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FLAMEHOLDER CONSTRUCTION

Filed Nov. 12, 1957

FIG_1

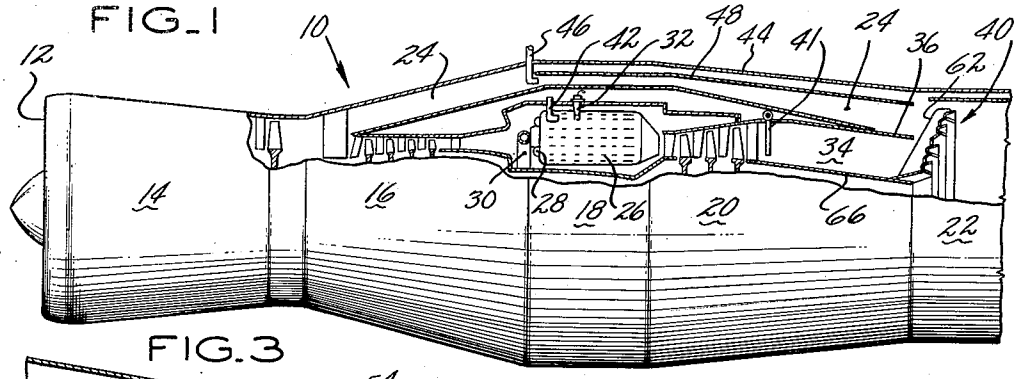


FIG_3

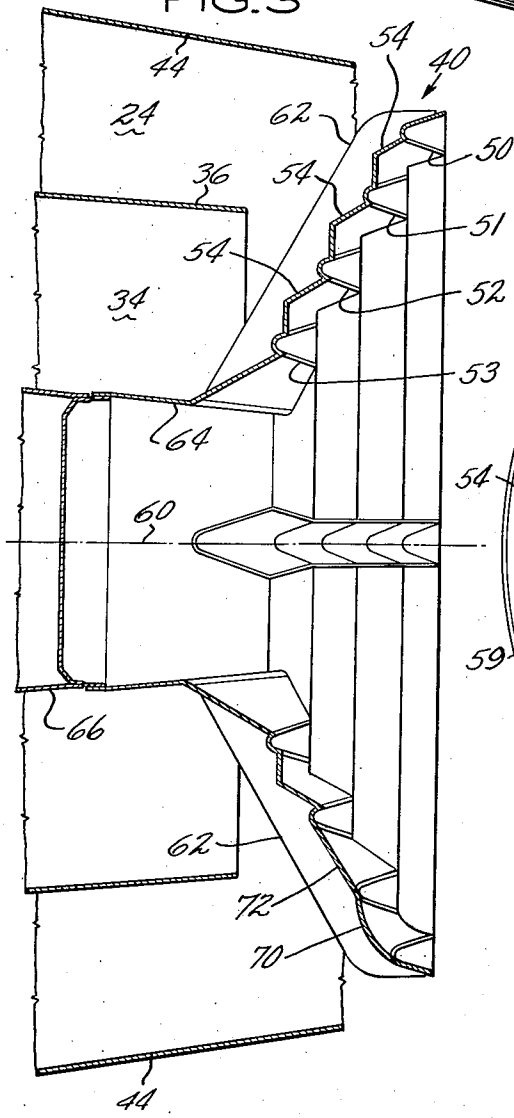
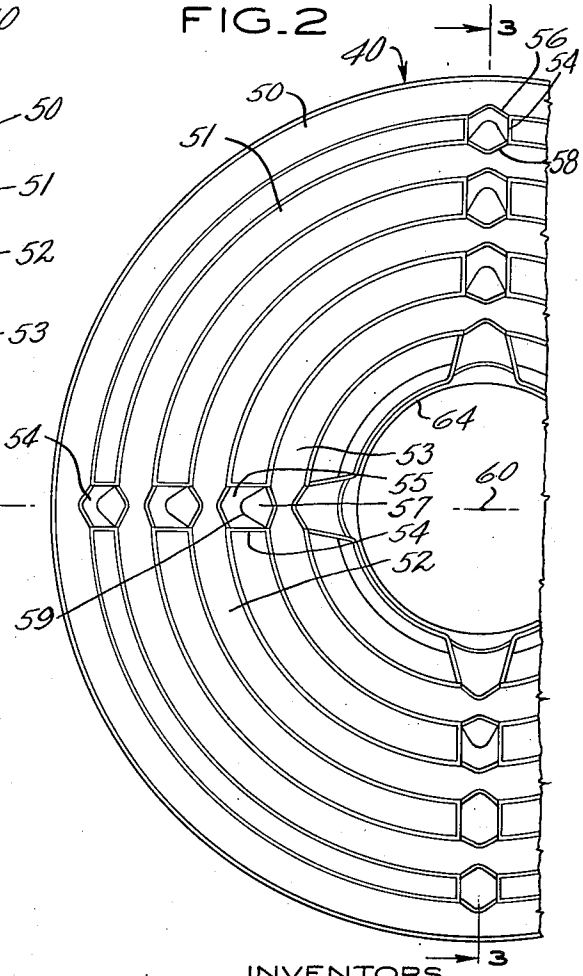


