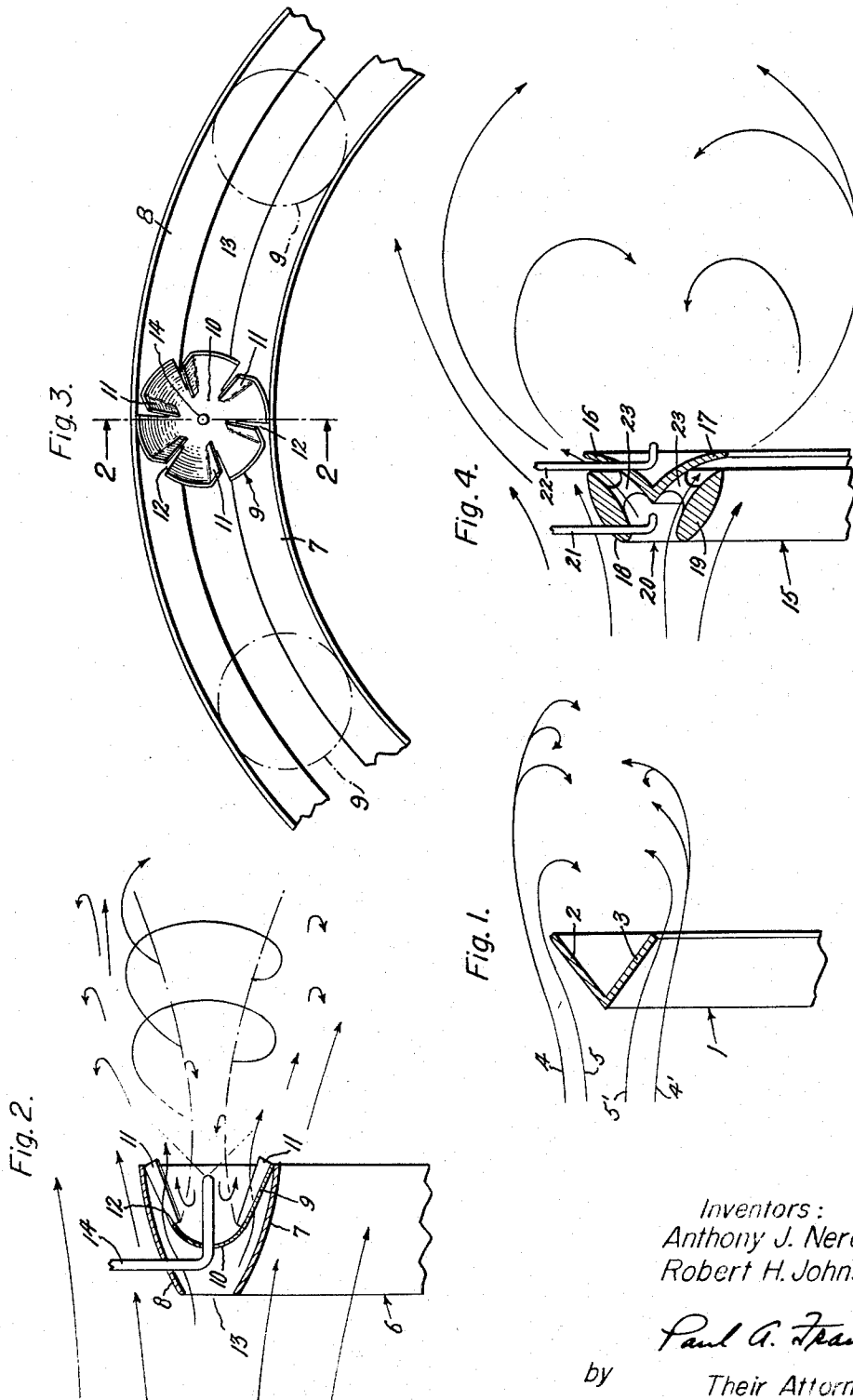


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AFTERBURNER FLAMEHOLDER

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AFTERBURNER FLAMEHOLDER

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This invention relates to flameholders of the type adapted to be mounted in a fast moving gas stream wherein fuel is to be burned, and which are utilized to create stagnant and turbulent areas or regions for more satisfactory burning of the fuel. More particularly, this invention relates to flameholders having increased vorticity characteristics.

