

Nov. 7, 1972

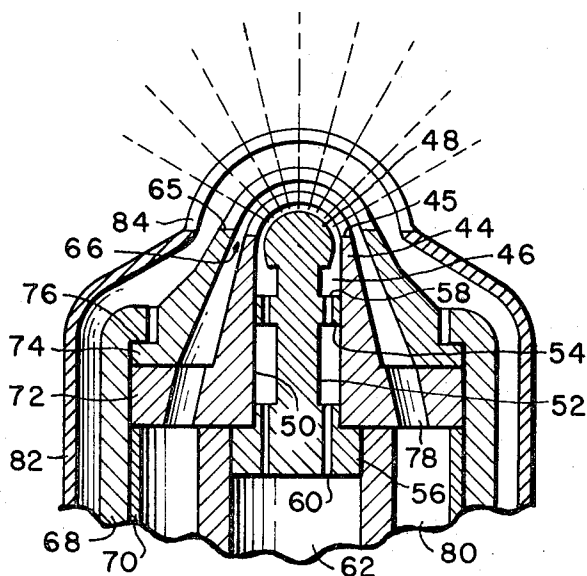
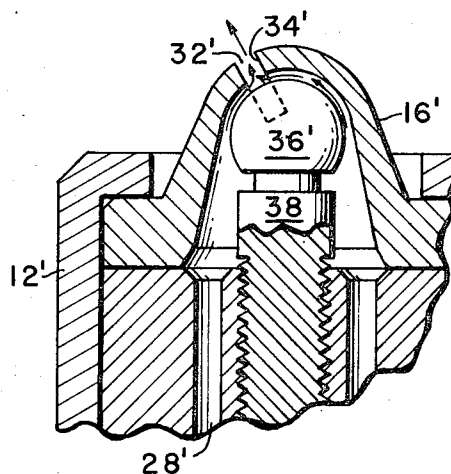
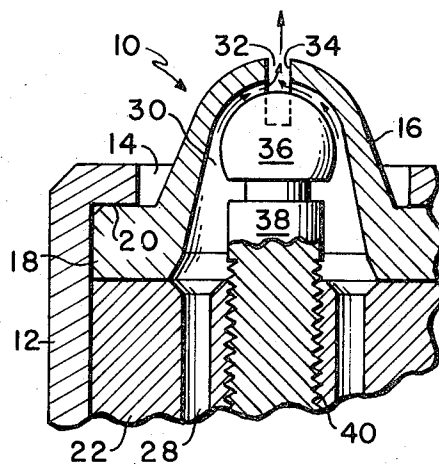
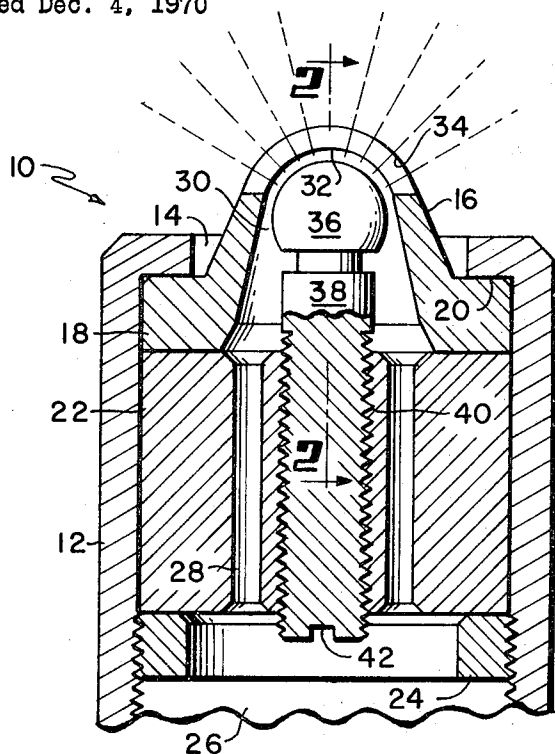
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3,702,175

