

[54] FUEL NOZZLE WITH MODULATING PRIMARY NOZZLE

3,598,321 8/1971 Bobzin.....239/464 X

FOREIGN PATENTS OR APPLICATIONS

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[57] ABSTRACT

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[58] Field of Search.....239/464, 533, 570, 571, 572, 239/584

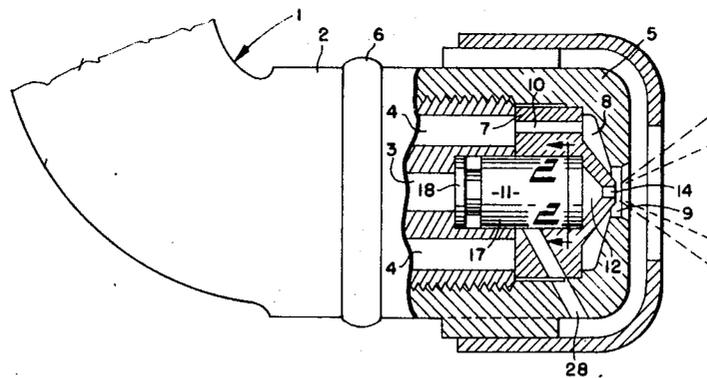
A dual orifice fuel nozzle characterized in the provision of a pressure responsive flow modulating member in the primary fuel supply passage upstream of the spin passages and spin chamber of the primary discharge orifice, said member being operative in response to increasing primary fuel pressure to decrease the flow through the primary discharge orifice and to increase the angle of the fuel spray pattern therefrom once engine ignition and/or some low power condition is reached.

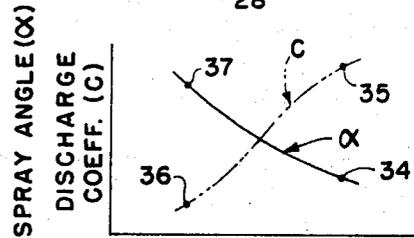
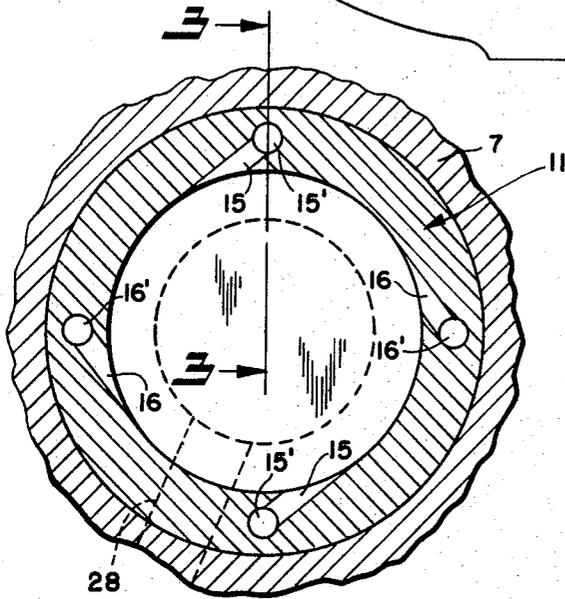
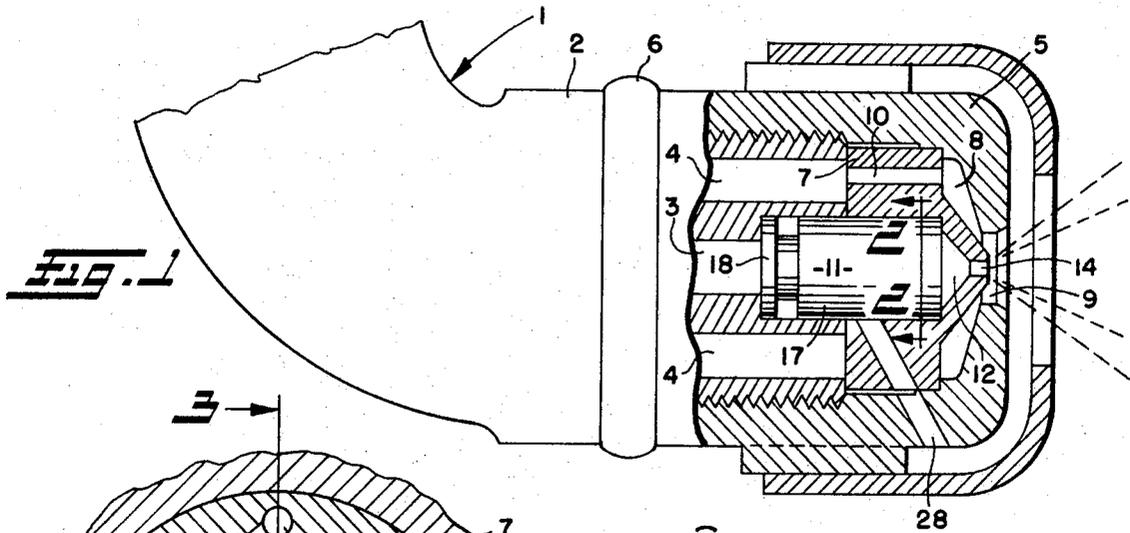
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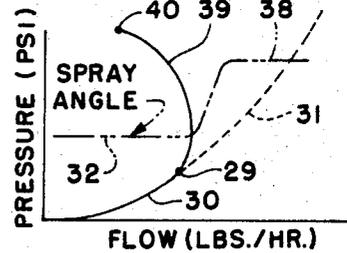
13 Claims, 5 Drawing Figures





