

[54] **FUEL NOZZLE FOR GAS TURBINE ENGINES**[75] Inventor: **Bernd Seiler**, Ampermoching near Munich, Germany[73] Assignee: **Motoren-Und Turbinen-Union Muenchen GmbH**, Munich, Germany[22] Filed: **Sept. 11, 1970**[21] Appl. No.: **71,478**[30] **Foreign Application Priority Data**

Sept. 12, 1969 Germany.....P 19 46 153.1

[52] **U.S. Cl.**.....**60/39.49**, 60/39.74 R, 239/410, 239/453, 239/585[51] **Int. Cl.**.....**F02c 3/24**, B05b 1/30[58] **Field of Search**.....60/39.49, 39.74 R; 239/410, 585, 453[56] **References Cited****UNITED STATES PATENTS**

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[57]

ABSTRACT

A fuel nozzle for gas turbine engines in which the fuel jets leaving the fuel metering sections draw-in air delivered by the compressor of the gas turbine engine through passages provided in the nozzle housing; a piston-shaped insert is arranged in the nozzle housing to move relative to the latter so as to vary the quantity of compressor air to be supplied to the fuel nozzle and/or the quantity of the fuel/air mixture to be discharged from the nozzle as the piston-shaped insert means is displaced.

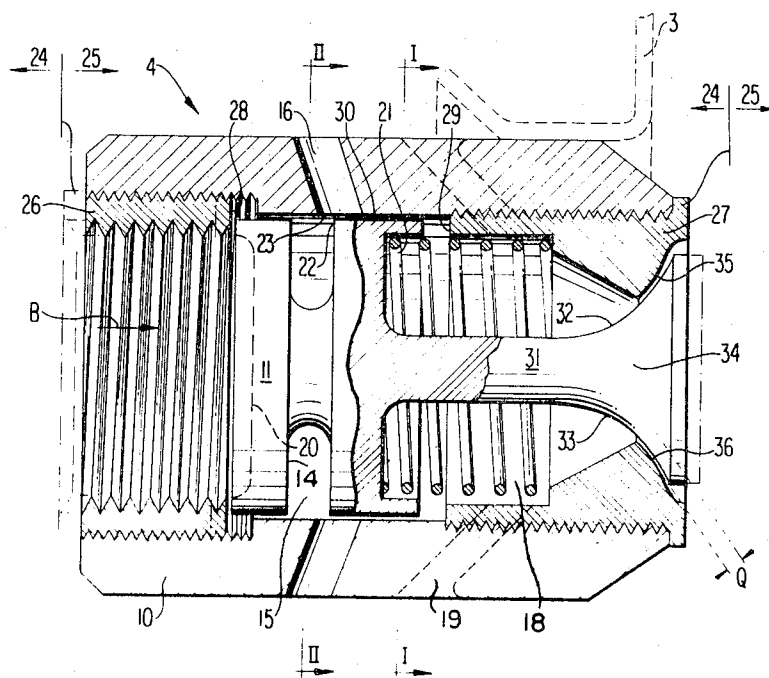
24 Claims, 9 Drawing Figures

FIG 1

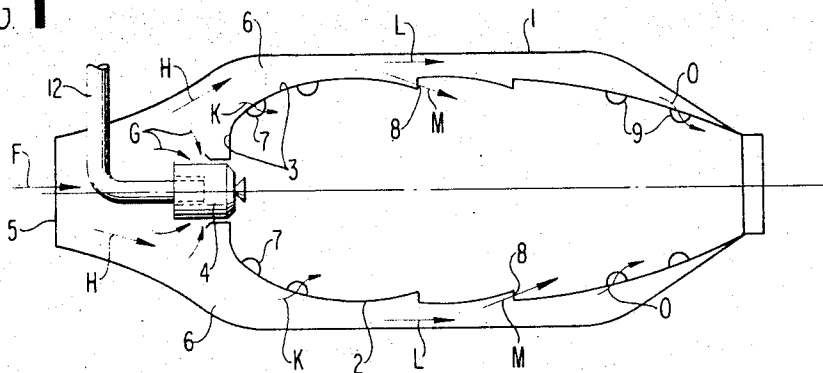


FIG 2

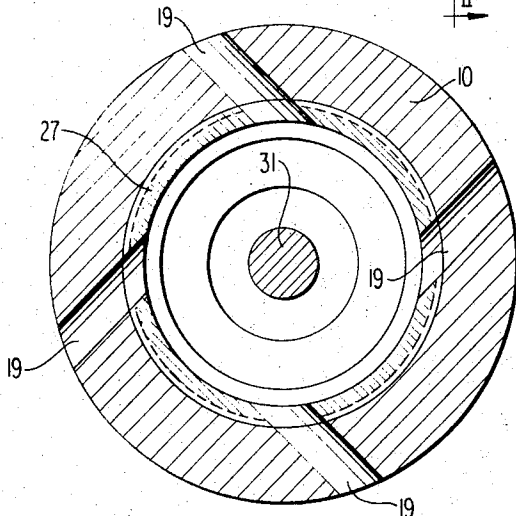
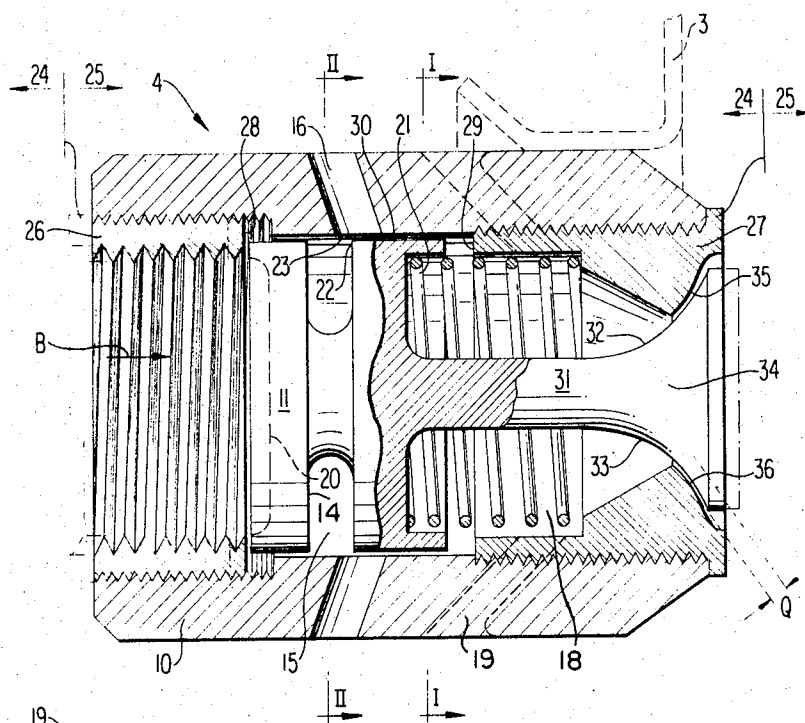
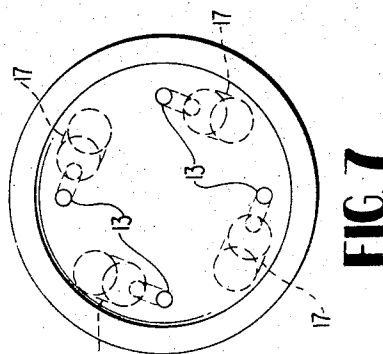
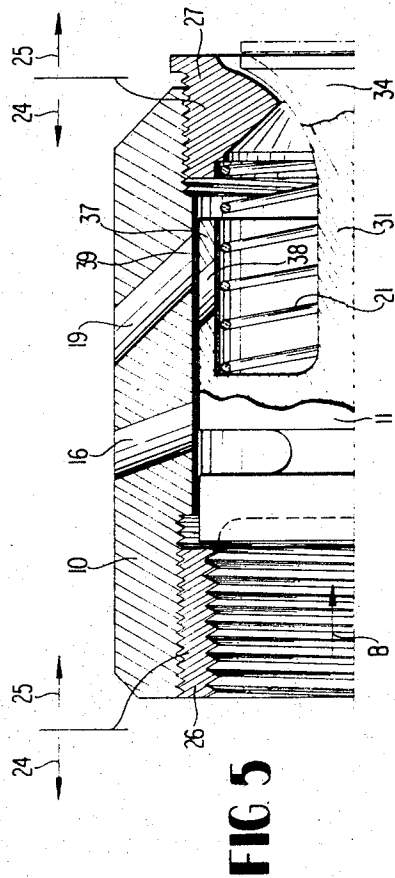
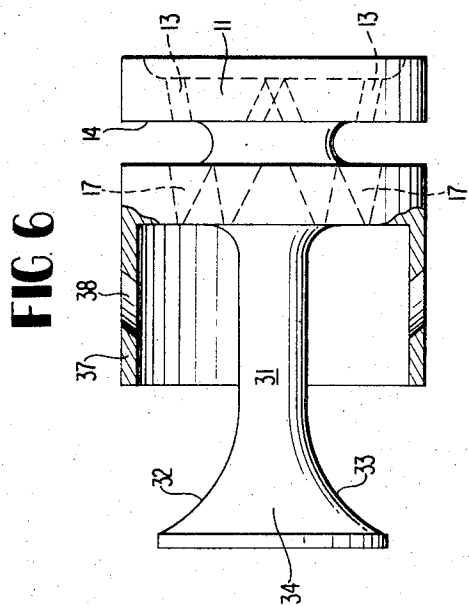
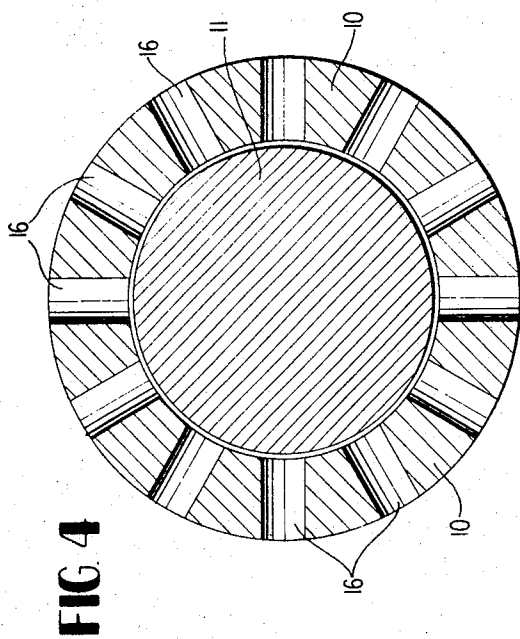


