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PREVAPORIZING BURNER CAN

Filed March 15, 1967

FIG. 1

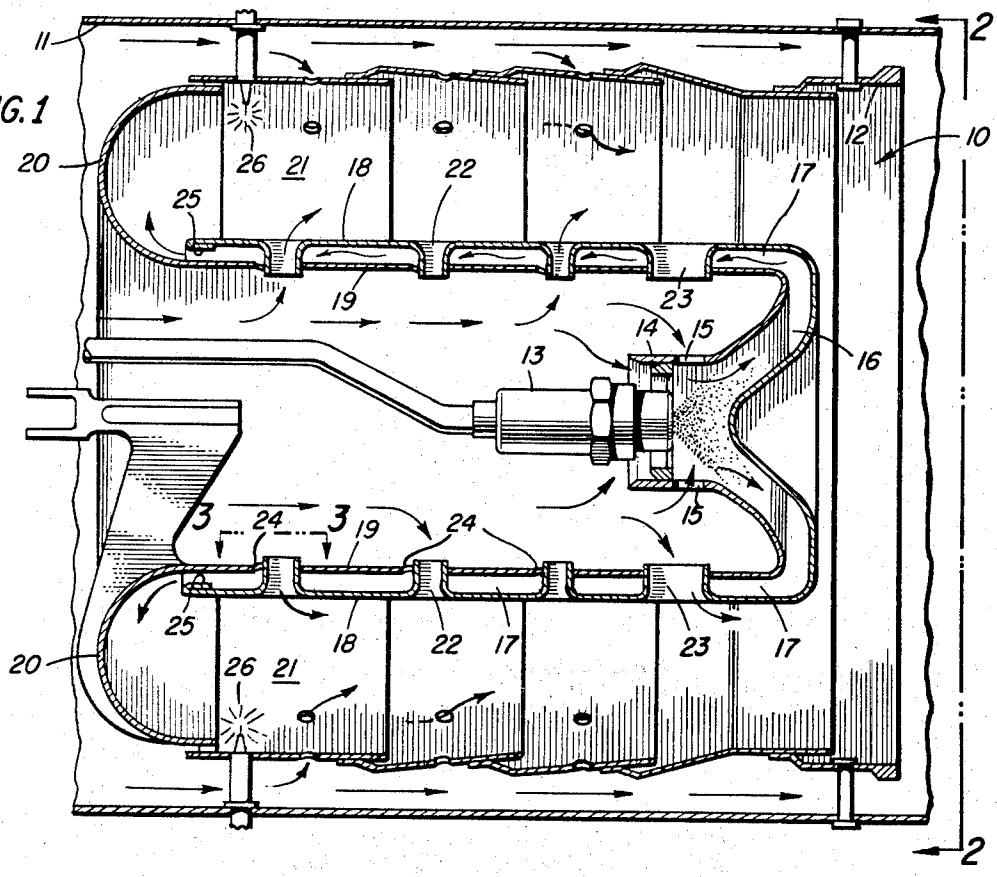


FIG. 2

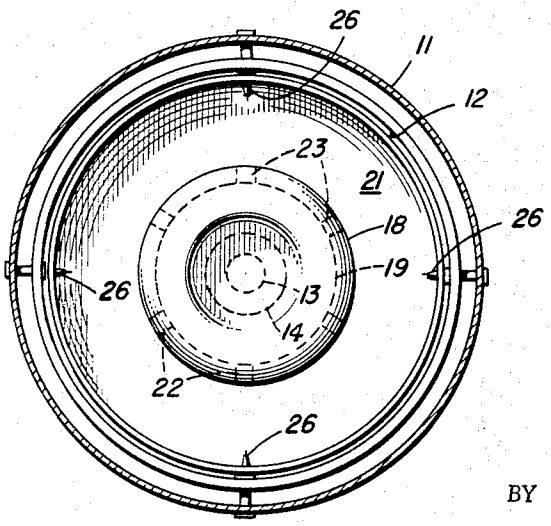
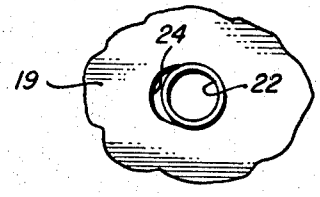


FIG. 3



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PREVAPORIZING BURNER CAN

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ABSTRACT OF THE DISCLOSURE

A prevaporizing burner can apparatus having an axially located annulus for distributing fuel in a vaporized state to the flame zone. For more efficient primary combustion, air from the main air-stream flow is premixed with the fuel through apertures in a fuel nozzle guide and is admitted to the flame zone through radial passages in the annulus. The passages also permit a further mixing of the fuel-air flow.

Background of the invention

The present invention relates generally to a combustion apparatus in which combustion of liquid fuel is required to be supported by a stream of air or other gas flowing through a duct with a flame-extinguishing velocity. More particularly, the instant invention concerns itself with a burner can or flame tube having means for prevaporizing the air-fuel mixture in order to adequately preheat and premix the fuel in preparation for burning, as, for example, in gas turbine or other jet propulsion power units and in gas turbines for other purposes.

