July 28, 1970 R. L. WILCOX 3,521,824

AIR-LIQUID FLAT SPRAY NOZZLE

Filed Oct. 11, 1968

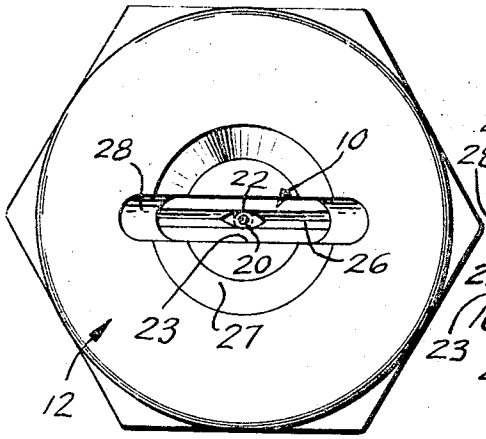


Fig. 2.

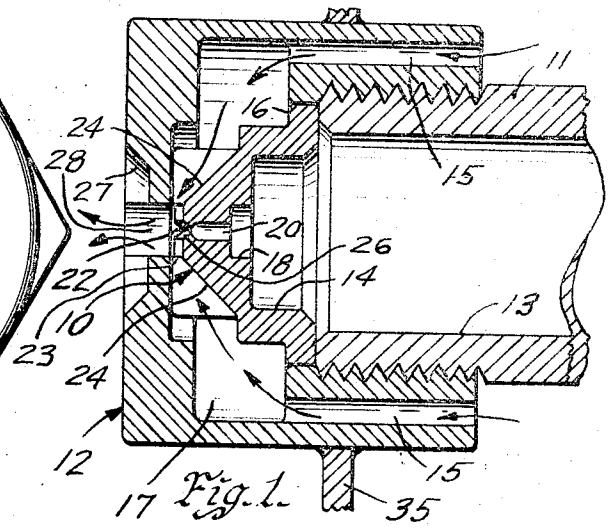


Fig. 1.

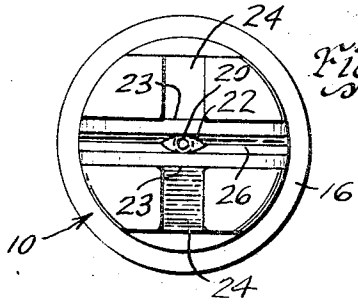


Fig. 3.

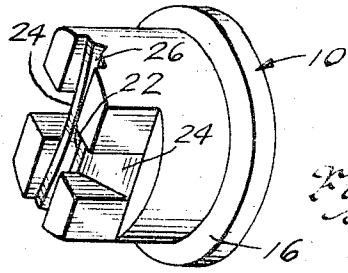
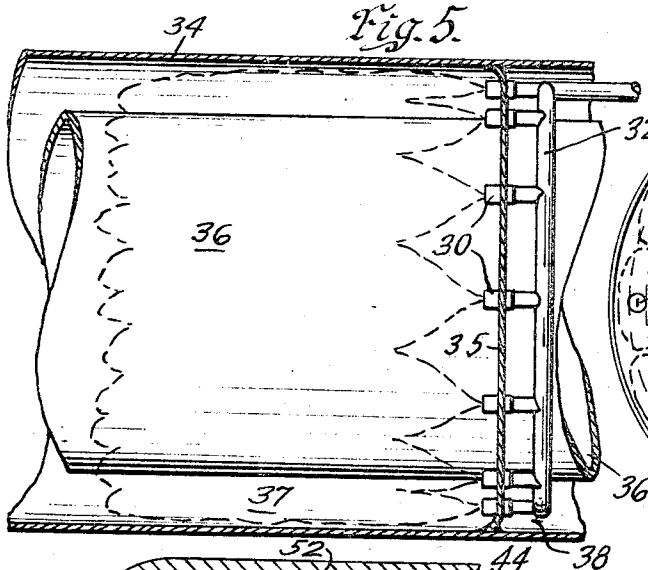


Fig. 4.

Fig. 5.



