Dec. 18, 1962 G. C. GRAHAM 3,069,099

FUEL INJECTION NOZZLE AND SPRAY DEVICE

Filed April 5, 1960 2 Sheets-Sheet 1

Fig. 1.

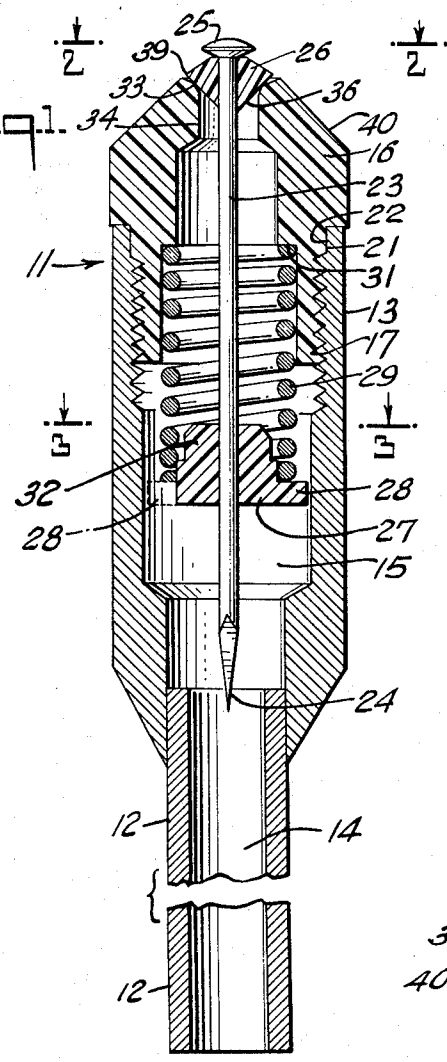


Fig. 4.

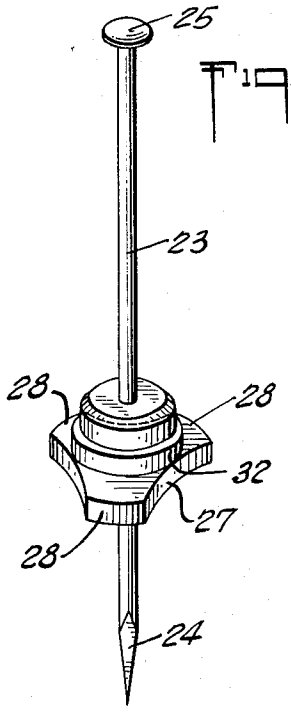


Fig. 5.

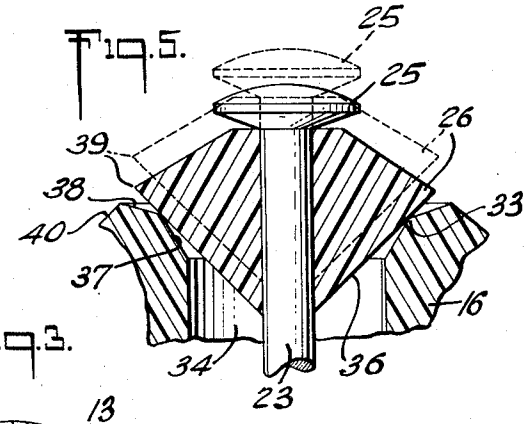


Fig. 2.

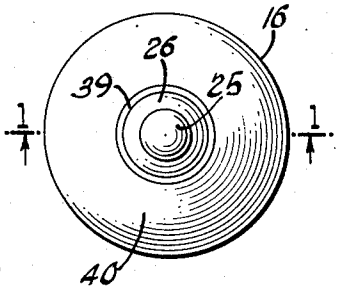
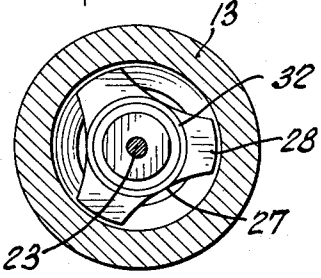


Fig. 3.



INVENTOR
GEORGE C. GRAHAM.
BY
J. Jordan Kennick
ATTORNEY

Dec. 18, 1962 G. C. GRAHAM 3,069,099

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Filed April 5, 1960 2 Sheets-Sheet 2

Fig. 6.