FIG_2



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FLAMEHOLDER CONSTRUCTION

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This invention relates to flameholders used for combustion purposes and more particularly to flameholders of the type useable in powerplants requiring combustion in areas having vastly different combustion supporting characteristics.

It is sometimes required 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 mixing ducted fan engines and in a ducted ramjet causing ignition and sustaining combustion with an ordinary flameholder under these conditions is very difficult. Experience has shown that even when large width flameholders are used the flame blowout limits encountered confine operation to low velocity, high pressure, and 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 a precarious 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 combustion is supported in both a stream of heated gas and an adjacent stream of cold air carrying a fuel having poor low temperature vaporization characteristics.

It is still 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 substantially radial flamespreader flow to a flameholder located in a cold airstream so as to ignite the cold airstream-fuel mixture and cause combustion thereof to be supported in the relatively stagnant area downstream of the cold air flameholder.

These and other objects and advantages of this invention will become apparent from the following detailed description of the drawing in which:

FIG. 1 is an external showing of a ducted fan engine partially broken away to illustrate an embodiment of our invention.

FIG. 2 is a rear view of our flameholder construction.

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

Referring to FIG. 1, we see an external showing of a modern aircraft mixing ducted fan engine **10** of the type illustrated in United States Patent Nos. 2,458,600, 2,610,465, and 2,753,685, comprising an air intake section **12**, a first compressor section **14**, a second compressor section **16**, a combustion section **18**, a turbine section **20**, and an afterburner section **22**, as well as a ducted section **24**. Air enters engine **10** through air inlet **12** and is compressed as it passes through compressor stage **14**. The air will then follow one of two possible routes, the first of which is comparable to passing through a turbojet engine and comprises passing through second compressor section **16** where it is further compressed and then entering combustion section **18** where it is heated due to the combustion occurring within combustion chambers **26** which receive fuel through fuel nozzles **28** and fuel manifold **30**. Spark plug **32** or other ignition means may be provided to ignite the atomized fuel mixture which

is injected into combustion chambers **26** by fuel nozzles **28**. Following this first path, the heated gases then pass through turbine section **20**, then through the gas passage **34** which is defined at its outer periphery by splitter duct **36** and may be defined at its inner periphery by tailcone or inner body **66** and is then introduced to flameholder unit **40** for secondary burning within afterburner **22**. The original fuel-air mixture originating within combustion chamber **26** may be chosen to be sufficiently rich that unburned fuel is introduced to gas passage **34** and hence flameholder unit **40**, or additional fuel may be added by means, for example, of conventional spray bars **41** within hot gas duct **34**. Ignition of the heated gases which pass through gas passage **34** may be effected downstream of flameholder unit **40** by any convenient means such as hot streak ignition unit **42** of the type taught in United States Patent No. 2,780,054 which projects an instantaneous stream of flaming raw fuel through combustion chamber **26**, turbine **20**, and gas passage **34**, eventually to ignite the fuel-heated gas mixture which exists downstream of flameholder unit **40** in the relatively stagnant, low pressure combustion supporting area formed downstream thereof. After the heated gas from duct **34** burns within afterburner **22**, it is discharged through a conventional exhaust nozzle of the type taught in United States Patent No. 2,770,944 to atmosphere to perform a thrust generating function.