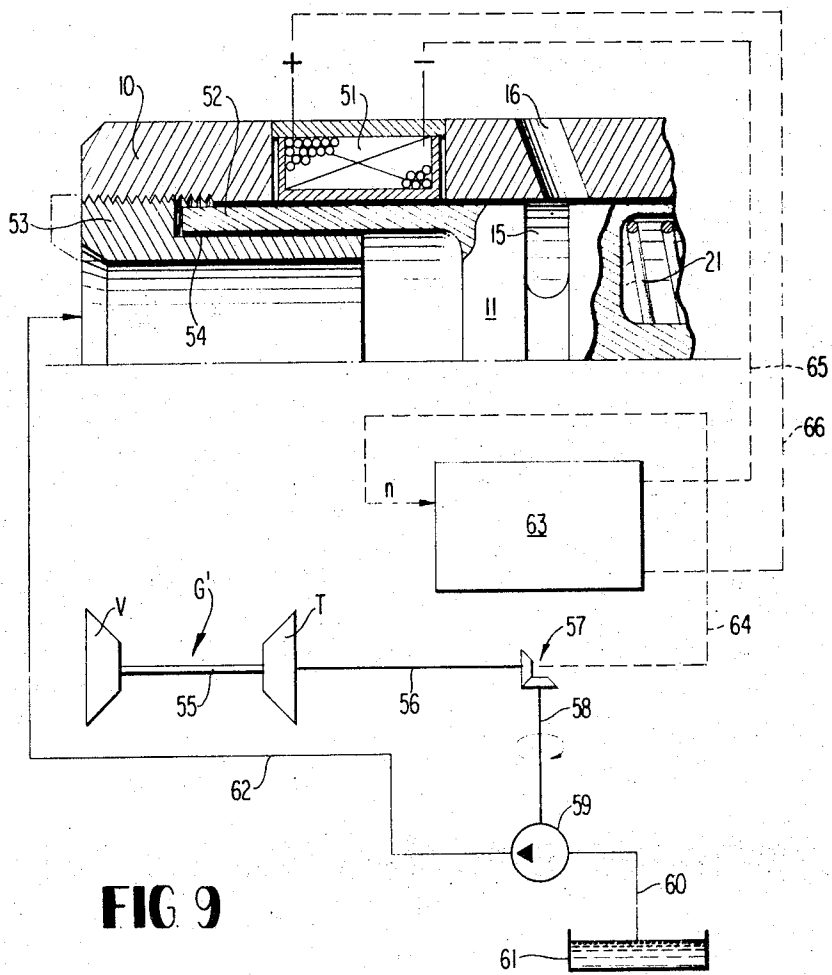
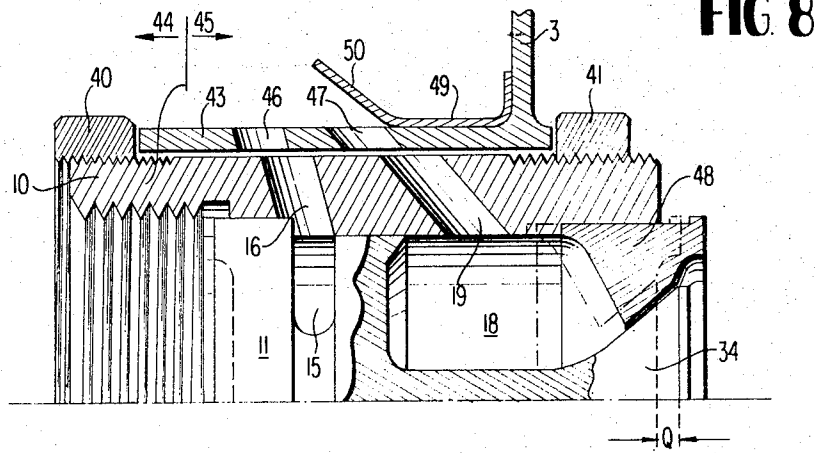
FIG 3

