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AIR ASSISTED FUEL NOZZLE

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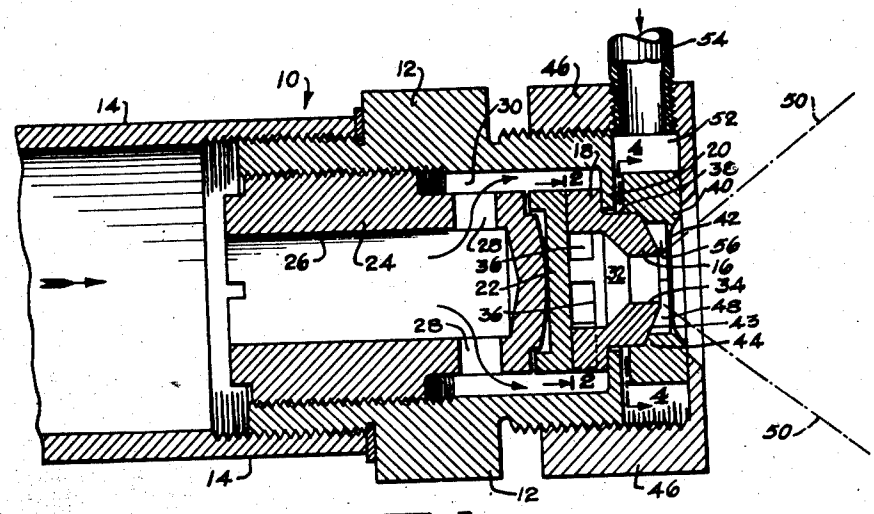


FIG. 1

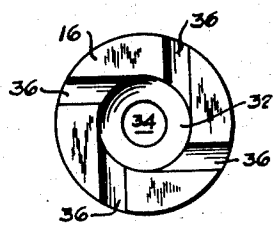


FIG. 2

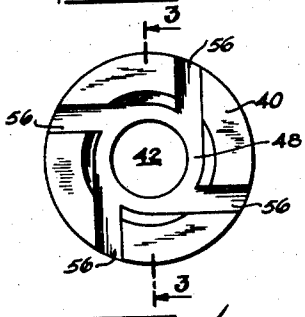


FIG. 4

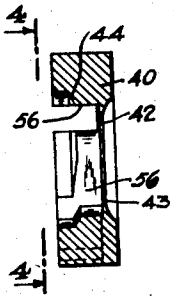


FIG. 3

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AIR ASSISTED FUEL NOZZLE

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4 Claims. (Cl. 299—114)

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This invention relates to liquid fuel nozzles and is particularly directed to a liquid fuel nozzle in which air or some other gas is used to help atomize the liquid fuel as said fuel discharges from the nozzle.

In conventional liquid fuel nozles, fuel is introduced into a chamber in the nozzle through passages substantially tangential to the periphery of said chamber and from this chamber the fuel discharges through a small orifice in the nozzle. This tangential arrangement of the nozzle fuel passages causes the fuel to whirl or rotate as it flows through the nozzle discharge orifice. Because of its whirling and axial motion relative to the nozzle, the fuel discharges from the nozzle in a hollow conical spray pattern thereby producing atomization of the fuel. That is, the spreading of the fuel into a hollow conical pattern, as well as the friction between the fuel and the surrounding air, causes the fuel to be broken up into small droplets or a fine mist. Where, as in a gas turbine, the fuel nozzles must supply fuel over a wide range of flow rates the fuel pressure must be quite low at low fuel flows otherwise excessive fuel pressures are required at high fuel flows. Thus, if the fuel flow range is from 5 to 100 pounds of fuel per hour, the range of fuel pressure is approximately 1 to 400. As a result, at low fuel flows the magnitude of the fuel discharge velocity is insufficient to cause good atomization of the fuel.

In order to increase the atomization of the liquid fuel discharging from a nozzle, particularly at low fuel flows, it has already been proposed to introduce air or some other gas into the nozzle for mixture with the fuel discharging from the nozzle so as to help atomize said fuel. In this connection attention is directed to copending application Serial No. 782,162, filed November 25, 1947. An object of the present invention comprises the provision of a novel fuel nozzle having a passage for a gas to be discharged from the nozzle so as to help atomize the fuel, particularly at low fuel flows. A further object of the invention resides in the improvement of such a nozzle whereby the atomizing gas has little or no affect on the rate at which fuel discharges from its nozzle. In accordance with the present invention, in each nozzle the liquid fuel passages and the atomization assisting gas passages are isolated from each other so that the fuel does not oppose the flow of the atomizing gas or tend to enter the passages for said gas and the atomizing gas does not oppose the fuel flow or tend to enter the nozzle fuel passages.