The second route available to the compressed air being discharged from compressor section **14** is through ducted passage **24** which is an annular passage defined by engine outer case **44** and splitter duct **36** or parts comparable thereto, all of which are preferably concentric, coaxial and of circular cross section. Atomized fuel is introduced to the cold air passing through duct passage **24** by fuel injection pipes **46** which are preferably equally spaced circumferentially about engine outer case **44**. While not essential, it may be deemed advisable to provide shield **48** which is of circular cross section and concentric and coaxial with outer case **44**, to prevent fuel from injection means **46** from contacting the engine outer case **44** and burning thereagainst. The cold air-fuel following this aforementioned second route through duct passage is discharged into afterburner unit **22** as passing through and around flameholder unit **40**. No external or special ignition means is provided to ignite the cold air-fuel mixture which is discharged from duct passage **24** into afterburner **22** through flameholder **40**, for unit **40** is so fabricated with relation to the remainder of engine **10** that the combustion occurring at the inner diameter portion of flameholder unit **40** is directed by aerodynamic flow along flamespreaders **54** toward the outer diameter area of flameholder unit **40**. In view of this aerodynamic flow, the flameholder inner diameter portion, in pilot flameholder fashion, causes ignition and sustained combustion of the cold air-fuel mixture from duct **24** in a relatively stagnant combustion zone created downstream of the outer diameter portion of flameholder unit **40**. This is the teaching of our invention as more fully described in connection with the description of FIGS. 2 and 3 which follows.

Referring to FIGS. 2 and 3, we see that our flameholder unit **40** comprises at least one flameholder **50** or **51** positioned to intercept and receive the cold air-fuel mixture discharged from duct passage **24** and further comprises at least one flameholder **52** or **53** positioned to intercept and receive the heated gas-fuel mixture discharged from gas passage **34**. While two such flameholders are shown herein, it should be borne in mind that any selected number or shape may be chosen without departing from the spirit of our invention. A series of substantially radially directed and inclined flamespreaders, flameholders or attachment units, such as **54**, extend be-

tween and aerodynamically join adjacent flameholders, such as 50 and 51. The number of radial connecting units 54 required depends on engine size and operating conditions. Flamespreaders or connecting means 54 are of substantially U-shaped or trough-shaped cross section and open in a downstream direction with respect to the gas passages and aerodynamically communicate with and join our flameholders, such as 50 and 51, which are annular rings of U-shaped or trough-shaped cross section, opening in a downstream direction. As will be observed by viewing the connecting lines 56 and 58 between a flamespreader 54 and adjacent flameholders, 50 and 51, there is an actual intertrough connection between these parts; that is, the trough interior of these parts is joined so that the trough of the flamespreader 54 actually enters into the trough of the flameholders 50 and 51. Flamespreader 54 is shown to be made of two pieces 55 and 57, which join along line 59 or may be curved or straight as shown at 70 and 72 respectively in FIG. 3.

By observing FIG. 3 it will be noted that each flameholder ring is concentric about axis 60 of engine 10, as is splitter duct 36 and outer case 44, but that each flameholder is spaced axially with respect to the others so that a flameholder such as 50, which is to be used to support the combustion of the cold air-fuel mixture from duct passage 24, is axially farther downstream than is a flameholder such as 52 which is intended to support combustion of the heated gas-fuel mixture discharged through passage 34. Our flamespreaders 54 are accordingly so inclined and this arrangement is made to establish an aerodynamic flow from the heated gas flameholders 52 and 53 toward the cold air flameholders 50 and 51 so that a heated and ignited or burning fuel-air mixture will be continuously directed along the trough interior and downstream of flamespreaders 54 into the cold air flameholders 50 and 51 from the heated gas flameholders 52 and 53 to serve to ignite and support the combustion of the cold air-fuel mixture discharged past flameholder unit 40 from duct 24.

