

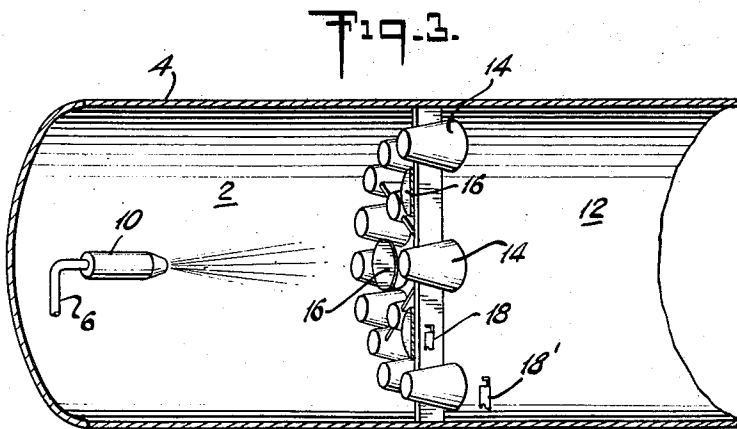
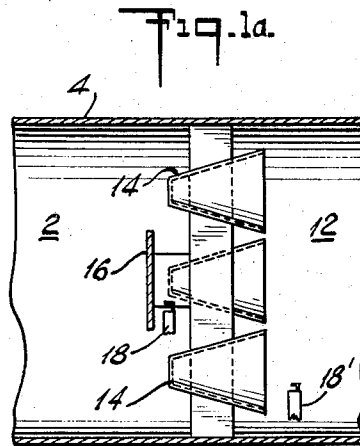
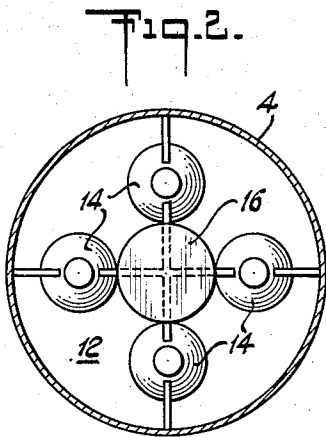
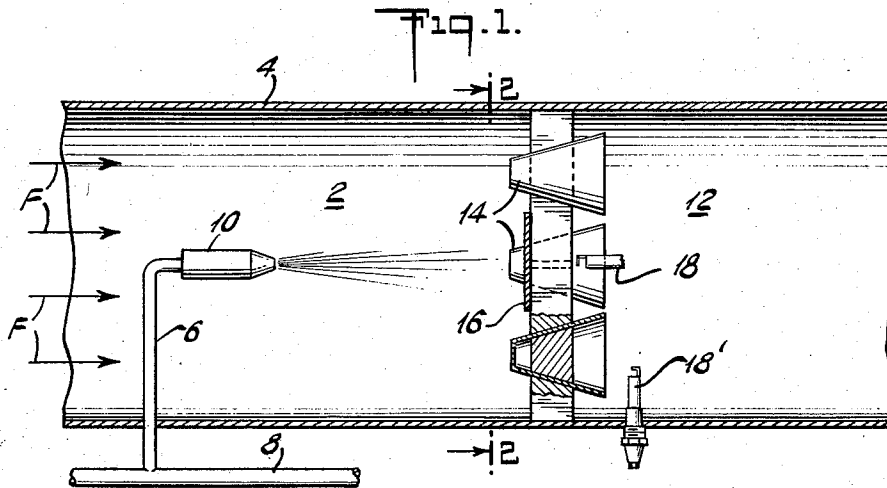
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2,859,588

FLAME HOLDER STRUCTURE FOR RAM JET COMBUSTOR

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FLAME HOLDER STRUCTURE FOR RAM JET
COMBUSTOR

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This invention relates generally to combustion apparatus of the jet propulsion type, and specifically to a ram jet combustor, in which fuel is burned in a moving stream of pressurized air, with the resulting products of combustion being discharged as a propulsive jet.

This application is a continuation-in-part of my co-pending application Serial No. 321,246, filed November 18, 1952, now abandoned.

