United States Patent

[11] **3,632,047**

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[45] Patented **Jan. 4, 1972**

[54] **FUEL INJECTION NOZZLE VALVE**
18 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **239/533**
[51] **Int. Cl.** **B05b 1/30**
[50] **Field of Search** 239/533, 452, 464, 63,87, 570, 584; 137/88, 98

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ABSTRACT: Fuel under pressure is conducted through restricted passages into the piston chamber of a nozzle body having a discharge orifice through which an axially movable valve projects. Pressurization of the piston chamber retracts the valve against a continuous closing bias to establish and control a discharge spray pattern. A signal pressure developed within the spray pattern is sensed at the projecting end of the valve to regulate its orifice opening position.

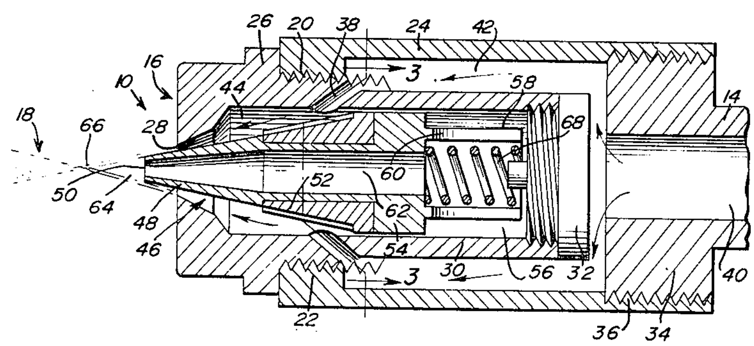


Fig. 1

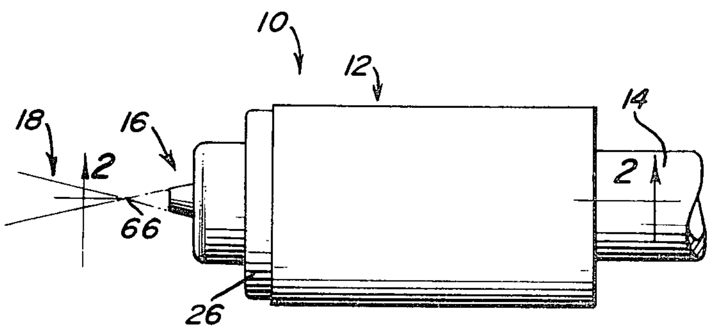


Fig. 3

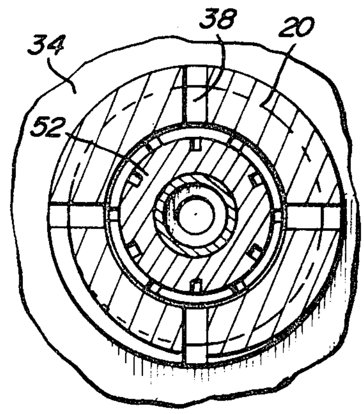


Fig. 2

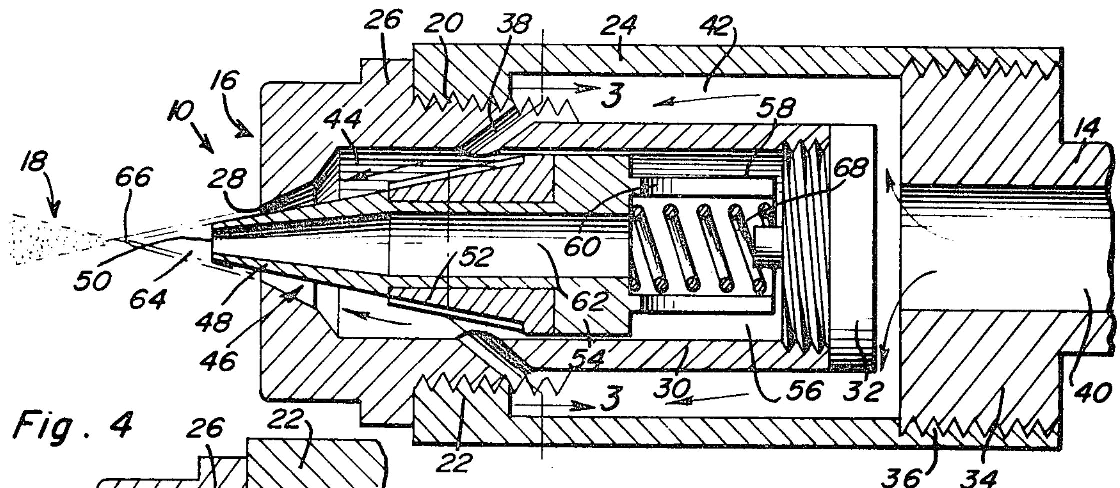


Fig. 4

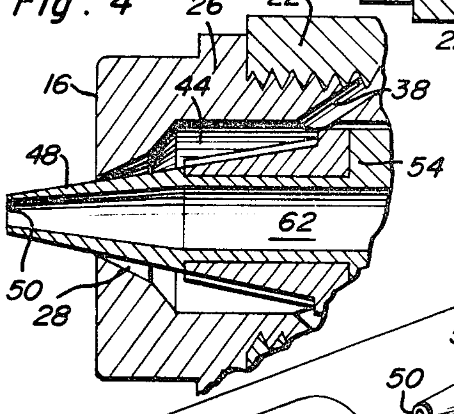
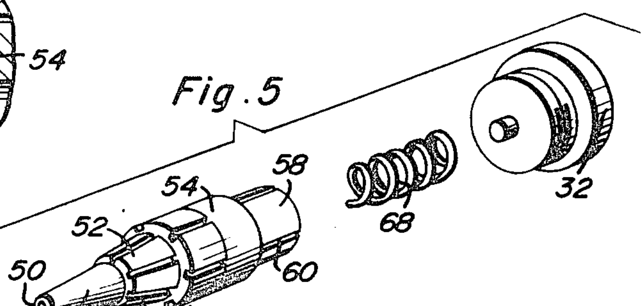