FLAT SPRAY FUEL NOZZLE

Filed Dec. 4, 1970

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

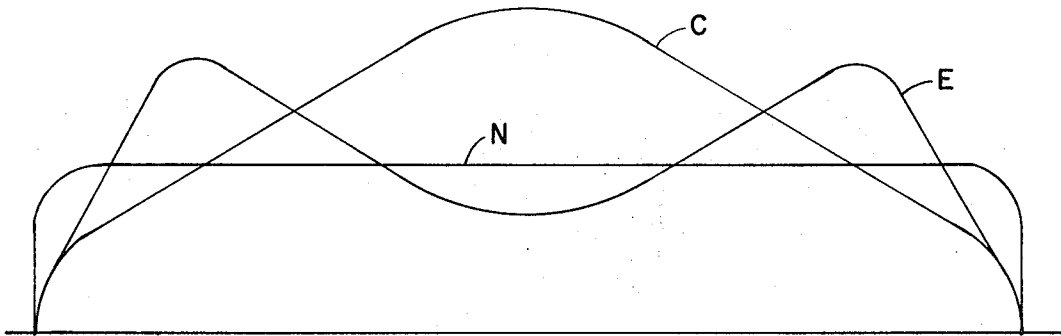


Fig 5

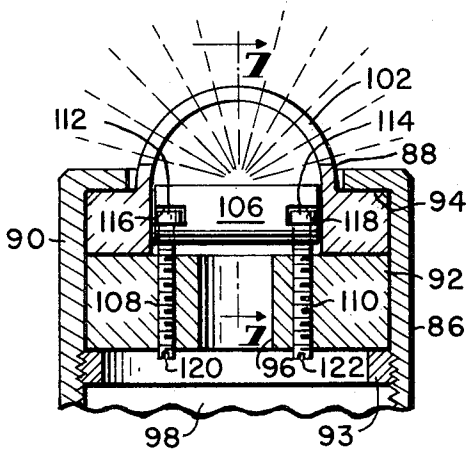
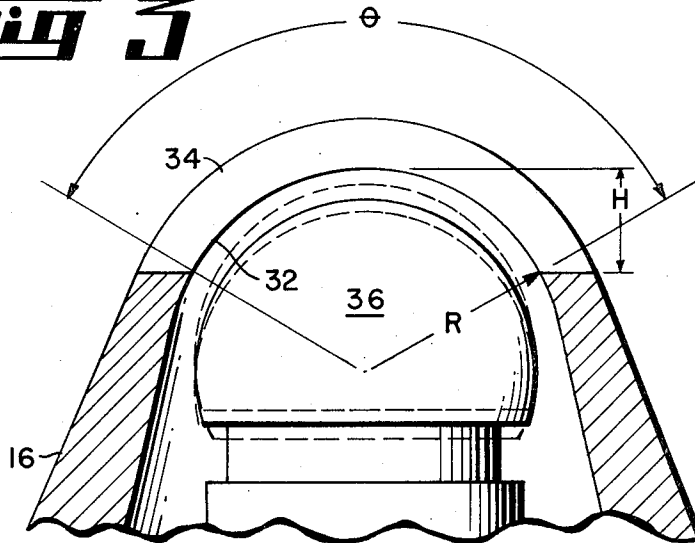


Fig 6

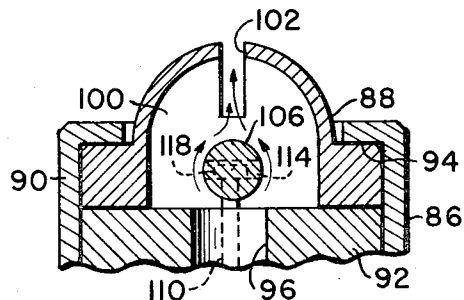


Fig 7

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3,702,175

FLAT SPRAY FUEL NOZZLE

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Int. Cl. F23d 11/16

U.S. Cl. 239—422

4 Claims

ABSTRACT OF THE DISCLOSURE

The disclosure illustrates a flat spray fuel nozzle comprising, in one form, a spherical chamber having an elongated outlet slot and a sphere in the chamber closely adjacent the slot. Fuel flow through the chamber is divided into two streams which are directed against one another at the inlet of the slot to provide greater turbulence and more efficient atomization. In another form the nozzle uses a bar positioned in front of a straight slot for dividing the flow.

The present invention relates to nozzles and more specifically to fuel nozzles that may be incorporated in gas turbine engines.

In recent years the annular combustor has been utilized in gas turbine engines to provide extremely high energy release rates for small combustor sizes. One of the requirements that becomes more severe when the combustor size is reduced is the need for uniform circumferential distribution of fuel within the annular combustor. This type of distribution is particularly important in the successful utilization of the combustor shown in the copending application of J. O. Melconian, entitled "Annular Combustor," Ser. No. 92,808, filed Nov. 25, 1970, now Pat. No. 3,645,095, and of common assignment with the present invention. In that combustor design the air flow adjacent each nozzle is split into two spaced streams to provide a substantial circumferential distribution of the combustion gases from individual nozzles. This type of combustor reduces the nozzle requirement for a given size combustor by one half. However, it is extremely important to provide a nozzle for this type of combustor that has an extremely flat and wide spray with a uniform distribution.

