April 29, 1969 D. J. LAPERA 3,441,223

NOZZLE

Filed March 8, 1967

FIG. 1

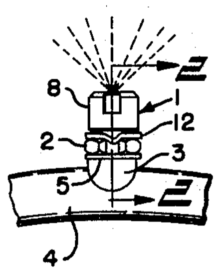
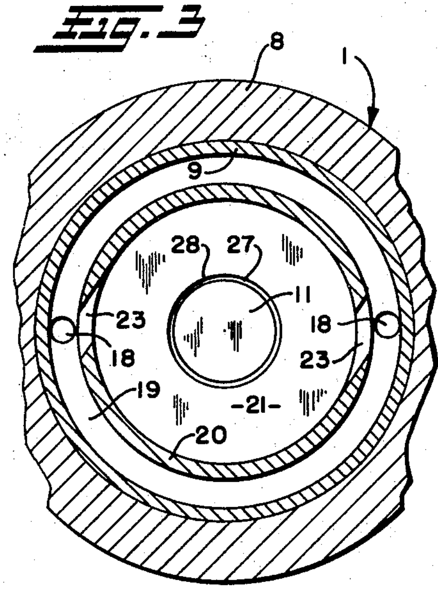


FIG. 3



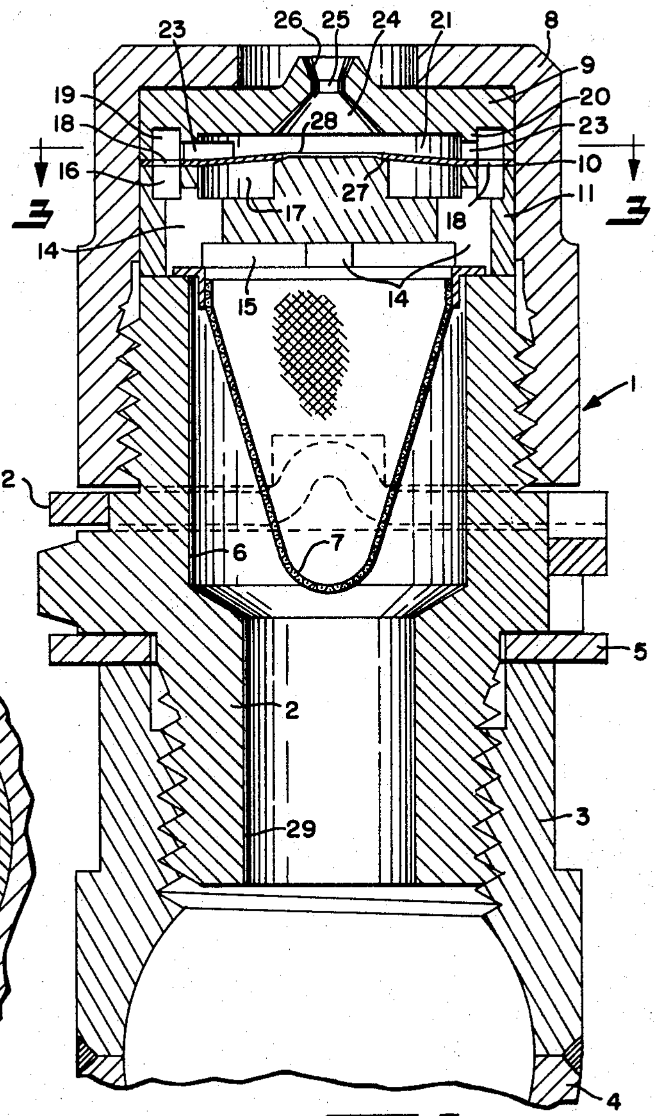


FIG. 2

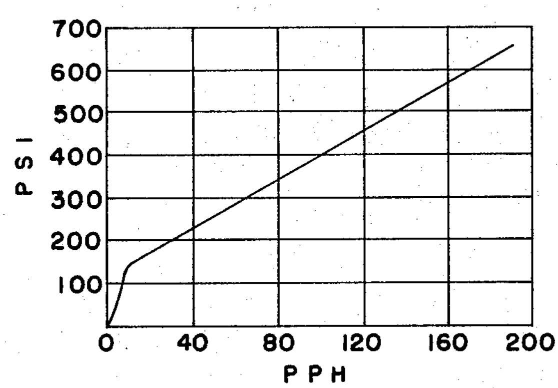


FIG. 4

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NOZZLE

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ABSTRACT OF THE DISCLOSURE

Fuel injection nozzle of the augmented simplex type having a single discharge orifice but yet having the pressure vs. flow characteristics of a veriable inlet area nozzle. Nozzle characterized by absence of sliding parts and by employment of larger than normal fuel flow passages thus rendering the nozzle less sensitive to malfunction or clogging due to contaminants in the fuel.

The present invention relates generally as indicated to a nozzle and more particularly to an augmented simplex nozzle i.e., a simplex nozzle having a variable area valve upstream of the single discharge orifice to augment the discharge from the nozzle orifice.

Hitherto, is such augmented simplex nozzles to meet prescribed flow vs. pressure specifications, it has been necessary to provide very small primary swirl passages, for example, on the order of .002" x .005" cross-section size in a nozzle which is required to have a flow of 7.5 to 9.5 p.p.h. at a pressure of 150 p.s.i., 63 to 77 p.p.h. at 300 p.s.i., and 171 to 209 p.p.h. at 650 p.s.i. The presence of contaminants in the fuel may be a problem in spray bar nozzles, for example, because the fuel manifold comprises a hollow ring to which individual nozzle mounts are welded and thus it may be quite difficult and expensive to attempt to thoroughly clean out all traces of welding slag, metal slivers, and like contaminants and, of course, it is not practically feasible to attempt to install fine filters in the respective nozzle to refilter and previously filtered fuel.