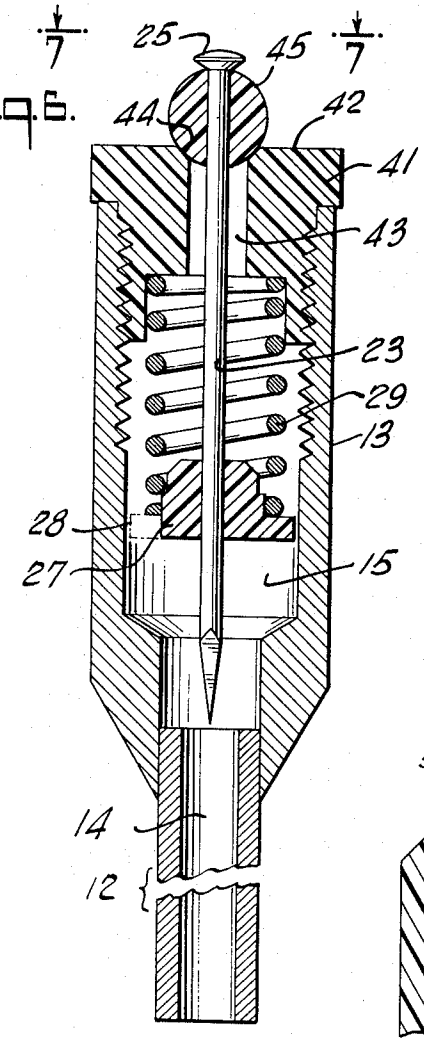
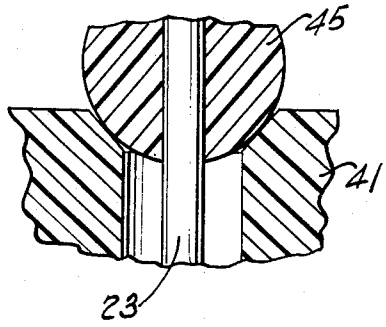


Fig. 8.



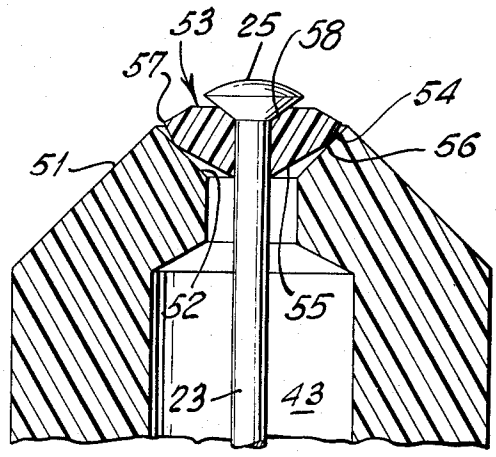


Fig. 7.

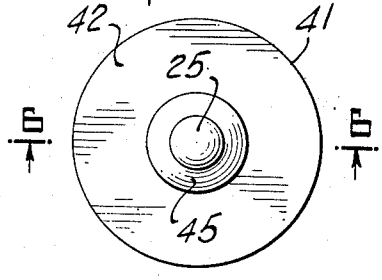


Fig. 9.

INVENTOR
GEORGE C. GRAHAM
BY
J. Jordan Kenick
ATTORNEY

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3,069,099

FUEL INJECTION NOZZLE AND SPRAY DEVICE

George C. Graham, 76 Crest Road, Ridgewood, N.J.

Filed Apr. 5, 1960, Ser. No. 20,061
17 Claims. (Cl. 239—453)

This invention relates to spray nozzles for fuel injection apparatus and the like.

In providing suitable fuel injection sysetms for automotive engines and the like, there are various structural and functional requirements for the fuel injection nozzle that must be fulfilled in order to provide for satisfactory fuel injection performance. Among other things, it is necessary to produce spray nozzles of inexpensive materials and to provide that the valve system thereof be adequately sensitive to open and close the orifice of the nozzle in response to successive discharges from the fuel injection pump. Furthermore, it is important to provide an efficient valve seating arrangement whereby closure of the orifice is rapidly achieved between pressure pulses that produce fuel sprays into the air intake stream of the engine. Also the valve head should be shaped in such a manner as substantially to prevent the drift of liquid fuel toward any of the exterior surfaces of the nozzle, and also to prevent the formation of liquid droplets thereon. Additionally the valve body adjacent the valve head should be shaped in such a manner as to prevent deleterious eddy currents from forming around the nozzle by the rush of the air intake stream to the cylinders of the engine. While the nozzle must open in response to fluid pressure from the fuel injection pump, it must not be responsive to the vacuum created in the engine manifold.