$$K \frac{A_s}{D_o D_s}$$

Fig. 4



FLOW (LBS./HR.)

Fig. 5

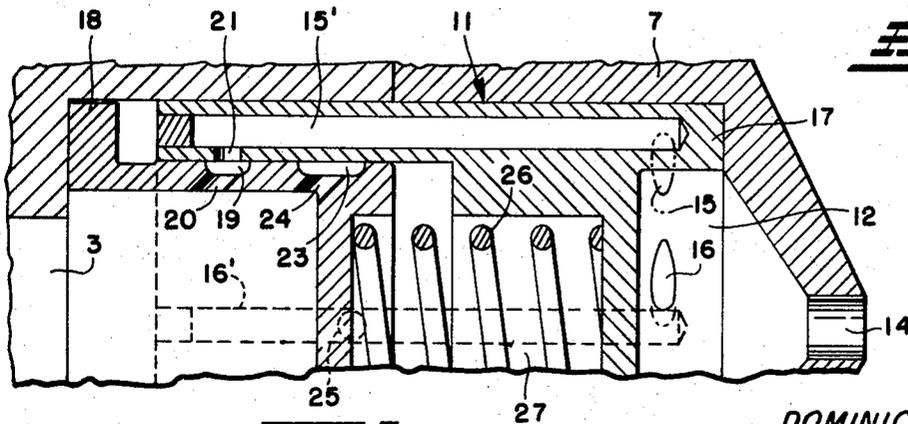


Fig. 3

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FUEL NOZZLE WITH MODULATING PRIMARY NOZZLE

BACKGROUND OF THE INVENTION

As known, a dual orifice nozzle has a primary fuel supply passage which leads to the primary discharge orifice of the nozzle by way of spin passages and a spin chamber effective to impart to the fuel a whirling motion so that upon leaving the orifice the fuel is broken up into fine droplets and spread out in a generally conical spray pattern. Such nozzle is also provided with a secondary fuel supply passage to which fuel is supplied from a flow divider or variable area valve for discharge through a secondary discharge orifice via secondary spin passages and a secondary spin chamber. Initially, the fuel is discharged only through the primary orifice to achieve required fine atomization at low fuel flows and pressures as during engine starting while for greater fuel flows and pressures the fuel is discharged from both the primary and secondary orifices with proper atomization being achieved by reason of the greater velocities of the fuel through the nozzle.

In a conventional dual orifice nozzle the primary flow increases as the square root of the increase in pressure and the primary spray angle remains generally constant. However, engine lighting and altitude re-lighting requires a relatively small primary spray angle but at rated engine power such small spray angle and the increased primary flow results in an over-rich fuel concentration in the center of the combustion chamber which will produce smoke and/or undesirably large quantities of unburned hydrocarbons. Accordingly, primary nozzles have heretofore been designed as compromises to tolerably lessen the primary fuel concentration during engine starting and to lessen, but not eliminate, the over-rich fuel concentration in the primary combustion zone at rated engine power.

SUMMARY OF THE INVENTION

In the present invention the primary nozzle of a dual orifice nozzle has a pressure responsive flow modulating member which throttles the flow of fuel through at least one of a plurality of primary spin passages which decreases the primary flow through the primary orifice despite increase in primary fuel pressure above a predetermined value. The accompanying decrease in the coefficient of discharge of the primary nozzle results in an increase in the primary spray angle whereby at rated engine power the larger primary spray angle and the lessened primary fuel flow avoids an over-rich fuel concentration in the primary combustion zone and therefore smoke and/or large quantities of unburned hydrocarbons is minimized. Furthermore, when the primary fuel pressure is below the aforesaid predetermined value the unmodulated flow to the primary spin passages results in a relatively small primary spray angle and a relatively high coefficient of discharge of the primary nozzle to facilitate starting of the engine.

