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S. G. WOODWARD ET AL

3,081,952

FUEL NOZZLE

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2 Sheets-Sheet 1

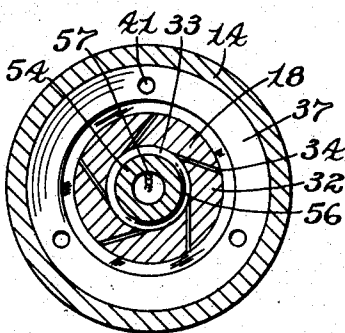
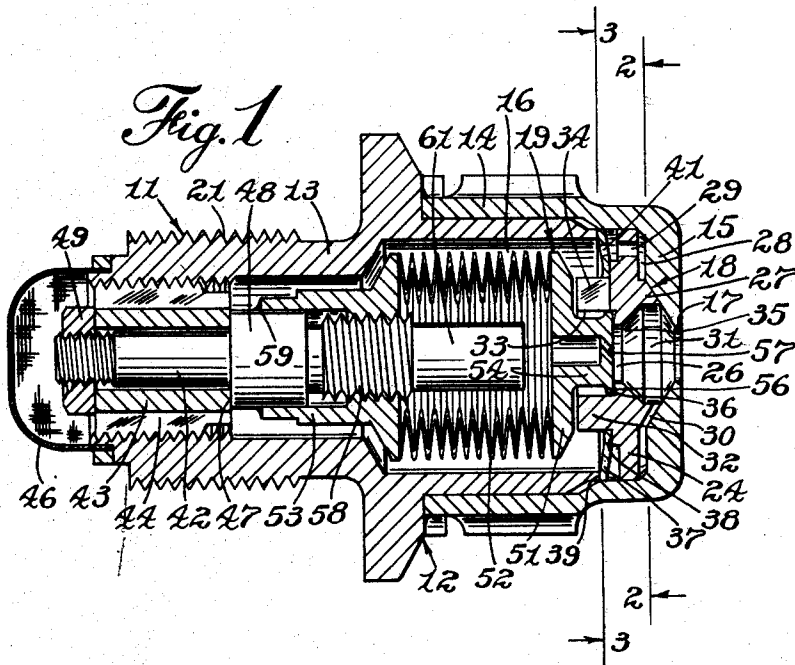


