May 3, 1960 C. NAPOLI 2,935,264

AUTOMATIC FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES

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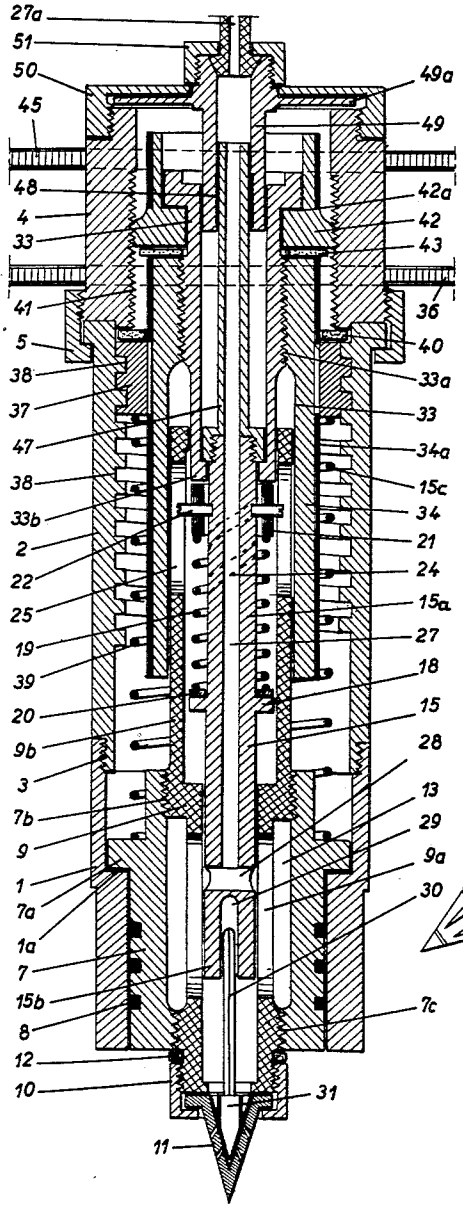


Fig.1

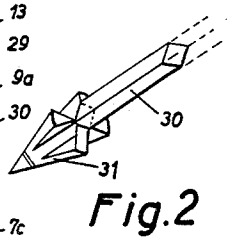


Fig.2

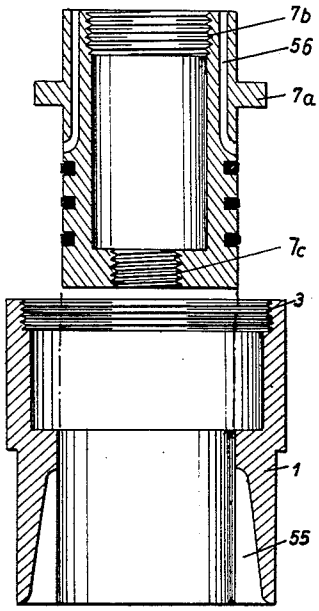


Fig.3

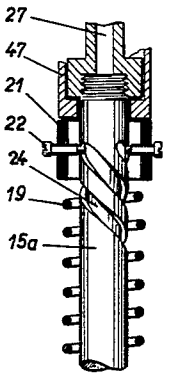


Fig. 4

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AUTOMATIC FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINES

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4 Claims. (Cl. 239—87)

This invention relates to a fuel injector and refers more particularly to an automatic fuel injector for internal combustion engines.

In modern automotive engineering there is a definite and increasing trend toward the adoption of internal combustion engines having fuel injection systems, whereby liquid fuels are injected into the combustion chamber when the combustion air is at a desired level of compression. Consequently, the compression can be large enough to ensure a high degree of efficiency without incurring the danger of premature ignition present in engines fed with carbureted mixtures.

Fuel injection, however, requires complicated and delicate assemblies that are difficult to manufacture and costly to maintain. These factors limit the adoption of fuel injection systems. Moreover, the injection pump must be driven by the engine which involves problems connected with the proper timing and flow of fuel from the pump to each injector. At high pressures, the injectors are apt to leak and, consequently, are difficult to repair.

An object of the present invention is to provide a self-contained injector which ensures perfect atomization of the fuel inside the cylinder, regardless of the pressure therein, without requiring an injection pump and engine-driven elements.

