

[54] FUEL NOZZLE FOR GAS TURBINE
ENGINES

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[58] Field of Search.....60/39.74 R; 431/181, 182, 351, 431/352; 239/419.5

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[57] ABSTRACT
A fuel nozzle for gas turbine engines, which is provided with fuel metering orifices for emitting fuel jets and in which compressor air to be admixed to the fuel, is drawn in by the fuel jets by way of apertures arranged in a cylindrical nozzle housing and located in front of an upstream flame tube wall of the flame tube associated with the combustion chamber.

20 Claims, 6 Drawing Figures

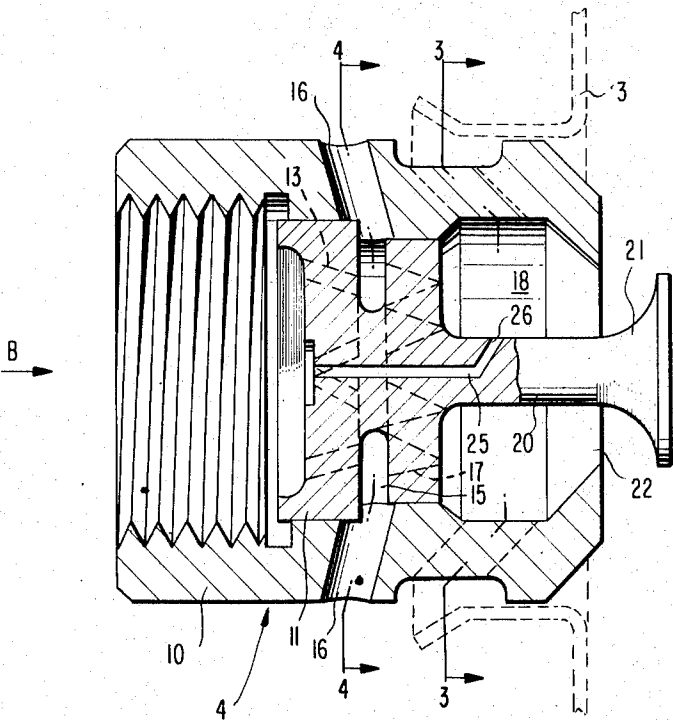


FIG. 1

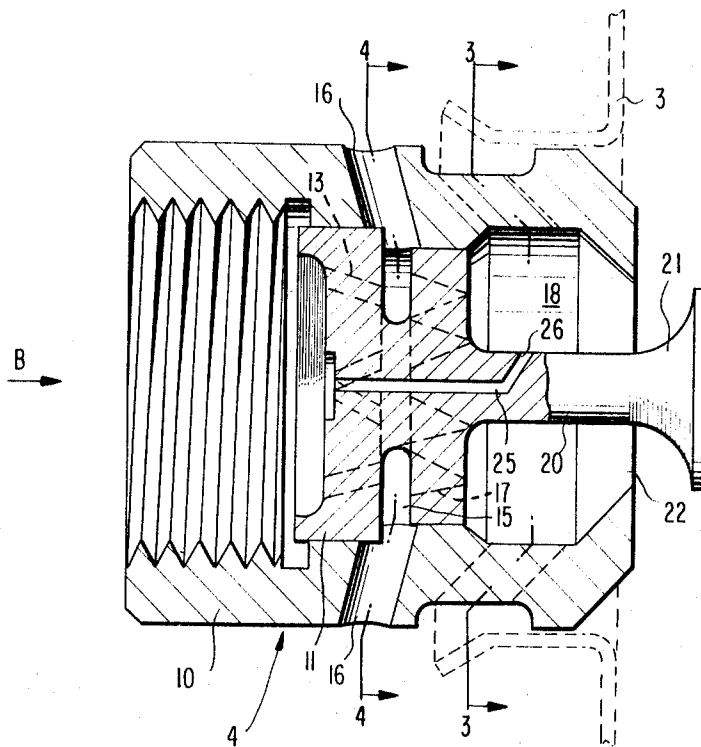
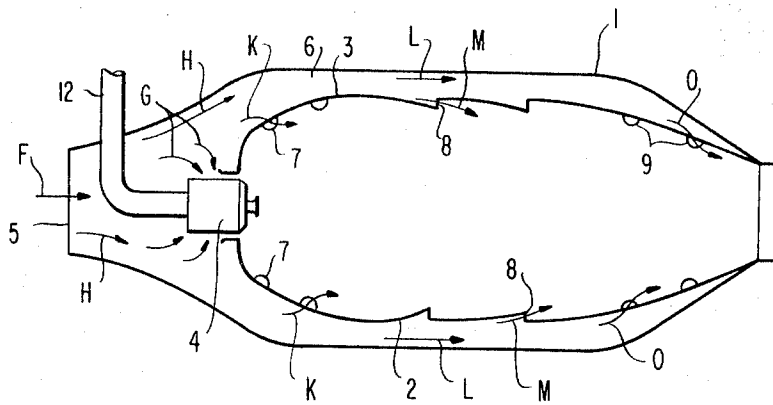