Fig. 3

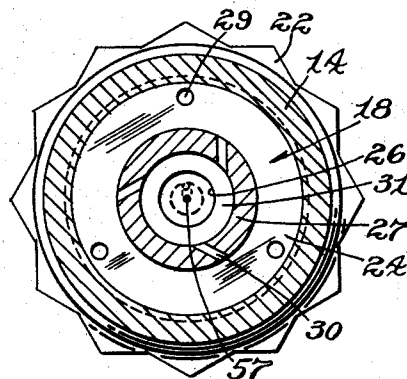


Fig. 2

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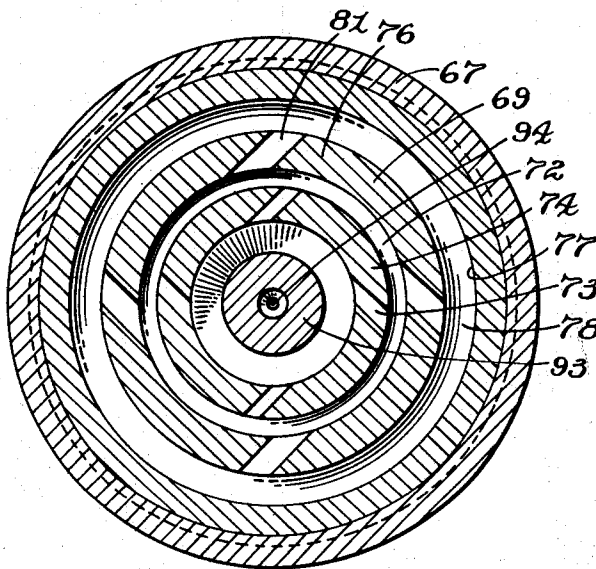
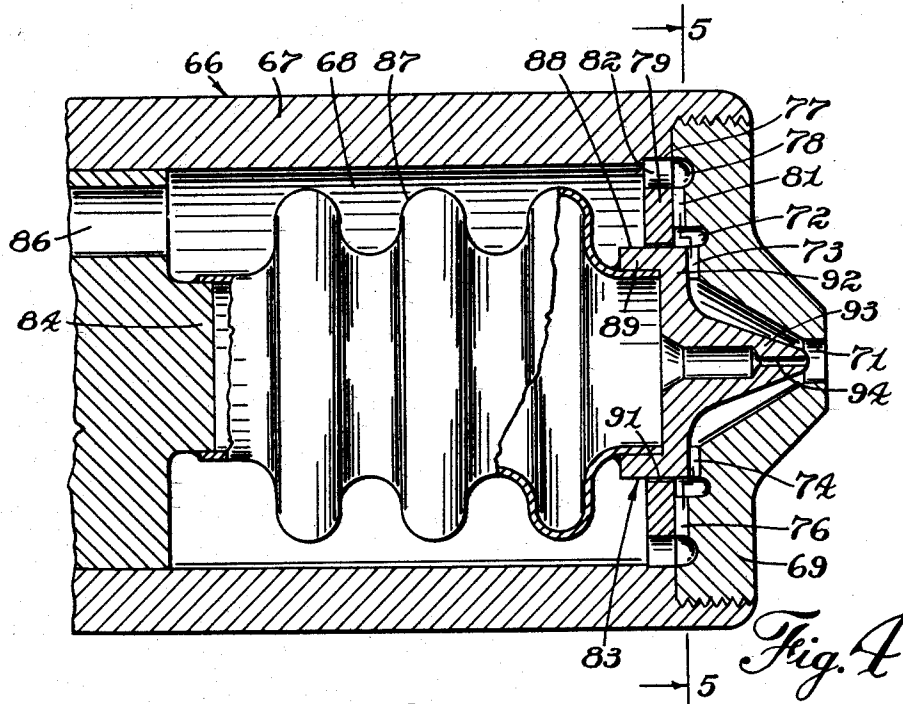
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2 Sheets-Sheet 2



WITNESS:

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FUEL NOZZLE

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5 Claims. (Cl. 239-464)

The present invention relates to a fuel nozzle of the type incorporated in jet engines and more particularly relates to a swirl type nozzle incorporating variable area metering means.

It is an object of the present invention to provide a fuel nozzle which is simple structurally, positive, efficient and reliable in operation and economical to manufacture in comparison to the other types of nozzles presently available for accomplishing substantially the same function.

It is an object of the present invention to provide a bellows actuated fuel nozzle.

It is another object of the present invention to provide a fuel nozzle the operation of which is not detrimentally affected by relatively dirty fuel.

It is still another object of the present invention to provide a fuel nozzle having fuel metering means providing a variable metered fuel flow.

It is a further object of the present invention to provide a fuel nozzle with a common variable pressure fuel source having a fixed primary fuel discharge and a variable secondary fuel discharge.

It is a further object of the present invention to provide a fuel nozzle having a piston valve articulated by a bellows adapted to vary the amount of fuel discharged responsive to the pressure differential between supplied fuel and downstream pressure existing at or near the nozzle orifice.

It is a further object of the present invention to provide a fuel nozzle having valve means which are guided by the metering means with the valve incorporating means for screening the fuel metering slots after the valve initially opens and for scouring a path in the guide means to clear undesirable dirt and sludge in the valve's path.

It is a further object of the present invention to provide a fuel nozzle in which the primary fuel metering means are independent of the valve means and in which both the primary and secondary fuel metering means are contained on a common fixed metering tip.

It is still a further object of the present invention to provide a fuel nozzle having the primary and secondary fuel metering means formed in one end wall of a support cavity and further having the fuel metering means adapted to cooperate with a valve to provide a variable secondary fuel discharge.

It is a still further object of the present invention to provide a fuel nozzle having valve means cooperating with a fuel outlet to provide a variable spin chamber to accommodate increases in the metered fuel flow and to obtain various values of spray angle and fuel flow.

