

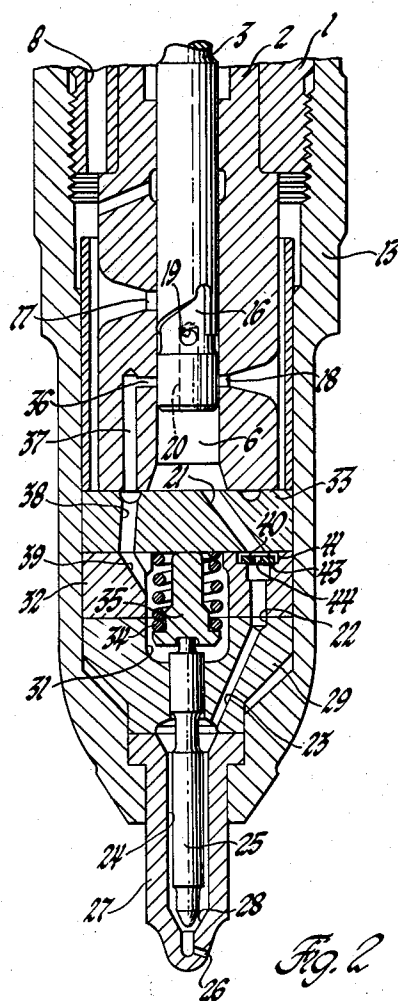
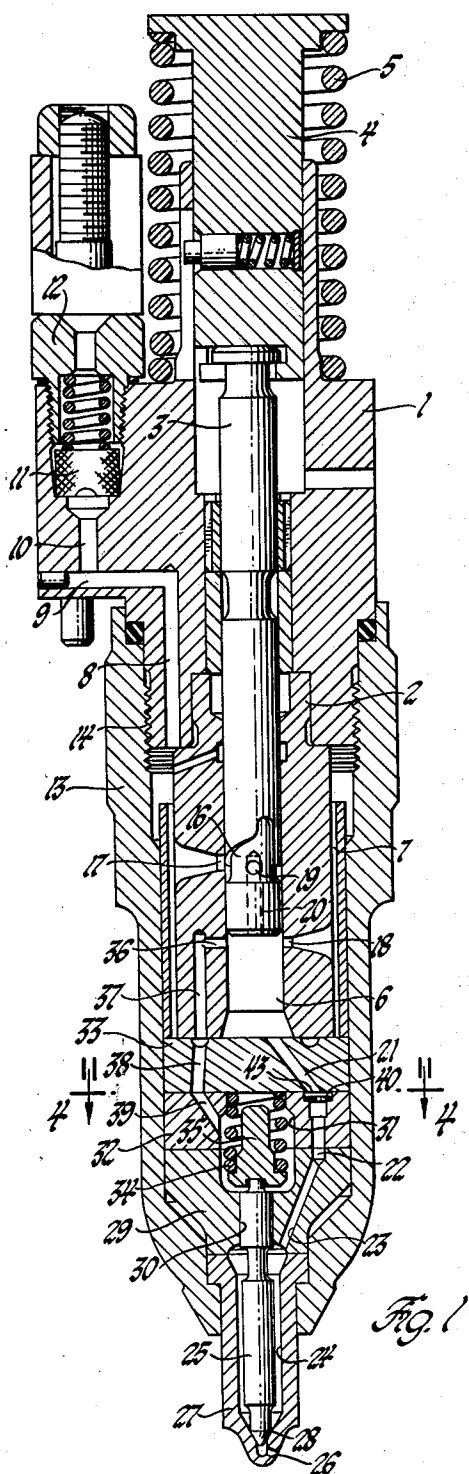
Dec. 24, 1963

