Oct. 21, 1952 W. M. NICHOLS 2,614,888

FUEL INJECTOR

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FIG. 2.

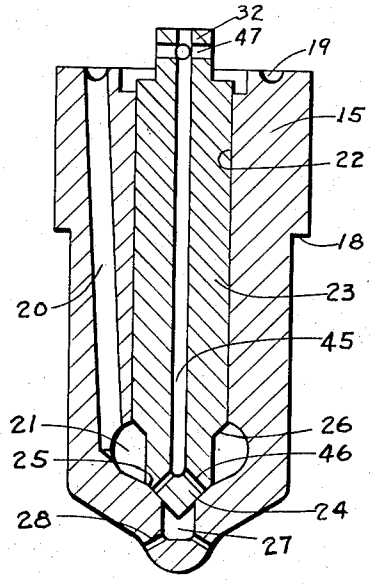


FIG. 1.

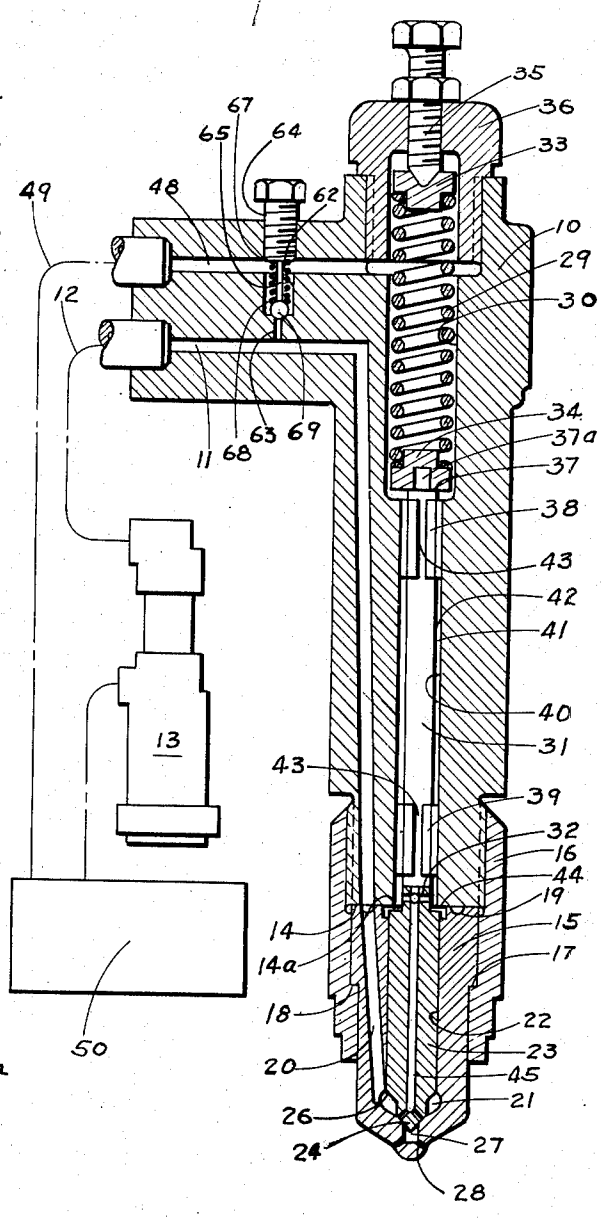
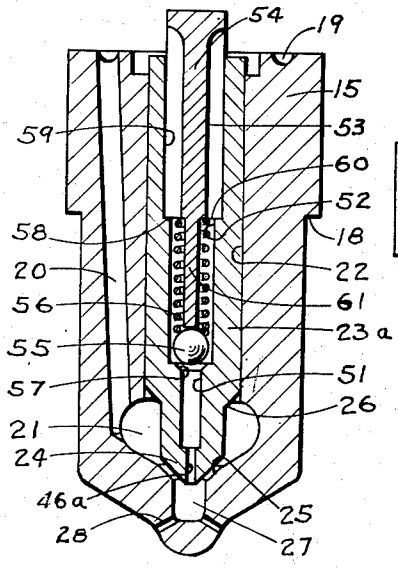


FIG. 3.



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FUEL INJECTOR

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10 Claims. (Cl. 299—107.6)

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This invention relates to fuel injection systems for internal combustion engines of the compression ignition type.