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In gas turbine engines fuel is supplied to the engine combustion chamber through a plurality of fuel nozzles. For efficient operation it is essential that all the nozzles of a given engine deliver fuel at equal rates of flow. Small variations in dimensions and finish of the liquid flow passages in a nozzle have considerable affect on the fuel flow characteristics of the nozzle. Unless the nozzles are made with a high degree of precision, the flow characteristics of nozzles made to the same specification will vary to such an extent, because of manufacturing tolerances, that the nozzles for a given engine must be matched for substantially similar flow characteristics. This matching involves testing a large group of nozzles and then segregating the nozzles into groups such that the flow characteristics of the nozzles of each group are substantially the same. The nozzles for any one engine are then taken from only one of said groups.

In the prior designs of fuel nozzles employing air or other gases for assisting the atomization of the fuel, the atomizing gas modified the fuel flow characteristics of the nozzle. Accordingly when such fuel nozzles are matched so as to obtain groups with substantially similar flow characteristics, they must be matched both with and without the atomization assisting gas. This makes the problem of obtaining matched fuel nozzles quite difficult. A still further object of this invention comprises the provision of a gas assisting fuel nozzle in which the atomization assisting gas has little or no affect on the fuel flow characteristics of the nozzle thereby minimizing the aforementioned added difficulties of obtaining matched groups of such nozzles.

Other objects of the invention will become apparent upon reading the annexed detailed description in connection with the drawing, in which:

Figure 1 is an enlarged axial sectional view of a nozzle embodying the invention;

Figure 2 is a view taken along line 2—2 of Figure 1;

Figure 3 is a sectional view, taken along line 3—3 of Figure 4, of the member having the swirl passages for the atomization assisting gas; and

Figure 4 is an end view of the member illustrated in Figure 3 and taken along line 4—4 of Figures 1 and 3.

Referring to the drawing, a fuel nozzle 10 comprises a hollow body member 12 adapted to be threadedly secured at one end to a fuel conduit 14. The other end of the body member 12 is provided with an opening through which an ori-

fice member 16 projects. The orifice member 16 has an external flange 18 which is held against an internal shoulder 20 on the body member 12 by means of an intermediate member 22 and a nut 24 threadedly secured within the body member 12. The nut 24 has a bore 26 communicating at one end with the fuel conduit 14. A plurality of radial holes 28 in the nut 24 connect its bore 26 with an annular space 30 within the nozzle.

The nozzle orifice member 16 is formed to provide a cylindrical chamber 32 between it and the adjacent intermediate member 22. The orifice member 16 forms an end wall of said chamber 32 and an orifice 34 extending through said end wall co-axially with said chamber has a diameter smaller than that of said chamber to form a restricted discharge orifice for said chamber. The surface of the orifice member 16 adjacent to the intermediate member 22 is provided with a plurality or circumferentially spaced grooves 36 extending inwardly from communication with the annular space 30 at the periphery of the member 16. Each of the grooves 36 opens into the chamber 32 at the cylindrical periphery of said chamber in a direction substantially tangent to said periphery, as best seen in Figure 2.

With this construction when liquid fuel is supplied through the conduit 14, it flows through the bore 26 and the holes 28 into the annular space 30. From the annular space 30 said fuel flows through the tangential grooves or passages 36 into the chamber 32. Because of the tangential disposition of the passages 36, a whirling motion is imparted to the fuel within the chamber 32 about the axis of said chamber and its orifice 34. This whirling or rotational motion of the fuel continues as it flows through the discharge orifice 34. Therefore, upon discharging from the orifice 34, the fuel has radial and axial components of velocity whereby the fuel forms a hollow conical spray jet. The fuel nozzle structure so far described is conventional.

In order to help atomize the liquid fuel, particularly at low rates of fuel flow, means are provided for discharging air or some other gas with the fuel so as to help atomize the fuel. For this purpose the orifice member 16 has an external cylindrical surface 38 projecting beyond the nozzle body member 12. A second orifice member 40 is provided with a cylindrical surface having a snug fit over said cylindrical surface 38 so as to accurately center the orifice member 40 relative to the orifice 34. The second orifice member 40 has an opening or orifice 42 extending through its end wall 43 co-axially with the orifice 34. In addition the second orifice member 40 has an annular shoulder 44 and a nut 46 is threaded on the nozzle body member 12 to axially clamp said shoulder 44 against the orifice member 16, thereby securing the orifice member 40 to the nozzle 10. The end wall 43 of the orifice member 40 is axially spaced from the end wall of the orifice member 16 through which the orifice 34 extends thereby forming a cylindrical chamber 48 between said end walls. The orifice 42 has a diameter smaller than that of the chamber 48 so as to constitute a restricted discharge orifice for said chamber. The restricted orifice 42 is sufficiently larger than the restricted orifice 34 so as not to interfere with the fuel spray jet 50 discharging from the orifice 34. Thus, as illustrated in Figure 1, the fuel spray jet 50 passes through the orifice 42 in clearance relation thereto. In a particular fuel nozzle in which the orifice 34 had a diameter of approximately 0.092" with its fuel spray jet having a cone angle of approximately 80°, it was found satisfactory to make the diameter of the orifice 42 equal to approximately 0.15" with the orifice 42 disposed so as to clear the fuel spray jet. In connection with these nozzle dimensions it should be noted that the scale of the drawing is approximately four times full size.