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FUEL NOZZLE FOR GAS TURBINE ENGINES

The present invention relates to improvements in a fuel nozzle for gas turbine engines with means for the admixture of compressor air to the fuel.

With a fuel nozzle of the type as described in the prior U.S. Pat. application Ser. No. 51,045, filed June 30, 1970, the invention essentially resided in the fact that the fuel jets emerging from the fuel metering orifices draw-in air delivered from the compressor of the gas turbine engine by way of bores or passages located in a cylindrical housing of the nozzle, whereby these bores or passages are arranged in front of the upstream flame tube wall of the flame tube associated with the combination chamber.

The invention according to the aforementioned patent application enables the fuel to be mixed intensively with the drawn-in air already inside the fuel nozzle; thus the fuel/air mixture can be supplied to the combustion space or zone of the combustion chamber in a state intensively prepared and mixed for the combustion process.

For this purpose, the fuel nozzle according to the aforementioned application includes a piston-shaped insert, arranged inside the cylindrical housing of the nozzle and provided with the fuel metering orifices, which lead into and terminate in a first chamber formed by an annular groove of that insert. This chamber is in communication with the bores or passages for drawing-in compressor air, while further bores or passages in the insert connect the first chamber to a swirl chamber.

The present invention represents an advantageous construction of a fuel nozzle of the type disclosed in the aforementioned application in that the position of the cylindrical housing of the fuel nozzle or of the piston-shaped insert arranged therein and thus, simultaneously, the quantity of the compressor air to be supplied to the fuel nozzle and/or — by adjusting the piston-shaped insert — the quantity of the fuel/air mixture to be discharged from the fuel nozzle are variable.

The solution of a fuel nozzle according to the aforementioned application is based on the assumption that only one end position is possible for the piston-shaped insert containing the fuel metering crifices as well as the fuel/air passages leading to the swirl chamber.

For this reason, it might be possible that, with an invariable end position of the piston-shaped insert of the swirl chamber, an excessive air quantity is introduced into the nozzle, so that the air portion of the fuel air mixture emerging from the fuel nozzle so strongly predominated that a reliable ignition or satisfactory combustion cannot be ensured.

To remedy this shortcoming, it will be possible, according to this invention, to bring the piston-shaped insert in the nozzle housing by axial movement into such an end position that it will partially close the air supply passages ending in the nozzle in order to decrease the air flow.

Thus the air requirement necessary for a completely satisfactory combustion process can be corrected in this manner according to the present invention.

With a fuel nozzle according to the instant invention, it may furthermore be advantageous if, e.g., not only the required quantity of air to be admixed to the fuel can be corrected but also the demand for a larger quan-

tity of the air/fuel mixture to be discharged through the nozzle. This is accomplished in that by moving the piston-shaped insert forwardly, the portion of the piston-shaped insert constructed in the manner of an injection cone effects a further opening of the nozzle.

An embodiment of the invention preferably applicable to aircraft engines is achieved in that the piston-shaped insert is displaceable under the effect of the pressure of the supplied fuel against a returning or resetting member, preferably a return spring, damping the axial movement of the piston-shaped insert.

When the pressure of the fuel to be supplied to the nozzle rises for an increased engine thrust, a nozzle according to the invention makes possible, by a displacement of the piston in the forward direction, on the one hand, a proportional increase of the fuel quantity to be supplied to the combustion zone of the combustion chamber and, on the other hand, a proportional increase of the quantity of air to be mixed with the fuel inside of the nozzle, which air together with the fuel is discharged from the nozzle.