With the above and other objects which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiments of the herein disclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate two complete embodiments of the invention constructed according to the best modes so far devised for the practical applications of the principles thereof and in which:

FIGURE 1 is a sectional side elevation of a fuel nozzle embodying the invention, portions thereof being broken

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away for the sake of clarity and illustrating the secondary fuel metering means in a closed position;

FIGURE 2 is a cross-sectional view taken through FIGURE 1 substantially along the plane of line 2-2;

FIGURE 3 is a cross-sectional view taken through FIGURE 1 substantially along the plane of line 3-3;

FIGURE 4 is a view similar to FIGURE 1 but illustrating a second embodiment of the invention, the secondary fuel metering means being illustrated in the closed position; and

FIGURE 5 is a cross-sectional view taken through FIGURE 4 substantially along the planes of lines 5-5.

Referring now more particularly to the accompanying drawing in which like reference characters indicate like parts, in FIGURE 1 the numeral 11 generally designates a fuel nozzle. A support 12 made up of a body 13 and a housing 14 defines an axial cavity 16 terminated by the extremity 15 in which there is formed a substantially frusto-conical shaped fuel outlet or orifice 17. Positioned within the cavity are a fuel metering tip generally designated as 18 and bellows actuated valve means generally designated as 19.

The fuel nozzle is threadedly received in the utilizing engine or equipment (not shown) by means of the threads 21 formed on the body 13. The housing 14 is fixedly secured to the body as by brazing or welding and has formed on its outer surface a plurality of faces or turning points 22 to facilitate mounting the nozzle in the equipment or engine.

The metering tip 18 positioned adjacent the extremity 15 in the cavity comprises a disc portion 24 which is centrally apertured at 26. An axially extending annulus 27 formed on the obverse face of the disc cooperates with the housing extremity 15 and the fuel outlet 17 to define a reservoir 28. A plurality of fuel passages 29 formed adjacent the peripheral portions of the disc 24 communicate between the cavity 16 and the reservoir 28. Annulus 27 defines a portion of the disc aperture 26 as well as a spin chamber 31. A plurality of metering slots 30 best illustrated in FIGURE 2 opening tangentially to the spin chamber communicate between the reservoir 28 and the spin chamber 31. The slots 30 provide fixed flow primary fuel metering means.

An axial tubular extension 32 formed on the rear face of the disc 24 defines a substantially cylindrical cavity serving as a secondary spin chamber 33. The spin chamber also defines a portion of the disc aperture 26 with the aperture and spin chamber being reduced in diameter to provide a shoulder serving as a valve seat 35. The effects on the hereinafter described piston valve 51 of downstream pressures created by the primary feed are also effectively reduced by the aperture reduction in diameter provided by the shoulder. The pressure within the aperture 26 and spin chamber 31 is greatest or highest at the outer wall of the spin chamber where the metered primary fuel emerges from the primary slots 30 and this pressure progressively decreases to substantially the level of the pressure at the discharge orifice or fuel outlet 17 as the metered primary fuel radially and axially approaches the orifice. The pressures within this area are also substantially stratified therefore the utilization of the smaller diameter shoulder, the diameter of which is appreciably smaller than that of the swirl chamber but larger than that of the orifice 17, is essential to prevent the piston valve from sensing a high back pressure generated by the primary fuel flow. A high back pressure sensed by the piston valve would supplement the valve actuating means and would, in effect, cause the valve to open and detrimentally reduce the relative pressure differential existing between the primary and secondary systems. Additionally, this shoulder diameter

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must be properly sized so as to prevent the metered secondary fuel from discharging directly through the orifice. It is desirable that the primary and secondary fuel be intermixed in the swirl chamber 31 before being discharged from the orifice in order to obtain a properly atomized fuel spray pattern. The valve seat is undercut as at 36 to provide a sharp contact point or seat. A plurality of slots 34 best illustrated in FIGURE 3 opening tangentially into the spin chamber 33 communicate between the cavity 16 and the spin chamber to provide secondary fuel metering means.

A beveled disc washer 37 compressively abuts against the shoulder 38 of the disc 24 and the shoulder 39 provided by the extremity of the body 13 to maintain the metering tip 18 properly positioned within the cavity. A plurality of passages 41 in the washer allow the passage of fuel to the primary metering means.

