Nov. 20, 1945. H. C. EDWARDS 2,389,492

FUEL INJECTOR

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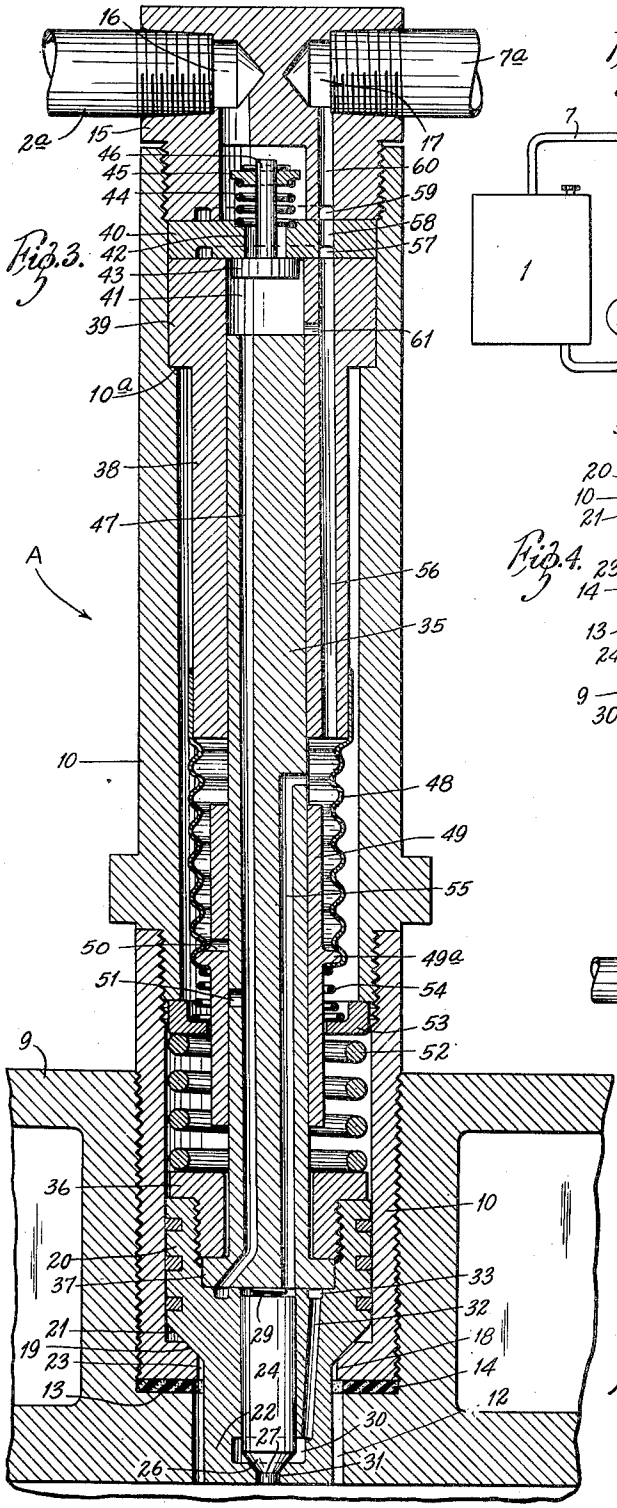


Fig. 3.

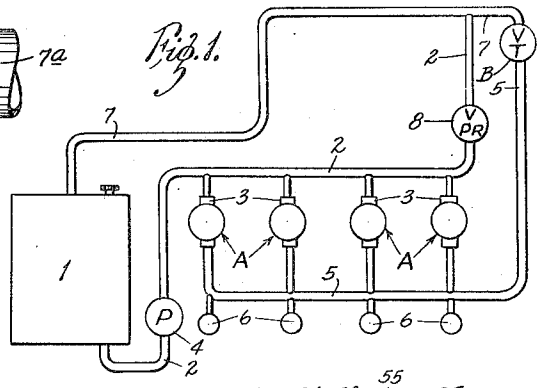


Fig. 1.