In dual-fuel engines of the class in which the gas fuel may be supplied to the cylinder with the induction air and a small charge of liquid fuel is injected as a spray into the cylinder to cause ignition, it is frequently desirable to use the minimum effective charge of such liquid ignition fuel. In injection equipment which is designed for optimum operation on full load, it is difficult accurately to control the liquid fuel supply when less than approximately 12% of full load quantity is supplied from the fuel pump. This results from various factors, among which are the compressibility of the fuel, the expansibility of the delivery tubes between the pump and the injector, and the presence of pressure waves which are set up in such delivery tubes by the action of the pump. Such pressure waves follow the compression stroke of the pump and travel through the fuel in the discharge tubing at the speed of sound, thereby affecting the amount of injection pressure. In order to reduce the liquid fuel to less than such 12% and still accurately control the amount thereof, some engine builders have installed smaller than usual pumps and nozzles. Such smaller equipment, however, will permit operation only at reduced load in proportion to the reduced size of the equipment

The object of this invention is, accordingly, to provide apparatus which will accurately control the supply of ignition fuel to the power cylinder of a dual fuel engine. Other objects of the invention are to provide such control means between the pump and the atomizing orifice (*a*) as a by-pass to divert from the atomizing orifices a predetermined proportion of the fuel; (*b*) as a by-pass to extend through the fuel injector valve to communicate with a return passageway to the fuel supply tank for the purposes of (*a*); (*c*) as a by-pass to originate in the valve opposite the valve seat and to communicate with a return passageway to the fuel supply tank for the purposes of (*a*); and (*d*) as a by-pass to originate in the valve between the valve seat and the atomizing orifice of the nozzle and to communicate with a return passageway to the fuel supply tank for the purposes of (*a*).

Fig. 1 is a cross section of a fuel injector with schematic representation of the connection of the fuel injector with the supply pump and fuel supply tank; and,

Fig. 2 is a cross section on an enlarged scale of the fuel nozzle and needle; and

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Fig. 3 is a cross section of an alternate structure of the fuel nozzle and needle.

Referring now to the drawings, my invention is shown embodied in a fuel injector for a dual fuel internal combustion engine. Nozzle holder 10 has a fuel inlet duct 11 in communication through a delivery line, shown schematically in Fig. 1 as 12, with a fuel pump, shown schematically in Fig. 1 as 13. The inlet duct leads inwardly and thence downwardly to the bottom face 14 of the holder. Nozzle 15 is maintained in rigid abutment with bottom face 14 of the holder by a sleeve nut 16 which is internally threaded in its upper portion for engagement with corresponding threading on the holder. Sleeve nut 16 is formed with an internal shoulder 17 which is clamped against a corresponding shoulder 18 of the nozzle when the nut has been screwed tightly into seated position. Nozzle 15 has an annular groove 19 in its upper face which is in communication with the inlet duct 11; and one or more passageways 20 lead from the groove 16 to a pressure chamber 21 formed in the lower portion of the nozzle. The fuel pump 13 is thus at all times in uninterrupted communication with the pressure chamber 21.

Nozzle 15 is provided with an axial bore 22 within which is slidably mounted a needle valve 23, the lower end of which has a conical tip or valve head 24 which is adapted to co-act with the valve seat 25 formed in the bottom wall of the chamber 21. Needle 23 has a tapered shoulder 26 extending into the chamber 21, and as fuel pressure builds up in the chamber, the needle is lifted thereby and fuel is permitted to escape past the valve seat into the reservoir 27 and thence through the atomizing jet orifices 28 into the power cylinder (not shown) for ignition purposes in the well-known manner.

Compression spring 29 is mounted in a bore 30 in the nozzle holder to constantly bias the rod 31 against the extension 32 formed at the upper end of the needle 23, thereby normally to maintain the needle in seated position. Spring 29 is maintained between an upper washer 33 and a lower washer 34, the upper washer 33 being maintained in retaining position by the adjustable screw 35 which is threaded through the cap nut 36 and the lower washer 34 being positioned astride the shoulder 37 and extension 37*a* at the upper end of rod 31. Spring 29 is of great strength and exerts a strong biasing force downwardly through the rod 31 upon the needle valve 23. The compression force of the spring

may be varied as desired by adjusting the screw 35.