H. G. HUMPHRIES
FUEL INJECTOR PUMP WITH HYDRAULICALLY
CONTROLLED INJECTION VALVE

3,115,304

Filed Oct. 11, 1961

2 Sheets-Sheet 1



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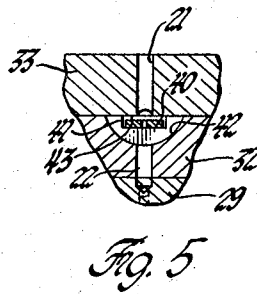
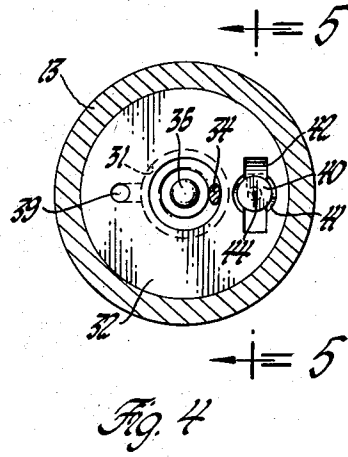
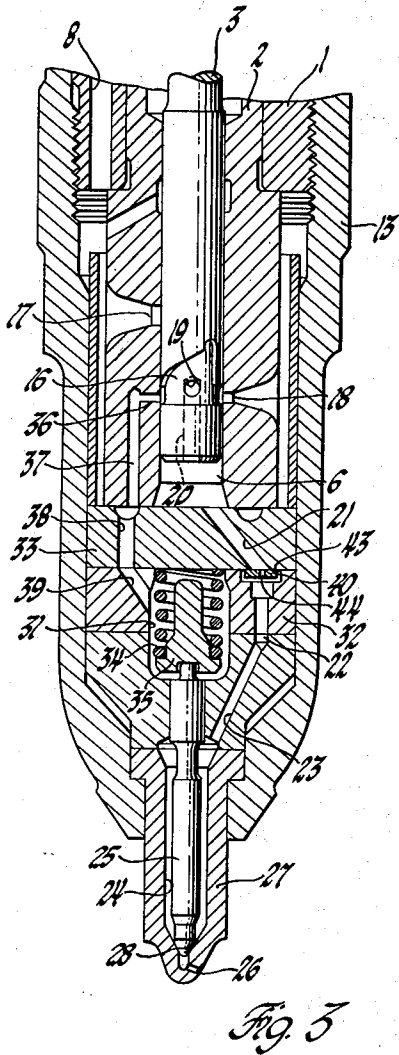
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FUEL INJECTOR PUMP WITH HYDRAULICALLY CONTROLLED INJECTION VALVE

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

In such unit injector-pumps employing a reciprocating plunger type pump it has long been known that a needle type valve, openable upon build-up of sufficient fuel pressure in the pumping cylinder, provides a very sharp and positive fuel cut-off at the end of injection. However, I have found that with only minor modification of the conventional injector of this type, these advantages can be further enhanced by subjecting the needle valve at the proper time to injection pressure to assist its closing action.

As the preferred arrangement for carrying out this objective, I provide the unit with an additional passage which connects the needle valve spring chamber with a side port in the pumping cylinder, which port is closed by the plunger during substantially the entire injection period but is uncovered by the plunger at or slightly prior to the end thereof. Also, in accordance with my invention, since such ending of injection is effected (as is conventional) by the plunger uncovering another port which vents the pumping cylinder of fuel pressure developed by the advancing plunger, I restrict the rate at which such venting may occur. As a result, the needle valve closing action effected by the injection pressure in the pumping cylinder is assured, and the further advantage is obtained of employing at least some of this pressure to assist return of the pump plunger by its spring and thereby maintain contact between the plunger driving cam and the plunger or its cam follower. Thus a more precise timing of fuel injection, together with quieter operation of the unit injector-pump, is accomplished.

As a further feature of the invention, I provide the "tip passage," through which the fuel is delivered from the pumping cylinder to open the needle valve and discharge into the engine, with an anti-blow-back or check valve arranged to accommodate restricted leakage in its closed position. Thereby, such fuel as may be trapped between this check valve and the needle valve, when both are closed, is permitted to dissipate gradually. This insures against the needle valve being forced open, with resultant "after-dribble" of fuel, following the initial closing of the needle valve, yet does not affect the main function of the check valve in preventing blow-back of engine combustion gases into the pumping cylinder in the event the needle valve should happen to stick open.

A better understanding of the manner in which these and other objects and advantages of the invention are realized will be apparent from the following description of one specific embodiment thereof selected for illustration, having reference to the drawings, wherein:

FIGURE 1 is a longitudinal sectional view through a unit injector-pump showing the arrangement for employing injection pressure to assist closing of the needle valve, together with the improved check valve and means for delaying dissipation of injection pressure in the pumping cylinder at the end of the injection stroke. In this view, the parts are shown in their relative positions at the beginning of the downward or injection stroke of the plunger.

FIGURE 2 is a fragmentary view similar to FIGURE

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1, but showing the parts in their positions during full injection.

FIGURE 3 is a similar fragmentary view, showing the parts in their positions at the end of injection.

FIGURE 4 is a transverse sectional view taken substantially along the line 4-4 of FIGURE 1.

FIGURE 5 is an enlarged sectional view taken substantially along the line 5-5 of FIGURE 4, illustrating details of the construction and arrangement of the check valve.