Fig. 5



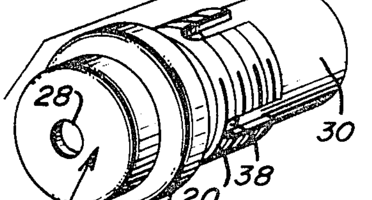


Fig. 13

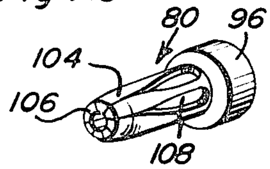


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Fig. 6

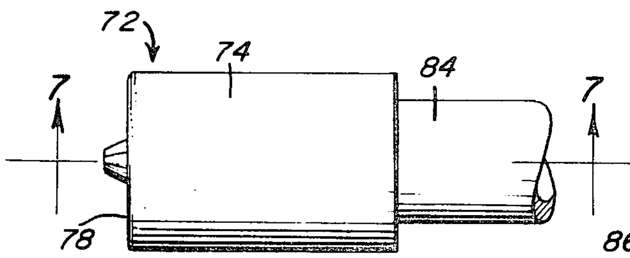


Fig. 8

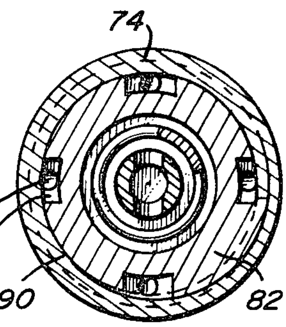


Fig. 7

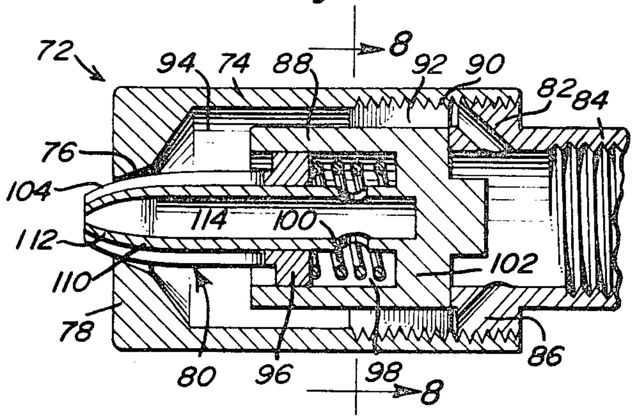


Fig. 9

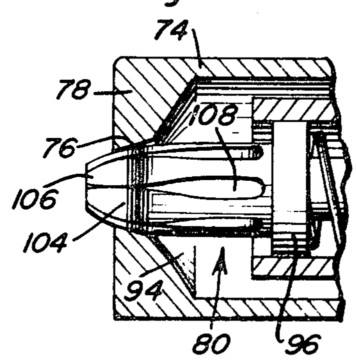


Fig. 10

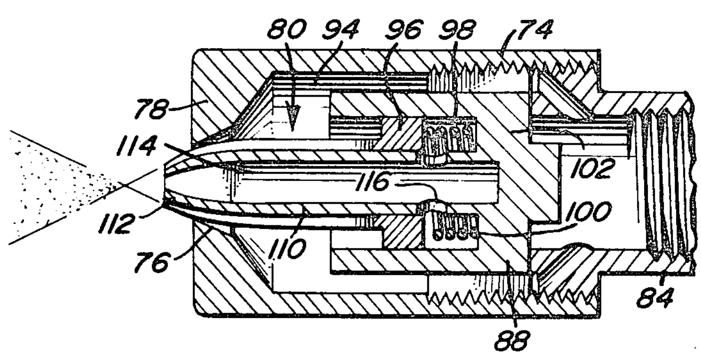


Fig. 11

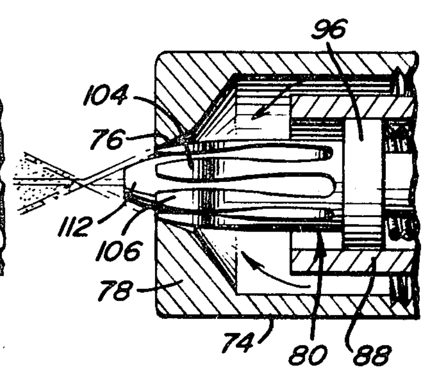
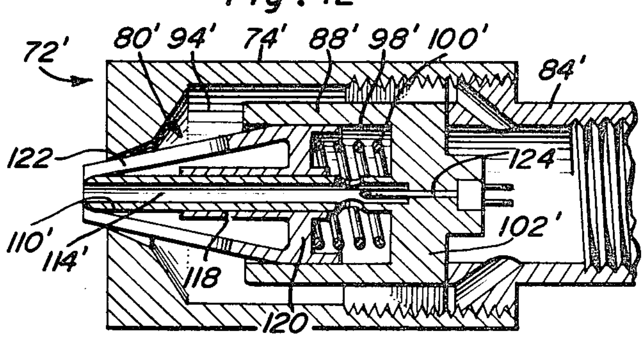


Fig. 12



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FUEL INJECTION NOZZLE VALVE

This invention relates in general to the injection of a fluid from a pressurized source into a region of lower pressure and more particularly to an injection nozzle assembly through which a liquid such as a fuel is injected in spray form into a combustion chamber. Nozzle assemblies for injecting liquid fuel into the combustion chambers of internal combustion engines, are well known. Although such injection nozzles are provided with facilities for adjusting and regulating the discharge of fuel therefrom, pressure- and flow-controlling devices independent of the injection nozzle are required in order to regulate the supply of fuel to the injection nozzle so that proper atomization of the fuel will be effected when discharged from the orifice of the injection nozzle. Accordingly, should any fluctuation in the flow of fuel through the injection nozzle occur, a proper spray pattern and atomization of the fuel necessary to obtain proper combustion conditions, is not maintained. It is therefore an important object of the present invention to provide an injection nozzle device which is self-regulating with respect to the maintenance of a proper discharge spray pattern regardless of variations in inflow of the fuel to the injection nozzle.