The valve means 19 are supported in the cavity 16 by a shank 42 supported in an adjusting screw 43 threadedly received in the body 13. The adjusting screw is provided with axial slots 44 which allow fuel to pass from a fuel supply system (not shown) and a filter 46 into the cavity. A shoulder 47 formed by the increased diameter portion 48 of the shank is drawn up against one end of the adjusting screw by a lock nut 49 threaded on the shank extremity to engage the opposite end of the adjusting screw. The bellows actuated valve means 19, once the adjusting screw is properly positioned in the support, will be preloaded and the adjusting means should then be locked in that position by brazing or welding.

The bellows assembly is supported on the extremity of the shank projecting into the cavity itself and comprises a piston valve member 51, a bellows actuator 52 and a bellows adjusting sleeve 53. The piston valve includes an axially elongated cylinder 54 slidably received in the secondary spin chamber 33. Adjacent the cylinder extremity there is formed a ring member 56 which is axially thin relative to the cylinder and has sharply defined edge portions. The thinness of the ring 56 relative to the cylindrical surface of the piston 54 is critically important since it provides a small area of contact between the valve and the wall of the spin chamber 33 which wall acts as the valve guide. The small area of contact thus minimizes the adverse effect of gum formations and dirt in the fuel, both of which create a drag on the valve and cause valve malfunctions to occur. The sharply defined edge portions of the ring provide a scouring or cleaning action which occurs during piston movements and thereby prevents a build-up of contaminants and insures free valve action. The effect of the radial protrusion of the ring, the sharp edges thereof, and the spatial separation between the rest of the valve piston and the guide surfaces of the spin chamber, serve the added function of throwing the contaminants into the fuel flow stream and thus disposes of them in an expedient manner. In the prior art nozzles with contiguous flush sliding surfaces, the contaminants massed between the surfaces, caused poor valve action and could not be easily disposed of into the fuel flow stream. The flat end face of the cylinder acts as the valve per se and, when in the closed position illustrated in FIGURE 1, is compressively urged by the bellows into engagement with the valve seat 35. A bleed passage 57 in the piston communicates downstream pressures to the bellows. The bleed passage opening at the fuel outlet is axially offset. In the event that fuel becomes entrapped in the bellows and is later expelled by the contractive action of the bellows then the resulting fuel discharge will be directed into a spin chamber and it will not materially disrupt the spray pattern of the metered fuel flowing from the nozzle. The bellows 52 is operatively secured at one extremity to the piston by any convenient method and is secured to the bellows adjusting sleeve at the opposite extremity. The bellows

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adjusting sleeve is threadedly received on the threaded portion 58 of the shank 42. Once properly positioned on the shank, the bellows adjusting sleeve is brazed or welded to the shank as at 59. The positioning of the adjusting sleeve is done prior to the preloading of the bellows previously described. A stemmed portion 61 of the shank 42 extends into the interior of the bellows to limit the contractive movements of the bellows.

In operation—fuel under varying pressure is introduced into the cavity 16 from the fuel supply system through the filter 46 and adjusting screw slots 44 and flows via the passages 41 and 29 into the reservoir 28 and thence through the primary fuel metering slots 30 into the primary spin chamber 31. The fuel is subsequently discharged from the spin chamber through the fuel outlet in a substantially conical atomized spray into the utilizing engine's combustion chamber (not shown). Until the fuel supply attains or exceeds a predetermined pressure the inherent compressive forces of the bellows 52 will maintain the valve 51 in compressive engagement with the valve seat 35. When the fuel pressure reaches a predetermined range, the bellows internal pressure, which is determined by the downstream pressure introduced into the bellows by the bleed 57, will be insufficient to support the bellows in the expanded condition and the bellows will gradually collapse. The collapse of the bellows will articulate the piston 51 away from the valve seat 35 thereby allowing additional fuel to flow from the cavity 16 through the secondary metering slots 34 into the secondary spin chamber 33 and thence via the aperture 26 and primary spin chamber to the fuel outlet or orifice 17 to supplement the primary fuel flow. As the piston is withdrawn from the valve seat, the thin sharp ring member 56 will provide a guiding action in cooperation with the inner surface of the axial extension 32 and will simultaneously act as a scouring means to remove detrimental dirt and/or sludge away from the surface of the extension 32 adjacent to the secondary fuel metering slot openings. As the fuel pressure increases, the bellows will increasingly collapse causing the piston to be withdrawn further from the seat to provide a greater area of secondary metering slots opening into the secondary spin chamber. Thus fuel pressure increases above a predetermined value will cause a variable secondary fuel metering system to become operative to supplement the fixed primary fuel supply. The limit of piston movement in the opening direction is determined by the shank stem portion 61.