The present trend in the design of jet engines is toward a greater utilization of the reheat or afterburner principle, which entails the injection of additional or reheat fuel into the exhaust gas stream of a jet engine at a location downstream of the turbine wheel where the combustion takes place. The combustion of fuel in the exhaust section is referred to as afterburning and is a process with which flameholders are usually associated.

In general, the flow characteristics of the exhaust gas stream of a jet engine are unfavorable for further fuel burning, considering the lack of satisfactory mixing of the fuel with the gas stream, and lack of stagnation areas where the velocity of the gas stream is sufficiently low to permit good burning. As a solution to these problems, it has become the accepted practice to place obstructions or flameholders in the exhaust section of jet apparatus in order that the exhaust stream may impinge thereon and thus provide turbulent patterns and stagnation areas in the downstream direction where proper mixing and burning may take place.

Flameholders usually take the cross-sectional configuration of a U or V or modifications thereof, and are positioned with the closed end or apex in the upstream direction. In plan view the configuration may be that of a circle, rectangle, or other structure which may be efficiently utilized in jet apparatus.

In the over-all turbulence or mixing patterns generated by the insertion of a flameholder in an exhaust section, the flameholder itself is not the only contributing factor. The spreading of the flame throughout the exhaust section generates a certain degree of turbulence in the narrow areas adjacent the flame. Furthermore, the random dispersion of the flame entrains some fuel gas mixture in its progress. It is therefore evident that if the relative size of the propagating flame were increased to utilize a greater area with more random dispersion, the length of the flame may be shortened and the area of burning within the exhaust section larger. Heretofore, complete burning in the exhaust section was obtained through use of multiple flameholders positioned radially and/or longitudinally in the exhaust section, but limitations on such an arrangement are stringent where the total cross-sectional area of obstruction becomes detrimental to full flow conditions.

Accordingly, it is an object of this invention to provide fuller afterburning in a relatively short length of exhaust section.

It is a further object of this invention to utilize flame dispersion to a greater degree in creating turbulence.

It is another object of this invention to provide a vor-

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tex generating flameholder to control the dispersion of the flame front.

In carrying out this invention in one form, one or more vortex generators are associated with a flameholder to generate a vortex or vortices larger than the vortex developed by the flameholder alone, without increasing the frontal area of obstruction of the flameholder. Reheat fuel may then be injected in the proper fuel-air ratio into these vortices.

These and other objects, features and advantages of the invention will be better understood when taken in connection with the accompanying drawing, and the scope will be pointed out in the appended claims.

Fig. 1 is a cross-section of a typical flameholder body;

Fig. 2 is a cross-section of a flameholder body incorporating vortex and generating means, taken along the line 2—2 of Fig. 3;

Fig. 3 is a partial elevation view of the embodiment shown in Fig. 2; and

Fig. 4 shows a cross-section of a flameholder body having flow guide members associated therewith.

Referring now to Fig. 1, there is shown a sectional view of a common type of flameholder body 1 having arm members 2 and 3 which form a V configuration. Body 1 is mounted in an exhaust gas stream with the apex in the upstream direction and the pattern of flow is shown by arrows 4, 4', 5 and 5'. A low pressure stagnation area is developed within and extends downstream of the arm members 2 and 3, while further downstream, arrows 4 and 5 degenerate to more turbulent or mixing patterns. Flameholders of this type are limited in the radial area of turbulence that can be developed from a predetermined frontal area of the flameholder exposed to the exhaust gas stream. The employment of these flameholders generally results in the combustion process being confined in radial dimensions and becoming lengthy in the downstream direction, with little utilization of flame-created turbulence.