FIG. 2

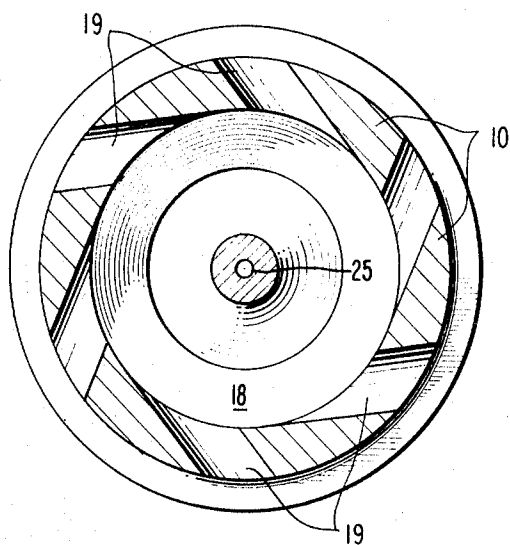


FIG. 3

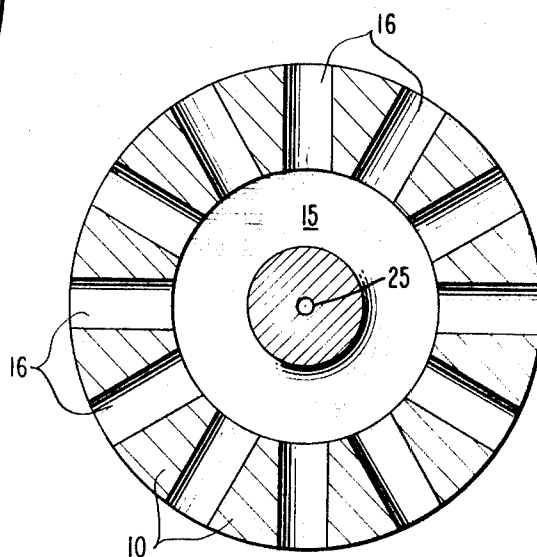


FIG. 4

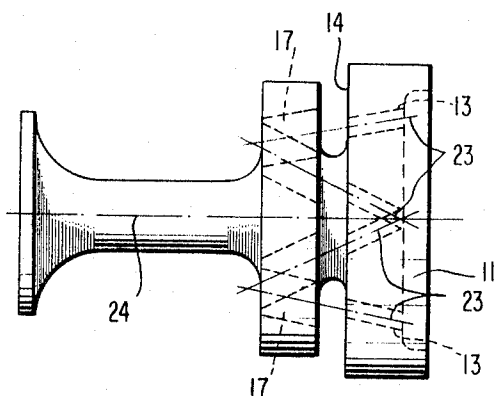


FIG. 5

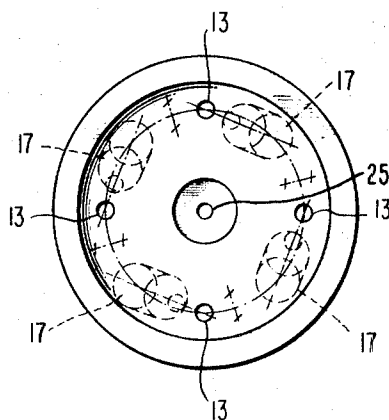


FIG. 6

FUEL NOZZLE FOR GAS TURBINE ENGINES

This invention relates to a fuel nozzle for gas turbine engines with means for admixing compressor air to the fuel.

In known combustion chambers for gas turbine engines, fuel under high pressure is generally atomized by means of one or several fuel nozzles and is injected into the combustion chamber primary zone. Also, the mixing of the fuel with the air required for the combustion process, as delivered by the compressor of the gas turbine engine, as well as the preparation of the fuel/air mixture is thereby effected only in the primary zone of the combustion chamber. The combustion air supplied by the compressor is fed into the primary zone of the combustion chamber either by way of openings—which alone are insufficient—or additionally by means of guide baffles producing a swirl and arranged in the upstream flame tube end wall or in its vicinity.

The use of vaporizers in gas turbine engines is also known, which include vaporizing ducts protruding into the combustion chamber, with the fuel/air mixture for the combustion process being vaporized in these ducts.

All of the aforementioned types of combustion chambers have in common that the preparation and vaporization of the fuel/air mixture is generally achieved only within the primary zone, i.e., within the upstream portion of the flame tube, thus necessitating a relatively great axial length of the combustion chambers.

Moreover, the devices described in connection with the prior art combustion chambers for the preparation of the fuel/air mixture are of rather complex construction and require structural expenditures that are not insignificant.