The fuel injection nozzle of the present invention satisfies the foregoing requirements completely, and moreover, I have formed several of the parts of comparatively light weight plastic materials so that inertia of the valve mechanism is reduced to a hitherto unattained minimum. The valve stem is formed of a thin, straight wire, common pin whose head extends outwardly from the valve head to provide a convenient gripping means for manually or mechanically checking the operation of the valve. Also a plastic spring retainer is mounted by means of a frictional interference fit on the valve stem whereby the requisite sensitivity of the valve head to fluid pressures may be adjusted and set for optimum functioning of the spray nozzle.

I also provide a novel valve seating arrangement whereby an annular narrow line contact is made between the valve head and the valve seat so that the sensitivity of the valve head for opening and closing the orifice of the valve housing is enhanced. The narrow line seating contact is arranged to be positioned as close as is physically possible, to the outer end of the nozzle orifice so that the speed of the ejected fuel spray will not be appreciably reduced by any excessive frictional surfaces. Both the valve head and the valve seat are made of plastic materials which mutually accommodate to each other quickly in forming a substantially liquid-tight seal for the spray nozzle.

Still other objects and advantages of the invention will be apparent from the specification.

The features of novelty which are believed to be characteristic of the invention are set forth herein and will best be understood, both as to their fundamental principles and as to their particular embodiments, by reference to the specification and accompanying drawings, in which:

FIGURE 1 is a longitudinal central section view of the spray nozzle constructed according to the present invention, the section view being taken on line 1—1 of FIG. 2;

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

FIG. 3 is a section view taken on line 3—3 of FIG. 1;

FIG. 4 is a perspective view of some of the elements shown in FIG. 1;

FIG. 5 is a greatly enlarged fragmentary section view, partly in elevation, of a portion of the structure shown in FIG. 1, an alternate position of some parts being shown in phantom outline;

FIG. 6 is a view similar to FIG. 1, taken on line 6—6 of FIG. 7, showing another embodiment of the present invention;

FIG. 7 is a view taken on line 7—7 of FIG. 6;

FIG. 8 is a greatly enlarged fragmentary view of the upper portion of the nozzle assembly shown in FIG. 6; and

FIG. 9 is a greatly enlarged fragmentary central section view, similar to FIG. 5, showing a still further embodiment of the invention.

Referring now to the drawings in detail, where similar reference numerals designate similar parts throughout, the nozzle assembly, generally designated 11, contains the improved valve structure of the present invention. Valve assembly 11 is attached to a connector tube 12 which is adapted to be connected by suitable means, not shown, to the source of fuel. The nozzle housing 13 comprises a cylindrical tube of brass, aluminum, steel or the like, which is secured coaxially to connector tube 12 by suitable leakproof means. The central aperture 14 of connector tube 12 is coaxially aligned with chamber 15 of nozzle housing 13.

Between the terminus of its threads and the forward end of nozzle housing 13, the interior wall of said nozzle body is tapered outwardly at 21 while the corresponding mating exterior wall 22 of valve body 16 is tapered inwardly at approximately the same angle. Thus when valve body 16 is threadably secured to the forward end of nozzle housing 13, the respective angled mating surfaces 21 and 22 form a substantially liquid-tight seal between said nozzle housing and said valve body whereby leakage is prevented. In some embodiments, the diameter of annular wall portion 22 of valve body 16 is arranged to be slightly greater than the corresponding angled diameter of annular wall portion 21 of nozzle housing 13 whereby the action of threadbly securing said valve body 16 to nozzle housing 13 causes the slightly resilient material of valve body to be forced into a liquid-tight fit with the mouth of said nozzle housing.

Positioned coaxially within valve housing 13 is a pin 23 in the form of a so-called straight or common pin, such as a household, tailoring, dressmaking, laundry pin or the like, the inner end of which has a sharp point 24, and the outer end of which has a head 25. Pin 23, which serves as a valve stem, extends through the center of valve head 26 made of a suitable plastic and somewhat resilient material, such as Delrin, nylon, or the like. The forward end of valve head 26 lies against the rear of pin head 25. Mounted on the inner portion of pin 23 is a spring retainer 27 which may be made of a suitable plastic and resilient material capable of forming an interference fit, said material being Delrin or the like.