One of the problems in satisfactory operation of ram jet apparatus under diverse conditions is the maintenance of satisfactory combustion throughout a wide range of overall fuel-air ratios, especially with leaner values. Under certain operating conditions, the lower limit of combustion may be passed easily and the combustion flame may die out; on the other hand, during periods of high fuel consumption when developing high power, localized areas of fuel-air mixture often become too rich for stable combustion or good fuel economy. Some extension of the operable limits of overall fuel-air ratio has been attained in combustion apparatus of the prior art by controlled distribution of fuel through a plurality of fuel supply manifolds each equipped with a number of fuel-emitting nozzles for the impregnation of localized portions of air at local fuel-air mixture ratios which are proper for satisfactorily stable combustion, while permitting variation of the number of nozzles actually in operation to change the overall fuel-air ratio. The extension of combustion limits by this method has the disadvantage of mechanical complexity. The present invention provides combustion apparatus having an improved range of satisfactory combustion while retaining all the advantages of mechanical simplicity.

Therefore, it is an object of the present invention to provide improved air combustion apparatus of the jet propulsion type enabling operation with stable combustion over an increased range of overall fuel-air ratios.

It is another object of the invention to provide combustion apparatus of the aforesaid type which is mechanically simple in structure and which can be easily and inexpensively manufactured.

It is still another object of the invention to provide combustion apparatus of the aforesaid type which is capable of operation with improved economy over a wide range of overall fuel-air ratios.

A further object of the invention is to provide combustion apparatus of the aforesaid type wherein improved mixing of the fuel and air over a wide range of fuel-air ratios is obtained.

These and other objects of the present invention will become apparent from a consideration of the following description taken in conjunction with the accompanying drawings in which

Figure 1 is a longitudinal partial cross section of a ram jet apparatus constructed in accordance with the present invention,

Figure 1a is a partial longitudinal cross section of a

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modification of the flame holder structure disclosed in Figure 1,

Figure 2 is a cross sectional view taken on line 2—2 of Figure 1, and

Figure 3 is a diagrammatic perspective sectional view of an apparatus similar to Figure 1, wherein a multiple installation of the novel flame holder structure is used.

Briefly, my invention contemplates an improved jet propulsion apparatus having a combustion chamber through which air or an equivalent gas flows, a fuel emitting device for introducing fuel into the flowing air or gas as a stream or solid narrow cone spray, and a flame holder structure including a fuel impingement or splash plate positioned in the path of the emitted fuel.

Referring to Figures 1, 1a and 2 of the drawings, a combustion apparatus constructed in accordance with my invention includes a combustion chamber 2 comprising cylindrical wall 4 defining a duct through which air flows in a generally axial direction, indicated by arrows F, at a relatively high velocity during operation of the propulsion engine of which it is a part.

A fuel supply pipe 6, connected to a fuel supply manifold 8, terminates within the combustion chamber in a nozzle 10, of the simplest design, such as a drilled hole, pintle, or solid cone type capable of providing a high velocity, narrowly confined stream or spray of fuel.

The nozzle 10 is shown positioned on the longitudinal axis of the combustion chamber 2, and is oriented therein to spray fuel in the same direction as the flowing air stream.

Downstream from the fuel nozzle 10, there is positioned a flame holder structure 12 consisting of a number of individual turbulence producing elements or flame holders 14, joined to each other and to the cylindrical wall by convenient fastening means and depicted as hollow truncated cones oriented with their axes parallel to the longitudinal axis of the chamber 2 and concentrically disposed thereabout with closed ends facing upstream and large ends open in the downstream direction. Each individual element 14 of flame holder structure 12 serves the conventional purpose of creating a localized area of turbulence within its open end periphery and a resultant localized low velocity air flow in which stable combustion can be maintained under conditions when the velocity of air flow through the combustion chamber is much greater than normal flame front propagation velocity during combustion, and when, therefore, in the absence of a flame holder, flame front combustion could not exist.

Although the disclosed flame holder is a preferred embodiment, it should be understood that other flame holder designs may be utilized with this invention.

Concentrically disposed on the axis of the combustion chamber 2 and nested among the flame holders 14, as shown in Figure 1, or located slightly upstream of the flame holders, as shown in Figure 1a, and directly in the path of fuel emitted from the nozzle 10, is an impingement or splash plate 16, located transversely of the air flow and arranged so that the fuel strikes it directly. The splash plate 16 may have the shape of a disc, as disclosed, or other equivalent surface capable of deflecting the fuel stream from its initial path and dispersing it into the adjacent turbulent air to enable the formation of a combustible fuel-air mixture in the vicinity of the periphery of splash plate 16.

A spark plug or other equivalent positive ignition device shown schematically at 18 is located at a distance sufficiently downstream from the splash plate 16 to allow adequate time for the fuel to mix with the air in satisfactory proportions to form an ignitable mixture. A similar ignition device is used adjacent a flame holder 14 as indicated at 18'.