Needle valve 23, which is normally maintained in seated position by the spring 29, is intermittently lifted by fuel pressure in the chamber 21 and intermittently snapped back by the spring as the fuel pressure drops in the chamber in response to the action of the fuel pump. Rod 31 is formed with upper and lower guide portions, 38 and 39 respectively, and is slidably mounted in the bore 40 formed in axial alignment with nozzle bore 22 and spring bore 30. The central portion 41 of the rod is of reduced diameter to provide a clearance 42 with the bore and the guide portions are formed with splines 43 for purposes hereinafter stated. Bore 40 is of lesser diameter than that of the nozzle bore 22 so that a portion of the bottom face 14 of the holder overhangs the needle shoulder 14a. Such overhanging portion 44 thus functions as an abutment to limit the upward movement or lift of the needle valve 23.

Needle valve 23 (as best seen in Fig. 2) is formed with an axial passageway 45 the lower end of which is in communication with a plurality of ducts 46 extending downwardly and outwardly to form in the valve head 24 ports which open opposite the valve seat 25 when the needle is in seated position. The upper end of the passageway 45 communicates through radial ports 47 with the rod bore 40. When the needle 23 is lifted by fuel pressure, a portion of the fuel will be by-passed through ducts 46 into passageway 45, thence through splines 43 in guide portion 39, the clearance 42, the splines 43 in guide portion 38, spring bore 30, and return passageway 48 to the return line (shown schematically at 49) to the fuel supply tank (shown schematically at 50). The number of ducts 46 are preferably equal to the number of jet orifices 28 and the diameters of such ducts are equal to the diameters of such orifices. It is thus apparent that the combined fuel transmission capacities of the ducts equal the combined fuel transmission capacities of the orifices and that the amount of fuel by-passed will equal the amount of fuel fed through the orifices into the power cylinder. This arrangement may of course be varied so that any predetermined portion of the fuel may be by-passed leaving a predetermined portion for supplying to the power cylinder. The number of ducts 46 may be varied or the diameters may be changed to effect this result.

An alternative construction of the invention is shown in Fig. 3. A duct 46a leads directly from the reservoir 27 to a bore 51 which communicates through counterbore 52 and splines 53 in valve member 54 with the rod bore 40. A by-pass is thus effected upon every valve lift to permit the escape of a portion of the fuel through the return line 49 to the fuel supply tank 50. The diameter of duct 46a bears a definite ratio to the diameters of jet orifices 28 so that the fuel transmission capacity of the by-passing means is predetermined.

Ball valve 55 is provided as a check valve to prevent the flow of fuel back from the return line into the power cylinder on the suction stroke of the piston; and also to prevent cylinder gases from flowing into the fuel delivery means after the needle valve has seated. Ball valve 55 is normally biased by compression spring 56 against the valve seat 57, said spring being seated at its upper end against the bottom face 53 of valve member 54. Valve member 54 is slidably mounted in a counterbore 59 formed in the upper portion of the needle valve 23a and is pressed downwardly by rod 31 which bears flush against the shoulder. A cylindrical extension 61 of the valve member 54 maintains the spring 56 in alignment and acts as a stop to limit upward movement of the ball valve 55 in response to fuel pressure. Spring 56 is preloaded to furnish sufficient force to maintain the ball in seated position against the pressure of such cylinder gases as may advance through orifices, 28, reservoir 27, duct 46a, and bore 51 when the needle valve 23a is seated and the power piston is on its compression stroke. Such spring 56 of course does not possess sufficient strength to withstand the pressure of the fuel advancing from the chamber 21 upon the lifting of the valve. When ball valve 55 functions as a check valve against back flow, the evacuation of air below the ball will cause the air pressure above the ball to force it into and maintain it in seated position.

As another alternate means of effecting the control of the fuel supplied to the jet orifice, by-pass means may be established directly between the inlet duct 11 and return means at passageway 48. A limited bore 62 may be formed in the holder intersecting the passageway 48 and terminating short of the inlet duct 11. A duct 63 connects the inlet duct 11 and said bore 62. The outer portion of bore 62 is threaded for the reception of an adjustable screw 64 the inner end of which is formed as a smooth portion 65 having a diameter less than the diameter of the bore. Surrounding such smooth portion and seated upon the shoulder 67 of the screw is a compression spring 68 which normally biases the ball 69 downwardly into seated position at the upper end of the duct 63. Spring 68 is pre-loaded to provide sufficient force to prevent the lifting of the ball by any inward force created by gases upon the compression stroke of the power piston to advance through the ports 28, reservoir 27, chamber 21, and duct 11 into duct 62. Such spring, however, does not possess sufficient strength to maintain the ball in seated position against the pressure exerted by the fuel in the passageway 11 and hence in the duct 63 upon the pumping stroke of the fuel pump. The diameter of duct 63 bears a definite ratio to the diameter of duct 11 so that the fuel transmission capacity of the by-passing means is predetermined.