Spring retainer 27 has a plurality of integrally formed radially extending arms 28 against which one end of a coiled spring 29 bears, the other end of said spring bearing against an annular shoulder 31 on the interior of valve body 16. Spring retainer 27 has an integral longitudinally extending stub 32 which serves to stabilize the position of spring 29 relative to said spring retainer. The action of spring 29 urging spring retainer 27 inwardly into valve housing 13 causes head 25 of pin 23 to urge the valve head 26 against its valve seat 33 formed at the mouth of valve body 16. Liquid within chamber 15 passes readily through the spaces between arms 28 in a longitudinal direction of nozzle housing 13.

The forward portion of valve body 16 is formed in

the shape of a truncated cone having an orifice **34** extending therethrough which communicates coaxially with chamber **15** of nozzle housing body **13**. The diameter of throat **34** is considerably less than that of chamber **15** in order that small volumes of liquid fuel may be efficiently handled by valve **26** at the mouth of valve body **16**.

The inner portion of valve head **26** is conical in shape and has an annular wall **36**, a circular portion of which normally impinges upon annular valve seat **33** under the action of spring **29**, FIGS. 1 and 5. Annular valve seat **33** is the circular apex between a pair of intersecting annular flats **37** and **38** formed at the mouth of orifice **34** of valve housing **16**. Annular flats **37** and **38** define between them an obtuse angle, and, accordingly, locate annular valve seat **33** at a position behind the end of valve body **16**.

In the embodiment shown in FIGS. 1 and 5, annular flat **37** slopes at an angle of 60° from the horizontal plane relative to the vertical axis of the nozzle and valve assembly, while annular flat **38** slopes 30° from said horizontal plane, said annular flats thus forming a large included angle between them, in this case, 150°.

This valve head and valve seating arrangement is of particular utility when employed in conjunction with fuel injection systems for internal combustion engines where small metered quantities of fuel are to be emitted in rapidly repeated fine sprays into, or at the intake valve openings of, the respective cylinders. The respective contours of valve wall **36** and of opposing flats **37** and **38** produce a circular conical flow orifice for the nozzle whereby fuel is ejected in a finely atomized mist which is readily vaporized when discharged into the intake stream of air passing into the engine cylinder.

Since there is virtually only a narrow line contact between valve head **26** and valve seat **33**, the rapidly pulsating discharges of the liquid fuel readily displace the valve from its seat in sensitive response to the pressure strokes of its respective fuel distributor piston. Also, upon the return stroke of the piston, when fuel pressure inside the nozzle housing is reduced, spring **29** rapidly brings valve head **26** back to its liquid sealing position on valve seat **33**.

Thus, the provision of an annular wall of conical cross section formed by flats **37** and **38** operating against the opposing flat annular valve head wall **36** provides for a considerably sharper make and break of fluid flow past said valve head when the latter opens and closes than would obtain were annular valve head wall **36** to mate instead with a flat walled annular valve seat.

In order to produce a finely atomized jet fuel spray from the nozzle, and to prevent the formation of fuel droplets, particularly at lower engine speeds, it is important to reduce to a practicable minimum the frictional resistance encountered by said spray as it passes the surfaces of the outer portion of the nozzle orifice beyond the valve seat. Accordingly, the width of annular flat **38** is made as narrow as possible, taking into consideration the nature of the materials of which valve body **16** is made. In one embodiment, FIGS. 1 and 5, where valve body **16** is made of Delrin, or the like, the width of annular flat **38** is .020", while in other embodiments, the width of said annular flat may be in the order of from .010" to .030", depending on the material of which said valve body is made. As a result of reducing the frictional surfaces to a minimum, the speed of the jet fuel spray is not retarded to the extent that undesirable droplets of fuel would be formed.

Valve head **26** is also formed in a manner as to minimize its frictional surfaces. The distance between the annular line on said valve head which mates with valve seat apex **33** and the perimeter **39** of said valve head is substantially coextensive with the width of annular flat **38**. Thus, the configuration of the valve seat and the cooperating valve body bring about the production of a superior finely atomized jet fuel spral from the nozzle

than has hitherto been realized in prior art injection nozzles.

Since both the valve head **26** and the valve seat **33** are made of a suitable plastic material such as nylon, Delrin, or the like, which have some limited characteristics of resilience or yieldability, the integrity of the seal between said valve head and said seat is thereby enhanced. Furthermore, in view of the multitudinous impacts that the valve head applies upon the valve seat—in the order of 40 oscillations per second at vehicle speed of 100 miles per hour—the employment of nylon or Delrin as the material out of which the valve head and the valve seat are made, ensures that considerably less wear will be realized than would be the case if either or both of said parts were made of metal. Also, since these two parts can be molded or otherwise made with considerable accuracy for fitting together, they will form an excellent liquid-tight seal therebetween within extremely close limits initially, and after being run for a short length of time, an effective conformance between the seat and the valve head is soon attained by reason of the mutual accommodation of these materials under repeated impacts.