Especially in view of the present developments towards higher combustion chamber loads with a relatively high combustion chamber outlet temperature which has become possible by blade materials of improved heat resistance and by advanced blade-cooling techniques, as well as towards smaller chambers—for the sake of reduced engine weight—it was realized that in the case of the described prior art combustion chambers with the described devices for the fuel injection and the preparation of the fuel/air mixture, the dwell time for an intensive mixing of the primary air with the fuel as well as for the satisfactory preparation and vaporization of the fuel/air mixture within the combustion chamber, is no longer sufficient to ensure a completely satisfactory combustion with a high combustion chamber outlet temperature and a uniform temperature profile.

It is also to be noted that the guide baffles producing the swirl or similar means, provided in the known combustion chambers for the mixing of fuel with the primary air, require marked, intensive swirls of the fuel and air components in the primary zone, in order to enforce a relatively uniform combustion already within the primary zone, which, however, leads to increased pressure losses and, consequently, to engine performance losses.

The object of the present invention is to provide a fuel nozzle which is to eliminate the described disadvantages inherent in the known combustion chambers. In particular, the fuel nozzle of the present invention is to obtain a uniform combustion chamber temperature profile in the desired small combustion chambers featuring high combustion chamber outlet temperatures. In addition thereto, a fuel nozzle is to be provided which requires small manufacturing expenditures and which can readily replace a nozzle of conventional design.

As solution to the underlying problem, the present invention proposes with a fuel nozzle of the type mentioned above that the fuel jets emitted from the fuel-metering orifices draw in air, supplied by the compressor of the gas turbine engine, by way of bores arranged in a cylindrical housing of the nozzle, whereby these bores are arranged in front of the upstream wall of the flame tube associated with the combustion chamber.

For this purpose, a special air supply line from the compressor to the nozzle is not required, since the nozzle with its compressor air inlet bores is to be arranged in that combustion chamber section through which compressor air flows.

