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FUEL INJECTOR WITH HYDRAULICALLY CONTROLLED INJECTION VALVE

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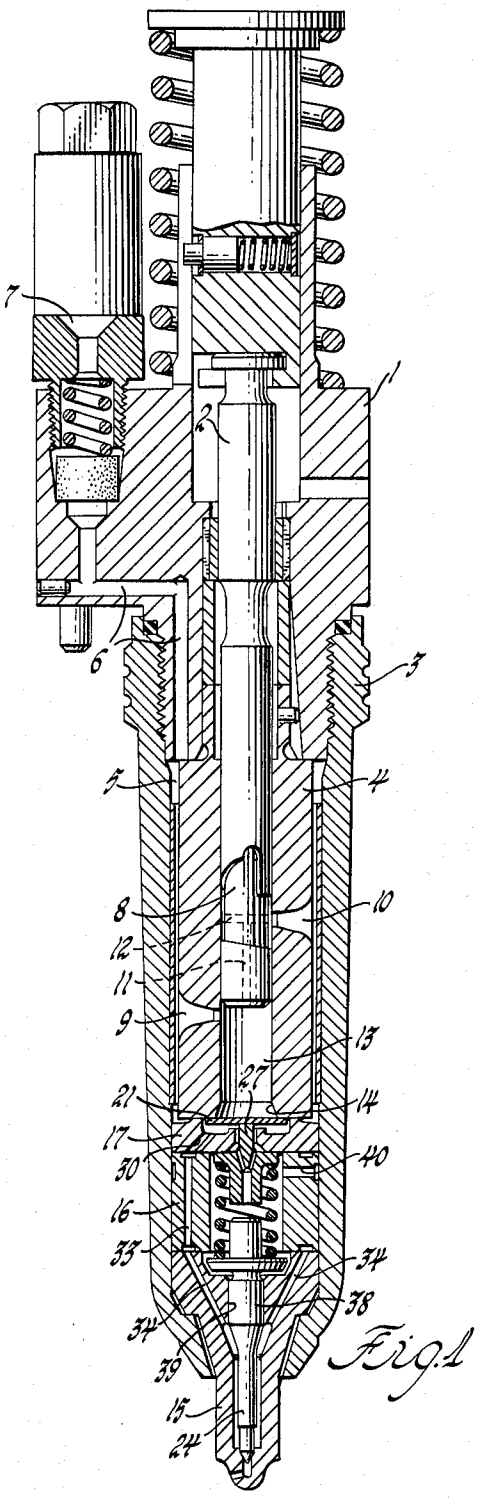


Fig. 1

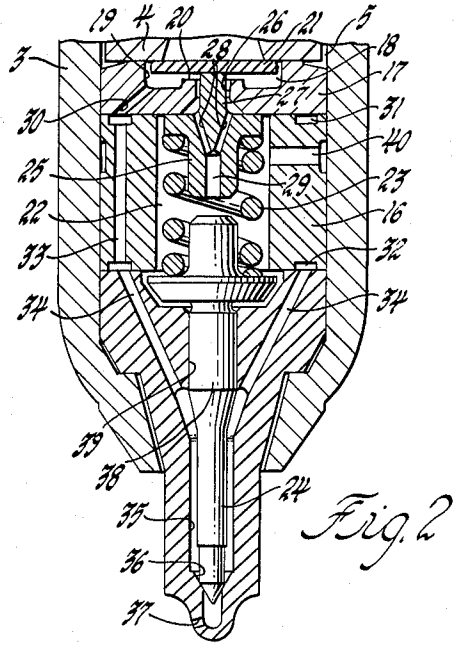


Fig. 2

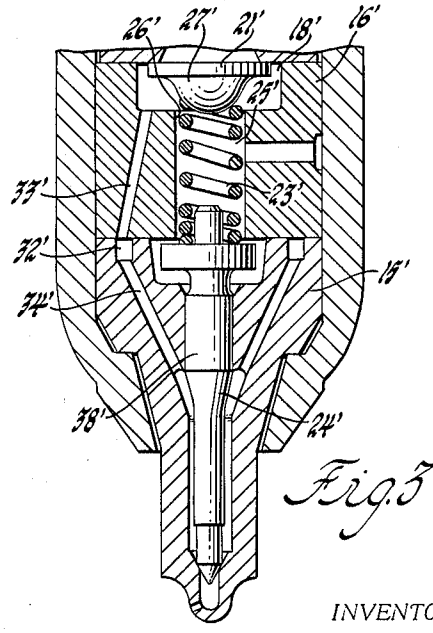


Fig. 3

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FUEL INJECTOR WITH HYDRAULICALLY CONTROLLED INJECTION VALVE

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This invention relates to fuel injection apparatus, and particularly to unit type fuel injector-pumps for diesel engines.