In one embodiment of the invention pin **23** comprises a light weight, common straight pin made of steel or wire or the like, while spring retainer **27** is made of Delrin, which designates an acetal resin produced by E. I. du Pont de Nemours & Co. (Inc.). By providing an initial central aperture in spring retainer **27** of from one to three thousandths of an inch less in diameter than the diameter of pin **23** and by forcing said pin through said aperture until the retainer is in the desired position, there will be formed a strong interference fit therebetween whereby the retainer will maintain its set position on said pin despite the multitudinous repeated oscillations that it will perform. The position at which retainer **27** is set on pin **23** determines the opening pressure for displacing valve head **26** from its valve seat, assuming spring **29** has been properly designed in relation to the area of the valve seat. It is a characteristic of the Delrin material that retainer **27** has a sufficiently high frictional engagement with pin **23** that, once it is properly adjusted in position, it will maintain that position for a long period of time under extended operating conditions.

By making spring retainer **27** out of Delrin or other suitable plastic material which forms a strong interference fit with a fine wire pin **23**, the overall mass and inertia of the valve assembly is considerably reduced; the tension adjustment or setting of spring **29** is facilitated; and various fastening or securing means, otherwise utilized in the prior art, are eliminated.

The shape of spring retainer **27** is such that there is ample space between its arms **28** to permit fluid freely to bypass the retainer without exerting any appreciable pressure on said retainer for displacing valve head **26**. In other words, it is intended that the opening pressure for displacing valve head **26** should be exerted by the liquid directly behind said valve head at valve seat **33** of nozzle body **16** in response to pressure discharges from the fuel distributor pump to which the nozzle is connected.

The outer ends of arms **28** of spring retainer **27** are arranged to be sufficiently close to the interior walls of chamber **15** whereby they serve as guides for ensuring a stable reciprocating motion of the retainer in a coaxial direction within the nozzle assembly. Furthermore, arms **28** jointly serve to stabilize the position of spring **29** in substantial coaxial alignment within chamber **15**.

Head **25** on pin **23** protrudes from the outer surface of valve head **26** and forms a convenient means for grasping by a suitable tool or even by the finger nails whereby valve head **26** may be manipulated in order to check the operation of the valve.

The annular perimeter **39** of valve head **26** is in the form of a sharp angle in cross-section, and divides valve head **26** into an inner and an outer portion. This shape of valve head **26** tends to prevent drift of liquid fuel by

surface tension or other means from the inner portion of said valve head to its outer portion where it might accumulate into droplets especially when the machine is operating at low speeds. In other words, the sharp apex of the valve head perimeter spaced apart from the orifice of the valve housing virtually ensures that minute quantities of fuel ejected by the nozzle at low throttle will be dispersed in a fine spray and will not tend to accumulate into droplets on the outer face of the valve head or the pin head.

Another salient feature of valve body **16** is that its forward end is in the form of a cone and its surface **40** slopes in the direction of the air stream to the engine cylinder, whereby this air stream passes directly into the path of the ejected fuel spray to effectively produce a properly atomized or fine mist fuel-air mixture.

Furthermore, the truncated conical shape of the forward end of valve body **16** substantially reduces the possibility of eddy current formation when air rushes past the nozzle in picking up the fuel spray for vaporization into a combustible mixture on its way to the cylinder of the engine. The outer portion of valve head **26** is also conical in shape and together with valve body **16** forms a cone-like projection into the intake air stream whereby prevention of eddy currents is enhanced and formation of liquid droplets on those parts is substantially obviated.

An alternative embodiment of the invention herein is illustrated in FIGS. 6 and 7 where the nozzle assembly is similar to that shown in FIGS. 1 through 5, except for the substitution of a valve housing **41** having a forward end surface **42** whose flat plane is substantially perpendicular to the longitudinal axis of the nozzle assembly. In this embodiment, throat **43** of the valve body terminates in an outwardly tapering flat annular valve seat **44** against which a spherical valve head **45** impinges under the action of spring **29** acting upon pin **23** pierced or extending through said valve head **45**. Annular valve seat **44** is arrayed at an angle of approximately 30° from the vertical axis of the nozzle assembly and in conjunction with the coacting surface of valve head **45**, there is formed a substantially circular narrow line contact therebetween for sealing off the flow of liquid from the nozzle.

