

Dec. 21, 1965

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3,224,684

FUEL INJECTION NOZZLE

Filed April 16, 1963

2 Sheets-Sheet 1

FIG. 2

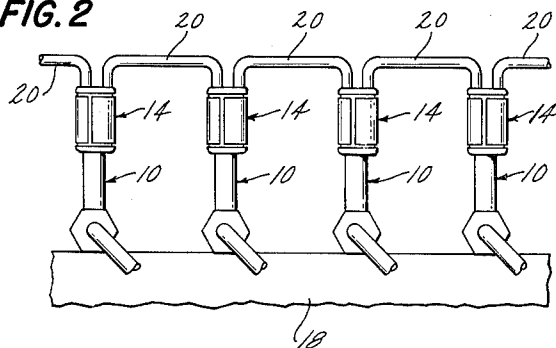


FIG. 4

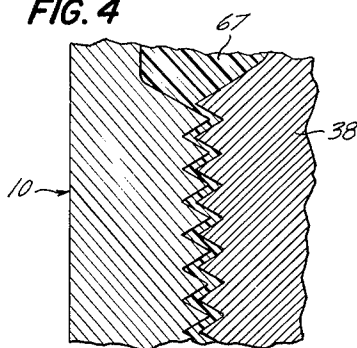


FIG. 1

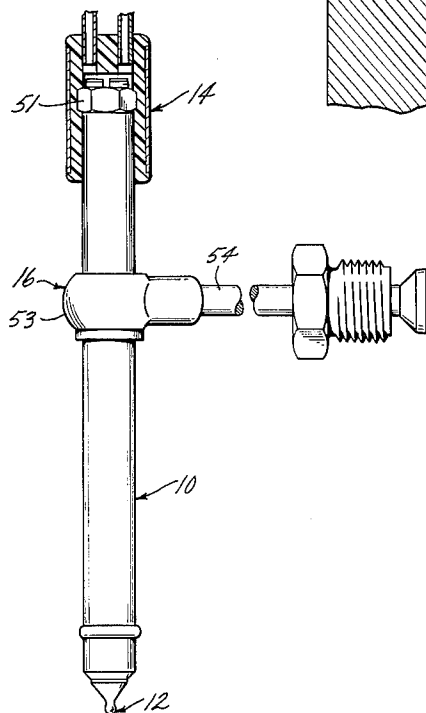
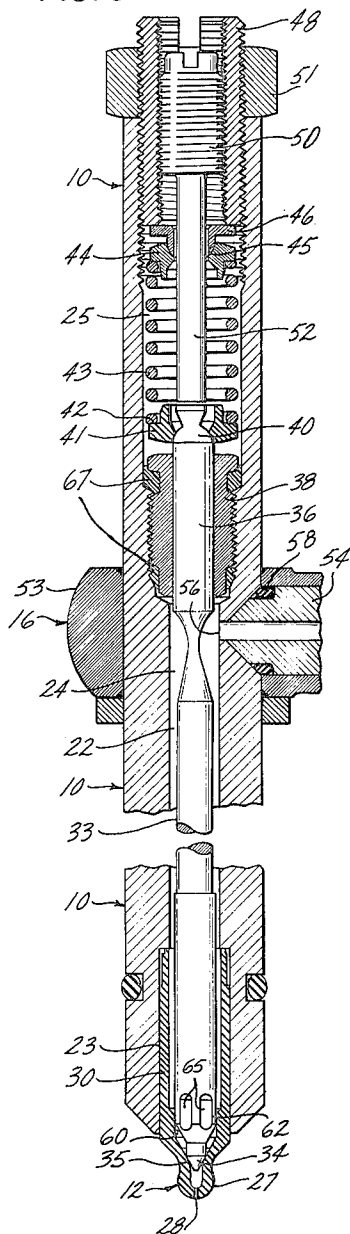