The flow modulating member herein is in the form of a spring biased valve member which on one side is exposed to primary fuel supply pressure and which on the other side is exposed to compressor discharge pressure or other suitable source such as secondary discharge pressure, said valve member being operative, upon increase of primary fuel supply pressure above a predetermined value, to progressively throttle a passage leading to at least one of a plurality of primary spin passages.

Other objects and advantages of the present invention will appear hereinafter.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary cross-section view of a dual orifice fuel nozzle embodying the present invention;

FIG. 2 is a much enlarged transverse cross-section view taken substantially along the line 2—2, FIG. 1;

FIG. 3 is a cross-section view taken substantially along the line 3—3, FIG. 2; and

FIGS. 4 and 5 are graphs of the characteristics of the flow modulated primary nozzle constituting the present invention.

DETAILED DESCRIPTION OF THE DRAWING

The dual orifice injection nozzle 1 herein illustrated comprises a housing 2 provided with primary and secondary fuel supply passages 3 and 4 which, as well known, communicate at their upstream ends with a fuel inlet port and with the outlet of a flow divider or variable area valve.

The secondary nozzle body and air shroud 5 is screwed onto the end of the housing 2 and may be welded thereto as shown at 6, and the primary nozzle body 7 is clamped between the secondary body 5 and the end of the housing 2 to form with the secondary body 5 a secondary spin chamber 8 and an annular secondary discharge orifice 9. The primary body 7 is provided with one or more helical spin passages 10 therethrough which intercommunicate the secondary passage 4 with the secondary spin chamber 8.

The primary body 7 retains a primary flow modulating unit 11 in a counterbore in the end of housing 2, said unit 11 defining with primary body 7 a spin chamber 12 leading to the primary discharge orifice 14 and providing two pairs of tangential spin passages 15;15 and 16;16. The body 17 of the flow modulating unit 11 has two pairs of primary fuel feed passages 15';15' and 16';16' leading to the respective pairs of spin passages 15;15 and 16;16. The flow modulating member 18 is slidably sealed in said body 17 and has a first peripheral groove 19 which through passage 20 communicates the fuel supply passage 3 with two radial passages 21 leading to the respective passages 15' and 15. The flow modulating member 18 is also provided with a second peripheral groove 23 which through passage 24 communicates the primary supply passage 3 with two radial passages 25 leading to the respective passages 16' and 16. The flow modulating member 18 is biased by the spring 26 to the position shown in FIGS. 1 and 3 and the chamber 27 behind said modulating member 18 is referenced to the compressor discharge pressure or other suitable source via the passage 28 shown in FIGS. 1 and 2.

The modulating member 18 will remain in the position shown until the primary fuel pressure in the passage 3 reaches the value of point 29 on the curve 30 of FIG. 5. Up to point 29 the flow of fuel through the primary nozzle progressively increases as the square root of the increase in pressure as shown in FIG. 5 with primary fuel flowing through both pairs of passages 15' and 16' and both pairs of spin passages 15 and 16 into the primary spin chamber 12. In the absence of the present invention the flow from the primary orifice 14 would continue as represented by the dotted line curve 31 and the primary spray angle a would remain constant as determined by the formula $K = A_s/D_oD_s$ where A_s is the effective area of the spin passages 15 and 16, and D_o and D_s are the diameters of the primary discharge orifice 14 and the spin chamber 12.

Under the foregoing conditions of operation, the primary spray angle a will be a minimum such as say, 45° (line 32 in FIG. 5 and point 34 in FIG. 4) and the discharge coefficient C will be maximum (point 35 in FIG. 4).

Accordingly, the primary fuel spray will have the desired high concentration to facilitate engine starting. However, as the primary fuel pressure increases above the predetermined value 29, the force of the increased pressure acting on the modulating member 18 will compress the spring 26 with the result that the left side of the peripheral groove 19 will commence to progressively cover the openings 21 thus to throttle the flow of primary fuel through the spin passages 15. As this occurs, the value of A_s , and thus K , decreases with accompanying decrease of the coefficient C to a minimum value of 36 in FIG. 4 and increase of the primary spray angle a to a maximum value 37 in FIG. 4 when the groove 19 completely cuts off flow through the spin passages 15. The maximum primary spray angle a may be, say 75° as represented by the line 38 in FIG. 5. When the primary fuel pressure increases above the value 29, the throttling action of the modulating member 18 decreases the primary flow from the orifice 14 as denoted by the reverse slope curve 39 in FIG. 5 which reaches a minimum value 40 at rated engine power. As evident the groove 23 in the modulating member does not throttle flow to

the other spin passages 16. The decreased primary flow 40 at rated engine power and the increased primary spray angle α (point 37, FIG. 4 and line 38, FIG. 5) prevents an over-rich smoke producing primary combustion zone. Furthermore, the small spray cone angle α of say, 45° facilitates engine starting because of the more concentrated fuel spray.