Due to the difficulties of illustrating this narrow line contact of FIG. 6, the greatly enlarged illustration of FIG. 8 is suggestive of the fact that valve head **45** makes contact with its valve seat **44** at a comparatively narrow line contact. In actual embodiments, the width of this line contact is considerably smaller than is suggested in FIG. 8, due to the inherent difficulties involved in making suitable representations in patent drawings. Here also, as is the case with the embodiment shown in FIGS. 1 and 5, the valve housing **41** and valve head **45** are both made of a suitable plastic material, such as nylon, Delrin, or the like, whereby there is a mutual dimensional accommodation between these parts to form a good seal therebetween.

In the embodiment of FIG. 6, the circular narrow line of valve **45** which makes contact with a narrow circular line on valve seat **44** is arranged to be positioned as close as possible to the forward edge of said valve seat in order to reduce frictional resistance encountered by the jet fuel spray so that the formation of fuel droplets would be minimized, as explained hereinabove in connection with the embodiment of FIGS. 1 and 5.

It is also understood that in the embodiment of FIGS. 6 and 8, the inner portion only of valve **45**, which mates with valve seat **44**, would be spherical in shape while the outer remainder portion of said valve may be truncated or assume other shapes as may be suitable or desired without altering the arrangement of the annular narrow line contact between the valve and its seat.

A further embodiment of the present invention is shown in FIG. 9 wherein the orifice of nozzle body **51** terminates in an outwardly flaring flat annular valve seat **52**. In this embodiment, the inner portion of valve head **53** has a pair of adjacent annular surfaces **54** and **55** which form therebetween an annular apex **56** which under the action of spring **29** forms a substantially line contact, liquid-tight seal with valve seat **52**. Here too, as is the case with the embodiments of FIGS. 1 and 6, an annular wedge-like valve and valve seat closure not only enhances the sensitivity of response of the light weight valve head to rapidly repeated pressure thrusts, but also enables the valve head rapidly to return to its seat under the action of spring **29** when the fluid pressure is released.

Valve head **53** has a sharp perimeter **57** which minimizes the possibility of droplets of fuel accumulating on the front or outer surface of said valve head. Here also, annular apex **56** of valve head **53** is arranged to impinge against an annular line contact on valve seat **52** as close as possible to the outer edge of said valve seat in order to reduce the frictional resistance of said valve seat surface against the jet fuel spray so as to minimize the formation of droplets, particularly at the lower engine speeds. The annular narrow line contact between valve head **53** and valve seat **52** is spaced apart from the outer edge of said valve seat in the order of from .010″ to .030″ to produce the results as described hereinabove in connection with FIGS. 1 and 5.

In the embodiment of FIG. 9, the central portion of outer face of valve head **53** has an annular recess **58** which accommodates the rear portion of pin head **25**. The depth of recess **58** is sufficiently shallow to permit the perimeter of pin head **25** to protrude forwardly from valve head **53** sufficiently to enable the grasping of said pin head for checking the operation of the valve.

An important advantage is gained by providing that valve heads **26**, **45** and **53**, and spring holders **27** and **46** be made of light weight plastic materials as specified hereinabove, and that pin **23** has a very small diameter of the order of about .015″ to .045″, said diameter being .029″ in one embodiment. The oscillating parts of the nozzle assembly comprise valve heads **26**, **45** or **53**, pin **23**, spring holders **27** or **46**, and spring **29**, which are required to oscillate as many as 40 times per second; thus, it is very important that the weight of these parts be kept down to a minimum. In actuality only three of these parts oscillate completely; namely, the valve head, the pin and the spring holder, while only a portion of spring **29** oscillates since one of its ends is always stationary. By forming the valve head and spring holder of light weight plastic materials, and providing a pin **23** of small diameter, the aggregate weight of these moving parts is very low compared to what it would be if all the parts were made of metals.

By avoiding where possible the use of metallic parts which may have a specific gravity as high as 7 or 8, and reducing the aggregate specific gravity of the moving parts to a minimum, I provide an extremely sensitive fuel injection nozzle which is capable not only of high speed oscillation, but also of efficiently ejecting small quantities of liquid in a fine spray and of effectively sealing the nozzle during the extremely short intermittent intervals when no fuel is being ejected from the orifice of the nozzle.

The present invention contemplates, however, that the annular narrow line valve closure arrangements described and claimed herein may be adapted to various liquid closures where either or both the valve head and valve seat may be made of materials other than plastics wherever the circumstances and conditions may require or permit it.