Another object of the present invention is to provide greater simplification and saving in the cost of manufacturing the device.

Still another object is to provide a considerable reduction in the bulk and weight of the injector of the present invention.

Other objects of the present invention will become apparent during the course of the following specification.

In the attainment of the aforesaid and other objectives, the inventive concept of the present invention may be realized through the provision of an automatic fuel injector which may be used inside a cylinder chamber without requiring an injection pump or other engine-driven element in order for it to perform completely and to atomize the fuel efficiently therein.

An outer shell may be provided with a series of concentrically disposed small cylinders and pistons slidably and sealably disposed within each other. A further series of similarly disposed smaller connections, each cooperating with one another may likewise be provided to move axially along the cylindrical prolongation of the respective cylinder or piston depending upon the position of each stroke. Radial splines may be fixed to a suitable cylinder for engaging the grooves of a rack, so that the height of the central piston may be varied during the injection of fuel with each stroke.

A fuller understanding of the present invention may be had by referring to the following description taken in conjunction with the accompanying drawings, showing by way of example, a preferred embodiment of the inventive idea.

In the drawing:

Figure 1 is an axial cross-section of the injector.

Fig. 2 is an enlarged perspective view of the pin and nozzle.

Figure 3 is a cross-section of an alternate arrangement of the injector for advancing the injector timing.

Figure 4 is a sectional view showing a portion of the injector illustrated in Fig. 1.

Referring now to the drawing in greater detail, wherein like reference numerals indicate like parts, the injector of the present invention is comprised of an outer cylindrical coaxial body or shell 1 provided with a shoulder 1*a* and to which is connected another outer cylindrical coaxial body 2 by means of a threaded portion 3. A block 4 is connected to the opposite end of body 2 by means of a bushing 5 illustrated in Figure 1.

A main spring-loaded piston 7 provided with a piston ring 7*a* and fitted with sealing rings 8 is disposed slidably inside of cylinder 1. Two threaded end portions 7*b* and 7*c* having threads of the same pitch are screwed onto one end of an intermediate cylinder 9. The opposite end of hollow cylinder 9 extends upwardly and outside of the threaded end portion 7*b*. A bushing 10 provided with internal threads secures a tapered atomizer cap or nozzle 11 to one end of the threaded end portion 7*c*.

Intermediate threaded portions 7*b* and 7*c*, cylinder 9 is provided with ports 9*a*, which are passageways for fuel flowing from the interior of cylinder 9 to a circular inner cavity 13.

The portion 9*b* of cylinder 9, which extends above the threaded portion 7*b* is greater in cross-section than threaded portion 7*b*. Cylinder 9 is provided with ports 25 in its side walls, and which are disposed above portion 9*b*.

A central piston 15 having a head 15*b* and a threaded portion 15*c* is disposed inside cylinder 9. A flange 18 is disposed intermediate the head 15*b* and threaded portion 15*c* upon which rests a washer 20 followed by one end of a spiral spring 19. The other end of the spring 19 rests against a bushing 21 which is coaxially and externally disposed in relation with the stem 15*a* slidably disposed inside the cylinder 9*b*.

The bushing 21 carries two radial pins 22, the external ends of which project outside of bushing 21 and extend into the ports 25. The internal ends of bushing 21 fit into two parallel spiral slots 24 and 24*a* disposed in the outer wall surfaces of piston 15*a*. When the piston 15 slides upwardly inside the bushing 21, it is forced to undergo angular movement by the pins 22 with respect to cylinder 9—9*b*.

The piston 15 has an inner axial bore 27 which extends over its entire length. A diametrical opening 28 communicates with ports 9*a*, and the inner cavity 13. Head 15*b* of the piston 15 is provided with an axial slot 29 of square cross-section into which fits a correspondingly shaped stem 30 of equal length.

Figure 2 represents an enlarged perspective view of the tapered pin 31, showing its tapered part cut into four sections. In the inactive position, the four sections cover the corresponding nozzle holes of the atomizer cap 11. When the pin 31 is rotated by piston 15, the four sections uncover the holes 11*a* of the cap 11, and an atomized jet of fuel is released from the nozzle on account of the heavy pressure existing in the inner lower part of cylinder 9. Normally in the inactive position, pin 31 does not leave its seat, since the base of the taper is larger than the inner diameter of cylinder 9.