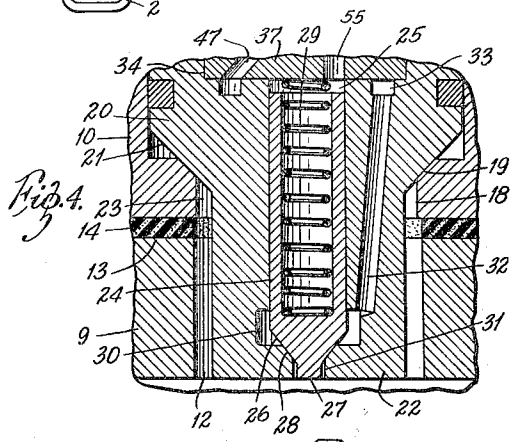


Fig. 4.

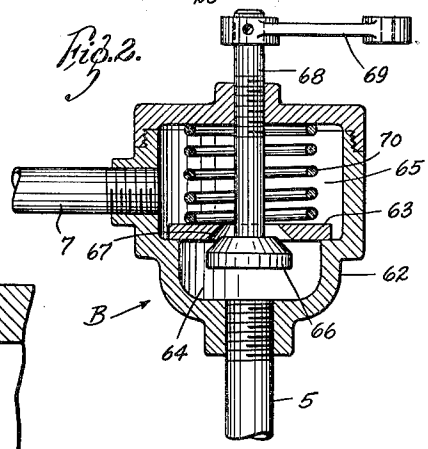


Fig. 2.

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FUEL INJECTOR

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6 Claims. (Cl. 123—139)

This invention relates to fuel injectors, particularly hydraulically operated fuel injectors for compression-ignition engines. It has for its principal object to provide a simple, economical and compact fuel injector of the above type that is operable by the air compressed in the engine cylinder to deliver fuel under pressure thereto and that will utilize the pressure of fuel by-passed from the injector to determine the quantity of fuel delivered thereby. The invention consists in the hydraulic injector and in the construction, combinations and arrangements of parts hereinafter described and claimed.

In the accompanying drawing, which forms part of this specification and wherein like symbols refer to like parts wherever they occur,

Fig. 1 is a diagram showing a fuel injection system provided with fuel injectors embodying my invention,

Fig. 2 is an enlarged central longitudinal sectional view of the throttle valve for the fuel by-pass conduit,

Fig. 3 is an enlarged central longitudinal sectional view through one of the fuel injectors; and

Fig. 4 is an enlarged fragmentary central longitudinal sectional view of the lower or discharge end portion of the fuel injector.

The fuel injection system shown in Fig. 1 comprises a fuel supply tank 1, a fuel injector A for each engine cylinder; a fuel supply conduit 2 leading from the supply tank to the fuel inlet 3 of each injector; a suitable fuel supply pump 4 for feeding the fuel through said conduit to each fuel injector, a fuel by-pass or overflow conduit 5 leading fom each injector to a suitable throttle valve B; cushioning chambers 6 located in the by-pass conduit adjacent to each fuel injector, and a conduit 7 for returning the by-passed fuel from the throttle valve to the fuel supply tank. As shown in the diagram, the fuel supply conduit 2 opens into the fuel return conduit 7 beyond the last fuel injector supplied thereby and is provided between the latter and said fuel return conduit with a suitable pressure relief valve 8 for regulating the pressure of the fuel delivered to the several injectors through said fuel supply conduit.

As shown in Fig. 3, each of the fuel injectors A comprises a hollow cylindrical housing or casing 10 made of two sections that are threaded together in endwise abutting relation. The fuel injector A is preferably mounted in an upright position on the head of the engine cylinder 9 with its lower end portion fitting in a bore 12 which extends downwardly through said head of said cylinder. As shown in the drawing, the outer end of the bore 12 in the cylinder head is counterbored to provide an outwardly facing annular supporting shoulder 13 for a sealing gasket 14; and the lower end portion of the housing 10 of the injector A is threaded into said counterbore in endwise abutting relation to said gasket. The exposed upper end of the housing 10 is closed by a threaded cap 15 that is provided with a fuel inlet opening 16, which is adapted to receive a branch 2a of the fuel supply or inlet conduit 2, and a fuel by-pass outlet opening 17, which is adapted to communicate with a branch 7a of the fuel by-pass conduit 5.