It will be noted that the plastic materials of which the valve body, the valve seat, and valve head, are made are intrinsically non-rusting and non-corrosive, and therefore, the possibility of jamming or other mechanical failure of these parts is substantially obviated.

Furthermore, it will be understood that the nozzle described herein is not only useful for fuel injection

purposes in internal combustion engines, but is also readily adaptable for use for general spraying and atomizing purposes when suitably connected to various pumping mechanisms or aerosol devices.

It is claimed:

1. A fuel injection nozzle comprising a nozzle housing, a valve body mounted on one end of said nozzle housing, said valve body being made of a tough but resilient plastic material, an annular valve seat on the outer end of said valve body, a valve head made of tough but slightly resilient plastic material adapted to be seated against said valve seat with an annular narrow line contact therebetween, a common pin extending through said valve head and positioned longitudinally in the interior of said valve body and said nozzle housing, a spring retainer mounted by an interference fit intermediate the ends of said pin, a spring connected between said body and said retainer and acting upon said retainer normally to cause the inward movement of said pin and to urge said valve head into seating contact with said valve body, and a head on said pin protruding outwardly from said valve head.

2. A nozzle according to claim 1 wherein both the valve head and said spring holder are made of a material having a substantially lower specific gravity than metallic material.

3. A fuel injection nozzle comprising a nozzle housing, a tubular valve body mounted on one end of said nozzle housing, said valve body being made of a tough but resilient plastic material having an orifice in the outer end thereof, a valve head made of a tough but slightly resilient plastic material adapted to be seated against said orifice, a pin extending through said valve head and extending longitudinally into the interior of said valve body and said nozzle housing, a spring retainer mounted intermediate the ends of said pin, a spring connected between the interior of said body and said retainer and acting upon said retainer normally to cause the inward movement of said pin and urging said valve head into seating contact with said valve body, both said valve head and said spring retainer being made of a material having a substantially lower specific gravity than metallic material, said pin having a diameter in the order of approximately .015" to .045".

4. A fuel injection nozzle comprising a valve body, said body being formed of a tough but slightly resilient plastic material and having an outlet orifice, said outlet orifice comprising a pair of adjacent annular surfaces whose planes are disposed at an angle relative to each other and form between them an annular apex acting as a valve seat, a valve head made of a tough but slightly resilient plastic material, the inner portion of said valve head being in the form of a cone positionable substantially coaxially relative to said orifice, spring biasing means connected between said valve and said valve body normally urging the conical surface of said valve head against said annular apex to form an annular narrow line contact, substantially liquid-tight seal for said valve body, and a fine straight wire pin extending through said valve head and into the interior of said valve body, a spring retainer on said pin, said spring biasing means being connected to said spring retainer.

5. A spray nozzle comprising a valve body having an outlet orifice therein, a valve head adapted to open and close said orifice, a wire pin extending through said valve head and positioned longitudinally in said valve body, a spring retainer mounted near the inner end of said pin, a spring connected between said body and said retainer normally urging said valve head into seating contact with said valve body, said spring retainer being formed of a resilient plastic material and having an aperture initially slightly smaller than the diameter of said pin whereby said spring retainer is positioned upon said pin by a frictional, interference fit and maintains its said position thereon through multitudinous oscillations of said valve head.

6. A nozzle according to claim 5, and further comprising a plurality of radial arms on said spring retainer between which liquid flows freely past said retainer without exerting appreciable pressure thereon.

7. A fuel injection nozzle comprising a valve body having an outlet orifice therein, a valve mounted on the outer end of said valve body for opening and closing said orifice, said valve body and valve being positionable in the path of the intake air stream of an internal combustion engine, the outer portion of said valve and the end of said valve body together being in the form of a unitary cone whereby formation of eddy currents around said valve body and valve is substantially minimized and the formation of fuel droplets on said valve and valve body is substantially obviated.

8. A fuel injection nozzle comprising a valve body, said body being formed of a tough but slightly resilient plastic material and having an outlet orifice, said outlet orifice comprising a pair of adjacent annular surfaces whose planes are disposed at an obtuse angle relative to each other and form between them an annular apex acting as a valve seat, said valve seat being positioned behind the end of said valve body, a valve head made of a tough but slightly resilient plastic material, the inner portion of said valve head being in the form of a cone positionable substantially coaxially relative to said apex, and spring biasing means connected between said valve and said valve body normally urging the conical surface of said valve head against said annular apex to form an annular narrow line contact, substantially liquid-tight seal for said valve body.