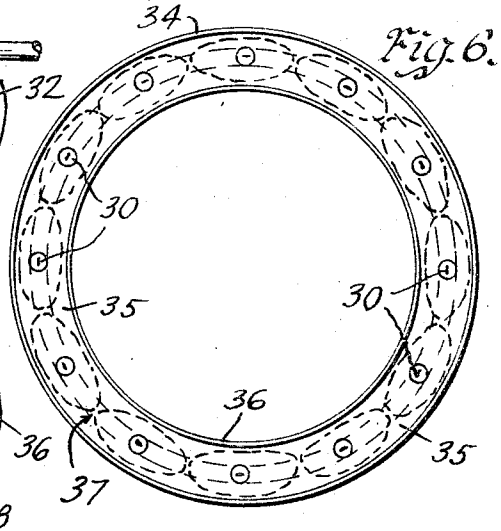


Fig. 6.

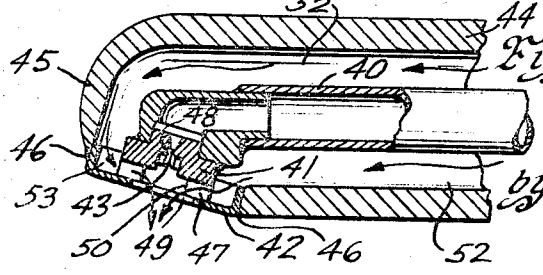


Fig. 7.

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3,521,824

AIR-LIQUID FLAT SPRAY NOZZLE

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Filed Oct. 11, 1968, Ser. No. 766,675
Int. Cl. B05b 7/06
U.S. Cl. 239—424.5 4 Claims

ABSTRACT OF THE DISCLOSURE

An air-liquid spray nozzle which emits a sheet of liquid through an elongated orifice or slit and has a pair of air discharge slots wider than the length of the slit for causing air to flow against the sides of the sheet to atomize the liquid. The nozzle is capable of providing a fine spray at flow rates at the lower end of the volume flow range with very low pressure air.

This invention relates to an air-liquid atomizing nozzle which produces a flat spray pattern at high liquid flow rates and low air pressures. The nozzles find particular use in jet engines, but also may be used in other applications where a flat spray pattern is desired with good atomization at low flow rates.

Nozzles presently used to atomize kerosene-type fuels for jet aircraft engines do not atomize as effectively at low flow rates as at higher flow rates. By "low flow" rates is meant flow volumes at the lower end of the rated capacity range. For example, when the engine is being started or when it is idling on the ground, the flow of fuel through one nozzle might be as little as two to five pounds per hour. At such times the air pressure generated by the engine is also low. As a result, the fuel is discharged from the nozzle in relatively large liquid particles or may even be a stream which is unbroken. When engines are operated at very low temperatures, say, —65° F., the viscosity of the fuel increases markedly and the problem of atomization is aggravated. It takes much more work or energy to break up a viscous stream.

Nozzles used at the present time in jet aircraft engines have a round liquid discharge orifice, an annular air jet, and emit a conical spray. This pattern is disadvantageous because it does not complement the shape of the combustion chamber into which the atomized fuel is discharged. In jet engines this chamber is annular and where a series of nozzles are mounted on the circumference of a circle in the annulus, the cone spray concentrates the fuel at the walls of the combustion chamber. A flat spray, on the other hand, conforms more closley to the shape of the chamber and provides more uniform distribution of the liquid particles within the space. For this reason, the flat spray pattern is more desirable.

Air liquid atomizing nozzles which produce a relatively flat spray pattern have been disclosed heretofore, as, for example, in Nieburg Pat. 2,569,251. Such nozzles operate efficiently only with high air pressure. The necessary pressure is achieved only with an expensive compressor. They will not operate, for example, on the low pressures available in a jet engine from compressor discharge. Nozzles which produce a flat spray pattern without any atomizing air are also well known, but these require very high liquid pressures at high liquid flow rates when designed to produce good atomization at low flow rates.

If such nozzles are to operate effectively at lower flow rates, the size of the orifice must be greatly reduced so that its minimum dimensions are reduced to less than .015" or .020". In this range the nozzle plugs up. Such plugging may be obviated by passing the liquid through expensive filtering equipment, but this is not practical for most applications.