An annular space 52 is formed about the orifice member 40 between said member and the nut 46. Air or some other gas is arranged to be supplied to this annular space through a conduit 54. The orifice member 40 is provided with a plurality of circumferentially spaced grooves 56 in its surface adjacent to the orifice member 16. The grooves 56 extend inwardly from communication with the annular space 52 at the periphery of the orifice member 40. In addition, each of the grooves 56 opens into the chamber 48 at the cylindrical periphery of said chamber in a direction substantially tangent to said periphery. With the arrangement illustrated, when air or other gas is supplied to the chamber 48 through the tangential passages 56, a whirling motion is imparted to said gas in the same rotative direction as the fuel. This whirling gas discharges from the chamber 48 through its restricted orifice 42 around the fuel also discharging therethrough from the orifice 34 thereby helping to atomize said fuel by adding to its axial and radial components of velocity. In addition some of the atomization of the fuel probably results from the shearing action on the fuel of the gas discharging around the fuel spray jet.

As already stated the orifice 42 should be so disposed and have such a diameter that the fuel jet passes through said orifice in clearance relation. For efficient use of the atomizing gas, the orifice 42 should have as small a diameter as possible and still provide an adequate flow passage for said gas between the end wall 43 and the adjacent wall of the orifice member 16. In addition the portion of the downstream surface of the end wall 43 adjacent to the orifice 42 preferably is substantially perpendicular to the axis of said orifice and forms a sharp edge with the minimum diameter portion of said orifice so as to minimize any tendency for the atomizing gas to cling to said wall surface as it discharges from the nozzle.

When the atomization assisting gas supplied to the nozzle 10 is shut off the orifice 42 and its chamber 48 obviously have no effect on the fuel flow characteristics of the nozzle since the fuel discharging from the orifice 34 passes through the orifice 42 in clearance relation thereto. When gas is supplied to the nozzle 10 for assisting in the atomization of the fuel, the atomizing gas contacts the fuel only after said fuel has discharged from the nozzle orifice 34, the larger nozzle orifice 42 offering no restraint to the fuel spray jet. Accordingly, the atomization assisting gas does not affect the fuel flow characteristics of the nozzle. Furthermore since the orifice 42 is sufficiently larger than the orifice 34 such that the fuel spray jet passes through the orifice 42 in clearance relation thereto, the fuel does not tend to enter the atomizing gas passages whether sad gas is or is not being used. In addition, because the orifice 42 is substantially larger than the orifice 34, the atomizing gas does not tend to enter the fuel passages of the nozzle.

It is quite important that the orifices 34 and 42 be accurately alined in order not to disturb the symmetry of the fuel spray jet when the atomizing gas is used and for efficient use of

said gas in helping to atomize the fuel. With the above described construction, this alinement is obtained simply by accurately centering the cylindrical surface 38 on the orifice member 16 and the mating cylindrical surface on the orifice member 40 relative to their respective orifices 34 and 42.

The whirling air or other gas discharging through the orifice 42 adds to the axial and radial components of the fuel discharging therethrough. Accordingly the atomization assisting gas can be used to vary the ratio of the radial and axial components of the fuel velocity thereby controlling the cone angle of the fuel spray jet. Thus, if the atomization assisting gas increases the ratio of the radial component of the fuel velocity to its axial component, the cone angle of the fuel spray jet would be increased upon use of said gas. Similarly if the atomization assisting gas decreases this ratio, the cone angle of the spray jet would be decreased when said gas was used. Whether the atomization assisting gas increases or decreases the ratio of the radial component of the fuel velocity to its axial component depends on the relative magnitudes of the axial velocity of said gas flowing through the orifice 42 and its rotational velocity. This in turn depends on the relative sizes of the orifice 42 and the cross-sectional area of the tangential passages 56. Thus, for a given size restricted orifice 42, if the cross-sectional area of the tangential passages 56 is decreased, then the rotational velocity of the gas in the chamber 48 is increased relative to its axial velocity.