I, therefore, particularly point out and distinctly claim as my invention:

1. A fuel nozzle comprising a nozzle body assembly defining therewithin a fuel inlet passage communicating with a discharge orifice via a spin chamber and a plurality of spin passages for discharge of the fuel from said orifice as a generally conical spray; and a pressure responsive flow modulating member movable in said assembly to decrease the flow of fuel through at least one of said spin passages in response to increase in fuel pressure in said inlet passage above a predetermined value, thus to decrease the discharge rate of fuel from said orifice and to increase the angle of the fuel spray therefrom.

2. The nozzle of claim 1 wherein said member, when moved in said assembly by increasing fuel pressure as aforesaid, throttles a passage leading from said inlet passage to said one spin passage.

3. The nozzle of claim 1 wherein spring means in said assembly biases said member so as to resist movement thereof until the fuel pressure exceeds such predetermined value.

4. The nozzle of claim 1 wherein said member has opposite sides thereof exposed to fuel pressure in said inlet passage and to a lower gas turbine reference pressure when said nozzle is installed in a gas turbine or the like.

5. The nozzle of claim 1 wherein said nozzle has a constant $K = A_s / D_o D_s$, wherein A_s is the effective area of the spin passages and D_o and D_s are the diameters of the discharge orifice and spin chamber respectively, such that with fuel pressures less than such predetermined value the fuel spray angle is minimum and the discharge coefficient of the nozzle is maximum to facilitate engine starting and such that as said member moves under the influence of increasing fuel pressure the value A_s , and thus K , decreases to result in increase in the fuel spray angle and in decrease in the discharge coefficient of the nozzle to minimize smoking and/or unburned hydrocarbons as the engine reaches its rated power.

6. A dual orifice fuel nozzle comprising a nozzle body assembly defining therewithin primary and secondary fuel inlet passages respectively communicating with concentric primary and secondary discharge orifices via respective primary and secondary spin chambers and spin passages for discharge of

fuel from said orifices as generally conical sprays; and a pressure responsive flow modulating member movable in said assembly to decrease the flow in said primary spin passage in response to increase in fuel pressure in said primary inlet passage above a predetermined value, thus to decrease the discharge rate of fuel from said primary orifice and to increase the angle of the fuel spray therefrom.

7. The nozzle of claim 6 wherein said member, when moved as aforesaid, throttles a passage leading from said primary inlet passage to said primary spin passage.

8. The nozzle of claim 6 wherein spring means in said assembly biases said member so as to resist movement thereof until the fuel pressure exceeds such predetermined value.

9. A fuel nozzle comprising a nozzle body assembly defining therewithin a fuel inlet passage communicating with a discharge orifice via a spin chamber and a spin passage for discharge of the fuel from said orifice as a generally conical spray; and a pressure responsive flow modulating member movable in said assembly to decrease the flow of fuel through said spin passage in response to increase in fuel pressure in said inlet passage above a predetermined value, thus to decrease the discharge rate of fuel from said orifice and to increase the angle of the fuel spray therefrom.

10. The nozzle of claim 9 wherein said member, when moved in said assembly by increasing fuel pressure as aforesaid, throttles a passage leading from said inlet passage to said spin passage.

11. The nozzle of claim 9 wherein spring means in said assembly biases said member so as to resist movement thereof until the fuel pressure exceeds such predetermined value.

12. The nozzle of claim 9 wherein said member has opposite sides thereof exposed to fuel pressure in said inlet passage and to a lower gas turbine reference pressure when said nozzle is installed in a gas turbine or the like.

13. The nozzle of claim 9 wherein said nozzle has a constant $K = A_s / D_o D_s$, wherein A_s is the effective area of the spin passage and D_o and D_s are the diameters of the discharge orifice and spin chamber respectively, such that with fuel pressures less than such predetermined value the fuel spray angle is minimum and the discharge coefficient of the nozzle is maximum to facilitate engine starting and such that as said member moves under the influence of increasing fuel pressure the value A_s , and thus K , decreases to result in increase in the fuel spray angle and in decrease in the discharge coefficient of the nozzle to minimize smoking and/or unburned hydrocarbons as the engine reaches its rated power.

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