A primary object of this invention is to provide a nozzle construction which emits a flat spray pattern, that is, one which is wider than it is thick and which at the same time provides good atomization at very low flow rates without using high pressure air for atomization. The width to thickness ratio of the spray may be 2:1. In a preferred form of the invention, the liquid is discharged through an elongated orifice or slit so that it emerges as a sheet, which is then broken up by two streams of air discharged from slots wider than the length of the elongated liquid orifice. I have discovered that by discharging liquid in a sheet and subjecting it to a stream of air on either side of the sheet at point of discharge, efficient atomization is effected at extremely low air pressures.

These and other objects of my invention will become clear from the following description when read in conjunction with the drawings in which

FIG. 1 is a longitudinal sectional view through a nozzle constructed in accordance with my invention;

FIG. 2 is an end view of the cap that fits over the orifice tip of the nozzle;

FIG. 3 is an end view of the nozzle tip;

FIG. 4 is a perspective view of the nozzle tip;

FIG. 5 is a side view in section showing nozzles disposed in the annular combustion space of a jet engine;

FIG. 6 is an end view of the combustion chamber shown in FIG. 4; and

FIG. 7 is a sectional axial view through a modified form of the invention.

Referring now to FIGS. 1–4, the nozzle has a tubular body member **11** terminating at one end in a cylindrical tip **10** which, for convenience, may be fabricated separately from the tubular member **11**. The tip **10** has a flange **16** which seats on the end of the tube **11** and is held in place by means of a cap **12** which screws on to the end of the tube **11**.

The interior of the tip **10** has a series of concentric bores **14**, **18**, and **20** of decreasing diameter. A groove **26** is cut in the face of the tip so that the bottom thereof is just slightly spaced from the dome-shaped bottom of the bore **20**. An elongated orifice **22** is cut through the bottom of the groove **26** so that it communicates with the interior of the bore **20**. The elongated orifice **22** is designed to shape the liquid stream into a sheet. It may be elliptical in shape or ti may have parallel side walls joined in curved ends, depending upon the instrument used to cut the orifice. The bore **20**, of course, must be of greater dimension than the length of orifice **22**.

A pair of radially-extending slots **24** are cut in the face of the tip at right angles to the axis of the discharge orifice **22**. The center line of the slots coincides with the center of the orifice and the width of the slots **24** is at least as wide as the orifice is long. In the form shown in FIGS. 1–3, slots **24** have inclined bottoms sloping toward the orifice at an acute angle from the nozzle axis. The cap **12** closes over the top of the slots so as to provide passageways having rectangular discharge orifices **23** for

supplying atomizing air to the end of the tip at the point where the liquid emerges from the groove **26**. The cap contains passageways **15** and **17** which serve as conduit means for bringing air under pressure to the slots **24**. The cap **12** has a dished face **27** and an elongated slot **26** of larger length and width dimensions than the orifice **22**. There is nothing critical about the size of the opening **26** so long as it permits the diverging sheet of liquid to flow freely from the end of the nozzle without obstruction. Also, the cap should not confine the liquid and air or have a metering effect on the combined fluids since the mixing should take place externally without confinement.

Nozzles of this construction are well adapted for use in jet aircraft engines as illustrated in FIGS. 5 and 6 of the drawing. The nozzles of the invention are designated by the numeral **30** in these figures and are mounted on the circumference of a circle in the wall **35** forming the end of the combustion chamber. A circular tube **32** constitutes a manifold through which liquid is fed to each of the nozzles **30** connected thereto. The combustion chamber has a cylindrical outer wall **34** and a cylindrical inner wall **36** to provide an annular combustion chamber **37**. The discharge ends of the nozzles project through the wall **35** into chamber **37**. The posterior of the nozzles is disposed within the chamber **38** which is maintained at elevated pressure by compressed air from the compressor discharge of the engine. The pressure will range from very slight positive pressure to a maximum of about 3 pounds per square inch at full throttle. This is the pressure which must be used to atomize the liquid spray. The compressed air from chamber **38** flows through the conduit **15** of the nozzle cap and out the slots **24**.

The flat spray emitted by the nozzles complements well the annular space in which the nozzles are mounted to provide uniform distribution of the fuel particles in the combustion chamber. Nozzles which produce a conical spray pattern cause the liquid spray to be concentrated on the sides of the chamber since the spray must be sufficiently great in diameter to overlap the spray from adjoining nozzles on either side. In contrast, the nozzle which emits a flat spray fills substantially the entire space assigned to it, thus providing uniform distribution of liquid particles within the chamber **37**.