Accordingly, it is a principal object of this invention to provide a fuel injection nozzle having such great contamination resistance that only course filters, if any, need be employed in the respective nozzles to filter out the larger contaminants which may result from fabrication of the fuel manifold, i.e., welding slag, metal slivers and the like.

It is another object of this invention to provide an augmented simplex nozzle which has no sliding parts, thus to render the nozzle operative even though there may be contaminants in the fuel.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

FIG. 1 is a fragmentary elevation view showing a nozzle embodying the present invention attached to a nozzle mount of a fuel manifold or spray bar;

FIG. 2 is a much enlarged radial cross-section view taken substantially along the line 2—2, FIG. 1, illustrating the interior construction of a preferred form of the present invention;

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

FIG. 4 is a typical pressure vs. flow curve of a nozzle according to the present invention.

Referring now more particularly to the drawing, the fuel injection nozzle **1** comprises a body or connector **2**, which has a threaded connection with the nozzle mount **3** of the spray bar **4**, a lock ring **5** being interposed between the mount **3** and the connector **2**. The connector **2** has a fuel passage **6** in which is located a course screen **7** to screen out, for example, particles over 0.007" size.

Screwed onto the connector **2** is a nozzle cap **8** between which and the end of the connector **2**, is clamped an orifice plate **9**, a thin metallic diaphragm **10**, and a spacer **11**, the peripheral supporting flange of the screen **7** being disposed in a counterbore in the spacer **11**. With the cap **8** thus assembled to clamp the parts **9**, **10**, and **11**, the ring **12** will be deformed into circumferentially spaced apart recesses in the connector **2** and cap **8** to prevent loosening of the cap **8**.