The lower gasket engaging end of the injector housing 10 has a central circular opening 18 therein for air compressed in the engine cylinder 9. The opening 18 is surrounded by an inwardly facing conical valve seat 19; and a piston 20 is reciprocable in the housing 10 of the injector and has a conical valve portion 21 adapted to seat against the valve seat 19 and thus cut off communication between the compression space in the engine cylinder 9 and the interior of said housing. The piston has a reduced nozzle portion 22 rigid therewith that extends downwardly therefrom through the opening 18 in the lower end of the housing 10 into the lower end of the bore 12 in the cylinder head. The nozzle 22 is of smaller diameter than the opening 18 and the lower end of the bore 12 so as to provide an annular passageway 23 between said nozzle and said opening and bore.

As shown in the drawing, a valve plunger 24 is reciprocable in an axial bore 25 provided therefor in the piston 20 and has a tapered portion near its lower end that forms a conical valve element 26 and terminates in a reduced pin or pintle 27. The conical valve element 26 of the valve plunger 24 is held down on a conical valve seat 28 in the valve bore 25 by means of a coil spring 29 located in a cavity in said plunger. The valve plunger 24 cooperates with the valve bore 25 to form an annular fuel chamber 30 above the valve seat 28; and the pintle 27 on said plunger cooperates with said valve bore to form an annular fuel discharge orifice 31 below said valve seat. The annular fuel chamber 30 is supplied with fuel under pressure through one or more fuel inlet passageways 32 that lead downwardly from an annular fuel inlet groove 33 in the bottom of an enlarged or counterbored upper end portion 34 of the axial bore 25 in the piston 20 and open into the fuel chamber 30 through the side thereof.

The piston 20 is provided with an upwardly extending axial extension plunger 35 of reduced

diameter whose lower end seats against the bottom of the counterbore 34 in the upper end of said piston and is clamped rigidly thereto by means of a ring nut 36 that is threaded into said counterbore in endwise abutting relation to an external annular shoulder 37 provided therefor on said end of said plunger, the contacting faces of the plunger and counterbore being lapped to provide a leak-proof joint therebetween. The upper end of the plunger 35 is reciprocable in a cylindrical barrel 38 that is rigidly secured in the hollow cylindrical body 10 of the injector by means of the cap 15 at the upper end thereof, the barrel having a head portion 39 that seats on an internal annular shoulder 10a provided therefor in said body and is held against said shoulder by endwise pressure transmitted to the barrel by said cap through a circular valve plate 40 clamped between the lower end of said cap and the upper end of said barrel.

The upper or working end of the plunger 35 cooperates with the upper end portion of the bore of the barrel 38 to form the movable wall of a compression chamber or space 41; and the fuel inlet passageway 16 in the cap 15 of the injector communicates with said compression space or chamber through a central inlet opening 42 in the valve plate 40. The inlet opening 42 in the valve plate 40 is closed by means of an inwardly opening disk valve 43 that is yieldably held in closed position by means of a coil spring 44 which seats on the upper face of said plate and bears upwardly against a spring seat 45 provided therefor on the upper end of the upstanding stem portion 46 of said valve. Continuous communication is established between the compression space or pump chamber 41 and the annular fuel inlet groove 33 in the nozzle 22 by means of a longitudinal passageway 47 that extends through the plunger from end to end thereof.

Rigidly secured to and depending from the lower end of the plunger receiving barrel 38 is an annularly corrugated bellows or accordion-like sleeve 48; and secured to the lower end of said sleeve is a fuel control sleeve or muff 49 in which the piston 35 is adapted to reciprocate. The fuel control sleeve 49 has a radial port 50 extending therethrough which opens into the interior of the axially resilient bellows sleeve 48. The plunger 35 has a radial port 51 therein adapted during the pressure or working stroke thereof to establish communication between the fuel passageway 47 therein and the interior of the bellows sleeve 48 through the port 50 in the control sleeve or muff 49 fixed thereto. The control sleeve 49 has an outstanding circumferential flange 49a formed thereon just below the port 50 therein; and the lower end of the bellows sleeve 48 is welded or otherwise secured to the upper face of said flange so as to form a leak-proof connection between said control and bellows sleeves.

The piston 20 is forced downwardly in the tubular housing 10 to close the opening 18 in the lower end thereof by means of a coil spring 52 that is mounted in said housing with its lower end seated on the plunger clamping ring nut 36 and with its upper end seated against an annular spring seat member 53 that seats against the lower end of the upper section of said housing. The bellows sleeve 48 operates to constantly draw the muff 49 upwardly around the plunger 35 towards the plunger supporting barrel 38; and this action is assisted by a small coil spring 54 that surrounds said muff and bears against the lower end of the flange 49a thereon and seats on the annular spring seat member 53 for the upper end of the heavy piston seating spring 52.