Foreign matter, such as dirt and sludge in the fuel, will not detrimentally affect the operation of the nozzle because of the unique structure of the ring member 56 and its scouring action.

The valve seat 35 and the pressures exerted by the bellows during its expansion will cause a complete close off of secondary fuel flow irrespective of the existence of dirt in the secondary metering system.

The modified embodiment of the invention illustrated in FIGURE 4 of the fuel nozzle has been generally designated as 66 and comprises a hollow support 67 defining a cavity 68. The extremity 69 of the support has a fuel outlet or orifice 71 formed therein which is surrounded by fuel metering means. The fuel metering means comprises the first fuel reservoir 72 formed in the surface of the cavity end wall 69 and coaxially disposed about the orifice 71. A plurality of metering slots 73 best illustrated in FIGURE 5 is formed in the innermost annulus 74 which defines one side of the reservoir 72 and communicates between the reservoir 72 and the fuel outlet 71. A second annulus 76 coaxial with the outlet and formed in the end wall 69 but axially rearwardly of the annulus 74 defines the other side of the reservoir 72 and in combination with the cavity support wall 77 defines a second fuel reservoir 78. A discoid guide member 79 positioned in the cavity also defines portions of both reservoirs. A plurality of metering

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slots 81 also illustrated in FIGURE 5 is formed in the annulus 76 and by the disc 79 to communicate between the reservoirs. Fuel is introduced into the reservoir 78 by means of a plurality of fuel passages 82 formed in the marginal portions of the guide 79.

A valve assembly generally designated as 83 is positioned in the cavity. A bellows support 84 is also secured in the cavity and channel means 86 are provided therein to enable fuel from a supply system (not shown) to be fed into the cavity. A bellows actuator 87 is secured at one extremity to the support 84 and at its other extremity is operably connected to a piston valve 88. The piston valve has a rearwardly extending cylindrical portion 89 slidably supported in the central aperture 91 of the guide 79. The valve portion 92 of the piston, when the bellows is expanded, will seat on the annulus 74 so as to cause all the fuel to be metered to the fuel outlet 71 through the primary fuel metering slots 73. As the bellows contracts due to an increase in the fuel pressure, the piston is withdrawn and the reservoir 72 is gradually enlarged to allow fuel to be metered directly to the fuel outlet 71.

A substantially conical protrusion 93 formed on the piston valve 88 is adapted to project into the substantially conical fuel outlet 71. The protrusion 93 causes the fuel outlet to become a spin chamber and as the piston is withdrawn, the chamber automatically enlarges to accommodate the increased volume of metered fuel. Passage means 94 provided in the cone 93 communicate downstream pressure to the bellows to thereby establish a pressure differential for bellows operation.

In operation—fuel under varying pressure is introduced into the cavity 68. Below a predetermined fuel pressure, the bellows will maintain its expanded position and articulate the piston valve 88 into compressive engagement with the annulus 74. Fuel will flow from the cavity into the reservoir 78 through the secondary metering slots 81 into the reservoir 72 and then through the primary metering slots 73 into the spin chamber defined by the piston cone 93 and the fuel outlet 71. The fuel will then be sprayed in an atomized conical shape from the outlet into the combustion chamber of the utilizing engine (not shown).

When the fuel supply introduced into the cavity reaches or exceeds a predetermined pressure, the bellows will begin to collapse causing the piston valve 88 to be guided in the member 79 away from the end wall 69. Movement of the piston causes the reservoir 72 to open directly into the spin chamber thus allowing fuel from the secondary metering means to flow directly into the outlet. Movement of the piston also causes the spin chamber to become enlarged due to the change of relative position between the fuel outlet and the piston cone. The enlarged spin chamber thus easily and conveniently accommodates the added fuel flow.