In order to achieve satisfactory operation of a combustion system over a wide range of air mass flow and density requires that the flame should not be extinguished under any conditions of operation. To obviate this, the range of air-fuel ratios over which burning will take place must be as wide as possible while maintaining combustion efficiency at a reasonable level with weak mixture. It is also desirable for pressure losses to be low and for an even temperature distribution over the cross-section of the flow to be achievable. Aside from preventing flame blow-out by the air flow, the attainment of a high standard of mixing as between the combustion air and the fuel to be burnt, and of atomization and distribution in the case of a liquid fuel, is required. Atomization means heretofore employed in gas turbine and similar combustion systems included the injection of liquid fuel droplets into an almost stagnant region protected by a baffle from the full blast effect of the air flow, with specially designed atomizing injection nozzles being provided to achieve a satisfactory spray of the fuel.

Recognizing the numerous drawbacks and inefficiencies in such a fuel distribution technique, vaporization systems came into being in an attempt to improve upon the standard of fuel-air mixing in preparation for burning.

Summary of the invention

The invention is directed to an improvement upon the existing apparatus employing a vaporizing means for mixing the air with fuel in preparation for burning. A nozzle guide acts to both direct fuel from the nozzle into a vaporizing annulus and through radial apertures therein, to initially admit air from the main airstream flow for premixing it with the fuel. This premixed air-fuel flow is vaporized from heat transfer through the outer wall of the annulus which is in direct exposure to and forms the inner wall of the burner can. The direction of the mixture in its fuel rich condition is reversed upon entering the annulus, led therethrough, and again reversed in direction and led to the primary combustion zone to form a flame around the prevaporizing passage. In order

to support primary combustion, penetration air from the main airstream flow is admitted into the burner can through passages provided in the annulus, which passages also serve to interrupt the fuel flow thereabout for further mixing. At the exit lip of the vaporizing annulus is provided a double plate to obviate the problem of burning in this area. Also provided are clearances around the upstream passages, on the upstream side, to allow for differential thermal growth between the outer annulus wall which is in direct contact with the flame in the can and the inner annulus wall.

It is therefore an object of the present invention to provide a combustion apparatus having a new and novel means for distributing fuel in a vaporized state to the burner can or flame zone in a manner whereby a preheating and premixing of the fuel is effected in preparation for burning both uncontaminated as well as contaminated liquid fuel.

Another object of the present invention is to provide in a combustion apparatus a fuel distribution means employing larger internal flow passages than heretofore used which are less sensitive to plugging due to contaminants, less sensitive to variations in fuel flow and capable of more efficiently distributing the fuel without resulting in serious profile effects such as streaks and hot spots.

Other objects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

Brief description of the drawings

FIG. 1 is a longitudinal section of the combustion apparatus according to the invention;

FIG. 2 is a sectional view taken at line **2**—**2** of FIG. 1; and

FIG. 3 is a view taken at line **3**—**3** of FIG. 1 showing an expansion clearance around one of the passages.

Description of the preferred embodiment

Turning now to the drawings wherein like reference characters designate like or corresponding parts throughout the several views, there is shown in FIG. 1 the combustion apparatus **10** according to the instant invention being axially supported within an outer cylindrical duct or casing **11** carrying the main airstream with the apparatus **10** so constructed so to interrupt the main flow of air by reducing its velocity sufficiently to support combustion of injected fuel. The design of the combustion apparatus **10** includes a burner can **12** comprised of a plurality of conventional overlapped annuli within which is axially located a single spray nozzle **13** for spraying fuel from a source, not shown, into a fuel guide **14** surrounding a part of nozzle **13** downstream thereof. Part of the air from the main airstream flow is led into guide **14**, as shown by arrows, through both the space between nozzle **13** and guide **14** and through a plurality of radial holes **15** provided in the guide for initially premixing the fuel with small quantities of air. This fuel rich mixture is thrust into conical passage **16** which reverses its direction and leads it radially outward to annulus **17** which has an outer liner or wall **18** and an inner wall **19**. Liner **18**, as is evident from the drawings, also forms the inner wall of burner can **12**. The fuel vaporizes and is more intimately mixed with the air as it flows along conical passage **16** and upstream along the annulus or prevaporizing passage **17**. This vaporization results from the heat transfer through liner **18** which is in direct contact with the flame in the can. This heat transfer serves the dual purpose of preventing liner **18** from becoming excessively hot while at the same time it provides the heat required to vaporize the fuel. As the fuel enters the dome section **21** of the burner can, it is again reversed in direction

by means of curved wall **20**. The mixture, still in a fuel-rich condition, at this point, is supplied with additional primary air just downstream of its entry point to provide the proper mixture to begin burning. This penetration air for maintaining efficient combustion is supplied, as shown by arrows, through a series of primary combustion passages or tubes **22** located in liner **18** and extending through holes in wall **19**. A row of secondary combustion tubes or passages **23** are also provided across annulus **17** in the same manner as tubes **22** in order to effectively dilute the hot gases to obtain a more even burner temperature profile into the turbine. Both passages **22** and **23** also act as baffles to aid in the mixing of the prevaporized flow in annulus **17**. The tubes were sized, figures omitted, by an iterative calculation in order to obtain a predetermined air flow at each respective axial combustion hole row by first assuming an overall combustion chamber pressure drop.