The nozzle of the present invention has been described as a fuel nozzle for supplying fuel to the combustion chamber of an engine such as a gas turbine. It should be apparent, however, that the nozzle of the present invention is not limited to this particular use but such a nozzle can be used for discharging or spraying other fluids.

While we have described our invention in detail in its present preferred embodiment, it will be obvious to those skilled in the art, after understanding our invention, that various changes and modifications may be made therein without departing from the spirit or scope thereof. We aim in the appended claims to cover all such modifications.

We claim as our invention:

1. A liquid spray nozzle having a first chamber therein, said chamber having a wall with an opening therethrough forming a first restricted orifice; means for supplying a liquid to said first chamber for whirling motion in said first chamber about the axis of its orifice whereby said liquid discharges through said orifice in a diverging jet, said wall having an external cylindrical surface co-axial with said first orifice; a member having an internal cylindrical surface fitted over said external cylindrical surface and having a shoulder engaging the outer surface of said wall and also having a wall spaced downstream from said first-mentioned wall to form a chamber between said walls, said second-mentioned wall having an opening therethrough forming a second restricted orifice co-axial with and larger than said first orifice; means for supplying a gas to said second-mentioned chamber, said gas discharging through said second orifice with said jet to help atomize the liquid in said jet; and means carried by said nozzle and engaging said member for holding its said shoulder in engagement with the outer surface of said first mentioned wall.

2. A liquid spray nozzle having a first chamber therein, said chamber having a wall with an opening therethrough forming a first restricted orifice; means for suppyling a liquid to said first chamber for whirling motion in said first chamber about the axis of its orifice whereby said liquid discharges through said orifice in a diverging jet, said wall having an external cylindrical surface co-axial with said first orifice; a member having an internal cylindrical surface fitted over said external cylindrical surface and having a shoulder engaging the outer surface of said wall and also having a wall spaced downstream from said first-mentioned wall to form a chamber between said walls, said second-mentioned wall having an opening therethrough forming a second restricted orifice co-axial with and larger than said first orifice, the portion of the downstream surface of said second-mentioned wall forming a sharp edge with the minimum diameter portion of said second orifice; means for supplying a gas to said second-mentioned chamber, said gas discharging through said second orifice with said jet to help atomize liquid in said jet; and means carried by said nozzle and engaging said member for holding its said shoulder in engagement with the outer surface of said first mentioned wall.

3. A liquid spray nozzle having a first chamber therein, said chamber having a wall with an opening therethrough forming a first restricted orifice; means for supplying a liquid to said first chamber for whirling motion in said first chamber about the axis of its orifice whereby said liquid discharges through said orifice in a diverging jet, said wall having an external cylindrical surface co-axial with said first orifice; a member having an internal cylindrical surface fitted over said external cylindrical surface and having a shoulder engaging the outer surface of said wall and also having a wall spaced downstream from said first-mentioned wall to form a chamber between said walls, said second-mentioned wall having an opening therethrough forming a second restricted orifice co-axial with said first orifice, said second orifice being sufficiently larger than said first orifice such that said jet passes through said second orifice in clearance relation thereto; means for supplying a gas to said second-mentioned chamber, said gas discharging through said second orifice with said jet so as to help atomize the liquid in said jet; and means carried by said nozzle and engaging said member for holding its said shoulder in engagement with the outer surface of said first mentioned wall.

4. A liquid spray nozzle having a first chamber therein; a first passageway communicating with said chamber for suppyling a liquid thereto; an opening through a wall of said chamber forming a first restricted orifice, said first passageway being so directed relative to said first chamber that said liquid is given a whirling motion in said chamber about the axis of its orifice whereby said liquid discharges through said orifice in a diverging jet, said wall having an external cylindrical surface co-axial with said orifice; a member having an internal cylindrical surface fitted over said external cylindrical surface and having a shoulder engaging the outer surface of said wall and also having a wall spaced downstream from said first-mentioned wall to form a second chamber between said walls, said second-mentioned wall having an opening therethrough

forming a second restricted orifice co-axial with said first orifice, the portion of the downstream surface of said second-mentioned wall forming a sharp edge with the minimum diameter portion of said second orifice and said second orifice being sufficiently larger than said first orifice such that said jet passes through said second orifice in clearance relation thereto; a second passageway communicating with said second chamber for supplying a gas thereto about said jet, said second passageway being so directed relative to said second chamber that said gas is given a whirling motion in said second chamber about the axis of said second orifice in the same rotative direction as said first-mentioned whirling motion, said gas discharging through said second orifice with said jet so as to help atomize the liquid in said jet; and means carried by said nozzle and engaging

said member for holding its said shoulder in engagement with the outer surface of said first mentioned wall.

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