Flameholder unit 40 is shown to comprise a plurality of thin web-type support members 62 which project from the body 64 of flameholder unit 40 and attaches to each flameholder ring, 50 through 54 for support and rigidity purposes. If web support member 62 were to be eliminated, the radial connectors 54 could extend forward of the flameholder rings to form a radial support. Flameholder body 64 is shown to attach to engine tailcone or inner body 66 by any convenient methods such as welding, but it should be borne in mind that it could as well be supported by struts projecting radially inwardly from outer case 44, and such would probably be the case if tailcone 66 terminated upstream of unit 40.

In operation, the heated gas-fuel mixture which passes through duct 34 passes flameholders, 52 and 53, creating a relatively stagnant-low velocity combustion supporting area downstream thereof, thereby permitting combustion of the heated gas-fuel mixture which is ignited initially by our hot streak igniter means 42. This ignited fuel-air mixture from flameholders 52 and 53 passes substantially radially outward and in the trough of flamespreaders 54 into the trough of flameholders 50 and 51 to cause the ignition of and to permit, in pilot fashion, sustained combustion of the cold air-fuel mixture discharged from duct 24.

Although only one embodiment of this invention has been illustrated and described herein, it will be apparent that various changes and modifications may be made in the construction and arrangement of the various parts without departing from the scope of this novel concept.

What is desired by Letters Patent is:

1. Combustion means comprising an inner body of substantially circular cross section, a first duct of substantially circular cross section concentrically enveloping said inner body and cooperating therewith to define a first annular gas passage through which hot gases are passed, a second duct of substantially circular cross section and coaxial with and enveloping and forming a second annular gas passage with said first duct through which cold gases are passed and with said second duct extending rearwardly therefrom to define a combustion chamber, said first and second annular gas passages having substantially radially aligned outlets each with an inner and an outer diameter, a first annular flameholder ring of trough-shaped cross section positioned immediately adjacent said first gas passage outlet and having an inner diameter greater than said inner diameter of said first gas passage outlet and having an outer diameter smaller than said outer diameter of said first gas passage outlet to be wholly located to intercept said hot gases and establish relatively stagnant combustion supporting areas therein in said combustion chamber, a second annular flameholder ring of trough-shaped cross section and axially spaced downstream from said first flameholder and positioned immediately adjacent said second gas passage outlet and having an inner diameter greater than said inner diameter of said second gas passage outlet and having an outer diameter smaller than said outer diameter of said second gas passage outlet to be wholly located to intercept said cold gases and establish relatively stagnant combustion supporting areas therein in said combustion chamber, and a radially directed and rearwardly tilted flamespreader of trough-shaped cross section joining said flameholders and positioned to establish gas flow from said first to said second flameholder.

2. Combustion means comprising an inner body of substantially circular cross section, a first duct of substantially circular cross section concentrically enveloping said inner body and cooperating therewith to define a first annular gas passage through which hot gases are passed, a second duct of substantially circular cross section and coaxial with and enveloping and forming a second annular gas passage with said first duct through which cold gases are passed in said combustion chamber, said first and second annular gas passages having substantially radially aligned outlets each with an inner and an outer diameter, an annular flameholder unit attached to and supported by said inner body and including at least one annular flameholder ring of trough-shaped cross section and opening in a downstream direction and extending transversally of the axis of said ducts and positioned immediately adjacent said first gas passage outlet and having an inner diameter greater than said inner diameter of said first gas passage outlet and having an outer diameter smaller than said outer diameter of said first gas passage outlet to be wholly located to intercept said hot gases and establish relatively stagnant combustion supporting areas therein in said combustion chamber, and also including at least one annular flameholder ring of trough-shaped cross section and opening in a downstream direction and extending transversally of the axis of said ducts and axially spaced downstream from said flameholder in said first duct hot gas and positioned immediately adjacent said second gas passage outlet and having an inner diameter greater than said inner diameter of said second gas passage outlet and having an outer diameter smaller than said outer diameter of said second gas passage outlet to be wholly located to intercept said cold gases and establish relatively stagnant combustion supporting areas therein in said combustion chamber, and further including at least one radially directed and rearwardly tilted flamespreader of trough-shaped cross section and opening in a downstream direction joining said flameholders and positioned to establish gas flow from said first to said second flameholder.

