 2,753,685 which comprises air inlet section 12, first compressor section 14, second compressor section 16, combustion section 18, turbine section 20, afterburner section 22, and ducted section 24. After entering engine 10 through air inlet 12, the air is compressed in passing through first compressor section 14 and then may follow one of two routes to get to afterburner section 22. In following the first of these routes, the air passes through second compressor section 16 and is heated in passing through combustion section 18 due to the combustion which is taking place in combustion chambers 26 by the burning of atomized fuel therein from fuel nozzles 28 and fuel manifold 30. Any ignition means such as spark plug 30 may be used to ignite the atomized fuel from nozzles 28 to cause combustion within chamber 26. Following this first route, the heated gas is then passed through turbine 12 and through gas passage 32 which is formed between splitter duct 34 and engine tailcone or inner body 36 and then enters afterburner 22 after passing around flameholder unit 40 which is attached to the downstream end of splitter duct 34. The second route through which the cold gas that is compressed by first compressor section 14 may pass in getting to afterburner 22 is through ducted section 24 which is an annular gas passage defined by splitter duct 34 and engine outer case 42. Fuel nozzles 44 project into gas passage 46 formed between outer case 42 and splitter duct 34 and are preferably equally spaced circumferentially about outer duct 42 and serve to inject atomized fuel into the cold gas, such as air, passing through passage 46. To prevent the fuel from nozzles 46 from depositing on and burning against the inner wall of outer case 42, protective shield 48 may be used and cooling air may be passed between outer case 42 and protective shield 48.

As shown in Fig. 1, flameholder unit 40 carries separate flameholder rings which intercept both the cold gas-fuel mixture passing through gas passage 46 and also intercept the heated gas-fuel mixture passing through gas passage 32. Fuel may be gotten into gas passage 32 by any convenient means, for example, fuel spray bars such as 50 may be positioned to inject fuel into afterburner 22. Any convenient ignition means, for example, hot-streak ignitor unit 52 may be used to ignite the heated or high temperature gas fuel-air mixture and permit its combustion to be supported within the relatively stagnant area.
downstream of flameholder unit 40. A hot streak ignitor is fully described in United States Patent Number 2,780,052.

Referring to Figs. 2, 3, and 4, we see my flameholder unit 40 in greater particularity. Fig. 2 shows splitter duct 34 to be located between outer case 42 and inner body 36 and each of these aforementioned members, 34, 36, and 42 are preferably of circular cross-section and concentric and coaxial about engine axis 54. In Fig. 2, flameholder unit 40 is shown to comprise a plurality of annular flameholder rings 56, 58, 60, and 62, but it should be borne in mind that any number of flameholder rings may be utilized without departing from the spirit of this invention. The flameholder rings are coaxial and concentrically located about axis 54 and are of trough or U-shaped cross section opening in a downstream direction. The flameholder rings are spaced axially with respect to each other and each is positioned to be radially perpendicular to axis 54. As shown in Fig. 2, flameholder ring 56 will intercept the cold or low temperature gas-fuel mixture passing through gas passage 46, flameholders 60 and 62 will intercept the heated or high temperature gas-fuel mixture passing through gas passage 32 and because flameholder ring 58 is positioned immediately downstream of and in substantial axial alignment with the after end 64 of splitter duct 34, to which it is attached, flameholder ring 58 will intercept both the cold gas-fuel mixture of gas passage 46 and the heated gas-fuel mixture of gas passage 32. It may be found desirable to fabricate flameholder ring of substantial width (radial dimension) to effect better cold and hot gas interchange and mixing. At least one and preferably a plurality of flamespreaders such as 66, 68, and 70 extend between and join the adjacent flameholder rings both to support the other flameholder rings from flameholder ring 58 and also to put the other flameholder rings into aerodynamic communication with flameholder ring 58. Flamespreaders 66, 68, and 70 are preferably of trough or U-shaped cross section and open in a downstream direction and are attached to the flameholder rings 58, 60, and 62 such that the trough interior of each enters into the trough interior of the part connected thereto. The flamespreaders 66, 68, and 70 are preferably radially directed or extending but axially inclined in a downstream direction as shown in Fig. 2 to join the axially spaced flameholder rings.

As best shown in Fig. 3, flameholder unit 40 carries axially extending circular flange or ring 72 at its forward end and leading edge flange 72 is of such size as to be connected to the after end 64 of splitter duct 34 by any convenient connecting means such as welding or rivet units 74 so that the entire flameholder unit 40 is supported from and by the after end 64 of splitter duct 34.

As best shown in Fig. 4, either or both flameholder unit flange 72 or splitter duct after or downstream end 64 may be provided with a plurality of expansion slots such as 76 to permit relative expansion between flameholder unit 40 and splitter duct 34 also, in this connection, rivet unit 74 may pass through circumferentially extending elongated slots in flange 72 and duct end 64 to further assist in permitting this relative thermal expansion.

In operation, my combustion mechanism works so that any ignition means such as hot streak ignitor 52 may be used to ignite the heated gas-fuel mixture of gas passage 32 so as to support the combustion in the relatively stagnant combustion supporting zone created by flameholder rings 58, 60, and 62 downstream thereof. Flameholder ring 58 performs the important function of serving as a pilot to ignite and cause combustion to be sustained in the relatively stagnant combustion supporting zone formed downstream of flameholder ring 56. Due to the inclination of flamespreaders 66 and the direction of the flow through gas passages 46 and 32, the combustion which is set up by flameholder ring 58 establishes a secondary combustion flow along the trough interior of flameholder 66 toward ring 56 and serves to ignite and support the combustion of the cold gas-fuel mixture from gas passage 46 which has passed around ring 56 to form a relatively stagnant zone downstream thereof.