The spacer **11** has several (herein four) relatively large diameter holes **14** axially therethrough which, at their inner ends, intersect the recess **15** in said spacer and which, at their outer ends, intersect outer and inner annular grooves **16** and **17** formed in the outer face of the spacer **11**. Considering the main fuel flow, the fuel in the outer groove **16** flows through openings **18** through the diaphragm **10**, into an annular groove **19** formed in the inner face of the orifice plate **9**. The annular rib **20** between such annular groove **19** and a recess **21** in the inner face of said orifice plate **9** is provided with tangential swirl slots **23**, for example, two slots, which impart a whirling motion to the fuel as it passes into the periphery of the vortex chamber constituted by the recess **21**. As the fuel flows through the conical portion **24** of the vortex chamber it acquires sufficient spin energy so that the fuel will emerge through the nozzle orifice **25** in the form of a thin conical sheet with an air core and as the sheet or film flows out along the conical lip **26**, it will assume a conical spray pattern and break up into small droplets of required size.

With reference to augmented or supplemental flow, the fuel enters the inner annular groove **17** through the holes **14**, and as the fuel pressure builds up to a predetermined value it will flex the diaphragm **10** away from the seat **27** to thus provide a variable area orifice as required for higher pressures and higher rates of flow. Preferably, the seat **27** is constituted by a central axial projection from the spacer **11** and is of frusto-conical form with the inner edge of the diaphragm opening **28** making line contact with the beveled side of such seat adjacent the flat end thereof for predictable and accurate results as to when the diaphragm begins to permit supplemental flow and also to provide a progressively increasing supplemental flow as the pressure increases. Furthermore, the diameter of seat **27** is only slightly larger than the opening **28** which lessens the possibility of wedging of the contaminants that pass the screen **7**.

By way of comparison with known nozzles, to meet the same pressure vs. flow specifications, the larger spin chamber **21** diameter in the present construction, i.e., .195" vs. .085" makes it possible to provide an inlet feed hole **29** which is about twice the diameter, i.e., .12" to .13" vs. .062" to .070". In the present construction the exit orifice **25** was of .028" to 0.30" diameter (1/6 to 1/7 of the spin chamber diameter) while in the known construction the exit orifice was of .040" to .041" diameter (nearly 1/2 of the spin chamber diameter). Likewise, in the known construction two swirl slots were provided, each of .0015" x .005" cross-section size, whereas, in the present construction each of the two swirl slots **23** were of .0075" x .0075" cross-section size, i.e., a swirl slot area herein is about 7½ times larger than in the previous known construction.

Aside from the foregoing which greatly increases the contamination resistance of the present nozzle **1**, the nozzle **1** herein also results in a considerable improvement in spray quality. For example, the fuel spray at pressures up to about 200 p.s.i. are in the fine mist category which becomes a jet type flow as the pressure approaches 650 p.s.i. During the transition, the combination of jet and swirl type flow was observed but this is quite common for this type of nozzle generally.

With further reference to the variable area supplemental flow, the edge of the opening **28** of the diaphragm **10** has a line contact around the seat **27** and, therefore, each of the nozzles **1** around the spray bar will have uniform flow characteristics since it is possible to accurately control the thickness and physical properties of the several diaphragms **10** and the initial deflection in the installed positions whereby the nozzles **1** will be effective to spray uniform quantities of fuel into the combustion chamber at progressively increasing pressures. As evident, there are no relatively sliding parts in the supplemental circuit and even if contaminants of size passing the screen **7** which would quickly clog known nozzles having sliding parts, these contaminants cannot interfere with the flexing of the diaphragm **10** toward and away from the seat **27**. Furthermore, because the seat **27** diameter is only slightly larger in diameter than the diaphragm opening **28**, contaminants are unlikely to become wedged between the seat **27** and the diaphragm **10**, and those that are so wedged would not materially affect the total flow at high pressures because of the relatively large diameter of the opening **28** (.08″ diameter, for example).

FIG. 4 shows a flow vs. pressure specification which has been met by the present nozzle **1** despite the great increase in swirl slot **23** size, i.e., .0015″ x .005″ entering an .085″ diameter spin chamber to .0075″ x .0075″ entering a .195″ diameter spin chamber.

The augmented flow through the variable area annular orifice between seat **27** and diaphragm opening **28** maintains a constant increase in total flow as the pressure increases. Also, the flow from the annular orifice is directed toward the center of the base of the conical portion **24** of the spin chamber where the fuel has already attained high spin velocity, thus to promote continued good atomization as the total flow increases.