From the foregoing description taken together with the accompanying drawing, it would be readily apparent that this invention provides a bellows actuated fuel nozzle having unique metering structures for incorporation in a utilizing jet engine without entailing any appreciable changes in the size, construction or an arrangement of parts of the latter.

We claim:

1. A fuel nozzle of the character described, comprising: a support having a cavity therein terminating at one extremity as a fuel outlet; means communicating with the cavity for providing pressurized fuel to the cavity; a disc defining separate primary and secondary fuel metering means positioned in the cavity adjacent said one extremity, said disc having an aperture formed therein communicating with the fuel outlet and providing a valve seat and at least one spin chamber; means including a first plurality of slot means formed on the obverse

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face of the disc adjacent said one extremity communicating between the cavity and a spin chamber adapted to provide fixed primary fuel metering means; a second plurality of elongated axial slots formed on the rear face of the disc communicating between the cavity and a spin chamber adapted to provide variable secondary fuel metering means; bellows actuator means in the cavity; a cylindrical piston valve operably connected to the bellows and articulated thereby for controlling the fuel flow through the secondary fuel metering means, one extremity of said piston valve being adapted to cooperate with the valve seat when the fuel pressure is below a predetermined value and the bellows is expanded to thereby stop the secondary fuel flow; radially extending ring means on the exterior cylindrical surface of the piston adjacent said one extremity thereof slidably engaging the disc aperture for guiding the piston valve and scouring the aperture walls during piston valve movements whereby detrimental dirt and sludge in the aperture are eliminated as the secondary fuel metering slot openings into the spin chamber are varied.

2. A fuel nozzle of the type set forth in claim 1 wherein the means adapted to provide the fixed primary fuel metering means includes further: a fuel reservoir between the obverse face of the disc and said one extremity of the cavity; and, a plurality of fuel passages in the disc communicating between the cavity and the reservoir, said first plurality of slot means communicating between the reservoir and the spin chamber.

3. A fuel nozzle of the character described, comprising: a support having an axial cavity terminated at one extremity by a fuel outlet; means communicating with the support cavity for supplying fuel under pressure; an apertured disc providing tip means positioned in the support adjacent to said one extremity and communicating with the fuel outlet providing primary fuel metering means on the front face of the disc and secondary fuel metering means on the rear face of the disc, said aperture defining separate but interconnected first and second spin chambers communicating with the fuel outlet; a valve seat in the aperture intermediate of the spin chambers, said valve seat defining an opening having a smaller diameter than the diameter of said first spin chamber whereby high back pressure generated in said first spin chamber is effectively prevented from entering said second spin chamber when the valve seat is exposed; an axially extending annulus on the front face of the disc coacting with said one end of the cavity, said primary fuel metering means including a plurality of slots being formed in the annulus and opening tangentially into the first spin chamber; fuel passage means in the disc for supplying fuel from the cavity to the primary fuel metering means; an axial annular extension formed on the rear face of the disc; said extension defining portions of the aperture containing the second spin chamber, said secondary fuel metering means comprising a plurality of slots formed in the extension communicating between the cavity and the second spin chamber and opening tangentially into the second spin chamber; a piston valve slidably supported in the extension for varying the fuel flow in the secondary fuel metering means by varying the secondary slot areas opening into the second spin chamber; and, bellows actuator means carried by the support operably connected to the piston valve for articulating the piston responsive to varying fuel pressure.

4. A fuel nozzle of the type set forth in claim 1 wherein the radially extending ring means is axially thin relative to the axial length of the cylindrical surface of the piston, said ring means having sharp edge portions adapted for scouring said aperture walls adjacent the secondary fuel metering slot openings and the disc valve seat.

5. A fuel nozzle of the type set forth in claim 3 in which the piston valve is adapted to cooperate with the

disc valve seat when the bellows assumes an expanded condition for closing off a secondary fuel flow, said piston valve including further a ring member adapted to guide the valve in the aperture when the bellows moves toward a contracted condition, said ring member being axially thin relative to the piston valve and having sharp portions adapted to scour the aperture surface adjacent the secondary fuel metering means.

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