Therefore it is an object of the present to provide a fuel nozzle that effectively and uniformly distributes fuel in a flat wide spray pattern having predictable characteristics.

These ends are achieved by a fuel nozzle which comprises a nozzle body having a flow path through it and an outlet for discharge of fuel in a spray pattern. An elongated slotlike orifice is positioned adjacent the outlet of the flow path so that the fuel is discharged in a flat spray pattern. The fuel flow is diverted and re-united upstream of the orifice to maximize turbulence and provide uniform atomization of the spray pattern.

The above and other related objects and features of the present invention will be apparent from a reading of the description of the disclosure shown in the accompanying drawing and the novelty thereof pointed out in the appended claims.

In the drawings:

FIG. 1 is a fragmentary longitudinal sectional view of a fuel nozzle embodying the present invention;

FIG. 2 is a view taken on line 2—2 of FIG. 1;

FIG. 3 is a greatly enlarged fragmentary view of the nozzle of FIG. 1 illustrating its spray pattern and distribution characteristics;

FIG. 4 is a fragmentary longitudinal sectional view of a nozzle employing an alternate embodiment of the present invention;

FIG. 5 is a fragmentary longitudinal section view of another nozzle embodying the present invention;

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FIG. 6 is a fragmentary longitudinal section view of still another nozzle embodying the present invention; and FIG. 7 is a view taken on line 7—7 of FIG. 6.

Referring to FIG. 1 there is shown a nozzle body, generally indicated by reference character 10, comprising an outer sleeve 12 having an opening 14 through which a spherical tip 16 extends. Spherical tip 16 has a flange 18 which abuts a shoulder 20 of the sleeve 12. A suitable threaded sleeve 24 holds a central disc 22, which abuts flange 18, and the spherical tip 16 within the nozzle body 12.

The nozzle body 10 has an inlet chamber 26 which is connected to a suitable source of pressurized fuel. The details of the fuel source and the method of connection to the nozzle body should be apparent to those skilled in the art. For this reason these elements are eliminated to simplify the description of the present invention.

A series of longitudinal passages 28 extend from the inlet chamber 26 through the central disc 22 to a generally spherical outlet chamber 30 formed in tip 16. An elongated slot 34 (see also FIG. 2) is formed in tip 16 to form a slotlike orifice 32 at its inner side and an outlet for discharge of fuel from the nozzle in a flat spray pattern.

A sphere 36 is positioned within chamber 30 closely adjacent orifice 32 by a shaft 38 threaded into a hole 40 in the central disc 22. The sphere 36 is displaced toward and away from the orifice 32 by any suitable means. As herein shown, shaft 38 is twisted by engaging slot 42 to advance the shaft 38 in the threaded hole 40.

When pressurized fuel is introduced into chamber 26, it flows through passages 28 to spherical chamber 30 where the sphere 36 diverts the fuel into an annular pattern which flows toward orifice 32 and is permitted to form a solid pattern along the inlet of orifice 32. This greatly increases the turbulence of the spray pattern discharged from the nozzle and increases the atomization. It has been found that with an arrangement of the above type effective atomization occurs at substantially lowered pressures relative to a swirl atomizing type nozzle. This in turn permits a much greater variation in flow between the minimum and the maximum flow rates that can be handled by the nozzle.

With such a nozzle the spray angle and distribution can be predicted and controlled, in contrast to present nozzles whose spray pattern and distribution is largely determined empirically. FIG. 3 illustrates how the spray pattern and distribution can be predicted. The spray angle θ of the fuel discharged from the nozzle is calculated by determining the distance R from the center of the sphere 36 to the inlet of orifice 32 and determining the distance H from the outermost tip of orifice 32 to its ends. The spray pattern in degrees is then twice the angle whose cosine equals

$$\left(\frac{R-H}{R} \right)$$

It has been found that with a nozzle of this type simple measurement of these parameters enables a reasonably accurate prediction of spray angle. It is pointed out that the width of slot 34 and the gap between sphere 36 and orifice 32 have relatively little effect on this parameter.

The distribution of fuel within the spray pattern may be controlled by displacing the sphere 36 toward and away from the slot 34. Although this causes a variation in the dimension R used in calculating the spray angle, the spray angle is so slightly changed that the effect is negligible. For the condition where sphere 36 is in the position shown in solid lines, there is a normal mass flow distribution, as shown by the distribution curve N. If the sphere 36 is displaced toward orifice 32 there is a greater

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distribution of fuel at the ends of the spray pattern, as shown by the fuel distribution curve E. This results because the flow of fuel toward the center of the orifice 32 is reduced relative to the flow adjacent the ends. If the sphere 36 is displaced away from orifice 32 there is a greater distribution in the center of the spray pattern, as shown by curve C. This results because the flow area in the center of orifice 32 is increased relative to the flow area of the ends. It should be pointed out that the distribution of fuel is on a relative basis for the nozzle positions and that for given pressure conditions the total flow for the displacement of the sphere 36 away from orifice 32 would be larger than the total flow for the displacement of the sphere 36 toward orifice 32.