In another embodiment of the invention, the piston-shaped insert may form a component part of a solenoid valve associated with the fuel nozzle; the solenoid valve, which is actuatable as a function of output signals of the gas turbine engine, brings about an adjustment of the piston-shaped insert.

A further advantageous embodiment of the present invention consists in the possibility of limiting the position of the piston-shaped insert or of its stroke, respectively, by means of adjustable stops.

If the piston-shaped insert is actuated, for example, by the fuel pressure or electromagnetically, it will be possible in this way, to set a maximum and a minimum outlet area or discharge cross-section for the fuel/air mixture leaving the nozzle, corresponding to the movement of the piston-shaped insert between two stops. At the same time, the maximum and the minimum air supply to the fuel nozzle can be set with the aid of the stops.

In another embodiment of the present invention, the quantity of the fuel/air mixture to be discharged through the nozzle is to be adjustable separately by means of one of the stops.

Simplified, this means that, e.g., it will not be required to adjust both stops each time by the same amount in one direction, but this means rather that one of the stops will be adjusted, independently of the other, so far to the front or to the rear that the quantity of air to be supplied to the fuel nozzle as well as the fuel/air mixture to be discharged through the nozzle will meet the operational demands.

In order to accomplish that the quantity of air which is to be supplied to the swirl chamber of the fuel nozzle by means of the pressure drop or gradient existing at the upstream flame tube wall, can also be metered as a function of the operational demands, the present invention proposes that the piston-shaped insert portion inside of the swirl chamber has an annular shroud, which is provided with bores or holes for the bleeding or setting, respectively, of the air quantity to be supplied to 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 conjunction

with the accompanying drawing which shows, for purposes of illustration only, several embodiments in accordance with the present invention, and wherein

FIG. 1 is a somewhat schematic center longitudinal cross-section of a can-type combustion chamber using a fuel nozzle according to the present invention;

FIG. 2 is a longitudinal center cross-section of a fuel nozzle according to the present invention in a first embodiment;

FIG. 3 is a cross-section along line I—I OF FIG. 2;

FIG. 4 is a cross-section along line II—II of FIG. 2;

FIG. 5 is a longitudinal center cross-section of the upper half of a fuel nozzle according to the present invention in a second embodiment;

FIG. 6 is a side view of a piston-shaped insert for a fuel nozzle according to FIG. 5 shown partially in cross-section along the longitudinal centerline;

FIG. 7 is a front view of the piston-shaped insert according to FIG. 6;

FIG. 8 is a longitudinal center cross-section of the upper half of a fuel nozzle according to the present invention in a third embodiment, and

FIG. 9 is a longitudinal center cross-section of the upper half of a fuel nozzle according to the present invention in a fourth embodiment including a schematic diagram of a control unit of a gas turbine engine.

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 consists of a cylindrical outer casing 1 and of a cylindrical flame tube 2 inserted therein.

For example, a fuel nozzle 4 according to the present invention can be inserted into the upstream flame tube wall 3, which will be further explained in detail hereinafter by reference to FIG. 2.

Air, as delivered by the compressor V of a gas turbine engine G' shown schematically as an example in FIG. 9, flows in the direction of arrow F through an inlet 5 into the outer casing 1, from where it reaches, on the one hand, in the direction of arrows G as combustion air, the fuel nozzle 4, and, on the other hand, in the direction of arrows H, an annular duct or channel 6 formed by the outer casing 1 and by the flame tube 2 contained in it. Within the area of the annular duct 6, the flame tube 2 is provided, in the upstream region, with apertures or holes 7, through which so-called secondary air can be introduced and admixed to the combustion process in the direction of arrows K. In order to cool the combustion chamber walls, compressor air may be routed to flow around the flame tube 2 (arrows L) and/or the compressor air may be used, e.g., in the direction of arrows M for cooling the inner walls of the flame tubes through slots 8. Downstream thereof, the flame tube 2 includes further holes or apertures 9 which may be provided in order to decrease the combustion chamber exit temperature (direction of arrows O of the compressor air).

The fuel nozzle shown in FIG. 2 and generally designated by reference numeral 4 consists of a cylindrical housing 10 with a piston-type insert 11 axially displaceably arranged therein.