The plunger 35 has a longitudinal leak-off passageway 55 therein which extends from the upper end of the nozzle valve plunger supporting portion of the axial bore 25 in the nozzle 22 and opens into the bellows sleeve 48 above the upper end of the muff 49. Continuous communication is established between the upper end of the bellows sleeve 48 and the fuel by-pass or overflow outlet 17 in the cap 15 for the housing 10 through a longitudinal passageway 56 in the plunger supporting barrel 38, an annular groove 57 in the bottom of the valve plate 40, a passageway 58 leading from said annular groove to an annular groove 59 in the lower end of said cap, and a passageway 60 leading from said last mentioned annular groove to said fuel by-pass or overflow outlet. The fuel by-pass passageway 56 in the barrel 38 is adapted, in the lowermost position of the plunger 35, to communicate with the pressure chamber 41 through a radial port 61 in said barrel.

The throttle valve B may be of any suitable construction that will provide an adjustable constriction in the by-pass conduit 5 leading from the fuel overflow opening 17 in the cap 15 of the injector A. As shown in Fig. 2, the throttle valve B comprises a hollow body or valve casing 62 having an annular valve plate 63 therein that divides said casing into two chambers 64 and 65, the by-pass conduit 5 opening into the chamber 64 and the fuel return conduit 7 leading from the chamber 65. A disk valve 66 cooperates with the opening in the annular valve plate 63 to provide a restricted annular passageway 67 between the chambers 64 and 65; and said disk has a stem 68 that is threaded through the housing 62 and is provided at its exposed end with an operating handle 69, whereby said valve can be adjusted axially to vary the size of the restriction 67. The valve plate 63 is seated against the normal pressure of the by-pass fuel in the chamber 64 by means of a coil spring 70; and the pressure of said spring is such that when the orifice or restriction 67 is entirely closed by the valve 66 the pressure builds up in the by-pass conduit 5 and chamber 64 and lifts the valve plate off its seat, thereby releasing such pressure.

The hereinbefore described fuel injector operates as follows:

The pressure of the compressed air in the engine cylinder 9 acts on the end face of the nozzle 22 and, when this pressure is sufficient to overcome the pressure of the piston operating spring 52, the piston 20 is lifted off the valve seat 19 and thus permits the compressed air to enter the injector housing 10 through the opening 18 in the lower end thereof. When raised off its seat 19, the piston 20 presents a larger area to the pressure of the compressed air in the engine cylinder 9, whereby the force moving the piston is greatly increased over the force previously required to raise the piston off its seat. During the upward travel of the piston 20 and plunger 35 rigid therewith, considerable kinetic energy is generated due to the mass of the plunger and piston; and this energy, together with the energy developed by the compressed air in the engine cylinder, is ample to create a suitable hydraulic pressure for opening the fuel discharge valve 24 and discharging the fuel through the annular orifice 31 in the injection nozzle 22. After the

upper or working end of the plunger 35 passes above and closes the spill or fuel by-pass port 61 in the plunger supporting bore of the barrel 38, fuel drawn into the pressure chamber 41 by the previous downward stroke of the plunger is forced from said chamber down through the passageway 47 in the plunger into the annular fuel inlet groove 33 in the nozzle 22 and thence through the fuel inlet passageway 32 into the annular fuel chamber 30 where the pressure of the fuel lifts the discharge valve 24 off its seat, thereby permitting discharge of the fuel through the annular discharge orifice 31 into the compressed air in the engine cylinder 9.

The quantity of the fuel injection depends upon the effective stroke of the plunger 35; and this stroke is determined by the difference between the normal spacing of the ports 50 and 51 and the distance traveled by the plunger controlling the port 61 leading from the pressure chamber 41. When the port 51 in the plunger 35 registers with the port 50 in the muff 49, the high pressure fuel within the longitudinal passageway 47 in said plunger is discharged into the bellows sleeve or Sylphon 48 and thence through the passageway 56 to the cap 15 into the fuel by-pass conduit 5. Any leakage on the injection stroke past the nozzle valve 24 passes through the passageway 55 into the bellows sleeve 48 and thence through the passageway 56 into the by-pass conduit 5.