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

1. A fuel spray nozzle comprising a connector having a fuel passage therethrough; a tubular nozzle cap secured to one end of said connector; an orifice plate, a flexible diaphragm, and a spacer clamped between said connector and cap; said diaphragm having a central opening thereof radially spaced from said opening thus clamped between said plate and spacer; said spacer having a central axial projection providing a seat against which the inner edge of said diaphragm opening is seated; said plate having a central discharge orifice axially spaced from said diaphragm and said projection and defining wtih said diaphragm a vortex chamber whose peripheral wall is intersected by nonradial spin slots; said spacer and plate having a passage communicating with said connector passage for fuel flow through said spin slots into said vortex chamber to impart a whirling motion to the fuel for emergence from said orifice in the form of a hollow conical spray; said spacer also having a passage communicating wtih said connector passage leading to the radial space around said projection whereby, upon increase of fuel pressure to a predetermined value, said diaphragm is flexed away from said seat to form an annular orifice for supplemental fuel flow therethrough into said vortex chamber and out through said discharge orifice.

2. The nozzle of claim **1** wherein said vortex chamber is of diameter several times that of said discharge orifice; and wherein said spin slots are of relatively large cross-section size to render said nozzle relatively insensitive to malfunction or clogging by contaminants in the fuel.

3. The nozzle of claim **1** wherein said projection is of diameter only slightly larger than said diaphragm opening and has a beveled seat having substantially line contact engagement with the inner edge of said diaphragm opening.

4. A spray nozzle comprising a nozzle body assembly defining therein a liquid passage which includes a vortex chamber having spin slots leading thereinto and having a discharge orifice from which the whirling liquid emeries as a hollow conical spray; a variable area valve in said assembly inwardly adjacent said vortex chamber comprising a flexible diaphragm having a central opening coaxial with said discharge orifice, and a seat engaged by the edge of said diaphragm opening; said diaphragm being flexed away from said seat upon predetermined increase in liquid pressure behind said diaphragm to form an annular orifice for flow of liquid into said vortex chamber to augment the flow entering the vortex chamber through said spin slots, one side of said diaphragm and said seat constituting a wall of said vortex chamber axially inwardly spaced from said discharge orifice, and the other side of said diaphragm being exposed to pressure of liquid in said liquid passage.

5. The spray nozzle of claim **4** wherein said seat is frusto-conical, having a flat end and beveled side to direct liquid flowing through said annular orifice toward the center of said vortex chamber.

6. The spray nozzle of claim **5** wherein said diaphragm has a peripheral portion radially spaced from said seat clamped in said nozzle body assembly for flexing of said diaphragm between its central opening and said peripheral portion.

7. The spray nozzle of claim **6** wherein the edge of said diaphragm opening has substantially line contact with the beveled side of said seat adjacent the flat end thereof.

8. The spray nozzle of claim **4** wherein said spin slots are of relatively large size and lead into the periphery of said vortex chamber at a diameter six to seven times that of said orifice whereby said nozzle is rendered relatively insensitive to malfunctioning or clogging by contaminants in the liquid.

9. The spray nozzle of claim **8** wherein the central opening in said diaphragm is of substantially larger diameter than said discharge orifice.

10. The spray nozzle of claim **4** wherein said diaphragm has a peripheral portion which is clamped between an orifice plate and a spacer, said orifice plate constituting the other wall of said vortex chamber and having said discharge orifice extending therethrough, and said spacer having a central projection providing said seat.

11. The spray nozzle of claim **10** wherein the outer face of said spacer has an outer annular groove communicating said liquid passage with an annular groove in said orifice plate, said annular groove in said orifice plate being in communication with said vortex chamber through said spin slots, and an inner annular groove in the outer face of said spacer surrounding said central projection in communication with said liquid passage for flow of fuel through said central opening in said diaphragm upon flexing of said diaphragm away from said seat.

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U.S. Cl. X.R.

239—492, 496, 535, 417.3