From a conventional fuel supply system, not shown in detail in FIG. 2, fuel under high pressure flows through a line 12 (FIG. 1) in the direction of arrow B

(FIG. 2) into the fuel nozzle 4 and from there through fuel metering orifices 13 (FIG. 6) arranged in the insert 11 into a chamber 15 (FIG. 2) formed by an annular groove 14 of the insert 11; the chamber 15 is in communication with substantially radially arranged passage or bores 16 which are equally spaced in the cylindrical housing 10 of the fuel nozzle (FIG. 4). By way of these passages 16, fuel entering the chamber 15 draws in compressor air. Fuel and drawn-in compressor air components are then directed by way of further passages or bores 17 of insert 11 (FIGS. 6 and 7) from the chamber 15 into the swirl chamber 18 of the fuel nozzle 4 (FIG. 2). Due to the pressure gradient at the upstream flame tube wall 3, additional compressor air is supplied to the swirl chamber 18 by way of passages 19 extending tangentially through the cylindrical nozzle housing 10 (FIG. 3), these passages 19 imparting a swirl-type motion to the inflowing compressor air in order to ensure an intensive mixing and preparation of the fuel/air components present in the swirl chamber.

Furthermore, the piston-shaped insert 11 associated with the fuel nozzle 4 according to FIG. 2 is to be actuatable as a function of the rising pressure of the fuel supplied to the nozzle by way of line 12. Thus, with an increasing fuel pressure, the piston-type insert 11 is progressively moved toward the right by the pressure acting on piston face 20 against the force of a return spring 21 supported within the swirl chamber 18. During this movement, the control edge 22 of piston-type insert 11 progressively opens outlet or discharge cross-sections 23 leading to chamber 15.

Thus, with progressive movement of piston-type insert 11 to the right, the fuel flowing into the swirl chamber 18 by way of passage 15, can draw-in a progressively increasing air quantity by way of passage 16.

As fuel pressure in line 12 decreases, the piston-type insert 11 is shifted toward the left by the action of resetting spring 21 with a simultaneous reduction of the outlet or discharge cross-sections 23 for the air to be drawn-in through passages 16.

Furthermore, adjustable threaded bushes 26, 27 are screwed into the cylindrical housing 10 of the fuel nozzle 4 in the direction of arrows 24, 25. The end positions of stops 28, 29, associated with threaded bushes 26, 27 control the dimension and extent of the maximum possible adjusting path or stroke of piston-shaped insert 11 as well as the coordination of the control edge 22 or of the chamber 15, respectively, to the passages 16.

If, e.g., the threaded bush 26 is further unscrewed out of the cylindrical housing 10 in the direction of arrow 24, as shown in the position indicated in dash and dotted lines, then piston-shaped insert 11 can, in its closed or normal rest position, completely close the outlet or discharge cross-sections 23 with a section 30 of its cylindrical surface.

Furthermore, it may be seen from FIG. 2 that piston-shaped insert 11 is centered in and protrudes through the swirl chamber 18 with the portion 31 of its minimum diameter and forms, on the downstream side, a spray cone 34 having uniformly diverging walls 32, 33.

Corresponding to the walls 32, 33 of the spray cone 34, the threaded bush 27 includes, at its downstream

end, diverging walls 35, 36 which may serve as contact or abutment faces for the spray cone 34 of the piston-type insert in its rest position so that a complete closing of the fuel nozzle 4 towards the combustion zone or space of the combustion chamber (FIG. 1) can be effected. Thus, with an increasing fuel pressure and the increasing rate of fuel/air mass flow through the fuel nozzle 4 associated with it, and due to the movement of the piston-shaped insert 11 to the right, the spray cone 34 can move further away from the walls 35, 36 of the threaded bush 27 and thus is able to open the fuel nozzle further (dash and dotted contour line of the spray cone 34).

In this way, an adjustment of the two stops 28, 29 by means of the threaded bushes 26, 27 controls the travel or adjusting path of the piston-shaped insert 11 and therewith also the outlet or discharge cross-section Q for the fuel/air mixture to be supplied from the swirl chamber 18 to the combustion zone of the combustion chamber (FIG. 1).

FIG. 5 is a modification as compared to FIG. 2 in that the piston-shaped insert 11 includes an annular shroud 37 inside the swirl chamber 18 (FIG. 6); the annular shroud 37 is provided with bores or passages 38, the position of which can be varied relative to the position of outlets or discharge apertures 39 of the passages 19 ending in the swirl chamber 18.

Upon movement of the piston-shaped insert 11, which, e.g., is a function of the pressure of the fuel in the supply line 12, it will also be possible to increase or decrease the quantity of air to be supplied to the swirl chamber 18 by way of passages or bores 19 with the aid of the pressure gradient at the upstream flame tube wall 3. The stops 28, 29 of the threaded bushes 26, 27 serve not only the purpose of controlling the travel of the piston-shaped insert 11 but also control the extent of the opening of the outlets or discharge aperture 39 and therewith the quantity of air to be supplied to the swirl chamber 18 through passages 19.