FIG. 3



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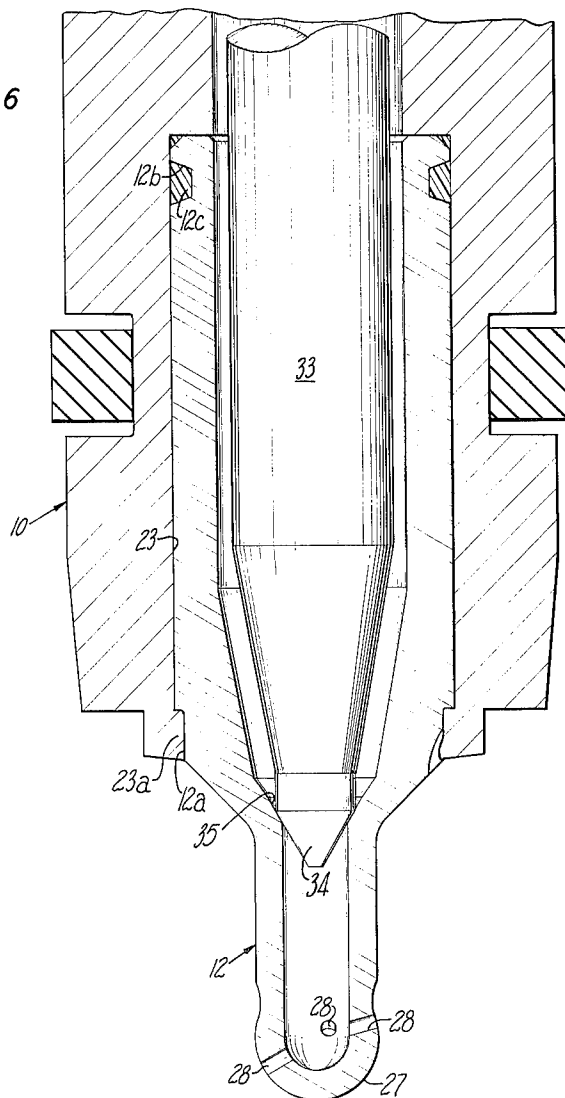
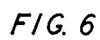
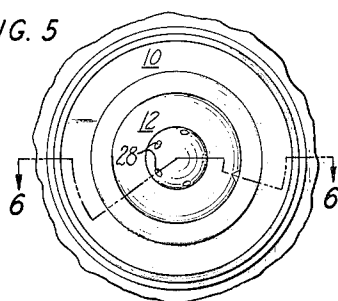


FIG. 5



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3,224,684

FUEL INJECTION NOZZLE

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Filed Apr. 16, 1963, Ser. No. 275,789

12 Claims. (Cl. 239—533)

This application is a continuation-in-part of copending patent application Serial No. 123,581, filed July 12, 1961, now abandoned.

This invention relates generally to fuel injection nozzles for internal combustion engines and more particularly to an improved nozzle of the type having a plunger valve that is operated by pressurized fuel supplied to the nozzle such as disclosed in my U.S. Patent No. 2,865,675 entitled Fuel Injection Nozzle.

In fuel injection nozzles of the type involved in this invention, it is essential that the nozzle discharge a fine atomized spray into the cylinders of the associated engine. To produce such an atomized spray the valve must "chatter," or open and close rapidly and frequently, during each injection period. In order to accomplish this, it is essential that the plunger valve be held in precise alignment with the valve seat and that it be free floating in its guide since any misalignment will interfere with the free and rapid reciprocation of the plunger in its guide. Accordingly, a primary object of the present invention is to provide an improved nozzle of the plunger valve type capable of precision operation while having greatly reduced susceptibility to seizure or binding of the plunger valve and similar nozzle malfunctions.

A further object of this invention is the provision of an improved nozzle of the plunger valve type having simplified and economical construction that permits reduced nozzle frontal area and simplified installation as well as assembly, all without reduction in the precision and reliability of valve operation.

An additional object of this invention is the provision of an improved nozzle of the plunger valve type having a plunger mounting that is self-aligning during assembly of the nozzle and which remains fixed in the aligned position after assembly to provide long and reliable valve operation.

It is a still further object of this invention to provide an improved method of manufacturing and assembling fuel injection nozzles of the plunger valve type whereby precision plunger alignment is automatically achieved in a nozzle that is very economical to construct.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth and the scope of the application which will be indicated in the appended claims.

In the drawings:

FIG. 1 is a front elevation view of a preferred embodiment of the nozzle of this invention, partially cut away to show details of the fuel leak-off collection facilities;

FIG. 2 is a schematic illustration of several of the preferred valves as installed in the cylinder block of an internal combustion engine;

FIG. 3 is a partial cross section view taken generally along the central axis of the nozzle;

FIG. 4 is an enlarged partial cross section view showing details of the plunger guide mounting;

FIG. 5 is an enlarged end view of the tip of a modified form of the nozzle of this invention; and

FIG. 6 is a fragmentary cross section view of the nozzle of FIG. 5 taken along line 6—6 of FIG. 5.