3. In a ducted fan type engine, an engine outer case, an engine tail cone concentrically located within said outer case, a splitter case concentrically located between said outer case and said tail cone and defining a sub-

stantially axially extending gas passage with each and with said gas passages having substantially radially aligned outlets each with an inner and an outer diameter and with said engine outer case extending rearwardly of said outlets to define a combustion chamber, means to pass cold air through one of said passages and hot gas from said engine through the other of said passages, a flameholder unit attached to and supported by said tail cone and including a first flameholder ring positioned immediately adjacent said hot gas passage outlet and having an inner diameter greater than said inner diameter of said hot gas passage outlet and having an outer diameter smaller than said outer diameter of said hot gas passage outlet to be wholly located to intercept said hot gas and establish a relatively stagnant combustion supporting area therein in said combustion chamber, a second flameholder ring spaced both axially downstream and radially from said first flameholder and positioned immediately adjacent said cold air passage outlet and having an inner diameter greater than said inner diameter of said cold gas passage outlet and having an outer diameter smaller than said outer diameter of said cold gas passage outlet to be wholly located to intercept said cold air and establish a relatively stagnant combustion supporting area therein in said combustion chamber, and a flamespreader joining said flameholders and establishing gas flow therebetween from said hot gas passage to said cold air passge.

4. In a ducted fan type engine having an axis, an engine outer case of substantially circular cross section, an engine tail cone concentrically located within said outer case, a splitter case of substantially circular cross section coaxial with and concentrically located between said outer case and said tail cone and defining a first annular gas passage with said tail cone and further defining a second annular gas passage with said outer case, said gas passages extending in substantially an axial direction and having substantially radially aligned outlets and with said engine outer case extending rearwardly of said outlets to define a combustion chamber, means to pass heated gas from said engine through said first passage, means to pass cold air through said second passage, means to add fuel to said heated gas and said cold air, a first annular flameholder ring of trough-shaped cross section and opening in a downstream direction and positioned immediately adjacent said first gas passage outlet and having an inner diameter greater than said inner diameter of said first gas passage outlet and having an outer diameter smaller than said outer diameter of said first gas passage outlet to be wholly located to intercept the first passage heated gas and fuel mixture and establish a relatively stagnant, combustion supporting area downstream thereof in said combustion chamber, means to ignite said heated gas and fuel mixture to cause combustion in said first flameholder stagnant area, a second annular flameholder ring located axially downstream of said first flameholder and being of trough-shaped cross section and opening in a downstream direction and positioned immediately adjacent said second gas passage outlet and having an inner diameter greater than said

inner diameter of said second gas passage outlet and having an outer diameter smaller than said outer diameter of said second gas passage outlet to be wholly located to intercept second passage cold air and fuel mixture and establish a relatively stagnant combustion supporting area downstream thereof in said combustion chamber, and at least one radially extending and rearwardly tilted flamespreader of trough-shaped cross section and opening in a downstream direction and establishing a relatively stagnant, combustion supporting area downstream thereof and tilted with respect to the engine axis and connected to each of said flameholders so that the trough interiors of said flameholders and said flamespreader are joined and establishing gas flow therebetween so that the combustion in said first flameholder stagnant area will pass across said flamespreader and ignite said cold air and fuel mixture in said second flameholder stagnant area thereby effecting combustion in both of said heated gas and fuel and said cold air and fuel mixtures and establishing gas flow therebetween.

5. In a ducted fan engine, three concentric and coaxial members of circular cross section shaped and cooperating to define two concentric annular gas passages having substantially radially aligned outlets and with the outer of said members extending rearwardly beyond said outlets to define a combustion chamber, means to pass heated gas through one of said passages and cold air through the other, and a unitary flameholder unit attached to and supported solely by one of said members and including a first flameholder ring positioned immediately adjacent said hot gas passage outlet and having an inner diameter greater than said inner diameter of said hot gas passage outlet and having an outer diameter smaller than said outer diameter of said hot gas passage outlet to be wholly located to intercept the heated gas, and further including a second flameholder ring spaced both axially downstream and radially from said first flameholder and positioned immediately adjacent said cold air passage outlet and having an inner diameter greater than said inner diameter of said cold gas passage outlet and having an outer diameter smaller than said outer diameter of said cold gas passage outlet to be wholly located to intercept the cold air of the other of said passages and still further including flamespreader means joining said flameholder rings.

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