The adjustable spring 19, positioned between washers 20 and bushing 21, pushes the bushing 21 against the lower end 33*b* of tube 33. External threads 33*a* screw the tube 33 firmly into a hollow cylinder 34, which is fitted externally over its entire length with splines 34*a* of square

cross-section disposed axially thereon. The cylinder 34 is rotated by means of a rack 36 which meshes with splines 34*a*. A sleeve 37 is fitted upon the splines 34*a* provided with matching inner splining, so that cylinder 34 and sleeve 37 can slide axially upon each other.

Sleeve 37 carries externally disposed long-pitched threads 38, which screw into a matching thread in the inner surface of cylindrical body 2.

Sleeve 37 is stressed by a spiral spring 39 which tends to maintain piston 7 in the rest position shown in Figure 1, while the upper part of the spring 39 tends to push the sleeve 37 against a washer 40 disposed adjacent the block 4. Block 4 carries internally disposed long-pitched threads 41 which accommodate a bushing 42 provided with axial splines on its outer surface. One end of bushing 42 separated by a washer 42 rests upon one end of cylinder 34. Bushing 42 bears against cylinder 34 by means of an inner shoulder 42*a* which engages a shoulder of tube 33 screwed to cylinder 34.

A rack 45 is disposed parallel to rack 36 and meshes with the splining of bushing 42.

A fuel feed tube 47 is positioned inside of tube 33 and communicates with and connects with the lower end of piston 15, while the upper end of tube 47 slides through a seal 48 contained in a tube 49.

The tube 49 carries a flange 49*a*, which is screwed into place by a bushing 50 and secured to the externally disposed threads of block 4. A fuel line 27*a* is fastened by means of a screw connector 51 to one end of the bushing 50.

The operation of the injector described above is as follows:

The device is shown in the rest position in Figure 1. No pressure exists in the combustion chamber or prechamber. When the air pressure has risen sufficiently for piston 7 to overcome the resistance of spring 39, piston 7 and cylinder 9 begin to rise, gradually closing the ports 9*a* through which the fuel flows into the inner cavity chamber 13.

The fuel is compressed to the desired injection pressure level when the ports 9*a* are totally closed to the circumferential inner cavity 13. The compression of the fuel and closure of the ports 9*a* begin when the piston head 15*b* enters the terminal part of cylinder 9. As soon as the pressure is reached, the spring 19, adjusted to the pressure, permits piston 15 to recede backwardly together with the movement of cylinder 9. The stem 15*a* of piston 15 is then forced against bushing 21, the position of which depends upon the position of bushing 42 and the position of rack 45.

As the piston 15 slides through bushing 21, the action and location of pins 22 cause the piston 15 and stems 15—15*a* to rotate the taper pin 31, which opens the nozzle atomizing holes 11*a*. During injection, the pressure of the fuel remains constant as piston 15 advances into cylinder 9. As soon as spring 19 is distended, fuel injection ceases, since the entire length of piston 15 has advanced completely. The stem 15*a* moves out of the bushing 21 the same distance as it has entered into the bushing 21, thereby causing the stem 15*a* to rotate in the opposite direction to close the nozzle atomizer holes.

The extent to which the piston 15 enters cylinder 9 determines the volume of injection which varies the length of the stroke of the piston extending into the compression chamber. In effect, piston 7 together with cylinder 9 generally travels the same distance. Consequently, the stroke of piston 15, which extends into the combustion chamber, depends upon the distance that head 15*b* enters the combustion chamber. Thus, the quantity of fuel injected is controlled by varying the operating stroke of piston 15 in the following manner: By moving the rack 45, the ring 42 rotates; by screwing the threads 41 of block 4, the cylinder 34 moves axially without rotating it; thus, cylinder 34 carries with it tube 33 together with piston 15, thereby causing the position of head 15*b* to change inside cylinder 9.

The adjustment of the injection advancement is effected by varying the tension of spring 39. This is done by moving the rack 36, which rotates the cylinder 34 and forces the sleeve 37 to move axially on the long-pitched threads 38.