Turning now to the drawings in which like numerals refer to like parts, the exemplary nozzle shown therein

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includes a generally tubular body 10 having a nozzle tip 12 affixed at one end, a fuel leak-off fitting generally designated 14 affixed at the other end and a fuel inlet fitting 16 secured to the body intermediate its ends. As seen in FIG. 2, the nozzles are mounted in the cylinder block of an internal combustion engine generally designated 18 with the fuel leak-off fittings 14 connected together by appropriate tubing 20 to describe a continuous fuel leak-off and collection path.

The body member 10 is formed from tubing having a continuous bore 22 extending throughout, which bore is of varying diameter including a front bore portion 23 and intermediate bore portion 24 and a rear bore portion 25. Tip 12 is provided with a parti-spherical end 27 having one or more fuel outlet passages 28 formed therein and with a tubular skirt or body member 30 extending therefrom and received in sealing engagement with the side wall of front bore portion 23.

The nozzle valve of this invention is in the form of an elongated plunger or rod 33 having a generally conical end 34 which cooperates with a conical seat 35 adjacent the forward end of tip 12. Plunger 33 is dimensioned to be of smaller diameter than the bore 22 in the nozzle body and the passageway formed in the skirt 30 of the tip so as to provide a fuel flow passageway. The rear or upper end 36 of the plunger is slidably supported in an upper guide member or collar 38, the plunger portion 36 and the collar 38 preferably having a lap fit therebetween to minimize fuel leakage therethrough. Adjacent the upper end of plunger 33 there is provided a parti-spherical end portion 40 on which is seated the parti-spherical recess of spring seat 41 which has a shoulder 42 that receives one end of plunger pressure spring 43. The other end of spring 43 is received by upper spring seat 44 having a parti-spherical recess 45 that rests against ball washer 46 whose position is adjustable along the length of the rear bore portion 25 by pressure adjust screw 48 threadably received in the upper end of body 10. By the foregoing arrangement of the spring 43, seats 41 and 44 and adjusting screw 48, the plunger 33 is continuously urged toward tip 12 so that tapered portion 34 sealingly engages valve seat 35. The parti-spherical relationship of the spring seats, the ball washer and end portion on the plunger insures that the spring will exert minimum forces laterally of the plunger. In accordance with the operating principles of this type of valve, fuel under pressure will overcome the seating force of the spring 43 to urge the plunger away from the valve seat and the maximum limit of such travel accorded to the plunger is adjustably determined by the lift adjust screw 50 that is threadably received within a bore in pressure adjust screw 48 and which is provided with an elongated stem 52, the lower end of which acts as a stop to limit the lift or upward movement of the plunger. The screws 48 and 50 are locked in the desired position by lock nut 51.

Turning now to the fuel inlet fitting 16, it is noted that this fitting generally comprises a connector inlet collar 53 disposed about the nozzle body 10 intermediate its ends and supporting a connector stud 54 having a central bore that communicates with an aperture 56 formed in the side wall of the nozzle body. The other end of the connector stud is provided with a connection screw fitting for attachment to tubing that communicates with the fuel pump. The collar 53 and stud 54 are brazed or otherwise sealed at 58 to the body 10 to preclude fuel leakage.

Turning now to the details of construction of the guide means for the plunger, it is noted that the bore of tip 12 is provided with a portion 60 of a diameter only slightly larger than the major diameter of the end portion 62 of plunger 33 so as to provide a sliding fit between the two members thereby to act as a lower guide member for the plunger adjacent the valve seat 35. In order to

permit the passage of fuel through the lower guide, there is provided a series of circumferentially spaced flats 65 on portion 62 of plunger 33 which define fuel passageways communicating between bore portion 23 and the valve seat.