In accordance with the present invention, the discharge of fuel from the orifice opening of nozzle body is directed conically over the external surface of a valve element nose portion causing a converging vortical flow pattern and atomization of the fuel. The nose end of the valve element monitors the discharge flow pattern and transmits a pressure signal to a control chamber to which the valve piston is exposed on a side opposite a pressure chamber through which the fuel flows. Thus, any increase in fuel pressure tending to retract the valve element and decrease the convergence of the flow pattern, is counteracted by reduction of the vacuum in the control chamber. This self-regulating action thereby maintains the proper discharge orifice opening in accordance with variations in the supply of fuel to the injection nozzle.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIG. 1 is a side elevational view of one form of injection nozzle constructed in accordance with the present invention.

FIG. 2 is an enlarged longitudinal sectional view taken substantially through a plane indicated by section line 2—2 of FIG. 1.

FIG. 3 is a partial transverse sectional view taken substantially through a plane indicated by section line 3—3 of FIG. 2.

FIG. 4 is a partial side sectional view showing the injection nozzle in an inactive operational condition.

FIG. 5 is a perspective view showing some of the assembled parts of the injection nozzle.

FIG. 6 is a side elevational view of another form of injection nozzle constructed in accordance with the present invention.

FIG. 7 is an enlarged longitudinal sectional view taken substantially through a plane indicated by section line 7—7 in FIG. 6.

FIG. 8 is a transverse sectional view taken substantially through a plane indicated by section line 8—8 in FIG. 7.

FIG. 9 is a partial side sectional view of the injection nozzle similar to that shown in FIG. 7.

FIG. 10 is a side sectional view through the injection nozzle of FIG. 7 shown in an active condition.

FIG. 11 is a partial side sectional view of the nozzle as shown in FIG. 10.

FIG. 12 is a side sectional view showing a modification of the injection nozzle as illustrated in FIGS. 7 through 11.

FIG. 13 is a perspective view of the valve assembly employed in the nozzle of FIGS. 6–11.

Referring now to the drawings in detail, FIG. 1 illustrates an injection nozzle generally referred to by reference numeral 10 through which a fluid such as a liquid fuel may be injected into a lower pressure region from a pressurized source in an atomized state. As shown in FIG. 1, the injection nozzle includes a nozzle body 12 connected to a source of fluid under pressure by a conduit section 14 so that the fluid may be discharged from a head portion 16 of the nozzle body in the form of a converging and diverging spray pattern generally referred to by reference numeral 18.

As more clearly seen in FIGS. 2 and 3, the head portion 16 of the nozzle body has an externally threaded tubular section 20 so as to be mounted within the internally threaded end portion 22 of a cylindrical housing 24. The internally threaded end portion 22 of the housing abuts the flange 26 of the head portion 16 which is also provided at its forward end with a centrally located orifice opening 28. Extending rearwardly from the externally threaded section 20 of the head portion, is a tubular chamber enclosing section 30 adapted to be closed at a rear end by a threaded plug 32 in axially spaced relation to the externally threaded coupling end 34 of the conduit section 14. The housing 24 is provided with an internally threaded end section 36 threadedly receiving the coupling end 34 of the conduit section.

As shown in FIGS. 2, 3 and 5, the threaded section 20 of the head portion 16 is provided with restricted passages 38. In the illustrated embodiment, four of such restricted passages are formed in circumferentially spaced relation about the threaded section 20 so as to conduct a controlled flow of fluid such as liquid fuel from the conduit passage 40 through the annular passage 42 to a pressure chamber 44 from which the fuel is adapted to be discharged from the orifice opening 28. An axially displaceable valve assembly 46 is enclosed within the tubular section 30 of the head portion 16 and includes a forwardly converging, pressure-sensing nose portion 48 which projects through the orifice opening 28 and terminates at end 50. Fixedly mounted on the valve assembly in rearwardly spaced relation to the pressure sensing end 50, is an externally grooved sleeve 52 abutting a pressure-responsive piston formation 54 of the valve assembly. The piston formation has a sliding fit within the internal cylindrical wall surface of the tubular section 30 so as to separate the pressure chamber 44 from a rear control chamber 56 pressure sealed by the plug 32. A tubular sleeve 58 projects rearwardly from the piston formation 54 into the control chamber 56 and is provided with slots 60 so as to establish continuous fluid communication between the control chamber 56 and a pressure-sensing bore or passage 62 that extends through the valve assembly to the pressure-sensing end 50. Thus, the space 64 as shown in FIG. 2 located just upstream of the point of convergence 66 in the discharge spray pattern 18, will be in fluid communication with the control chamber 56. Since this space 64 is at a lower pressure than the region into which fuel is injected, in view of the vortical flow pattern 18, the valve assembly 46 is able to sense the condition of the flow pattern 18 and in particular any forward movement of the point of convergence 66.