It will be understood that nozzles of different liquid flow capacities can be constructed in accordance with this invention. Whatever the capacity of the nozzle, the difficulty with atomization occurs at the lower end of the flow range. For example, a conventional conical-pattern nozzle which is designed to spray up to 250–300 pounds per hour will show inferior atomization or no atomization at all at flow rates of 8 to 10 pounds per hour unless relatively high pressure air, say, 0.5 p.s.i. is used to break up the stream. Tests on a nozzle of this capacity constructed in accordance with this invention produced a flat sheet of liquid at a flow rate of 8 pounds per hour. Air at a pressure of 0.072 pound per square inch discharged through the slots **24** converted the sheet into a fine particle sized spray. Nozzles designed for spraying 45 pounds per hour will operate satisfactorily at 2 to 3 pounds per hour and 0.05 p.s.i. air pressure. Atomization of this kind greatly facilitates starting engines during which period the flow rate is low and the air pressure is low. With fuel of higher viscosity (when operating at low temperatures), the pressure must be increased to obtain fine atomization, but a great improvement was noted even at pressures less than 0.1 p.s.i. Conventional nozzles will not operate at these pressures.

As the liquid pressure increases to, say, 10–20 p.s.i., with a corresponding increase in volume of liquid discharged, the fan pattern of the spray widens and becomes thicker, although the width is still greater than twice the thickness. At these higher flow rates and pressures, the effect of the air is not as marked since atomization does occur solely by forcing the liquid through the

elongated orifice. Addition of air, however, does result in more finely subdivided particles.

I have found that if the air is directed to impinge against the liquid sheet or spray downstream of the orifice end, it results in a division of the spray and inferior atomization. It is important that the air be directed at the stream as it emerges from the orifice. At this point, although the air is not confined, external mixing readily takes place with efficient atomization.

The nozzle of the invention appears to operate successfully at low air pressure because a thin sheet of liquid requires much less energy to atomize than a cylindrical stream. Surface tension seems to form a protective layer around the cylindrical stream which is difficult to penetrate. This is not true of a thin sheet.

FIG. 7 shows a modified form of the invention in which the nozzle tip **41** is disposed at an angle to the cylindrical body **44** of the nozzle. In this construction, tip **41** is brazed to a central liquid conduit **40** within body **44**. The cap **42** is brazed to the turned end **45** of body **44** as indicated at **46**. Thus, this nozzle is of integral, unitary construction and finds use where the spray must be directed at an angle to the axis of the nozzle body and the conduits leading thereto. Tip **41** differs from tip **10** in that the slots **47** are normal to the plane of the liquid sheet or stream, rather than at an acute angle as are slots **24**. Also, the cap **42** has an elongated opening **49** which is relatively larger than the opening **26** and terminates short of the sides **50** of the slots **47**. Air is fed through annulus **52** and flows through passages **53** and slots **47** to the end of the tip **41**. The orifice **43** is like the orifice **22** and is cut through the bottom of groove **48** cut across the face of the tip **41**. The air discharge ports at the end of slots **47** are wider than the length of the elongated orifice **43** and serve to bring atomizing air to the liquid as it emerges from the end of the tip. This nozzle operates in similar fashion to the one described in FIGS. 1–4.

Other modifications will occur to those skilled in the art without departing from the principles of the invention illustrated by the constructions shown in the drawings.

What I claim is:

1. A spray nozzle for atomizing liquids comprising a cylindrical body member, an orifice tip for said body member having a groove extending across the face thereof, an elongated orifice cut through the bottom of said groove for discharging liquid therefrom in a flat spray pattern, conduit means for supplying liquid to said orifice, a pair of generally radially-extending slots disposed in said face at right angles to the axis of said elongated orifice and terminating at said grooves on opposed sides of said orifice, said slots being at least as wide as the length of said elongated orifice, a cap enclosing the end of said body and said tip, an elongated opening through said cap having its axis parallel to the axis of said orifice, said opening being longer and wider than said orifice, and passages in said cap for conducting air to said slots, whereby a flat thin stream of liquid emitted from said orifice is atomized by streams of low pressure air discharged from said slots.