The upper guide member or collar 38 is provided in the preferred embodiment with external threads which engage mating internal threads provided on the side wall of the bore, which threads are provided with a thread engagement factor of .0080 to .0143 inch clearance on the pitch diameter so that, comparatively speaking, the upper guide member is loosely disposed within the bore. The final positioning of the collar relative to the bore and thus the proper alignment of the plunger relative to the lower guide and valve seat is accomplished through the utilization of a settable resin, preferably an epoxy resin, that is disposed in the clearance spaces between the mating threads. The epoxy resin, when cured, sets up into a hard material that rigidly positions the collar relative to the bore of the nozzle body. If desired, and as shown in the drawings, the upper guide member can be provided with annular recesses 67 into which excess resin is "squeezed" during assembly of the nozzle so that, when the resin is "set," a seal is provided.

In the embodiment of FIG. 3, the lower guide surface is accurately positioned relative to the valve seat during manufacture of the tip and is, because of the unitary nature of the tip, accurately positioned relative to the valve seat. In view of the very great distance between the lower guide member and the upper guide member relative to the distance between the lower guide member and the valve seat, very little movement of the upper guide member is required to permit proper seating of the conical tip 34 in the seat 35 and thus proper alignment of the plunger relative to the nozzle body.

The assembly and manufacture of this improved nozzle involves the proper and accurate machining of all associated parts forming a part of the construction. The tip is assembled to the body and sealed thereto as is the connector inlet, collar stud, etc. The upper guide collar 38 is then coated with an epoxy resin along the threads and inserted into the bore in the nozzle body to the desired depth therein by rotating the collar relative to the body. If desired, a special tool may be utilized to effect this assembly operation and to preset the location of the upper guide member longitudinally of bore portion 25. Because of the clearance provided between the matching pitch diameters on the outside diameter of the guide member and the inside diameter of the nozzle body, the positioning of the guide in the body is, in effect, controlled by the valve seat and plunger. The plunger is inserted into the upper guide while the epoxy is still in semi-fluid state and the conical tip is urged into proper seating engagement with the valve seat by a suitable tool having a plunger loading spring. As the spring-loaded plunger moves to align itself relative to the seat 35 and lower guide 60, the upper guide member 38 is shifted within the limits of thread clearance by whatever small distance is required to permit the proper alignment necessary for repetitive seating of the tip 34 on the seat 35. The entire assembly is then placed in an oven for speedy curing of the epoxy resin. After the epoxy has been properly cured, the spring-loaded plunger tool is removed and the upper valve assembly parts, i.e., the spring seats 41 and 45, the spring 43 and ball washer 46, the pressure adjust screw 48, the lift adjust screw 50 and the lock nut 51 are inserted in the body and the nozzle is ready for final adjustment and test. It is noted that in the foregoing assembly procedures the upper valve assembly parts and the spring 43 can be utilized, if desired, instead of a special tool to exert the desired spring pressure on the plunger 33 to effect proper alignment of the collar and plunger prior to curing of the epoxy resin.

Referring now to the embodiment of the invention shown in FIGS. 5 and 6, there is shown one form of this

invention in which the lower guide for the plunger 33 which, in the embodiment of FIG. 3 is formed by the reduced diameter portion 60 of the bore of tip 12 is eliminated. Also, the spaced flats 65 which are provided on the portions 62 on the plunger 33 of the embodiment of FIG. 3 are eliminated to simplify the nozzle tip design and to provide an improved flow path for the fuel to the nozzle discharge openings 28 since there is less restriction to such flow as well as reduced risk of cavitation due to the fact that fuel may flow throughout the entire annular space between the plunger 33 and the bore of tip 12.

It has been found that when the upper guide member 38 is precisely aligned in position by the settable resin in the manner indicated above in connection with the embodiment of FIG. 3, the plunger 33 will be supported concentrically with the valve seat 35 of the tip 12 without other lateral support or guide means and thus will function properly to provide an atomized spray discharge from the nozzle despite relative rotation between the plunger and the valve seat.

The elimination of the lower guide is possible since the valve seat and the plunger may be precisely aligned despite manufacturing variations and tolerances in the parts of the fuel injection nozzle due to the fact that the upper guide member may be precisely shifted into alignment with the valve seat. The settable resin between the upper guide member 38 and the inner wall of the body member 10 will accommodate any misalignment or eccentricity in the pitch diameters of the threads on the guide member 38 and the mating threads on the body member 10.

In the embodiment of FIGS. 5 and 6, the tip 12 is secured within the front bore portion 23 of the body member 10 with an interference fit. The interference fit is accomplished by providing the tip 12 with an outer diameter on the order of .0007 thousandths inch larger than that of the front bore portion 23 of the body 10. The tip may be assembled by heating the body member 10 to approximately 250° F. to expand the bore 23 slightly so that the tip, which is kept at room temperature, may be inserted therein. Upon the cooling of the body member 10, it will be apparent that the tip 12 is secured to the body member 10 by an interference fit. Such an interference fit will further provide a high pressure mechanical seal between the tip and the body member 10 to prevent the leakage of fuel therebetween.

After the tip is assembled in the body member 10, the end 23a of the body member 10 is crimped into engagement with the reduced diameter portion 12a of the tip 12 to further mechanically secure the tip to the body member 10.

It is preferred that the upper end of the tip 12 be provided with a groove 12b about the periphery thereof and that the groove be filled with a semi-liquid epoxy resin prior to assembly of the tip 12 in the body member 10 to provide, after assembly and curing of the resin, an annular seal ring adhering to the front bore portion 23 and the groove 12b of the tip. It will be noted that the groove is of substantial depth relative to the diameter of the front bore portion 23 so that any differential in the temperatures of the body member 10 and the tip 12 encountered in use as a result of a transient temperature gradient thereacross will not cause the epoxy ring 12c to be stressed beyond its elastic limit due to thermal shock as might occur with, say, a thin film of epoxy between the bore 23 and the tip 12 along the length thereof. The use of this arrangement for securing the tip to the body member 10 is possible despite the manufacturing variations in the concentricity of the valve seat 35 and the outer periphery of the tip 12 due to the arrangement heretofore described for precisely aligning and securing the upper guide member 38 concentrically with the valve seat 35.

From the foregoing description of the construction and operation of this improved fuel injection nozzle, it is noted that there is provided an extremely economical

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yet precision-operating nozzle of the plunger type. through utilizing a tubular body, it is possible to make the working end of the nozzle (i.e., the distance between the connector inlet collar and the tip) sufficiently long to simplify the installation of the nozzle into the engine cylinder head or block and the nozzle cross section diameter or frontal area can be substantially reduced to minimize nozzle locating and installation problems. Additionally, the unique alignment structure provided by this invention substantially reduces the manufacturing cost of the item while increasing its life expectancy under precision operation conditions.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure above described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

I claim:

1. In a fuel injection device, a nozzle body having an outwardly opening bore forming a valve chamber having a valve seat, a plunger of smaller diameter than said bore disposed within said bore, and guide means supporting said plunger for reciprocation longitudinally of said chamber toward and away from said valve seat comprising a guide member positioned within said bore and spaced from the opening thereof, said guide member being of smaller diameter than said bore so as to be loosely disposed therein to provide a clearance therebetween and a hardened resin disposed in said clearance between said guide member and the side wall of said bore securing said guide member within said bore to support said plunger in precise alignment with said valve seat regardless of manufacturing variations in the fabrication of the device.

2. In a fuel injection device, a nozzle body having an outwardly opening bore forming a valve chamber, a plunger of smaller diameter than said bore disposed within said bore, a valve seat disposed adjacent the opening of said bore and cooperating with said plunger to close the opening of said bore, spring means in said bore continuously urging said plunger toward said valve seat, and guide means supporting said plunger for reciprocation longitudinally of said chamber toward and away from said valve seat comprising a guide member positioned within said bore and spaced from the opening thereof, said guide member being of smaller diameter than said bore so as to be loosely disposed therein to provide a clearance therebetween and a hardened resin disposed in said clearance between said guide member and the side wall of said bore positively securing said guide member within said bore in precise alignment with said valve seat for guiding said plunger for movement toward and away from said valve seat.

3. In a fuel injection device, a nozzle body having an outwardly opening bore forming a valve chamber, a plunger of smaller diameter than said bore disposed within said bore, a nozzle tip having a valve seat formed therein and cooperating with said plunger to close the opening of the bore and a guide portion formed therein adjacent said valve seat, and a guide member in said bore spaced from said nozzle tip and cooperating with the guide portion of said tip to support said plunger for reciprocation longitudinally of said chamber toward and away from said seat comprising a collar disposed about said plunger and of smaller diameter than said bore so as to be loosely disposed therein to provide a clearance therebetween, and a hardened resin disposed in said clearance between said collar and the side wall of said bore securing said collar in said bore concentrically with said valve seat thereby to insure precise alignment of said plunger relative to said valve seat.

4. The combination as set forth in claim 3 wherein spring means are provided in said bore continuously urging said plunger toward said valve seat.

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5. The combination as set forth in claim 3 wherein a portion of said bore is provided with screw threads and the outer periphery of said collar is provided with screw threads of lesser pitch diameter than the threads on said bore and said resin is disposed in the clearance spaces between said threads, said guide member being provided with a generally annular recess adjacent one end thereof to receive excess resin from said clearance spaces.

6. In a fuel injection device, an elongated generally tubular nozzle having an outwardly opening bore forming a valve chamber, a nozzle tip disposed in said bore opening and having a valve seat formed therein, a plunger of smaller diameter than said bore disposed within said bore and having one end thereof cooperating with said valve seat to close said bore, guide means in said bore intermediate the ends of said plunger, said guide means being of smaller diameter than said bore so as to provide an annular clearance therewith, a hardened resin disposed in said clearance between said guide means and the side wall of said bore to seal and secure said guide means in said bore and to support said plunger in precise alignment with said valve seat, coil spring means between the end of said plunger opposite said valve seat and the end of the valve body to continuously urge said plunger toward said valve seat.

7. In a fuel injection device, an elongated generally tubular nozzle having an outwardly opening bore forming a valve chamber, a nozzle tip disposed in the bore opening and secured and sealed thereto by an interference fit and having a valve seat formed therein, a plunger of smaller diameter than said bore disposed within said bore and having one end thereof cooperating with said valve seat to close said bore, guide means in said bore intermediate the ends of said plunger, said guide means being of smaller diameter than said bore so as to be loosely disposed therein to provide an annular clearance with said bore, spring means operative between the end of said plunger opposite said valve seat and said valve body to continuously urge said plunger toward said valve seat, and a hardened resin disposed in said clearance between said guide means and the side wall of said bore to seal and secure said guide means in said bore to support said plunger in precise alignment with said valve seat regardless of manufacturing variations and tolerances in the fabrication of the device.

8. The fuel injection device as set forth in claim 7 wherein the magnitude of spring force exerted upon said plunger is adjustable by advancing a pressure adjust screw that threadably engages said valve body and said pressure adjust screw and said plunger are provided with part-spherical seats for said spring to minimize spring forces exerted laterally of said plunger.

9. In a fuel injection device, a nozzle body having an outwardly opening bore forming a valve chamber having a valve seat, a plunger of smaller diameter than said bore disposed within said bore, and guide means supporting said plunger for reciprocation longitudinally of said chamber toward and away from said valve seat comprising a guide member positioned within said bore and spaced from the opening thereof, said guide member being of smaller diameter than said bore so as to be loosely disposed therein to provide a clearance therebetween and a hardened resin disposed in said clearance between said guide member and the side wall of said bore to support said plunger in precise alignment with said valve seat by having its longitudinal axis concentric with said valve seat.

10. A fuel injection nozzle comprising a nozzle body having an outwardly opening bore forming a valve chamber having a valve seat, a plunger of smaller diameter than said bore disposed within said bore, a guide member supporting the plunger for reciprocal movement longitudinally within said chamber toward and away from the valve seat, said guide member being positioned within said bore and of smaller diameter than said bore so as to

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be loosely disposed therein to provide a clearance therebetween, and a hardened sealant disposed in said clearance to seal said guide member to said bore and to rigidly secure said guide member in precise alignment within the bore.

11. A fuel injection nozzle comprising a nozzle body having an outwardly opening bore forming a valve chamber having a valve seat, a plunger of smaller diameter than said bore disposed within said bore, an externally threaded guide supporting the plunger for reciprocal movement longitudinally within said chamber toward and away from the valve seat, the external threads of said guide member threadably engaging mating internal threads forming in said bore and having a smaller pitch diameter than said internal threads in said bore to provide a clearance therebetween to loosely dispose said guide member in said bore, and a hardened sealant disposed in said clearance to seal and to rigidly secure said guide member in precise alignment within the bore.

12. The nozzle as set forth in claim 11, wherein the

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guide member is provided with a generally annular recess filled with hardened sealant adjacent one end thereof.

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