In the prior United States Patent No. 3,075,707 to Rademaker, a needle valve type injector-pump is disclosed which incorporates a check valve for preventing blow-back of combustion gases from the engine cylinder into the pump cylinder of the injector. This check valve is seatable against the open end of the pump cylinder for preventing such blow-back of combustion gases, and when thus seated it uncovers an opening into the spring chamber of the injector so that residual fuel pressure existing in the fuel delivery or "tip" passage after the check valve closes can assist the spring in effecting rapid closing of the needle valve to end injection.

I have found that a surprising improvement in the result sought by Rademaker can be obtained through a modification of his arrangement so as to provide the needle valve spring with the added function of assisting the seating action of the check valve against the pump cylinder immediately upon the fuel pressure in the tip passage dropping to a low enough value to allow closing of the injector valve at the end of injection. A faster and more positive check valve action is thereby obtained, resulting in improved needle valve operation.

These and other advantages of the invention will be more clearly understood from the following description of two illustrative embodiments thereof, having reference to the attached drawing, wherein:

FIGURE 1 is a longitudinal sectional view through a unit injector-pump incorporating my novel arrangement.

FIGURE 2 is an enlarged view similar to FIGURE 1, showing the lower or injector portion in greater detail.

FIGURE 3 is a view similar to FIGURE 2, but showing a modified form of the invention.

Referring now in detail to the drawing, and first to FIGURE 1, the upper portion of the illustrated injector-pump is conventional and comprises a housing **1** in which a plunger **2** is reciprocable. Forming an extension of and threaded to the lower end of the housing **1** is a nut **3** within which is supported a bushing **4**, forming the pump cylinder for the plunger **2**. An annular reservoir space **5** surrounding the bushing **4** within the nut is supplied with fuel via passages **6** in the housing from an external fuel connection **7**. The plunger has the usual by-pass means including an external groove **8**, by which opening and closing of ports **9** and **10** in the bushing are controlled, and connecting axial and transverse passages **11** and **12** for bypassing fuel from the pumping chamber **13** to the annular fuel space **5** when the groove **8** is in registry with one or the other of the ports **9** and **10**. Thus during each downward or injection stroke of the plunger from its position shown, fuel is initially bypassed to the annular fuel space **5** from the pumping chamber **13** below the plunger, but after the groove **8** has moved out of registry with upper port **10** and the lower port **9** is closed by the plunger, fuel is displaced under high pressure through the opening **14** in the lower end of the bushing **4** until the groove moves into registry with the lower port **9** to again bypass the fuel and end injection. Other details of the upper or pump part of the unit are not important to the present invention, being common to the

constructions shown and described in such prior U.S. patents as Engel, Jr., 2,951,643 and Teichert 2,898,051, and hence will not require further description here.

Clamped to the lower end of the bushing **4** by the nut **3** is a fuel injector, including a valve body comprising a spray tip **15**, spring chamber body **16** and the spacer block **17**. As best shown in FIGURE 2, the block **17** has a cavity **18** facing the lower or open end of the bushing **4**. The entrance **19** to this cavity, it will be noted, overlies in lateral extent the transverse extremities of the pumping chamber **13**, and projecting centrally upwardly from the bottom of the cavity is a protuberance **20** which forms a seating surface for a circular flat disc check valve **21**.

The body **16** is annular in shape and defines a spring chamber **22** which encloses resilient means in the form of a coil spring **23** whose lower end seats on the upper end of the injector needle valve **24**. Within the spring chamber and seated on the upper end of this spring is a movable seat **25**. Extending centrally through the spacer block **17** and connecting the spring chamber with the cavity **18** is an opening **26**, whose upper entrance is defined by the check valve seating surface on the protuberance **20**. The movable spring seat **25** has an upwardly projecting portion **27** which is substantially smaller than the opening **26** and extends therethrough into abutment with the underside of the check valve **21**. Drilled passages **28** and **29** may be provided in this spring seat to assure fluid pressure communication between the spring chamber and the opening **26** to the cavity at all times.