In a further modification of the embodiments as shown in FIGS. 2 and 5 an embodiment of a fuel nozzle according to the present invention not shown in the drawings, would be conceivable which would have no return spring 21 and in which the piston-shaped insert 11 would not be actuated as a function of the pressure of the fuel supplied.

In this modified embodiment, the piston-shaped insert 11 could be adjusted relative to its original position by loosening the threaded bushes 26, 27 and could subsequently be fixed in its new position with the aid of stops 28, 29 by tightening the threaded bushes 26, 27 so that it would be possible in this manner to meet, e.g., the demand for a larger or smaller quantity of air to be admixed to the fuel.

FIG. 8 essentially differs from the embodiments of the fuel nozzles according to FIGS. 2 and 5 in that the cylindrical housing 10 of the fuel nozzle can be moved relative to its enclosing sleeve 43 in the direction of arrows 44, 45, which is effected by means of nuts 40, 41 screwed onto the cylindrical housing 10. The same time, sleeve 43 may be rigidly connected to the upstream flame tube wall 3 of a combustion chamber (FIG. 1).

Depending on the position of the cylindrical housing 10, the passages or bores 46, 47 in the sleeve 43 will,

more or less, coincide with the passages or bores 16 and 19 in the cylindrical housing 10. The amount of air to be supplied to the chamber 15 as well as to the swirl chamber 18 can thus be adapted to the operating conditions.

If required, the outlet or discharge cross-section Q for the air/fuel mixture to be supplied from the swirl chamber 18 to the combustion zone of the combustion chamber can be controlled by means of an adjustable threaded sleeve 48, which is moved relative to the spray cone 34.

A stiffener baffle or reinforcing plate 49 connected to the upstream flame tube wall 3 and to the sleeve 43 serves with its section 50 for a direct flow guidance of the drawn-in air by way of passages 47, 19 to the swirl chamber 18.

Deviation from the embodiments as shown in FIGS. 2 and 5, FIG. 9 illustrates a fuel nozzle, the piston-shaped insert 11 of which is solenoid-operated, i.e., is operated electromagnetically. For this purpose, a solenoid 51 is inserted into the cylindrical housing 10 of the fuel nozzle, an upstream section 52 of the piston-shaped insert 11 forming the armature. Adjustable threaded bushes 53, 27 (FIG. 2) limit the maximum control stroke of the piston-shaped insert 11 by means of stops 54, 29.

The fuel nozzle, as shown in FIG. 9, can be installed into several combustion chambers according to FIG. 1 which may be arranged coaxially to the shaft 55 of the gas turbine engine G' (FIG. 9). The hot gases leaving the combustion chamber drive the turbine T and the compressor V connected to the turbine by shaft 55. A shaft 56, branched off from turbine T, drives a further shaft 58 by way of an angular gear 57, thus driving a fuel pump 59, which draws fuel from a tank 61 by way of a line 60. Thus, the fuel pump 59 will deliver the fuel to the fuel nozzle by way of line 62 as a function of the gas turbine engine speed. Furthermore, in FIG. 9, an electrical control unit 63, of conventional construction can be seen, into which the r.p.m. value n , as picked up by way of a line 64, is fed as a signal. The electrical control unit 63 amplifies the stored r.p.m. value and initiates, by energizing solenoid 51 by way of lines 65, 66, and adjustment of the piston-shaped insert 11 to the right, if the rotational speed of the gas turbine engine G' exceeds a predetermined value. If the rotational speed of the gas turbine engine G' drops below a predetermined value, the force of resetting spring 21 will move the piston-shaped insert 11 back to its initial position. Otherwise, the function of the piston-shaped insert 11 will be the same as that of an insert according to FIG. 2 or 5.

While I have shown and described several embodiments according to 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 intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

What I claim is:

1. A fuel nozzle for use on gas turbine engines and the like comprising: fuel metering orifice means for emitting fuel jet therefrom, first mixing means for

receiving the fuel jets from said fuel metering orifice means, first air intake means in communication with the said first mixing means responsive to the fuel jets for drawing air into said first mixing means wherein the fuel and air is preliminarily mixed, second mixing means in communication with said first mixing means for receiving the pre-mixed fuel and air for further mixing of the fuel and air before the mixture is emitted from said nozzle, said first mixing means including a first chamber and said second mixing means including a second chamber, said first and second chambers being arranged in a common housing, a piston-type insert means positioned in said housing, and adjusting means for adjusting the supply of air through said first air intake means, said adjusting means including means for varying the position of said insert means with respect to said housing.