In FIG. 1, and more plainly in FIG. 3, a radial and axial clearance **24** is shown around the primary combustion tubes **22** to allow for differential thermal growth between inner wall **19** and outer liner **18** of the annulus. The outer liner **18**, being directly exposed to the combustion flame, will grow or expand more than wall **19**. While no clearance is provided around the secondary combustion slot **23**, a graduated clearance is provided about passages **22** on the upstream side. This graduated design will effectively compensate for any expansion of liner **18** with respect to wall **19**. Since the outer liner is fixed relative to the inner liner at the secondary passage **23**, it can only grow toward the front of the can relative to the inner liner, thereby taking up the clearance provided in the first three rows of holes. Any leakage that occurs will be into the vaporizing annulus **17** since the pressure drop is in this direction. This leakage is not critical to burner can performance.

As shown in FIG. 1 of the drawings, a double plate **25** at the vaporizing annulus exit is provided to anticipate the problem of burning in this area. Since the fuel that exits the annulus **17** is all vaporized, combustion takes place close to this exit lip. Combustion experience has shown that the thinner the material that is used to construct burner can liners the faster it will burn if it is exposed to the combustion flames.

In FIGS. 1 and 2, a plurality of apertures are radially located in each of the overlapped burner can annuli in order to admit (as shown by arrows) an additional quantity of air from the main airstream flow for both cooling burner can **12** and for supplying additional penetration air to the air-fuel mixture in the can. The flow of the remaining primary air between duct **11** and burner can **12** is depicted by arrows. Also, for convenience in initially starting the combustion, an ignition spark plug having terminals **26** may be provided as shown.

The novel burner can according to the instant invention is useable for a variety of purposes. For example, it may be the essential part of the ram-jet device or it may be connected between the compressor and the turbine of a gas-turbine plant. The burner can is also designed to permit the burning of uncontaminated fuel or of fuel contaminated with impurities without serious profile effects such as streaks and hot spots. This may be attributed to a premixing and a more even distribution of the fuel at the nozzle guide **14** and along the conical passage **16** before entering annulus **17** for vaporization. The normal cooling effect derived from the vaporization of the fuel is therefore adequate in preventing hot spots and streaks in the vaporizing passage **17** and in the conical passage **16** during combustion. Performance of the burner can has been herein rendered unimpaired since the fuel is premixed and preheated before burning in a manner not heretofore devised. In addition, the use of a single fuel supply nozzle versus a multi-nozzle supply simplifies the instant combustion apparatus and renders it more efficient in operation since larger internal flow passages are necessitated which are less sensitive to variations in fuel flow. The single fuel supply nozzle also simplifies the manifold distribution system, thereby reducing blockage to air flow. This results in a more uniform air distribution to the critical downstream portion of the combustion apparatus in the vicinity of the conical passage and the annulus or prevaporizing passage. The advantage of a more uniform exit temperature profile is herein accomplished because of a prevaporization and premixing of the fuel with air before the introduction of the necessary pentration air to adequately support combustion. Furthermore, since the heat of the burning gases serves to vaporize the fuel with most of this vaporization taking place within the prevaporizing passage, a shorter axial burner can length and less weight in the burner can is made possible.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. In a combustion apparatus comprising in combination an outer casing having an air inlet for receiving air from the main airstream flow, a burner can within said casing, a prevaporizing duct within and extending along said burner can and having an outlet into said burner can, a premixing passage within said prevaporizing duct having at one end an inlet to receive fuel and a predetermined amount of air from the main airstream flow, and at the other end an outlet into said prevaporizing duct, said can, duct and passage together defining a flow path for the fuel which passes downstream along said passage to the outlet thereof, reverses direction to pass upstream along said prevaporizing duct to the outlet thereof, and then reverses again to pass downstream into and along said burner can, and ignition means in said burner can for initiating combustion therein and accordingly, by heat transfer to the fuel flowing through said prevaporizing duct, vaporizing the fuel carried therein after the fuel is premixed with air in said passage, the improvement comprising

rows of radially located hollow tubes disposed across said prevaporizing duct and opening into the main airstream flow so as to both interrupt the fuel flow through said duct for further mixing the fuel-air flow and to admit air from the main airstream flow into said burner can in order to permit efficient primary combustion; and

clearances provided around the upstream rows of said hollow tubes to allow for differential thermal growth between said burner and said prevaporizing duct.

2. In the combustion apparatus of claim **1** wherein said premixing passage includes a nozzle guide having a plurality of apertures radially located in its sidewall for allowing an initial premixing of fuel with small quantities of air.

3. In the combustion apparatus of claim **2** further including a main single fuel spray nozzle for injecting fuel into said premixing passage.

4. In the combustion apparatus of claim **3** wherein a double plate is provided at said duct outlet to prevent excessive burning thereof.

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