A plurality of circumferentially spaced passages **30** (one only, shown) are provided in the spacer block **17** to connect the cavity **18** with an annular groove **31** in the upper end of the spring chamber body. This groove **31** is connected with a similar annular groove **32** on the bottom face of the spring chamber body by a longitudinal passage **33**, and this lower groove **32** is, in turn, connected by a plurality of inclined passages **34** to a central passage **35** surrounding the needle valve **24**. These passages **30**, **33**, **34**, **35** and the cavity **18** collectively constitute a "tip" passage for delivery of the injection fuel under pressure from the pumping chamber to the injector outlet. This outlet is in the form of a tapered seat **36** for the needle valve, below which are connecting spray orifices **37** leading into the engine combustion chamber (not shown). Below the upper or spring seat portion of the needle valve **24** is a piston portion **38**, of smaller diameter than that of the check valve **21**, which slidably fits a bore **39** in the spray tip, the latter serving to guide opening and closing movements of the needle valve. It will be noted that this piston portion **38** is exposed at its lower end to the fuel pressure in the tip passage means which tends to raise the needle valve toward open position, and the upper end of this piston portion **38** is exposed to whatever fuel pressure exists within the spring chamber. Avoidance of any build-up of excessive pressure within the latter is provided by a transverse bleed passage **40** through one side wall of the spring chamber body. Although the outer end of this bleed passage **40** appears in the drawing to be closed by the nut **3**, sufficient clearance exists therein around the spring chamber body **16** and the spacer block **17** to enable venting of such excessive fuel pressures to the annular fuel space **5** described above.

In operation, during displacement of fuel at injection pressure from the pumping chamber **13**, the fuel pressure therein maintains the check valve **21** seated against the protuberance **20**, blocking application of such fuel pressure to the spring chamber **25**. This fuel at injection pressure is, however, free to pass into the cavity **18** and thence through the remainder of the tip passage (**30**, **33**, **34**, **35**) where it acts against the lower end of the piston

portion 38 of the needle valve to raise the needle valve and open the outlet 36 for injection of fuel into the engine via the spray orifices 37. Upon the plunger reaching its position wherein the plunger groove 8 registers with the lower port 9, injection fuel pressure within the pumping chamber and in the tip passage immediately dissipates by reason of the fuel being bypassed through the plunger passages 11 and 12 and groove 8 to the fuel space 5 which is at relatively low (e.g., 40 p.s.i.) supply fuel pressure. The check valve 21 thereupon moves upward into seating engagement with the lower end of the pump cylinder bushing 4, and the residual fuel still existing in the tip passage and the cavity 18 is applied to the upper end of the needle valve 24 via the opening 26, movable spring seat passages 28 and 29, and spring champer 25. The needle valve spring 23 serves the very important dual function, during this action, of quickly forcing the check valve 21 upwardly against the pushing 4 to uncover the opening 26 so that such residual pressure may assist the spring 23 in effecting rapid closing of the needle valve 24. It will be appreciated that the larger effective area of the check valve than that of the needle valve piston portion 38 enables the spring to yield under a lower fuel pressure in the pumping chamber 13, to allow the check valve to open the lower end 14 thereof, than is required to compress the spring for opening movement of the needle valve. As a result, a very fast operation of the check valve is obtained, and consequently a more positive and quicker closing of the needle valve is effected for more precise timing and efficient engine operation.

In the modified form of the invention illustrated in FIGURE 3, the same result is obtained with a somewhat simplified arrangement of parts. In this form, the spring chamber body 16' is constructed so as to provide the cavity 18' for the check valve 21' in its upper end, thereby eliminating the need for the separate spacer block 17 in the previous form. Also in this arrangement, the check valve 21' is provided with a depending projection 27' which forms the movable seat engaging the upper end of the spring 23', thereby eliminating the need for such a separate spring seat as shown at 25 in the previously described form. The passage 33' through the spring chamber body connects directly with the cavity 18' at its upper end, and with an annular groove 32' formed in the upper end of the spray tip 15'. The other parts are essentially the same as those corresponding thereto in FIGURES 1 and 2, and are therefore correspondingly numbered except with the reference numerals primed. The operation is identical with that described for FIGURES 1 and 2, it being only significant to mention that the depending projection 27' on the check valve acts to close the opening 26' formed by the upper end of the spring chamber 25' when the pump pressure reaches a value sufficient for injection to occur.