The nozzle shown in FIGS. 1 and 2 utilizes a slot 34 which has a plane passing through the central axis of the nozzle body 10. There may be particular instances where it is desired to angle the spray pattern discharged from the nozzle, such as when the nozzles are to be mounted in a combustor from a radially outward direction rather than an axial direction. For this purpose the embodiment shown in FIG. 4 is utilized. This arrangement utilizes a slot 34' in a tip 16' that is angled with respect to the central axis of the shaft 38' that supports the sphere 36'. This embodiment also achieves maximum turbulence and effective atomization. This arrangement would utilize a suitable form of mechanism for displacing the sphere 36' toward and away from the slot 34', as will be apparent to those skilled in the art.

The nozzles described above are referred to as simplex nozzles because they have a single flow path through which the fuel must pass. The flow ratio of this type of nozzle is determined by the ability of the single flow path to effectively handle a maximum and minimum flow of fuel. The nozzle shown in FIG. 5, however, is of the duplex type which has low-flow and high-flow flow paths to increase the flow capacity of the nozzle.

This nozzle has a spherical primary tip 44 forming a spherical chamber 46 in which a sphere 48 is positioned. A slot 45 in tip 44 forms a slotlike orifice adjacent sphere 48 and an outlet for the discharge of fuel. A passage 50 extends longitudinally through tip 44 from chamber 46. A shaft 52 is integral with sphere 48 and has flanges 54, 56 which abut the walls of passage 50 to secure shaft 52 and sphere 48 in place. A series of ports 58, 60 in flanges 54, 56, respectively, connect the chamber 46 with a primary inlet chamber 62.

A secondary spherical tip 64 surrounds the primary tip 44 to form a secondary spherical chamber 66. A slot 65 in tip 64, coincident with slot 45, forms a slotlike orifice adjacent the spherical primary tip 44 and forms a further outlet for the discharge of fuel. Secondary tip 64 is secured in a retaining sleeve 68 by a sleeve 70 which sandwiches a flange 72 of the primary tip 44 and a flange 74 of the secondary tip 64 against a shoulder 76 of sleeve 68. A series of ports 78 in flange 72 connect the secondary spherical chamber 66 with an annular secondary fuel inlet chamber 80.

The primary and secondary fuel inlet chambers 62 and 80 are supplied with fuel from a suitable distribution system which permits flow only to the primary fuel inlet chamber 62 for low flow rates and, additionally, supplies fuel to the secondary fuel inlet chamber 80 for high flow rates. This distribution is generally provided by a transfer valve which is displaced in response to the attainment of a predetermined back pressure in the primary chamber to uncover flow paths to the secondary fuel inlet chamber.

In operation of this nozzle the sphere 48 promotes turbulence in the fuel stream going to slot 45 for low flow rates. For higher flow rates when the fuel flow additionally passes through the secondary flow path, the primary spherical tip 44 acts to promote turbulence in the secondary spherical chamber 66 at the inlet to slot 65. This utilizes the same principle applied to the primary

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slot to increase the atomization of the secondary slot.

For even greater atomization an outer air shroud 82 may be used to surround sleeve 68 and secondary tip 64. The shroud 82 has an elongated slot 84 coincident with slots 65 and 45. This enables transfer of energy from the air to the fuel flowing from the nozzle and increase turbulence.

In another embodiment, air may be utilized in the secondary flow path instead of fuel. By utilizing an air flow in the secondary path the minimum flow rate from the primary nozzle can be substantially reduced because the energy transfer from pressurized air in the secondary flow path to the fuel discharged from the primary slot increases turbulence and promotes effective atomization.

FIGS. 6 and 7 illustrate still another embodiment of the present invention. A spherical tip 88 having a flange 90 is positioned in an outer sleeve 86. A central retaining disc 92 is held within sleeve 86 by a threaded sleeve 93 to maintain flange 90 against a shoulder 94 of sleeve 86. A central passage 96 in disc 92 leads from an inlet chamber 98 to a generally spherical chamber 100 coaxial with the sleeve 86. An elongated slot 102, formed in the spherical tip 88, extends from an arcuate periphery to a straight slotlike orifice 104 forming the outlet for chamber 100.