The fuel nozzle, according to the present invention, effects the intake of, i.e., sucks in the fuel in a way similar to the principle of a water jet pump, due to the pressure differential between the supplied fuel and the compressor air. An intensive swirling and mixing of the fuel/air components is effected within the nozzle, and the fuel/air mixture can be fed to the combustion chamber out of the nozzle orifice for combustion in a thoroughly mixed condition, i.e., already intensively prepared for the combustion process.

In a further embodiment of the present invention, a piston-type insert provided with the fuel-metering orifices may be arranged on the inside of the cylindrical housing; the orifices terminate in a first compartment or chamber formed by an annular groove of this insert, which compartment is in communication with the compressor air inlet bores whereby further bores in the insert connect the first compartment or chamber with a swirl chamber. The thorough mixing of the fuel with the drawn-in compressor air thus takes place essentially within the swirl chamber.

In order to intensify the mixing of the fuel/air components within the swirl chambers, according to the present invention, further bores may be provided, which, within the area of the swirl chamber section, extend through the cylindrical housing of the fuel nozzle in a generally tangential direction; compressor air is adapted to be fed to the swirl chamber by way of these bores due to the pressure differential prevailing at the upstream flame tube wall.

It is further suggested by the present invention that that section of the piston-type insert which has the smallest diameter, extends through the swirl chamber, and, with its outer end emerging from the nozzle outlet, forms a uniformly diverging spray cone, in order to supply the atomized fuel/air mixture uniformly distributed to the combustion chamber.

According to a further feature of the present invention, the bores in the cylindrical housing associated with the first compartment or chamber, can penetrate this housing equally spaced in a generally radial direction.

According to the invention, it is further advantageous, if the fuel metering orifices or cross sections, through which the fuel supply to the compartment is effected, have a smaller size than the bores connecting the first compartment with the swirl chamber.

According to the present invention, it may also be advantageous for a particularly intensive mixing and preparation of the fuel/air components that one fuel-metering orifice and one bore of the insert each, connecting the first compartment with the swirl chamber, have a common, inclined longitudinal center axis.

In order to facilitate, for example, engine starting, a fuel/air mixture richer in fuel with good ignition properties may be required. For this purpose, it is suggested by the invention to provide an additional central fuel supply bore in the insert, which is connected with one or several injection orifices terminating in the swirl chamber.

These and other objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawing which shows, for purposes of illustration only, one embodiment in accordance with the present invention, and wherein:

FIG. 1 is a center longitudinal cross section of an individual can-type combustion chamber incorporating a fuel nozzle according to the present invention;

FIG. 2 is a center longitudinal cross section, on an enlarged scale, through a fuel nozzle according to the present invention;

FIG. 3 is a section taken along line 3—3 in FIG. 2;

FIG. 4 is a section taken along line 4—4 in FIG. 2;

FIG. 5 is a side view of the insert associated with the fuel nozzle according to the invention, which includes fuel-metering orifices and bores for the air supply to the nozzle; and

FIG. 6 is a front elevational view of the insert according to FIG. 5.

Referring now to the drawing wherein like reference numerals are used throughout the various views to designate like parts, and more particularly to FIG. 1, the can-type combustion chamber shown in this figure essentially consist of a cylindrical outer casing 1 and of an inserted cylindrical flame tube 2.

A fuel nozzle 4, according to the invention, which will be explained more fully hereinafter by reference to FIGS. 2 through 6, is inserted into the center of the upstream flame tube wall 3.

The air supplied by a compressor of a gas turbine engine (not illustrated in the drawing) flows in the direction of arrow F by way of an inlet aperture 5 into outer casing 1, from where one portion is routed as combustion air in the direction of arrows G to fuel nozzle 4, while the other portion flows in the direction or arrows H into an annular duct 6 formed by the outer casing 1 and the flame tube 2 located within the casing 1. Within the area of the annular duct 6, the upstream section of the flame tube 2 is provided with openings 7, by way of which so-called secondary air can be admixed to the combustion process in the direction or arrows K. For cooling the combustion chamber walls, the flame tube 2 may be circulated by compressor air (arrows L) or, for example, this compressor air might also be utilized in the direction of arrows M by way of slots 8 for the cooling of the flame tube inner walls. In its downstream section, the flame tube 2 is equipped with additional openings 9 which are provided for reducing the combustion outlet temperature (arrows O indicate the direction of the compressor air).