In the operation of the above-described combustion apparatus, with a low fuel flow rate, corresponding to a low overall fuel-air ratio, the comparatively low velocity fuel stream emitted from nozzle 10 impinges on the splash plate 16, disperses, and undergoes atomization and partial vaporization in the immediate downstream vicinity to form a combustible fuel-air mixture which is ignited by spark plug 18 to initiate combustion. Thus, at low fuel flow rates, the splash plate itself creates sufficient localized turbulence to serve as a flame holder upon which the flame front resulting from the combustion of the low fuel quantity is more reliably stabilized than on the regular flame holders 14.

At high fuel flow rates, the deflecting action of splash plate 16 serves to disperse the higher velocity fuel stream over a wider transverse area within the combustion chamber 2. The fuel is scattered throughout the substantially higher velocity air then flowing through the combustion chamber, which contributes to improved mixing of each increment of fuel with sufficient air to insure its complete combustion without the presence of localized areas of rich fuel-air mixtures, ignition being accomplished by the ignition devices 18 and 18'. The flame front resulting from the combustion of fuel thus dispersed across the combustion chamber by the deflecting action of the splash plate 16 stabilizes on the regular flame holders 14.

To those skilled in the art, it will be obvious that the configuration of the flame holder structure of Figure 1a would be more suitable for operation during periods when high overall fuel-air ratios exist, because of the wider dispersion of the fuel desired across a transverse section of the faster flowing air. Further, it is considered to be within the range of mechanical skill to have the position of the splash plate adjustable (not shown) for variable and so more economical employment depending upon the fuel flow rate.

Figure 3 discloses the multiple installation of the flame holder structure of Figure 1, the same or similar elements bearing identical numeration. Only one fuel nozzle is shown opposite a splash plate, for clearness of depiction, but in actual operation, each splash plate would be positioned downstream of a corresponding fuel nozzle. It should be apparent that the modification of Figure 1a may also be used in a multiple installation, or that the position of splash plate 16 may be made adjustable.

Thus, it may be seen that there has been shown and described an improved combustion apparatus of the jet propulsion type providing improved fuel dispersion for more complete and efficient combustion of all increments of fuel, without localized excessively rich mixtures at high overall fuel-air ratios, and providing improved combustion stability at low overall fuel-air ratios, which thereby enables economical operation with stable combustion over an increased range of overall fuel-air ratios.

Obviously many modifications and variations of the invention, as hereinbefore set forth, may be made without departing from the spirit and scope thereof. For example, the depicted embodiments of the invention, installed in a

cylindrical combustion chamber, may serve as one of several identical incremental parts of a larger combustion chamber of annular cross section (not shown), with each increment operating in the same manner and affording the same advantages as hereinbefore set forth. Therefore only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. In combination with a jet propulsion device of the ram jet type having a combustion chamber, flame holding and igniting means therefor comprising a flame holder structure mounted in said chamber transverse to the direction of air flow therethrough, and ignition means for igniting combustible fuel-air mixtures positioned adjacent and downstream said flame holder structure, means for providing fuel to said combustion chamber in the direction of air flow therethrough and being located upstream with respect to said flame structure, said structure comprising a plurality of flame holder elements in the shape of hollow truncated cones with bases open downstream and a splash plate separate from and surrounded by said elements and located with respect to said means for providing fuel for the direct impingement of fuel thereon, whereby said fuel is dispersed over said plate and said elements to provide localized combustible fuel-air mixtures in their downstream vicinities.

2. In combination, in a ram jet propulsive device having a combustion chamber through which an air stream is directed, fuel emission means for injecting fuel into said air stream in said combustion chamber and in the same direction of flow as that of said air stream, fuel impingement means disposed in said chamber transverse to the flow of said air stream and in the path of said fuel for direct impingement thereon thereby creating a localized area of turbulence in said air stream and dispersing fuel transversely of said air stream in said localized area of turbulence to form a localized combustible fuel-air mixture, means for igniting said fuel-air mixture to produce a flame front being located downstream of said splash plate, and flame holder means separate from and spaced in surrounding relationship to said fuel impingement means for stabilizing said flame front adjacent said fuel impingement means, said flame holder means comprising elements in the shape of hollow truncated cones with open bases located so that the trailing edges of said flame holder means are downstream of said fuel impingement means.

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