9. A nozzle according to claim 8 wherein the width of the annular surface of the orifice adjacent the end of said valve body is in the order of from .010" to .030".

10. A fuel injection nozzle comprising a valve body, said body being formed of a tough but slightly resilient plastic material and having an outlet orifice, said outlet orifice comprising a pair of adjacent annular surfaces whose planes are disposed at an angle relative to each other and form between them an annular apex acting as a valve seat, a valve head made of a tough but slightly resilient plastic material, the inner portion of said valve head being in the form of a cone positionable substantially coaxially relative to said orifice, spring biasing means connected between said valve and said valve body normally urging the conical surface of said valve head against said annular apex to form an annular narrow line contact and substantially liquid-tight seal between said valve head and said valve body, a fine straight wire pin extending through said valve head and into the interior of said valve body, and a spring retainer on said pin, said spring biasing means being connected to said spring retainer.

11. A spray nozzle comprising a valve body having an orifice said orifice consisting of adjacent inner and outer annular flat surfaces whose planes are disposed at an obtuse angle relative to each other and which form between them an annular apex acting as a valve seat, said valve seat being positioned behind the end of said valve body, and a circular valve head mounted in said valve body, said valve head coacting with said valve seat for opening and closing said orifice, the perimeter of said valve head having the form of a sharp annular apex, said apex being substantially co-extensive with and spaced slightly apart from the outer perimeter of said outer annular flat surface when said valve head is in contact with said valve seat.

12. A nozzle according to claim 10 wherein the outer surface of said valve body and the outer surface of said valve head together form a unitary cone-like projection for extension into the intake air stream of an internal combustion engine.

13. A fuel injection nozzle comprising a valve body

formed of a tough but slightly resilient plastic material having an outlet orifice, said outlet orifice comprising a pair of adjacent annular surfaces whose planes are disposed at an angle relative to each other and form between them an annular apex acting as a valve seat, said apex being positioned behind the end of said valve body, a valve head made of a tough but slightly resilient plastic material, the inner portion of said valve head being in the form of a cone, the conical surface of said valve head coacting with said annular apex to form a substantially liquid-tight seal therebetween, spring biasing means connected between said valve head and said valve body normally urging said valve head into a seating position against said valve seat.

14. A spray nozzle comprising a valve body having an orifice, said orifice consisting of adjacent inner and outer annular flat surfaces whose planes are disposed at an obtuse angle relative to each other and which form between them an annular apex acting as a valve seat, said valve seat being positioned behind the end of said valve body, and a circular valve head mounted in said valve body, said valve head coacting with said valve seat for opening and closing said orifice, the perimeter of said valve head having the form of a sharp annular apex, said apex being substantially co-extensive with and spaced slightly apart from the outer perimeter of said outer annular flat surface when said valve head is in contact with said valve seat, the width of said annular flat surface and the width of the valve surface extending between its perimeter and the annular line of contact with said apex, each being in the order of from .010" to .030".

15. A spray nozzle according to claim 14 wherein the widths of said outer annular flat surface and of the opposing surface of said valve are substantially equal.

16. A fuel injection nozzle comprising a valve body, said body being formed of a plastic material and having an outlet orifice, said outlet orifice comprising a pair of adjacent annular surfaces whose planes are disposed at an obtuse angle relative to each other and form between them an annular apex acting as a valve seat, said valve seat being positioned behind the end of said valve body, a valve head made of a plastic material, the inner portion of said valve head being in the form of a cone positionable substantially coaxially relative to said apex, and spring biasing means connected between said valve and said valve body normally urging the conical surface of said valve head against said annular apex to form an annular contact, substantially liquid-tight seal for said valve body.

17. A fuel injection nozzle comprising a valve body, said body being formed of a tough but slightly resilient plastic material and having an outlet orifice, said outlet orifice comprising a pair of adjacent annular surfaces whose planes are disposed at an angle relative to each other and form between them an annular apex acting as a valve seat, a valve head made of a tough but slightly resilient plastic material, the inner portion of said valve head being in the form of a cone positionable substantially coaxially relative to said orifice, spring biasing means connected between said valve and said valve body normally urging the conical surface of said valve head against said annular apex to form an annular narrow line contact and substantially liquid-tight seal between said valve head and said valve body, a pin extending through said valve head and into the interior of said valve body, and a spring retainer on said pin, said spring biasing means being connected to said spring retainer.

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