Although but two specific embodiments of the invention have been described and shown, it is to be appreciated that various changes in the parts and their arrangement may be made without departing from the spirit and scope of the invention which I now claim:

I claim:

1. In a unit fuel injector-pump, a pump cylinder open at one end for fuel delivery, an injector opposite said end including a fuel delivery outlet, an injection valve movable to open and close said outlet, passage means connecting said cylinder end and said outlet, a bore slidably guiding opening and closing movements of said injection valve, a chamber communicating with the end of said bore toward which the valve moves during opening, said injection valve having a piston portion in said bore exposed to fuel pressure in said passage means for moving the valve in its opening direction, said passage means including a cavity facing said cylinder end, said cavity having an opening to said chamber oppositely of said cylinder end and a seating surface defining the entrance to said opening, a check valve in said cavity movable in one direction into closing engagement with said cylinder end to block reverse flow through said passage means to said cylinder and movable in the opposite direction into closing engagement with said seating surface to block communication between said passage means and chamber, and resilient means biasing said injection valve into closing engagement with said outlet and biasing said check valve into closing engagement with said cylinder end, said resilient means being yieldable under a first predetermined fuel pressure developed in the cylinder to accommodate movement of the check valve away from said cylinder end for flow of fuel into said passage means, and yieldable under a higher predetermined fuel pressure in the passage means to accommodate movement of the injection valve away from said outlet.

2. In a unit fuel injector-pump, a pump cylinder open at one end for fuel delivery, an injector opposite said end including a fuel delivery outlet, an injection valve reciprocably movable to open and close said outlet, passage means connecting said cylinder end and outlet including a cavity facing said cylinder end, a chamber between said cavity and said outlet and having an opening to said cavity, said injection valve having a piston portion exposed at one end to fuel pressure in said passage means tending to move the injection valve in the direction to open said outlet, said piston portion being exposed at its opposite end to fuel pressure in said chamber tending to move the injection valve in the direction to close said outlet, a check valve in said cavity movable in one direction to close said cylinder end and movable in the opposite direction to close said opening to the chamber, and spring means interposed between said valves and having operative engagement with said check valve via said opening to bias the check valve in the direction to close said cylinder end and operatively engaging the injection valve in said chamber to bias the injection valve in the closing direction against said outlet.

3. In a unit fuel injector-pump, a pump cylinder open at one end for fuel delivery, an injector having a fuel outlet, passage means connecting said outlet and cylinder end, said passage means including a cavity facing said cylinder end, an injection valve movable to open and close said outlet, a chamber between said cavity and outlet and having an opening to said cavity, said injection valve having a piston portion with one end exposed to fuel pressure in the passage means tending to open the injection valve and its other end exposed to fuel pressure in said chamber tending to close the injection valve, a check valve in said cavity movable in one direction therein to close said cylinder end against reverse flow from said passage means into said cylinder and movable in the opposite direction to close said opening, and means resiliently biasing both said check valve against said cylinder end and said injection valve against said outlet, said biasing means being yieldable to accommodate movement of the check valve away from said cylinder end and into closing relation with said opening in response to a predetermined cylinder fuel pressure and yieldable to accommodate opening of the injection valve in response to a higher fuel pressure in said passage means.

4. In a fuel injector, a valve body including a cavity having a fuel supply entrance, a fuel injection outlet remote from said cavity, passage means connecting said cavity and outlet, a chamber separate from said passage means, said chamber and cavity having a connecting opening, an injection valve movable to open and close said outlet, said injection valve having a portion exposed to fuel pressure in said passage means tending to open the injection valve and exposed to fuel pressure in said chamber tending to close the injection valve, a check valve in said cavity movable in one direction therein toward said entrance to block reverse flow therethrough from said passage means and cavity and movable in the opposite

direction to close said opening to said chamber, and spring means in said chamber operatively engageable with both said check valve and said injection valve and biasing them toward said cavity entrance and said injection outlet, respectively.

5. The invention of claim 4, including a movable seat for said spring means in said chamber, said seat having a projection extending through said opening for abutting engagement with said check valve.

6. The invention of claim 4, wherein said check valve includes a projection extending through said opening for abutting engagement with said spring means.

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