Inverted hollow cone 78 is carried by engine inner body or tailcone 36 and opens in a downstream direction and is coaxial with the flameholder rings and serves to establish a relatively stagnant combustion supporting zone downstream thereof in conjunction with the flameholder rings.

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

1. Combustion supporting mechanism comprising two coaxial ducts of circular cross-section defining two gas passages, means to pass heated gas through the gas passage defined by the inner of said ducts, means to pass cold gas through the gas passage formed between said ducts, a flameholder unit of generally circular form having a ring flange attached directly to the downstream end of said inner duct and said flameholder unit is supported solely by said inner duct, said flameholder unit having a first flameholder ring of trough shaped cross section and opening in a downstream direction positioned directly and immediately downstream of said inner duct to intercept both said heated gas and said cold gas and form a relatively stagnant combustion zone downstream thereof and further having a flameholder ring of trough shaped cross section and opening in a downstream direction positioned one in each of said gas passages and each being spaced axially from said first flameholder ring and further having a radially extending and axially inclined flamespreaders of trough shaped cross section and opening in a downstream direction joining said first flameholder ring to the others of said flameholder rings, and means to permit relative expansion between said inner duct and said flameholder unit.

2. Combustion supporting mechanism comprising a flameholder unit of generally circular form about an axis and having an axially extending ring flange adapted to attach to an axially extending circular surface of a support member as its sole support connecting means, means to provide leading edge flange 72 of said ring of trough shaped cross section and of relatively large radial dimension and opening in a downstream direction positioned immediately adjacent to and substantially axially aligned with said flange and further having at least one flameholder ring of trough shaped cross section and opening in a downstream direction positioned radially on each side of and each spaced axially from said first flameholder ring and with each flameholder ring parallel to all other flameholder rings and positioned concentrically about said axis and further having a plurality of radially extending and axially inclined flamespreaders of trough shaped cross section and opening in a downstream direction extending between and joining adjacent flameholder rings.

3. Two gas passages concentric about an axis and having upstream and downstream ends and gas passage separating mechanism, a flameholder unit of generally circular shape thereof extending circular flange adapted to engage said mechanism so that said mechanism is the sole support for said unit, a plurality of axially spaced annular flameholder rings concentric about said axis and positioned so that a first one of said rings attaches to said flange and is positioned in substantial axial alignment therewith and with at least one of said rings being of larger diameter than said first ring and spaced axially therefrom on the downstream side.
thereof and further with at least one of said rings being of smaller diameter than said first ring and spaced axially therefrom on the downstream side thereof, and at least one radially extending axially inclined flamespreader extending between and joining each of said larger diameter and said smaller diameter rings to said first ring.

4. An engine of the ducted fan type comprising an outer case of circular cross section, a splitter duct of circular cross section and an inner body of circular cross section each of which is coaxial and concentric with said splitter duct located between said outer case and said inner body so that a first gas passage is formed between said inner body and said splitter duct and so that a second gas passage is formed between said splitter duct and said outer case, means to pass a heated gas-fuel mixture through the first of said gas passages, means to pass a cold gas-fuel mixture through the second of said gas passages, a flameholder unit of generally circular form having a ring flange attached directly to the downstream end of said splitter duct so that said flameholder unit is supported solely by said splitter duct, said flameholder unit having a first flameholder ring of trough shaped cross section and opening in a downstream direction positioned downstream of and connected to said ring flange and a second and third flameholder ring of trough shaped cross section and opening in a downstream direction with said second and third flameholder rings located respectively in said first and second gas passages and each being spaced axially downstream from said first flameholder ring and further having a radially extending and axially inclined flamespreader of trough shaped cross section and opening in a downstream direction joining said first flameholder ring to said second and third flameholder rings, and means to ignite said heated gas-fuel mixture so that combustion will be supported downstream of said first flameholder ring and said second flameholder ring in said first passage and further so that secondary combustion flow occurs along said flamespreader joining said first flameholder ring and said third flameholder ring in said second passage to ignite and support combustion of the cold gas-fuel mixture downstream thereof with said first flameholder ring acting as a pilot for said third flameholder ring in said second passage, and an inverted hollow cone attached to said inner body, concentric about said axis and opening in a downstream direction.

5. Combustion supporting mechanism comprising two coaxial ducts of circular cross section defining two gas passages with outlets in substantial radial alignment, an annular flameholder unit attached directly to and supported by the smaller of said ducts and including a first annular flameholder ring positioned immediately adjacent and downstream of said outlet of the first of said two gas passages and further including a second annular flameholder ring positioned immediately adjacent and downstream of said outlet of the second of said two gas passages.

6. Combustion supporting mechanism comprising two coaxial ducts defining two gas passages, means to pass heated gas through the gas passage defined by the inner of said ducts, means to pass cold gas through the gas passage formed between said ducts, a flameholder unit having a flange attached directly to the downstream end of said inner duct so that said flameholder unit is supported solely by said inner duct, said flameholder unit having a first flameholder positioned directly and immediately downstream of said inner duct to intercept both said heated gas and said cold gas and form a relatively stagnant combustion zone downstream thereof and further having a flameholder positioned one in each of said gas passages and each being spaced axially from said first flameholder and further having a radially extending and axially inclined flamespreader joining said first flameholder to the others of said flameholders and means to permit relative expansion between said inner duct and said flameholder unit.

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