For use as part of the apparatus of the invention, nozzle assemblies having by-pass means of various capacities may be kept on hand. As the operator may desire to vary the supply through the nozzle, he may run off the sleeve nut 16, replace the nozzle assembly with one having a different by-pass, and screw the assembly back into operative position.

It will be understood that the invention is not to be limited to the specific construction or arrangement of parts shown, but that they may be widely modified within the invention defined by the claims.

I claim:

1. A fuel injector comprising a nozzle holder, a nozzle having a bore, a pressure chamber in the nozzle, an annular valve seat in the pressure chamber wall, a valve having a body, a shoulder, and a head, the body being slideable within the nozzle bore, the shoulder being adapted to receive fuel pressure to open the valve, and the head being normally seated upon the valve seat and extending therethrough, spring means normally biasing the valve into seated position, a

fuel inlet passageway leading to the chamber and adapted to transmit fuel thereto to intermittently open the valve, an atomizer in communication with the pressure chamber, fuel conducting means through the valve in immediate communication at one end with the pressure chamber when the valve is in open position, and fuel transmission means in communication with the other end of the fuel conducting means adapted to return fuel to the source of supply, the fuel transmission capacities of the fuel conducting means and of the atomizer having a predetermined constant ratio to each other whereby fuel from the pressure chamber will pass through the atomizer and through the conducting means in a selected ratio.

2. A fuel injector, according to claim 1, in which that end of the fuel conducting means, which is in immediate communication with the pressure chamber when the valve is in open position, is disposed opposite the valve seat.

3. A fuel injector, according to claim 1, in which that end of the fuel conducting means, which is in immediate communication with the pressure chamber when the valve is in open position, is disposed between the valve seat and the atomizer.

4. A fuel injector comprising a nozzle holder, a nozzle having a bore therein, a pressure chamber, an atomizer having an orifice of selected cross-section in communication with the pressure chamber, fuel transmission means leading to the chamber, a valve slideably mounted in the nozzle bore, a valve seat within the pressure chamber, spring means to normally maintain the valve in seated position, said valve being adapted to open in response to fuel pressure, a duct of selected cross-section extending through the valve, said duct having an opening at one end adapted to establish immediate communication with the pressure chamber when the valve is in open position, and fuel return means in communication with the other end of the duct, the fuel transmission capacity of the atomizer orifice bearing a selected constant ratio to the fuel transmission capacity of the duct whereby predetermined portions of the fuel in the pressure chamber will be supplied to the atomizer and conducted through the duct to the fuel return means.

5. A fuel injector comprising a nozzle holder, a nozzle having a bore therein, a pressure chamber, an atomizer having an orifice of selected cross-section in communication with such chamber, fuel transmission means leading to the chamber, an annular valve seat within the pressure chamber, a valve slideably mounted in the nozzle bore, said valve having a head and a shoulder, spring means to maintain the valve head in seated position, said valve being adapted to open in response to fluid pressure upon its shoulder, a duct of selected cross-section extending through the valve and having an opening at one end adapted to establish immediate communication with the fuel chamber when the valve is in open position, and fuel return means in communication with the other end of the duct, the fuel transmission capacity of the atomizer bearing a desired ratio to the fuel transmission capacity of the duct whereby portions of the fuel in the pressure chamber will be supplied to the atomizer and through the duct to the fuel return means in desired constant ratio.

6. A fuel injector, according to claim 5, in which the duct opening adapted to establish immediate communication with the fuel chamber is disposed within the valve head.

7. A fuel injector, according to claim 5, in which the duct opening adapted to establish immediate communication with the fluid chamber is disposed in the valve head opposite the valve seat.

8. A nozzle for a fuel injector comprising a body, a compression chamber therein, fuel transmission means in communication with the pressure chamber, a bore opening into the pressure chamber, a valve slideably mounted in the bore and extending into the pressure chamber, said valve being adapted to be normally seated by spring means but to open in response to fuel pressure, a fuel atomizer having an orifice of selected cross-section, and a duct having a selected cross-section extending through the valve and being adapted to immediately communicate with the compression chamber when the valve is in open position, said duct having a fuel transmission capacity bearing a predetermined ratio to the fuel transmission capacity of the atomizer.

9. A nozzle, according to claim 8, in which one end of the duct is positioned opposite the valve seat when the valve is in seated position.

10. A nozzle, according to claim 8, in which one end of the duct is positioned between the valve seat and the atomizer when the valve is in seated position.

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