The fuel nozzle 4, reproduced in FIG. 2 at an enlarged scale of approximately five times its actual dimensions, consists of a cylindrical housing 10 having a piston-type insert 11 (FIG. 2) arranged on the inside of the housing 10. Fuel under high pressure flows from a fuel supply system, not illustrated in the drawing, by way of a supply line 12 (FIG. 1), in the direction of arrow B (FIG. 2), into the fuel nozzle 4 and from there by way of fuel-metering orifices 13 (FIG. 5) arranged in the insert 11, into a chamber or compartment 15 (FIG. 2) formed by an annular groove 14 of this insert 11; the chamber or compartment 15 is connected with generally radially arranged and equally spaced bores 16 which extend through the cylindrical housing 10 (FIG. 4) at mutually uniform spacings. The fuel injected into the compartment 15 draws-in compressor air by way of these bores 16. Fuel and drawn-in compressor air components are directed by way of additional bores 17 in the insert 11 (FIGS. 5 and 6) from the chamber or compartment 15 into the swirl chamber 18 of the fuel nozzle 4 (FIG. 2). Due to the pressure differential at the upstream flame tube wall 3, additional compressor air is supplied to the swirl chamber 18 by way of bores 19 (FIG. 3) extending tangentially through the cylindrical nozzle housing 10, whereby the bores 19 impart a swirl upon the incoming compressor air, to ensure thorough mixing and preparation of the fuel/air components present in the swirl chamber 18.

The insert 11 extends through the swirl chamber 18 with the portion 20 of its smallest diameter and protrudes from the nozzle orifice 22 as a spray cone 21 with walls of uniformly diverging shape. This spray cone effects the supply of the prepared fuel/air mixture to the upstream flame tube section in a finely atomized and uniformly distributed condition.

In order to enrich with fuel the fuel/air mixture leaving the orifice 22, a central fuel supply bore 25 with a fuel-discharge aperture 26 opening into the swirl chamber 18 is arranged in the insert 11 (FIG. 2).

As can also be seen from FIGS. 5 and 6, the common longitudinal center axes 23 of the corresponding fuel-metering orifices 13 and of the bores 17, are, relative to the longitudinal center axis 24 of the insert 11, inclined simultaneously from the front top inwardly to the rear as well as from the front top laterally toward the outside. The degree of inclination as well as the number of fuel-metering orifices 13 and of bores 17 is not decisive for the invention, and they can be varied according to the requirements which are made in practice of the fuel nozzle as well as of a combustion chamber.

In addition, the fuel nozzle according to the present invention is applicable to all types of existing combustion chambers, i.e. also to typical annular combustion chambers or to can-annular combustion chambers with individual flame tubes, in gas turbine engines for aviation, vehicle and industrial application.

While I have shown and described only one embodiment in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to those skilled in the art, and I therefore do not wish to be limited to the details shown and described herein but intended to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. A fuel nozzle for gas turbine engines comprising fuel metering orifice means for emitting fuel jets therefrom, first mixing means arranged to receive the fuel jets from said fuel metering orifice means and including air intake means in communication with said fuel metering orifice means and responsive to the fuel jets for drawing air into said first mixing means wherein the fuel and air is preliminary mixed, and swirl means arranged to receive the premixed fuel and air for further mixing the fuel and air before the mixture is emitted from said nozzle.