2. A fuel nozzle according to claim 1, wherein the first chamber is formed between an annular groove in said insert means and the walls of said housing, said first air intake means including at least one first air intake aperture through the walls of said housing, and wherein the effective opening of said at least one first air intake aperture is varied by the edges of said annular groove upon a change in position of the insert means.

3. A fuel nozzle according to claim 2, wherein second air intake means including at least one second air intake aperture in said housing walls leading to said second chamber are provided for supplying additional air to be mixed with the premixed fuel and air in said second chamber.

4. A fuel nozzle according to claim 3, wherein each of said at least one second air intake apertures are tangentially arranged for imparting a swirling motion to the fuel and air mixture.

5. A fuel nozzle according to claim 1, wherein the fuel supply pressure for supplying said fuel metering orifice means is in communication with a first end face of said insert means, and wherein the means for varying the position of said insert means includes the fuel pressure force supplied against said first end face.

6. A fuel nozzle according to claim 5, wherein resetting means are provided in said housing for dampening the movement of the insert means.

7. A fuel nozzle according to claim 6, wherein said resetting means is a return spring.

8. A fuel nozzle according to claim 5, wherein said fuel metering orifice means extend from said first end face through said insert means to said first chamber.

9. A fuel nozzle according to claim 3, wherein said insert means includes an annular shroud extending over portions of the second chamber, said annular shroud including means for varying the effective opening of each of the at least one second air intake apertures in response to movement of said insert means.

10. A fuel nozzle according to claim 9, wherein the means for varying the opening of the at least one second air intake apertures includes apertures arranged on said shroud for selective alignment with the at least one second air intake apertures.

11. A fuel nozzle according to claim 2, wherein the end of said insert means downstream of said second chamber is formed as a spray cone, wherein said housing is provided with a correspondingly shaped cone

bush member which cooperates with said spray cone to vary the emission of fuel and air mixture from the nozzle in response to movement of said insert means, and wherein said cone bush member is movably adjustable with respect to said housing for varying the effective stroke of said insert means.

12. A fuel nozzle according to claim 5, wherein said housing is provided with adjustable stop means for varying the limit position of said first end face with respect to said housing.

13. A fuel nozzle according to claim 12, wherein said housing is provided with further adjustable stop means for varying the limit position of an end face of said insert means which faces oppositely with respect to said first end face.

14. A fuel nozzle according to claim 3, wherein the end of said insert means downstream of said second chamber is formed as a spray cone, wherein said housing is provided with a correspondingly shaped cone bush member which cooperates with said spray cone to vary the emission of fuel and air mixture from the nozzle in response to movement of said insert means, and wherein said cone bush member is movably adjustable with respect to said housing for varying the effective stroke of said insert means.

15. A fuel nozzle according to claim 9, wherein the fuel supply pressure for supplying said fuel metering orifice means is in communication with a first end face of said insert means, and wherein the means for varying the position of said insert means includes the fuel pressure force supplied against said first end face.

16. A fuel nozzle according to claim 1, wherein said means for varying the position of said insert means includes solenoid valve means formed in part by portions of said insert means.

17. A fuel nozzle according to claim 16, wherein means are provided for actuating said solenoid valve means as a function of output signals of a gas turbine engine using the fuel nozzle.

18. A fuel nozzle according to claim 9, wherein said means for varying the position of said insert means includes solenoid valve means formed in part by portions of said insert means.

19. A fuel nozzle according to claim 18, wherein means are provided for actuating said solenoid valve means as a function of output signals of a gas turbine engine using the fuel nozzle.

20. A fuel nozzle according to claim 17, wherein said output signals correspond to the engine rotational speed.

21. A fuel nozzle according to claim 2, further comprising an annular sleeve in surrounding engagement with said housing, wherein said sleeve includes apertures communicating with a compressed air supply, and wherein said sleeve is axially adjustable with respect to said housing to vary the supply of air to the at least one first air intake aperture.

22. A fuel nozzle according to claim 9, further comprising an annular sleeve in surrounding engagement with said housing, wherein said sleeve includes apertures communicating with a compressed air supply, and wherein said sleeve is axially adjustable with respect to said housing to vary the supply of air to the at least one first air intake aperture and to the at least one second air intake aperture.

23. A fuel nozzle according to claim 9, wherein a plurality of first air intake apertures and a plurality of second air intake apertures are provided, said first and second apertures being symmetrically spaced around the respective first and second chambers.

24. A fuel nozzle according to claim 2, wherein the air supplied to the first air intake means is from the compressor system of a gas turbine engine utilizing the fuel nozzle.

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