A bar 106 having a circular cross section is positioned in chamber 100 with its longitudinal axis parallel to the longitudinal axis of orifice 104. The bar 106 is adjustably positioned toward and away from slotlike orifice 104 by means of rods 108, 110 that are threaded into the central discs 92 and have flanged ends 112, 114, respectively received in slots 116, 118 in the ends of bar 106. The position of the shafts 108, 110 and the bar 106 relative to slot 104 are varied by turning shafts 108, 110 through a tool (not shown) received in slots 120, 112, respectively.

The fuel flow in this nozzle passes from inlet chamber 98 through passage 96 to chamber 100. In that chamber the flow is divided into separate streams by bar 106 and the streams are directed against one another along the inlet of slotlike orifice 104. This causes an increase in turbulence and permits the fuel to be discharged from the outlet of slot 102 in a flat spray pattern. The ends of bar 106 are adjusted by turning bars 108, 110 to vary the distribution of fuel in the path to obtain a correct fuel pattern for the desired application. It should be apparent to those skilled in the art that forms other than the straight cylindrical form may be employed for bar 106 to achieve different spray distribution characteristics.

While preferred forms of the present invention have been described, it should be apparent to those skilled in the art that fuel nozzles may be employed that are different from those shown without departing from the spirit and scope of the present invention.

Having thus described the invention, what is claimed as novel and desired to be secured by Letters Patent of the United States is:

1. A fuel nozzle comprising:

a nozzle body with a fuel flow path therethrough having an inlet for receiving pressurized fuel and an outlet for discharge of fuel from said nozzle body in a spray pattern;

said nozzle body including a generally spherical top at the outlet end thereof and a generally spherical chamber within said tip, said spherical tip having an elongated slot extending outward from said spherical chamber, whereby fuel is discharged in a flat spray pattern;

a bar having a circular cross-section positioned within said chamber with its longitudinal axis parallel to the longitudinal axis of said slot for dividing the fuel flow into separate streams and directing the streams against one another adjacent said slot thereby maximizing turbulence and atomization of the fuel, said bar being adjustably positioned toward and away from said slot at a given position thereby producing

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a predetermined distribution of fuel discharged from said nozzle.

2. A fuel nozzle comprising:

a nozzle body with a fuel flow path therethrough having an inlet for receiving pressurized fuel and an outlet for discharge of fuel from said nozzle body in a spray pattern, said nozzle body including a first generally spherical tip at the outlet end thereof and a first generally spherical chamber within said tip, said spherical tip having an elongated slot extending outward from said spherical chamber whereby fuel is discharged in a flat spray pattern;

a sphere positioned in said first generally spherical chamber adjacent the slot in said first tip whereby said sphere promotes turbulence adjacent said slot;

a second generally spherical tip having a generally spherical chamber surrounding said first tip and having an elongated slot formed therethrough coincident with the slot in said first tip, thereby forming a second outlet for discharge of fuel from said nozzle; said first chamber being supplied with fuel for low fuel flow rates and both said first and second chambers being supplied with fuel for high fuel flow rates whereby the first tip promotes turbulence adjacent the slot in said second tip.

3. A fuel nozzle as in claim 2 further comprising a third generally spherical tip having a third generally spherical chamber surrounding said first and second tips and having a slot coincident with said first and second slots, said third spherical chamber being supplied with pressurized air whereby the atomization of said nozzle spray is further enhanced.

4. A fuel nozzle comprising:

a nozzle body with a fuel flow path therethrough having an inlet for receiving pressurized fuel and an outlet for discharge of fuel from said nozzle body in a spray pattern;

said nozzle body including a generally spherical tip at the outlet end thereof and a generally spherical chamber within said tip, said spherical tip having

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an elongated slot extending outward from said spherical chamber, whereby fuel is discharged in a flat spray pattern;

a bar positioned within said chamber with its longitudinal axis parallel to the longitudinal axis of said slot for diving the fuel flow into separate streams and directing the streams against one another adjacent said slot thereby maximizing turbulence and atomization of the fuel;

means for adjustably positioning said bar at a given position relative to said slot thereby producing a predetermined distribution of fuel discharged from said nozzle.

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U.S. Cl. X.R.

239—424, 456, 590, 597

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,702,175 Dated November 7, 1972

Inventor(s) Sidney C. Watkins

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 45, after "present" insert -- invention -- .

Col. 3, line 59, "secondray" should read -- secondary -- .

Col. 4, line 62 (Claim 1), "top" should read -- tip -- .

Col. 6, line 6 (Claim 4), "diving" should read -- dividing -- .

Signed and sealed this 8th day of May 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents