Jan. 10, 1967 R. P. HEINTZ 3,297,261

FUEL INJECTION NOZZLE VALVE

Filed Dec. 2, 1964 2 Sheets-Sheet 1

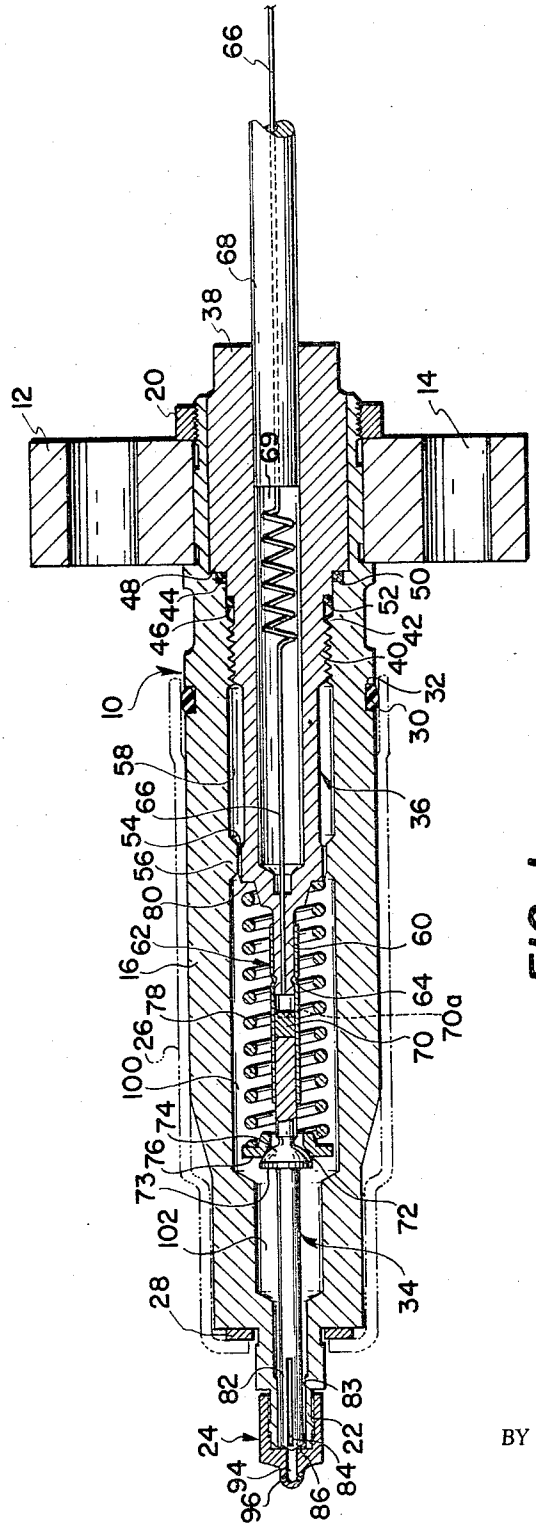


FIG. 1

INVENTOR.
RICHARD P. HEINTZ
BY Stephen M. McHale
ATTORNEY

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FUEL INJECTION NOZZLE VALVE

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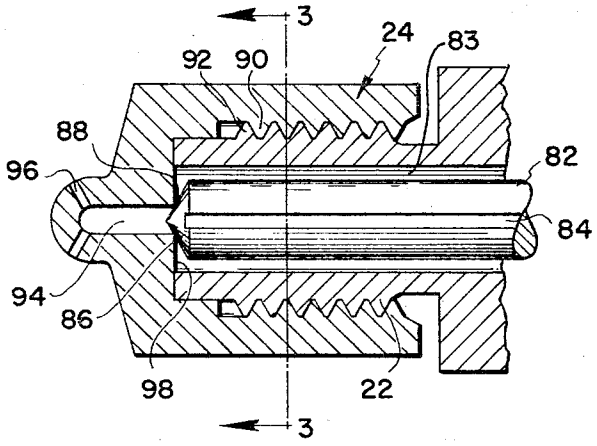


FIG. 2

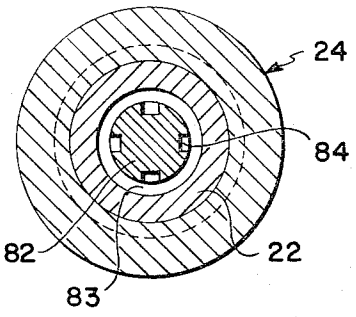


FIG. 3

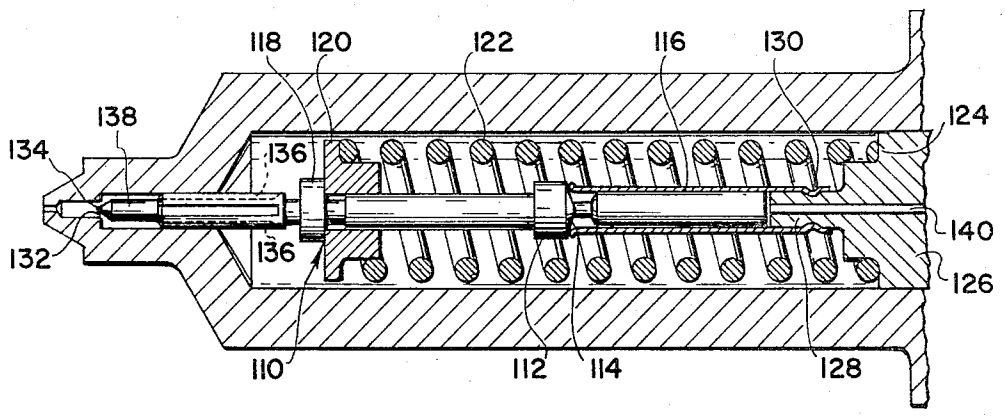


FIG. 4

INVENTOR.
RICHARD P. HEINTZ
BY Stephen M. Michaels
ATTORNEY

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FUEL INJECTION NOZZLE VALVE

Richard P. Heintz, Kalamazoo, Mich., assignor to Pneumo Dynamics Corporation, Cleveland, Ohio, a corporation of Delaware

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11 Claims. (Cl. 239—534)

The present invention relates to an improved fuel injection nozzle valve for injecting fuel into the combustion chamber of internal combustion engines and the like.

Present fuel injection nozzle valves of the type here concerned are generally characterized by the presence of relatively slidable or movable valve components which require manufacturing to rather close tolerances to satisfactorily provide controlled movement between such components. The diasdvantages inherent in present such valve constructions are well understood by those skilled in the art. Not only are manufacturing costs understandably relatively high, but valve malfunction frequently occurs as a result of improper seating of the relatively movable components due, by way of example, to contaminants in the fuel delivered to the valve interior. Present injector valves are further characterized by relative inflexibility in use in that the injector openings are normally formed in the valve housing to provide a predetermined discharge path of the injected fuel to afford optimum engine operation. Thus, to permit use of the valve with the cylinder heads of different engines, the same discharge opening arrangement must be satisfactory for such different engines, and if not, a different valve must be employed.

An object of the present invention is to provide a fuel injection nozzle valve which is not dependent upon close tolerances in the relatively movable components thereof thereby substantially reducing the cost of manufacture of the valve as well as reducing the likelihood of malfunctioning.

A further object of the present invention is to provide a fuel injection nozzle valve having an improved, simplified means for supplying fuel to the valve interior.

A more specific object of the present invention is to provide a novel flexible sleeve enveloping the valve poppet of the nozzle valve, the pressure of the fuel delivered to the valve resiliently expanding such sleeve to permit the fuel to enter the valve accumulating chamber, with the pressure in the latter during injection tightly closing the flexible sleeve around the poppet to prevent leakage from the accumulator chamber to the fuel supply line.

Yet another object of the invention is to provide a fuel injection valve adapted to accommodate fuel supply lines of varying lengths thereby to facilitate timing of the fuel system.

A still further object of the present invention is to provide a fuel injection valve having a replaceable nozzle to accommodate mounting of the valve for use with variously designed engines.

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 drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawings:

FIG. 1 is a longitudinal cross-sectional view of the fuel injection nozzle valve of the present invention;

FIG. 2 is an enlarged fragmentary view of a portion

of FIG. 1, more clearly showing the removable nozzle of the injection valve;

FIG. 3 is a sectional view taken on line 3—3 of FIG. 2; and

FIG. 4 is a slightly modified form of fuel injection nozzle valve.

Referring now in detail to the drawings, wherein like parts are designated by like reference numerals, and initially to FIG. 1, the fuel injection nozzle valve of the present invention is generally indicated at **10** and is adapted to be mounted to the cylinder head of an internal combustion engine in any suitable manner, such as, for example, by means of a mounting flange **12**. The latter is formed with a plurality of openings commonly designated at **14** for such mounting and it will be understood that the forward or nozzle end of the valve extends into the combustion chamber for supplying fuel thereto, all in a well-known manner.

The valve **10** comprises an elongated valve body **16** which is formed with a shoulder **18** relatively adjacent the outer ends thereof for receiving the mounting flange **12**, with the extreme outer end of the body being threaded to receive a jam nut **20** for rigidly securing the valve body to the mounting flange. The valve housing **16** further includes a reduced nozzle end portion **22** which is adapted to receive a replaceable nozzle generally indicated at **24**, the details of which will be hereinafter described in detail when particular reference is made to FIGS. 2 and 3. A shielding jacket **26**, shown in dashed lines in FIG. **1**, is adapted to slip over the valve body **16** to protect the same from the cooling system liquid flowing through the engine cooling passages through which the injector valve extends. The shielding jacket is apertured at its closed end to permit the same to be slipped over the valve body, with a sealing gasket **28** being provided at such closed end for sealing the same. A sealing washer **30** is disposed within an annular groove **32** formed therefor in the exterior of the valve body for sealing the shielding jacket adjacent the open end thereof.

The valve body **16** is internally bored and is adapted to receive a poppet generally indicated at **34** and a retainer assembly generally indicated at **36**. Referring initially to the latter such assembly, the same comprises a retainer sleeve **38** threadedly received in the valve body through an intermediate threaded section **40** which engages a threaded section **42** formed on the interior of the valve body. The retainer sleeve **38** is further formed with stepped shoulders **44** and **46**, the former of which is adapted to tightly contact an annular shoulder **48** formed in the valve body for limiting the forward movement of the retainer assembly in the valve body. A pair of sealing rings **50** and **52** are disposed around the retainer sleeve **38** immediately forward of the shoulders **44** and **46** to seal the mounting of the retainer sleeve within the valve body.

The retainer sleeve **38** is formed relatively adjacent the forward end thereof with a plurality of radially directed shoulders commonly designated at **54** the outer ends of which terminate closely adjacent an inwardly directed annular shoulder **56** formed on the interior of the valve body. The shoulders **54** are arcuately spaced around the retainer sleeve and function not only to axially align the retainer sleeve within the valve body but permit flow of the fuel under pressure into the annular chamber **58** formed between the valve housing bore and the periphery of the retainer sleeve. The extreme forward end **60** of the retainer sleeve **38** is of substantially reduced diameter and is adapted to telescopically receive one end of a flexible, metallic sleeve generally indicated at **62**, with the latter being preferably adhesively secured to and crimped on such forward end **60** of the retaining sleeve as indicated at **64**. The flexible metallic sleeve **62** can be made from any commercially available metal having the re-

quired characteristics, and 300 series stainless steel has proved highly satisfactory for this purpose.

Fuel is directed to the interior of the valve by means of flexible, preferably metallic hypodermic tubing **66**. The flexible tubing **66** enters the valve interior through a plastic, flexible protective tube or sheath **68** secured within the retainer sleeve at the adjacent end thereof by means of epoxy adhesive or the like. The protective tube **68** extends to the fuel control valve to which the flexible tubing **66** is connected. The forward end of the tubing **66** extends through a longitudinal opening provided therefor in the forward end **60** of the retainer sleeve **38**, with suitable adhesive means being provided to secure the tubing in place within such retainer forward end. The tubing **66** is relatively thin-walled and diametrically relatively small, having, by way of example, an outside diameter of .0365 inch and an inside diameter of .0235 inch. The tubing is thereby relatively flexible to facilitate bending thereof if necessary, and the inside diameter is such as to supply the desired fuel quantities to the valve.

In the form shown a portion of the flexible tubing **66** is coiled in the cavity or chamber **69** defined by the intermediate section of the retainer sleeve through which the tubing extends. The use of flexible tubing capable of such bending is a distinct advantage over inflexible fuel lines commonly in use. By coiling the tubing where necessary, the length of tubing for all the injectors of the fuel system can be made the same, with the varying distances of the respective injectors from the fuel control valve being accommodated in each instance by coiling of the tubing within the chamber **69** the required amount. Thus, the injector most distant from the control valve will require little or no coiling of the flexible supply tubing while the injector located nearest the control valve will necessitate considerable coiling of the supply tubing. By employing equal lengths of tubing for each of the several injectors in the fuel system, the timing for the system can be accurately set at the control valve, with the response times for each injector being the same by virtue of the equal tube lengths. It will be apparent that the encased tubing **66** could also be coiled exteriorly of the valve as well.

The end of the poppet **34** disposed adjacent the forward end of the retainer sleeve **38** is adapted to telescopically receive the flexible sleeve **62** for relative movement under conditions to be hereinafter described. The flexible sleeve and the telescoping fit thereof around the poppet provide a distinct advantage in terms of manufacturing costs. The inside diameter of the sleeve and the outside diameter of the poppet can be manufactured with rather wide tolerances, with the subsequent collapsing and expanding of the sleeve during operation automatically effecting the desired tightness of fit. Further, it will be apparent that the sleeve **62** serves to support the trailing end of the poppet and thus align the poppet in the housing and guide the movement thereof. A spacer **70** is provided within the flexible sleeve **62** at the end of the poppet to regulate and limit the rearward movement of the poppet during injection.

The poppet **34** further includes a relatively enlarged intermediate portion **72** having a forward, flat surface **73** and a curved rear surface **74**, the latter forming a seat for a spring retaining member **76**. A helical compression spring **78** seats at one end against such retainer and at its other end against an annular shoulder **80** formed on the retainer sleeve **38** immediately forward of the radial shoulders **54**. The force of the helical compression spring **78** biases the forward end of the poppet valve to a seating position to prevent injection of the fuel from the nozzle **24**, and during the injection period the spring is compressed, as will be hereinafter described.

As best seen in FIGS. 2 and 3, the forward end **82** of the poppet **34** loosely fits within the forwardmost end portion **22** of the valve housing whereby fuel can be delivered through the annular chamber **83** formed there-

between to the forward end of the poppet. The poppet at such forward end **82** is further formed with a plurality of longitudinally extending grooves **84** to facilitate the delivery of the fuel to the forward end of the poppet. The extreme forward end of the poppet is conical shaped as indicated at **86** and is adapted to engage an annular edge **88** formed on the nozzle **24**. Such edge contact, as well as the annular space between the poppet end **82** and the housing end **22**, permits manufacturing without particular regard to close manufacturing tolerances, while at the same time providing highly satisfactory valve operation.

The nozzle **24** is internally threaded as indicated at **90** for mounting the nozzle on the exteriorly threaded forward end **22** of the valve housing. A passage **94**, the inner end of which is defined by the edge **88**, is formed in the nozzle, with the forward or outer end of such passage communicating with injector openings commonly designated at **96**, the number and size of which can be varied as desired to achieve optimum fuel delivery to the combustion chamber. The nozzle **24** is further formed with an annular flat face **98** which is adapted to engage the adjacent end of the valve body thereby to accurately position and limit the mounting of the nozzle **24** on the forward end of the valve housing. As noted above, the particular design of the engine may require, for optimum operation, a nozzle having a particular injector opening arrangement, and the quick assembly and disassembly of the nozzle without necessitating replacement of the entire valve is an obvious advantage over present valve designs wherein the injector openings are formed in the valve body or in members which effectively constitute the valve body.

The valve housing, in the regions surrounding the poppet **34** and the flexible sleeve **62**, defines an accumulator chamber comprising a main section **100** and a forward, relatively smaller section **102** in both of which the pressurized fuel accumulates prior to injection, as will be presently explained.

The operation of the fuel injection valve just described is as follows. Assuming the poppet is seated following injection, fuel is delivered to the valve through the flexible supply tube **66** at operating pressures ranging up to 20,000 p.s.i. The fuel emanates from the end of the tube **66** into the area defined by the leading end of the retainer sleeve **38** and the adjacently disposed end of the spacer **70**, with the flexible sleeve **62** defining the radially outer limits of such area. The fuel entering the described area, being at control line pressure substantially higher than the pressure in the accumulator following injection, will act outwardly against the relatively thin wall of the flexible sleeve **62** thereby expanding the same away from the periphery of the spacer **70** and poppet **34** sufficiently to permit the pressurized fuel to flow along the thus formed annular opening into the accumulator chamber. The entire accumulator chamber and adjoining passages **58** and **83** will eventually become filled or charged with fuel at control line pressure. The poppet remains seated against the annular edge or shoulder **88** during charging due to the combined forces of the spring **78** and the control line pressure.

To inject fuel from the valve, the control valve (not shown) functions to cut off the fuel supply to the supply line **66** thereby producing a drop in control line pressure. The pressure in the accumulator chamber and adjoining passages acting against the conical surface **86** and the forward end **73** of the intermediate portion **72** of the poppet is then sufficient to force the poppet rearwardly unseating the same and permitting injection of the fuel outwardly of the valve through passage **94** and injector openings **96**. When the control line pressure at the beginning of the injection period drops off, the pressure in the accumulator chamber forces the flexible sleeve **62** around the poppet but yet permits relative movement therebetween to effect unseating of the poppet. However,

additional drops in control line pressure cause the sleeve to tightly contract around the poppet thereby to form a seal therewith to prevent leakage of the fuel from the accumulator chamber back through the supply line **66**. The rearward movement of the poppet **34** compresses the spring **78** against the shoulder **80** of the retainer sleeve. The degree of movement of the poppet and the compression of the spring **78** are controlled by the length of the spacer **70**. To provide more reliable sealing of the flexible sleeve **62**, the sealing is desirably limited to the interface between the sleeve and the poppet, and not to the adjacent faces of the spacer **70** and the forward end **60** of the retainer sleeve. To preclude sealing in the latter area during injection, a slot **70***a* is formed in such adjacent face of the spacer.

As the fuel is injected into the combustion chamber through the injection openings **96**, a progressive pressure drop occurs within the accumulator chamber due to the expansion of the fuel remaining therein. The force on the poppet due to the pressure within the accumulator chamber during the injection eventually becomes less than the compressive force of the spring **78**, at which time the spring moves the poppet back to a position wherein the conical forward end **86** thereof seats on the annular shoulder **88** of the nozzle thereby terminating injection. The accumulator chamber is subsequently recharged as described to complete the cycle. It will be apparent that the quantity of fuel injected is dependent upon the injection pressure, i.e., the pressure in the accumulator at the beginning of the injection period, and the force of the spring **78** which controls the pressure in the accumulator at the termination of the injection period. The reseating of the poppet to terminate the injection period can also be controlled by reapplication of the control line pressure as regulated by the control valve.

It will be noted that the described valve construction is novel in many respects when compared to present injection valves of this general type. The fuel is delivered to the valve interior through a flexible fuel supply line and is supplied to the accumulator chamber through an annular opening provided by a resiliently distensible sleeve which is adapted to expand when subjected to the relatively high control line pressures. The employment of a flexible fuel supply line permits the same to be coiled within the retainer sleeve or exteriorly of the valve in the described manner thereby to allow use of supply lines of equal length. The valve is of simple construction and eliminates complemental mating surfaces requiring close manufacturing tolerances thereby providing substantial cost reduction.

There is illustrated in FIG. 4 a slightly modified valve construction. In this valve form the poppet generally indicated at **110** is formed with a further relatively enlarged portion **112** presenting a conical surface **114** adapted to engage the leading end of the flexible sleeve **116**. The remainder of the valve construction is generally similar, with the poppet **110** further comprising an intermediate, diametrically enlarged portion **118** adapted to contact and retain a spring retaining member **120**. A helical compression spring **122** is disposed between the retainer **120** and an annular shoulder **124** formed on the retainer sleeve **126** relatively adjacent the forward end thereof. The reduced forward end **128** of the retainer sleeve **126** is adapted to receive the flexible sleeve **116** which is crimped thereto as indicated at **130**. In the FIG. 4 form the valve nozzle has been integrally formed with the valve body, providing a flat annular shoulder **132** against which the forward conical end **134** of the poppet is adapted to seat. The pressurized fuel is adapted to enter the forward portion of the valve body adjacent the nozzle end thereof through a plurality of grooves commonly designated at **136** formed in the leading end **138** of the poppet.

The operation of the FIG. 4 form of injection valve is generally similar to that described above. In this form, however, when the poppet is unseated during injection, the conical section **114** of the poppet contacts the leading curved edge of the flexible sleeve **116** thereby providing a tight seal and preventing fuel leakage back through the area between the end of the poppet and the flexible sleeve **116** to the supply tubing **140**. At substantially the same time as the conical section **114** of the poppet engages the curved leading end of the flexible sleeve, the bottom of the poppet will engage the leading end of the retainer, and thus the force moving the poppet rearwardly will not be absorbed completely by the leading edge of the retaining sleeve.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

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

1. A fuel injection nozzle valve comprising a valve body having an outlet portion defining injector opening means, a poppet within said body having a forward end portion adapted to close said opening means, spring means biasing said poppet to a closed position, said poppet and said body defining therebetween an accumulator chamber in which pressurized fuel collects during valve pressurization, means for supplying fuel under pressure to said valve, and flexible sleeve means telescopically disposed around the trailing end of said poppet, said sleeve being expanded by said pressurized fuel during valve pressurization to provide an annular passage between said sleeve and said poppet to permit delivery of said fuel to said accumulator chamber prior to injection, said sleeve being collapsed tightly around said trailing end of said poppet by the pressure in the accumulator chamber during injection thereby to prevent leakage of fuel from said accumulator chamber to said supply means.

2. The combination of claim **1** wherein said flexible sleeve means is of metallic material.

3. The combination of claim **1** wherein said means for supplying fuel under pressure to said valve comprises a metallic tube the leading end of which terminates within said flexible sleeve adjacent the trailing end of said poppet.

4. A fuel injection nozzle valve comprising a valve body having an outlet portion defining injector opening means, a retainer sleeve within said body and secured thereto, a poppet within said body forwardly of said retainer sleeve having a forward end portion adapted to close said opening means, spring means biasing said poppet to a closed position, said poppet and said body defining therebetween an accumulator chamber in which pressurized fuel collects during valve pressurization, means for supplying fuel under pressure to said valve, and flexible sleeve means telescopically disposed closely around the trailing end of said poppet and secured to said retainer sleeve, said sleeve being expanded by said pressurized fuel during valve pressurization to provide an annular passage between said sleeve and said poppet to permit delivery of said fuel to said accumulator chamber prior to injection, said sleeve being collapsed tightly around said trailing end of said poppet by the pressure in the accumulator chamber during injection thereby to prevent leakage of fuel from said accumulator chamber to said supply means.

5. The combination of claim **4** wherein said flexible sleeve means is metallic and wherein said means for supplying fuel to said valve comprises a flexible metallic tube extending through said retainer sleeve and terminating within said flexible sleeve adjacent the trailing end of said poppet.

6. A fuel injection nozzle valve comprising a valve body having an outlet portion defining injector opening means, an axially movable poppet within said body having a forward end portion adapted to close said opening means, an elongated, axially fixed retainer sleeve within said body and secured thereto and having a reduced for-

ward end portion of relatively the same diameter as said poppet and disposed adjacent to the trailing end thereof, spring means interposed between said retainer sleeve and said poppet for biasing said poppet to a closed position, said poppet and said body defining therebetween an accumulator chamber in which pressurized fuel collects during valve pressurization, means for supplying fuel under pressure to said valve, and flexible metallic sleeve means telescopically disposed within said spring and around the trailing end of said poppet and the reduced forward end of said retainer sleeve and secured to the latter, said sleeve thus serving as a means of support for said poppet, said sleeve being expanded by said pressurized fuel during valve pressurization to provide an annular passage between said sleeve and said poppet to permit delivery of said fuel to said accumulator chamber prior to injection, said sleeve being collapsed relatively tightly around said trailing end of said poppet by the pressure in the accumulator chamber during injection thereby to prevent leakage of fuel from said accumulator chamber to said supply means.

7. The combination of claim 6 wherein said means for supplying fuel to said valve comprises a flexible metallic tube having an outer end exteriorly of the valve for communication with a controlled source of fuel and an inner end extending through and secured to the forward end of said retainer sleeve.

8. A fuel injection nozzle valve comprising a valve body having a reduced forward end portion, a nozzle removably secured to such forward end portion, said nozzle being formed with injector openings and a passage communicating such openings with the interior of said valve, a poppet within said body having a forward end portion disposed within and spaced from said reduced forward end of said valve body, said poppet being adapted to close said passage, spring means biasing said poppet to a closed position, an accumulator chamber defined by said body in which pressurized fuel collects during valve pressurization, means for supplying fuel under pressure to said valve, and flexible sleeve means telescopically disposed around the trailing end of said poppet, said sleeve being expanded by said pressurized fuel during valve pressurization to provide an annular passage between said sleeve and said poppet to permit delivery of said fuel to said accumulator chamber prior to injection, said sleeve being collapsed tightly around said trailing end of said poppet by the pressure in the accumulator chamber during injection thereby to prevent leakage of fuel from said accumulator chamber to said supply means.

9. A fuel injection nozzle valve comprising a valve body having an outlet portion defining injector opening means, a poppet within said body having a forward end portion adapted to close said opening means, spring means biasing said poppet to a closed position, said poppet and said body defining therebetween an accumulator chamber in which pressurized fuel collects during valve pressurization, said poppet having an intermediate, enlarged portion presenting a rearwardly directed conical surface, means for supplying fuel under pressure to said valve, and flexible sleeve means telescopically disposed around the trailing end of said poppet, said sleeve being expanded by said pressurized fuel during valve pressurization to provide an annular passage between said sleeve and said poppet to permit delivery of said fuel to said accumulator chamber prior to injection, said sleeve being formed with a curved leading edge adjacent said conical surface of said enlarged portion of said poppet, said conical surface tightly contacting said curved edge substantially simultaneously with injection responsive to a drop in pressure in said fuel supply means, thereby preventing leakage of fuel from said accumulator chamber to said fuel supply means.

10. A fuel injection nozzle valve comprising a valve body having an outlet portion defining injector opening means, a retainer sleeve within said body and secured thereto, a poppet within said body forwardly of said retainer sleeve having a forward end portion adapted to close said opening means, spring means biasing said poppet to a closed position, said poppet and said body defining therebetween an accumulator chamber in which pressurized fuel collects during valve pressurization, flexible tube means for supplying fuel under pressure to said valve, said retainer sleeve being constructed and arranged to provide a chamber through which said flexible supply tube extends, said chamber being of a transverse dimension substantially in excess of the diameter of said supply tube thereby to accommodate coiling thereof, and means intercommunicating said flexible supply tube and said accumulator for supplying fuel thereto.

11. A fuel injection nozzle valve comprising a valve body having an outlet portion defining injector opening means, a poppet within said body having a forward end portion adapted to close said opening means, spring means biasing said poppet to a closed position, said poppet and said body defining therebetween an accumulator chamber in which pressurized fuel collects during valve pressurization, means for supplying fuel under pressure to said valve, axially fixed sleeve means telescopically disposed around and supporting the trailing end of said poppet, said sleeve means thereby serving to align said poppet in said housing, said sleeve and said poppet being spaced when fuel under pressure is supplied to said sleeve to define an annular passage for supplying such fuel to said accumulator chamber.

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EVERETT W. KIRBY, *Primary Examiner.*