As shown in FIGS. 2 and 4, fluid under pressure from the source enters the pressure chamber 44 through restricted passages 38 and is adapted to be discharged through the forwardly converging orifice opening 28 forming an annular discharge passage about the nose portion 48 of the valve assembly. The valve assembly is continuously biased to a closed position as shown in FIG. 4 by means of a coil spring 68 which is enclosed within the tubular sleeve 58 and reacts between the piston formation 54 and the inside end of the plug 32. When fuel under pressure is supplied to the pressure chamber it reacts against the forward end of the piston formation 54 causing the valve assembly to be retracted rearwardly from the closed position shown in FIG. 4 to the position shown in FIG. 2 against the continuous bias of the spring member 68. Fluid under pressure may therefore be discharged from the orifice opening 28 forming the spray pattern 18 as shown. The control chamber 56 being in fluid communication with the space 64 will accordingly expose the side of the piston formation 54 opposite the pressure chamber 44 to a lower pressure than that of the region into which fluid is injected. The control chamber 56 therefore is not merely vented to some constant ambient pressure but instead receives a variable signal pressure reflecting any change in the discharge spray pattern 18. The signal pressure within the control chamber 56, the static pressure of the fluid being discharged from the pressure chamber 44 and the continuous bias of the spring 68 therefore determines the valve opening position of the valve assembly 46. The grooves 70 formed on the sleeve portion 52 of the valve assembly are exposed to the fluid flowing through the pressure chamber 44 in order to prevent vortical flow and turbulence while the fluid passes through the pressure chamber 44.

It will be apparent from the foregoing description that pressurization of the chamber 44 by fluid under pressure from the source will cause retraction of the valve assembly limited by abutment of the tubular sleeve 58 with the plug 32. The static pressure urging the valve assembly in a retracting direction and the vacuum pressure in control chamber 56 will of course be opposed by the constant bias of the spring member 68 so as to automatically position the valve assembly in an open position as shown in FIG. 2. Should there be any increase in the mass flow rate of fluid to the injection nozzle, the valve assembly will tend to retract even further enlarging the annular opening of the discharge orifice 28 with a corresponding forward displacement of the point of convergence 66 to thereby reduce the degree of atomization of the liquid fuel. A corresponding reduction in the vacuum of space 64 is then sensed by the valve assembly through the passage 62 thereby decreasing the vacuum or increasing the pressure within the control chamber 56. Thus, rearward retraction of the piston formation 54 under an increasing pressure within the pressure chamber 44, is counteracted by an increase in the signal pressure in the control chamber 56 opposing the retracting movement. The converging spray pattern 18 and atomization of the liquid fuel being injected is thereby maintained regardless of the variation in the pressure or inflow of fuel to the injection nozzle.

The same type of fuel atomizing spray pattern is automatically maintained by another form of injection nozzle 72 as shown in FIGS. 6 through 9. The injection nozzle 72 includes a cylindrical nozzle body generally referred to by reference numeral 74 having forwardly converging orifice opening 76 in its end wall 78 through which a valve assembly 80 projects. The opposite axial end of the nozzle body 74 is internally threaded so as to threadedly receive the coupling end 82 of a conduit section 84 through which fuel under pressure is supplied to the injection nozzle. The coupling end portion 82 of the conduit section is provided with restricted passages 86 and abuts a chamber enclosing member 88 having an externally threaded section 90 formed with a plurality of circumferentially spaced recesses 92 in fluid communication with the restricted passages 86. Accordingly, fuel under pressure is conducted from the conduit section into a pressure chamber 94 surrounding the valve assembly 80.