2. A fuel nozzle according to claim 1, wherein said fuel metering orifice means is provided with at least one orifice of a predetermined diameter and said first mixing means is provided with at least one bore having a diameter larger than the diameter of said orifice, said bore being spaced from said orifice and adapted to receive the fuel jet therefrom, the flow of the fuel jet from said orifice into said bore causing said air intake means to draw air into said first mixing means.

3. A fuel nozzle according to claim 1, wherein said fuel metering orifice means is provided with at least one orifice of a predetermined diameter and said first mixing means includes at least one transfer port having a diameter larger than the diameter of said orifice and arranged for receiving fuel jets therefrom, and chamber means for communicating between said orifice and said transfer port, said air intake means being in communication with said chamber means and responsive to the fuel jets flowing therethrough for drawing air into said chamber means for mixing with the fuel jets.

4. A fuel nozzle for gas turbine engines, with fuel-metering orifice means and with means for mixing compressor air with fuel, characterized in that fuel jets emitted from the fuel-metering orifice means draw-in air supplied by a compressor of the gas turbine engine by way of aperture means arranged in a housing of the nozzle and in that said aperture means are arranged in front of an upstream flame tube wall of a flame tube associated with a combustion chamber, a piston-type insert means arranged inside said housing, said insert means being provided with said fuel-metering orifice means which terminate in a first chamber, said first chamber being operatively connected with the aperture means for the compressor air intake, while further aperture means in the insert means provide a communication between said first chamber and a swirl chamber.

5. A fuel nozzle according to claim 4, characterized in that the nozzle housing is substantially cylindrical.

6. A fuel nozzle according to claim 4, characterized in that said first chamber is formed by an annular groove in said insert means.

7. A fuel nozzle according to claim 4, characterized in that compressor air is adapted to be supplied to the swirl chamber by way of additional aperture means extending through said housing within the area of said swirl chamber in a generally tangential direction, by the effect of the pressure differential prevailing at the upstream flame tube wall.

8. A fuel nozzle according to claim 4, characterized in that the portion of the insert means with the smallest diameter extends through said swirl chamber and protrudes from the nozzle orifice as a uniformly diverging spray cone.

9. A fuel nozzle according to claim 8, characterized in that the aperture means associated with the first chamber extend through said housing in a generally radial direction and are equally spaced.

10. A fuel nozzle according to claim 9, characterized in that fuel-metering orifice means effecting the fuel supply to first chamber, are of a smaller size than the further aperture means connecting the first chamber with said swirl chamber.

11. A fuel nozzle according to claim 10, characterized in that one fuel-metering orifice means as well as one further aperture means each have a common, inclined longitudinal center axis.

12. A fuel nozzle according to claim 11, characterized in that a central fuel supply bore is provided in the insert means, which is operatively connected with one or more fuel injection apertures.

13. A fuel nozzle according to claim 12, characterized in that the nozzle housing is substantially cylindrical.

14. A fuel nozzle according to claim 4, characterized in that the portion of the insert means with the smallest diameter extends through said swirl chamber and protrudes from the nozzle orifice as a uniformly diverging spray cone.

15. A fuel nozzle according to claim 4, characterized in that the aperture means associated with the first chamber extend

through said housing in a generally radial direction and are equally spaced.

16. A fuel nozzle according to claim 4, characterized in that fuel-metering orifice means effecting the fuel supply to said first chamber, are of a smaller size than the further aperture means connecting the first chamber with said swirl chamber.

17. A fuel nozzle according to claim 4, characterized in that one fuel-metering orifice means as well as one further aperture means each have a common, inclined longitudinal center axis.

18. A fuel nozzle according to claim 4, characterized in that a central fuel supply bore is provided in the insert means, which is operatively connected with one or more fuel injection apertures.

19. A fuel nozzle according to claim 16, characterized in that one fuel-metering orifice means as well as one further aperture means each have a common, inclined longitudinal center axis.

20. A fuel nozzle according to claim 16, characterized in that the aperture means associated with the first chamber extend through said housing in a generally radial direction and are equally spaced.

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