To overcome this problem we employ a modifying flameholder having vortex generators as shown in Figs. 2 and 3. Referring now to Fig. 2, there is disclosed a flameholder body 6 having arm members 7 and 8 disposed in angular relationship to each other. Flameholder body 6 is positioned in the exhaust gas stream with the apex in the upstream direction in a manner similar to that as described for Fig. 1. One or more vortex generators 9 are mounted within arm members 7 and 8 and next adjacent the downstream ends by general methods of metal joining including welding and riveting. Each vortex generator 9, as shown in Figs. 2 and 3, comprises a cup-shaped element 10 having a plurality of vanes 11 joined to its inner surface and openings 12 disposed therebetween. In order to provide for admission of a part of the exhaust gas stream into vortex generators 9, an opening 13 is made in the apex of flameholder body 6. Opening 13 permits a part of the exhaust gas stream to flow into those areas between cup-shaped element 10 and arm members 7 and 8. In the invention as illustrated, opening 13 is shown as continuously annular; however, either individual openings or a series of openings for each vortex generator 9 may be provided with good results. The gas stream then flows from the aforementioned areas through openings 12 to strike vanes 11 positioned within cup-shaped element 10 at an angle to the surface thereof such that the gas stream is given a whirling or tangential movement in order to generate an unconfined or free vortex in the downstream direction. The vortex thus generated causes vortical flow patterns of greater radial and longitudinal dimensions than those generally available from the common V type of flameholder and rotating about a longitudinal axis relative to the gas

stream. Further, multiple vortices of this type not only cause better mixing patterns but also show a lesser pressure drop than the conventional V type of flameholder of equal frontal area.

Reheat fuel may be introduced into the exhaust section in whole or in part by one or more fuel nozzles 14 which are mounted in arm 8 to spray fuel directly into the generated vortex thus taking full advantage of increased turbulence and mixing patterns. Spraying fuel directly into a vortex is a desirable feature which facilitates control over fuel-air ratios at critical areas where ignition is to commence or where blowout may take place.

The principle of deriving a greater area of turbulence with a minimum area of frontal obstruction may be utilized by other arrangements in addition to that described above.

Referring to Fig. 4, there is shown a modified V flameholder body 15 having curved arm members 16 and 17. Flameholder body 15 is positioned in the exhaust gas stream with the apex in the upstream direction. In order to provide directive means for wide angle divergence of the gas flow, a pair of angularly disposed air foil or flow guiding elements 18 and 19 are mounted in concentric relationship to the flameholder body 15 with the apex of the air foil elements spaced apart as at 20 to permit gas flow therebetween. In this arrangement the air foil elements 18 and 19 form a decreasing passage between themselves and their corresponding arm members 16 and 17. Fuel may be introduced both into the opening 20 and into the area partially enclosed by the arm members 16 and 17, as shown in Fig. 4, where one or more fuel nozzles 21 spray fuel into the apex opening of the air foil elements, and one or more fuel nozzles 22 spray fuel into the relatively low pressure and velocity areas within the confines of the arm members 16 and 17. In the invention as illustrated the opening 20 of the apex end of the air foil elements 18 and 19 is shown as continuously annular; however, opening 20 may be in the form of individual openings arranged to correspond with the fuel nozzles or the desired turbulence areas. Any suitable means may be employed for mounting the air foil elements 18 and 19 on the arm members 16 and 17 including the welding of strut members 23 therebetween.

In the operation of the flameholder as disclosed in Fig. 4, a portion of the exhaust gas stream enters the opening 20 of the air foil elements 18 and 19 taking up fuel sprayed from nozzle 21. Thereafter, the fuel gas mixture flows into the decreasing passage between an air foil element and an arm member where it is given a nozzle effect to increase its velocity, and is then directed in a wide angle divergence turbulent pattern with a low pressure center. Fuel is also injected into the center of this wide angle pattern through nozzles 22. The combination of fuel added both to the outer area and the core of a vortex permits flame propagation to spread throughout the desired area in lesser time while utilizing flame turbulence to a greater degree.

It is thus understood that the combination of the gutter type flameholder having a predetermined frontal area, together with the vortex generators or the air foil elements presents a frontal area to the gas stream of that of the gutter flameholder only.