The valve assembly 80 includes a valve element having a piston formation 96 which is slidingly mounted within the chamber enclosing member 88. The piston formation separates the pressure chamber 94 from a control chamber 98 within which a valve closing spring member 100 is housed reacting between the piston formation 96 and the end wall 102 of the chamber enclosing member. Extending forwardly from the piston formation 96, are a plurality of flexible fingers 104 that are held in contracted positions abutting each other at a convergent nose end 106 of the valve element by the orifice opening 76 of the nozzle body when the valve assembly is in its closed position as illustrated in FIGS. 7 and 9. The space between the flexible fingers 104 is enlarged at 108 adjacent the piston formation so as to serve a twofold purpose of rendering the fingers 104 flexible enough to expand and contract radially and to prevent vortical flow and turbulence within the pressure chamber 94 through which the fluid flows.

The valve element is slidably mounted on a rigid tubular member 110 that projects from the chamber enclosing member 88 through the orifice opening 76. The tubular member is provided with a converging nose portion 112 with respect to which the flexible fingers 104 of the valve element are radially expanded in response to slidable displacement in a rearward direction in order to separate the fingers at the nose end 106 as more clearly seen in FIG. 11. The tubular member 110 is also provided with a signal pressure-sensing passage 114 communicating with the control chamber 98 through circumferentially spaced openings 116. The tubular member 110 is furthermore axially fixed in order to limit the maximum size of the orifice opening which is determined by the axial position of the valve element 80. Since flow through the discharge orifice is conducted between the separated flexible fingers 104 of the valve element in its retracted position, greater control over fluid flow is exacted. The positioning of the valve element 80 in accordance with variations of pressure in the pressure chamber 94 and the condition of the spray pattern as sensed through the passage 114 is similar to that described in connection with the injection nozzle 10.

An injection nozzle 72' similar to the injection nozzle 72 of FIGS. 6 through 11, is illustrated in FIG. 12. The injection nozzle 72' includes a nozzle body 74', a chamber enclosing member 88' and conduit section 84'. An axially fixed, pressure-sensing tubular member 110' is also associated with the injection nozzle 72' slidably mounting a modified form of valve element 80'. The valve element 80' includes an inner tubular portion 118 extending axially from the radially inner portion of the piston formation 120 in order to slidably mount the valve element on the tubular member 110'. The piston formation 120 is slidably received within the chamber enclosing member 88' while forwardly converging flexible finger portions 122 extend forwardly from the radially outer portion of the piston formation to be contracted about the end of the tubular member 110' in the valve closing position from which the piston is displaced by exposure of the piston formation 120 to the static pressure of the fluid within the pressure chamber 94'. The piston formation is also exposed to the signal pressure within the control member 98' housing the valve closing spring 100'.

FIG. 12 also shows by way of example a heat injector element 124 mounted within the end wall portion 102' of the chamber enclosing member and projecting into the pressure-sensing bore or passage 114'. Heat energy may accordingly be introduced into the fluid being discharged from the injection nozzle. Alternatively, some other fluid agent may be introduced into the spray pattern by means of a secondary injector replacing the heating element 124. The mounting of a secondary injector or heating element projecting into the pressure-sensing passage 114' as shown in FIG. 12, may also be applied to the other forms of injection nozzles 10 and 72 hereinbefore described.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

I claim:

1. An injection nozzle assembly adapted to be connected to a source of fluid under pressure comprising a nozzle body having a discharge orifice opening and a pressure chamber in communication with said orifice opening, conduit means connected to said body for supply of said fluid to the pressure chamber, valve means projecting from the pressure chamber through the orifice opening for blocking discharge of the fluid, means mounted on the valve means and responsive to pressure of said fluid in the pressure chamber for retracting the valve means to unblock the orifice opening, biasing means for opposing said retraction of the valve means, and regulating means extending through the valve means and responsive to discharge of the fluid from the orifice opening for varying the opposition to said retraction of the valve means.