When the rack 45 passes through a slot tangential to the inner surface of block 4 and engages the splining of bushing 42, the bushing 42 will move axially by way of its long-pitched threads 41, thereby entraining tube 33 together with cylinder 34 without rotating them.

Tube 33 is connected in its axial movements with stem 15*a* by means of an inner shoulder 33*b* disposed on the lower edge of the tube 33. The movement of shoulder 33*b* is restricted by stem 15*a*, since it is bound between bushing 21 and the head of tube 47. Therefore, the transverse movement of rack 45 produces only axial sliding of piston 15 into cylinder 9. The cylinder 34 and tube 33 do not interfere with the movement of bushing 37. For the same reason, by moving rack 36, the movement of cylinder 34, whatever its vertical position, causes sleeve 37 to revolve and to move along the threaded portions 38, thereby changing the tension of the spring 39 without causing any movement of bushing 42 and piston 15.

When the compression level in the chamber or prechamber is sufficient to allow the lifting of piston 7, the movement of spring 39 is retarded if its tension is increased, and, consequently, the frequency of operation of the injector, as described above, is also diminished.

One change with respect to the injector, as described above, may be had by making the spring 39 perform only the function of pulling the piston 7 towards the rest position illustrated in Figure 1. The adjustment of the injection advancement is obtained by the back pressure produced inside the injector body to retard the travel of piston 7.

In accordance with this arrangement, the change above-mentioned is illustrated in Figure 3, wherein like reference numerals indicate like parts. Calibrated ducts 55 are provided in the shell wall 1*a* and communicate with ducts 56 in the body of the piston 7'. During the compression stroke, part of the compressed air is bled from the cylinder chamber to the back face of piston 7', which closes the air passage or communication as soon as piston 7' moves forward sufficiently enough to seal off ducts 55 from ducts 56. Thus, the value of the back-pressure which retards the stroke of piston 7' is controlled by the engine speed. An increase in speed will decrease the volume of air which is bled to provide back-pressure. Consequently, the value of the back-pressure will be lower and the angle of advancement greater, and vice versa.

It is to be understood that the present invention is not restricted to the embodiments described hereinabove, since it is possible to produce still other embodiments without departing from the inventive concept herein disclosed, and it is desired, therefore, that only such limitations be imposed on the appended claims as are herein described.

What I claim is:

1. A fuel injector for internal combustion engines comprising, an outer shell, a main spring-loaded piston disposed slidably sealably within a lower portion of said shell, an intermediate cylinder having a port therein and engaging said main piston, a central piston provided with spiral grooves and disposed slidably axially within said intermediate cylinder, a flange carried by said central piston, said central piston having an inner bore, a diametrical opening communicating with said inner bore, and an axial slot of prismatic section at one end of said piston, a nozzle having a plurality of holes removably carried by said main spring-loaded piston, a stem extending into said second-mentioned axial bore and a pin

integral with said stem and divided into several sections adapted to open and close said nozzle holes, a bushing mounted coaxially on said central piston, radial pins carried by said bushing and engaging said port of said intermediate cylinder and said spiral grooves of said central piston, an adjustable spiral spring disposed coaxially on said central piston intermediate said bushing and said flange, and a fuel feed tube carried by said central piston and communicating with said inner bore, said intermediate cylinder having lower ports, the walls of said main piston and said intermediate cylinder being spaced to form an inner cavity communicating with said lower ports.

2. A fuel injector for internal combustion engines in accordance with claim 1, comprising a spring coaxially disposed on said main piston for loading said main spring, and tension varying means, said tension varying means comprising a rack, a sleeve and a plurality of splines carried by said sleeve and meshing with said rack, said sleeve having a plurality of externally disposed threads meshing with internally disposed threads of said outer shell.

3. A fuel injector for internal combustion engines in accordance with claim 1 wherein the quantity of fuel injected at each stroke is controlled by a device, said device comprising a rack, another bushing, and a plurality of splines fixed to the outer surface of the last-mentioned bushing.

4. A fuel injector for internal combustion engines in accordance with claim 1 wherein the lower part of said outer shell is provided with calibrated ducts, said ducts being adapted to engage other ducts in said main spring-loaded piston for bleeding compressed air to the back face surface of said main piston.

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