2. A nozzle for atomizing liquids comprising a hollow body having an elongated orifice in the end thereof for discharging liquid in a flat spray pattern, conduit means for supplying liquid to said orifice, a cap member disposed over said one end of said body and having an opening therethrough larger in dimensions than said orifice to permit liquid from said orifice to pass therethrough, a pair of radial slots defined by said cap and body for conducting atomizing air to opposed sides of a liquid stream discharged from said orifice, said slots being wider than the length of said orifice and disposed at right angles to the axis of said orifice, and conduit means for supplying compressed air to said slots, whereby atomizing of the liquid occurs immediately upon discharge from said orifice externally of said nozzle.

3. The nozzle of claim 2 in which said elongated orifice is elliptical in shape.

4. The nozzle of claim 1 in which said body tip and cap are integrally connected to provide a unitary structure.

References Cited

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EVERETT W. KIRBY, Primary Examiner

U.S. Cl. X.R.

239—299, 519, 597, 601

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,521,824 Dated July 28, 1970

Inventor(s) Richard L. Wilcox

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

In the Specification:

Page 1, col. 2, line 53, "ti" has been corrected to

-- it --.

In the Drawing:

In FIGS. 2 and 3 the large elongated elliptical orifice 22 has been reduced in size such that its major axis falls within the confines of the dotted circle, which is bore 20 shown in FIG. 1, and this smaller elliptical orifice has taken the place of the concentric solid circle which appeared within the dotted circle in FIG. 2 and 3.

In addition, in FIGS. 2 and 3, the lead line of reference numeral "20" has been dotted and directed to the dotted circle and the lead line of reference numeral "22" in FIGS. 2 and 3 has been directed to the reduced elliptical orifice 22 as herein amended.

Finally in FIGS. 2 and 3, the bottom and the shading of the V-shaped groove 26 adjacent the reduced sized elliptical orifice 22

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PO-1050
(5/69)

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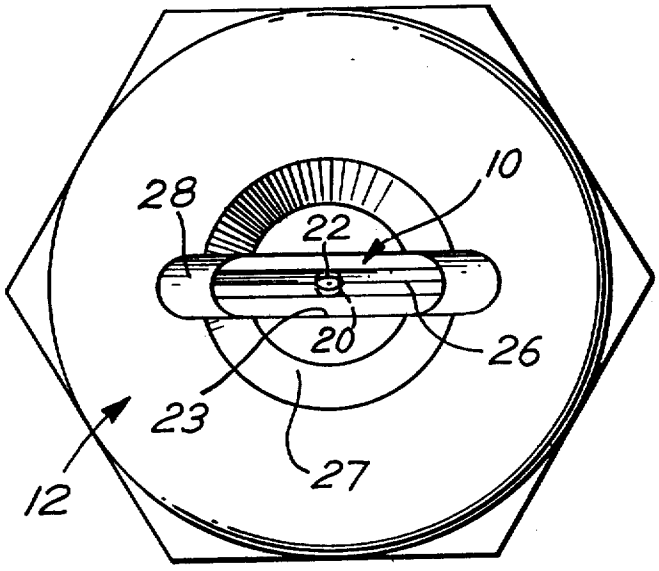


Fig. 2.

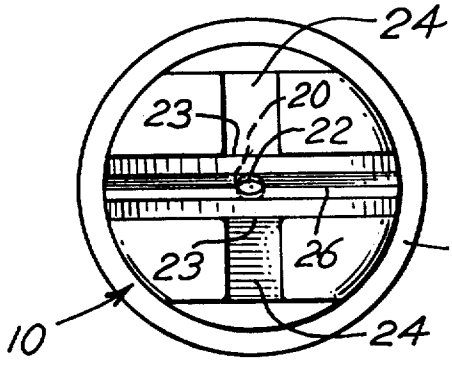


Fig. 3.

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(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,521,824 Dated July 28, 1970

Inventor(s) Richard L. Wilcox

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

has been extended to the periphery of the reduced orifice.

[See revised drawings attached hereto].

In the Claims:

Claim 1, line 50, "grooves" has been corrected to -- groove --.

Claim 1, line 53, after "body" -- member -- has been inserted.

Signed and sealed this 30th day of November 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents

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