2. The combination of claim 1 wherein said regulating means includes means mounted within the nozzle body form-

ing a control chamber separated by the pressure responsive means from the pressure chamber, and pressure-sensing means extending from the control chamber through the valve means to monitor said discharge of the fluid.

3. The combination of claim 2 wherein said biasing means comprises a spring member enclosed within the control chamber in engagement with the pressure-responsive means forwardly urging the valve means to an orifice-blocking position.

4. The combination of claim 3 including means for securing the chamber forming means to the nozzle body having restricted passages establishing fluid communication between the conduit means and the pressure chamber.

5. The combination of claim 4 wherein said valve means includes a forwardly converging element slidably connected to the pressure responsive means and having an externally grooved surface portion within the pressure chamber.

6. The combination of claim 5 wherein said sensing means comprises an inner portion of the forwardly converging element through which a passage extends.

7. The combination of claim 2 wherein said valve means includes a forwardly converging element slidably connected to the pressure responsive means and having an externally grooved surface portion within the pressure chamber.

8. The combination of claim 7 wherein said sensing means comprises an inner portion of the forwardly converging element through which a passage extends.

9. The combination of claim 1 wherein said valve means includes a forwardly converging element slidably connected to the pressure responsive means and having an externally grooved surface portion within the pressure chamber.

10. The combination of claim 9 wherein said sensing means comprises an inner portion of the forwardly converging element through which a passage extends.

11. The combination of claim 3 wherein said sensing means comprises a tubular member projecting from the chamber enclosing means through the orifice opening and having a forwardly converging end portion engageable by the valve means.

12. The combination of claim 11 wherein said valve means comprises a tubular element connected to the pressure responsive means and slidably mounted on the tubular member, said tubular element having flexible portions contracted by the nozzle body into engagement with the end portion of the tubular member in the orifice blocking position of the valve means.

13. The combination of claim 2 wherein said sensing means comprises a tubular member projecting from the chamber forming means through the orifice opening and having a forwardly converging end portion engageable by the valve means.

14. The combination of claim 13 wherein said valve means comprises a tubular element connected to the pressure-responsive means and slidably mounted on the tubular member, said tubular element having flexible portions contracted by the nozzle body into engagement with the end portion of the tubular member under the urge of the biasing means to block discharge of fluid from the orifice opening.

15. The combination of claim 1 wherein said regulating means includes means forming a control chamber within which the pressure-responsive means is received, and pressure-sensing means extending from the control chamber through the orifice opening to monitor said discharge of fluid therefrom.

16. An injection nozzle assembly adapted to be connected to a source of fluid under pressure comprising a nozzle body having a discharge orifice opening and a pressure chamber in communication with said orifice opening, conduit means connected to said body for supply of said fluid to the pressure chamber, valve means projecting from the pressure chamber through the orifice opening for establishing a spray pattern of the fluid discharged in response to pressurization of the pressure chamber by the fluid, and flow control means extending through the orifice opening for displacing the valve means relative to the orifice opening in response to variations in said supply of the fluid to maintain said spray pattern.

17. The combination of claim 16 wherein said flow control means includes a piston connected to the valve means closing a control chamber within the nozzle body, sensing means extending from the control chamber through the valve means for transmitting a signal pressure to the control chamber lower than the fluid pressure in the pressure chamber during discharge flow from the orifice opening and means for exerting a continuous closing bias on the valve means while subjected to the valve opening urge of pressure in the pressure and control chambers on the piston.

18. An injection nozzle assembly adapted to be connected to a source of fluid under pressure comprising a nozzle body having a discharge orifice opening and a pressure chamber in communication with said orifice opening, conduit means connected to said body for supply of said fluid to the pressure chamber, valve means projecting from the pressure chamber through the orifice opening for establishing a spray pattern of the fluid discharged in response to pressurization of the pressure chamber by the fluid, pressure responsive means acting on the valve means for displacement thereof relative to the orifice opening in accordance with variations in pressure in the pressure chamber and signal pressure-sensing means connected to the pressure-responsive means and extending through the orifice opening with the valve means for regulating said displacement of the valve means in accordance with variations in the spray pattern.

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