As above pointed out, the thottle valve B in the fuel by-pass conduit 5 provides a restriction 67 therein that causes the by-passed fuel to build up a pressure within said by-pass conduit which pressure serves to lengthen the axially resilient bellows sleeve 48 so that the distance between the ports 50 and 51 becomes less as the pressure increases and thus cuts down the effective length of the injection stroke of the plunger 35. Adjustment of the throttle valve B to vary the size of the restriction 67 changes the axial position of the muff and thus varies the quantity of fuel delivered by the injector.

The hereinbefore described fuel injector has several important advantages. It is of simple, economical and compact construction and is actuated solely by the pressure of the compressed air in the engine cylinder, thereby eliminating the separate fuel injection pump hereinbefore employed for the injector and the drive between the engine and said pump. It also provides for adjusting the quantity of the fuel injection merely by changing the size of the restriction in the fuel by-pass conduit so as to vary the effective stroke of the fuel injection plunger and the quantity of fuel delivered thereby.

Obviously, the hereinbefore described injector admits of considerable modification without departing from the invention. Therefore, I do not wish to be limited to the precise details of construction shown and described.

What I claim is:

1. A fuel injector comprising a casing having a pump chamber with a fuel inlet passageway and a fuel outlet passageway, a member reciprocable in said casing and forming a movable wall of said pump chamber, a spring for imparting a suction stroke to said member, said member being operable by engine cylinder compression to impart a compression stroke to said plunger against the pressure of said spring, said member having a fuel discharge passageway through which fuel is discharged from said pump chamber during the pressure stroke of said member, said casing having a fuel by-pass conduit adapted to communicate with said fuel discharge passageway during the pressure stroke of said member, and means operable by the pressure of the fuel in said by-pass conduit for controlling the point in the pressure stroke of said member at which said fuel discharge passageway is brought into communication with said by-pass conduit.

2. A fuel injector comprising a casing having a pump chamber with a fuel inlet passageway and a fuel outlet passageway, a member reciprocable in said casing and forming a movable wall of said pump chamber, a spring for imparting a suction stroke to said member, said member being operable by engine cylinder compression to impart a compression stroke to said plunger against the pressure of said spring, said member having a fuel discharge passageway through which fuel is discharged from said pump chamber during the pressure stroke of said member, said casing having a fuel by-pass conduit adapted to communicate with said fuel discharge passageway during the pressure stroke of said member, means operable by the pressure of the fuel in said by-pass conduit for controlling the point in the pressure stroke of said member at which said fuel discharge passageway is brought into communication with said by-pass conduit, and adjustable means for varying the pressure in said by-pass conduit.

3. A fuel injector comprising a casing having a pump chamber with a fuel inlet passageway, a piston reciprocable in said casing and having an exposed surface with a fuel discharge orifice therein, a plunger reciprocable with said piston and forming a movable wall of said pump chamber, said piston and plunger having communicating passageways connecting said pump chamber and fuel discharge orifice; mechanical means for moving said piston in one direction to impart a suction stroke to said plunger, said piston being oeprable in the other direction by engine cylinder compression on said exposed surface of said piston to impart a pressure stroke to said plunger, a fuel control sleeve surrounding said plunger and having a fuel by-pass port therein, an axially extensible bellows sleeve surrounding said plunger with one end fixed to said casing and the other end supporting said fuel control sleeve, and a fuel by-pass conduit communicating with said bellows sleeve, said plunger having a fuel by-pass port adapted to register with said control sleeve by-pass port during the pressure stroke of said plunger, said fuel by-pass conduit having a restriction therein for creating a back pressure in said bellows sleeve to determine the length thereof and the axial position of the port in said fuel control sleeve relative to the port in said plunger.

4. The combination set forth in claim 3, wherein means are provided for changing the size of the restriction in said fuel by-pass conduit to vary such back pressure and the axial position of said fuel control sleeve.

5. The combination set forth in claim 3, wherein means are provided whereby an increased area of the piston is exposed to the engine cylinder compression after an initial portion of the pressure stroke of said plunger.

6. The combination set forth in claim 3, in which said pump chamber has a spill port therein communicating with said by-pass conduit and adapted to be covered by said plunger during the initial portion of the pressure stroke thereof.

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