While other modifications of this invention and variations of apparatus which may be employed within the scope of the invention have not been described, the invention is intended to include all such as may be embraced by the following claims.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. In a jet engine exhaust gutter type flameholder of a predetermined frontal area, the improvement of providing greater turbulence from the same predetermined frontal area, comprising in combination, a pair of arm members,

positioned in the said exhaust in spaced apart relationship, said arm members being angularly disposed relative to each other and mounted with the smaller end in the upstream direction, a plurality of vortex generators next adjacent the downstream ends of said arm members and within said arm members, vanes on said vortex generators generating a free vortex downstream of said flameholder and rotating about a longitudinal axis with respect to the gas flow and at least one fuel nozzle arranged to spray fuel into the vortices developed by said vortex generators.

2. A flameholder device for the exhaust of jet apparatus wherein fuel is to be burned, comprising in combination a pair of arm members joined at one end and open at the other, said arm members being positioned in the exhaust section with the apex in the upstream direction, vortex generators positioned next adjacent the downstream end of said arm members and within said arm members, vanes on said vortex generators generating a free vortex downstream of said flameholder and rotating about a longitudinal axis with respect to said gas stream said arm members having an opening in the apex upstream from the said vortex generators, and fuel nozzles arranged to spray fuel into the vortices developed by the gas flow through said openings and said vortex generators.

3. A flameholder device for fast moving gas streams comprising in combination, a pair of arm members joined at one end and open at the other, said arm members being positioned in the said fast moving gas stream with the joined end in the upstream direction and providing a predetermined frontal area, and an air foil element positioned adjacent at least one of said arms on the upstream side thereof to define a radially directed passage therebetween whereby a portion of the gas stream is caused to flow through said passage to issue therefrom in a radial direction, said combination of air foil elements and arm members presenting a frontal area of only that of said arm members.

4. A flameholder for fast moving gas streams comprising in combination a pair of arm members angularly disposed relative to each other, the said arm members being positioned in the said gas stream with the apex end in the upstream direction and providing a predetermined frontal area, a pair of air foil elements angularly disposed relative to each other and spaced apart at the apex, said angularly disposed arm members and said angularly disposed air foil elements being arranged in concentric relationship with the said air foil elements on the upstream side to define a radially directed passage therebetween, whereby a portion of the gas stream flows into the said passage to issue therefrom in a radial direction, said combination of air foil elements and arm members presenting a frontal area of only that defined by said arm members.

5. In a flameholder device adapted to be mounted in a fast moving gas stream wherein fuel is to be burned, the combination comprising a pair of arm members joined at one end and open at the other, said arm members being positioned in the fast moving gas stream with the joined end in the upstream direction and providing a predetermined frontal area, an air foil element positioned adjacent each of said arm members in spaced apart relationship therefrom to define a radially directed flow passage, and at least one fuel nozzle arranged to spray fuel into the said passage, whereby the portion of the gas stream flowing into the said passages is caused to take up the said fuel and carry it outwardly in a radial direction, the combination of said air foil elements and said arm members presenting a frontal area of that defined by said arm members only.

6. A combination flameholder and fuel spraying device adapted to be mounted in a fast moving gas stream wherein fuel is to be burned, comprising a pair of arm members forming a V type of flameholder body having a predetermined frontal area, a pair of flow guiding elements form-

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ing a V type configuration having an open apex, the said arm members and the said flow guiding elements having arcuate cooperating surfaces defining radially directed flow passages and being positioned in the gas stream in spaced apart concentric relationship with the apexes thereof in the upstream direction, the combination of said air foil elements and said arm members presenting a frontal area of that of said arm members only, a plurality of fuel nozzles arranged to spray fuel into the portion of the gas stream entering the said apex openings and flowing in said flow passage, and a plurality of fuel nozzles arranged to spray fuel into said passage, whereby fuel is supplied to the central and surrounding areas of the vortex developed by the flameholder.

7. In a gutter type flameholder of a predetermined frontal area which provides a given turbulent flow pattern when positioned in a gas stream, means on said flameholder increasing the given turbulent pattern, said means including a flow control member, said flow control mem-

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ber having a predetermined frontal area so that the only frontal area exposed to the said air stream is the predetermined frontal area of said gutter flameholder, and means on said flameholder to inject fuel centrally into said turbulent flow pattern.

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