Referring now to the drawings in detail, and first to FIGURE 1, the upper portion of the unit is conventional and comprises a housing 1 in which is fixedly supported a bushing 2. Reciprocable therein is a plunger 3 whose upper end is connected to a cam follower 4, and between this follower and the housing is a plunger return spring 5 urging the plunger outwardly of the bushing. The bore 6 of the bushing below the plunger 3 constitutes the pumping cylinder, and surrounding the bushing is an annular reservoir 7 into which fuel may be introduced (via passages 8, 9, 10 and filter 11) from an external fuel connection 12. This reservoir is contained in a lower housing or nut 13 whose upper end is threadedly connected as at 14 to the housing 1. Adjacent its lower end, the plunger 3 has the usual bypass means in the form of an external metering groove 16 and transverse and axial passages 19 and 20, by which upper and lower inlet and bypass ports 17 and 18 are connectable with the pumping cylinder 6 during the downward or pumping stroke of the plunger. The side ports 17 and 18, as will be seen, are in communication with the reservoir chamber 7 so that when the plunger is in its uppermost position shown the pumping cylinder and all passages and ports connected with it are filled with fuel. The lower end of the cylinder is open for fuel displaced by the plunger during its downward stroke, such fuel being delivered via a passage 21, and connecting passages 22 and 23, to an annular passage 24 surrounding a needle type injection valve 25 and terminating with an outlet in the form of spray orifices 26 in the lower end of the spray tip 27. Passages 21-24 are referred to as the fuel delivery passage, or "tip passage."

The needle valve 25, whose lower end normally closes off fuel flow through the outlet 26 by engaging the conical seat 28 at the spray tip, is slidably guided adjacent its upper end in a spacer block 29. A bore 30 is provided in the latter for this purpose and opens at its upper end into a spring chamber 31. In the construction shown, this spring chamber is partly formed in the lower spacer block 29, and partly in an intermediate spacer block 32. The upper end of the spring chamber is closed by an upper spacer block 33 which abuts the lower end of the bushing 2. It will be noted that the needle valve 25 is movable into the spring chamber 31 in its opening direction, against a coil spring 34 tending to bias the valve closed, this spring being seated at its upper end against the upper spacer block 33 and at its lower end on a spring seat 35 carried by the upper end of the needle valve. This spring seat extends upwardly within the spring chamber a sufficient distance to limit opening travel of the needle valve by abutment with the upper spacer block 33 (FIGURE 2).

Opposite the lower inlet and bypass port 18 there is provided an additional port 36 which is connected via passages 37, 38 and 39 with the spring chamber 31 at all times. Being located at or at substantially the same height in the pump cylinder as the lower inlet and bypass port 18, this port 36 remains covered by the plunger 3 during its pumping stroke (FIGURE 2) until the metering groove 16 on the plunger uncovers it at substantially the same time the port 18 is uncovered by the

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plunger (FIGURE 3). Such uncovering of the spring cage port 36 preferably occurs slightly in advance, e.g. .005-.015 inch of plunger travel, of the uncovering of the port 18 by the groove 16.

Check valve means is provided between the pumping cylinder and the injection valve to prevent blow-back of combustion gases through the orifices 26 and "tip passage" 21-24 to the pumping cylinder in the event the needle valve should fail to close during operation. In the arrangement shown, this check valve means takes the form of the flat wafer 40 located in a counterbore 41 provided at the upper end of the passage 22 in the intermediate spacer block 32. In its normal position shown this check valve lies against the bottom of the counterbore 41, and fuel is free to flow past the check valve via a slot 42 milled transversely through the counterbore as best shown in FIGURES 4 and 5. In the event of combustion gas blow-back, the flat disc moves into abutment with its seat 43 on the lower face of the upper spacer block 33, substantially blocking reverse fluid flow into the pump cylinder via the passage 21. A restricted leakage path for some flow past the "closed" check valve when thus seated is provided, however, by a small central orifice 44 in the disc 40.

During operation, downward movement of the plunger on its pumping stroke initially closes off ports 18 and 36, following which continued downward movement of the plunger results in fuel within the pumping cylinder being bypassed through the plunger passages 20 and 19 to the groove 16 and back to the fuel supply reservoir 7 via the upper inlet and bypass port 17. When the plunger has moved down far enough to also close the latter port 17 fuel pressure quickly builds up in the cylinder 6 and tip passage 21-24 sufficiently to raise the needle valve off its seat 23 and begin injection through the outlet orifices 26. The fuel pressure within the spring chamber 31 at this time is relatively low (substantially the same as that in fuel supply reservoir 7) and does not prevent the needle valve from moving upwardly in its opening direction. Upon the plunger moving downwardly a sufficient distance (FIGURE 3) that the groove 16 uncovers the spring chamber port 36, the relatively high fuel injection pressure within the pump cylinder 6 is transmitted to the spring chamber 31 where it acts therein to supplement the needle valve spring 34 in effecting quick closing of the needle valve. Simultaneously, or immediately thereafter, the plunger groove 16 also uncovers the lower fuel inlet and bypass port 18, venting the pump cylinder to the fuel supply reservoir 7, with the result that fuel pressure in the tip passage 21-24 falls off sharply to allow the needle valve to close. Any relatively higher pressure of the fuel below the check valve than above it in the tip passage 21-24, as might cause the check valve to close after the needle valve 25 has closed, will be bled off gradually through the restricted orifice 43 in the check valve disc. Such bleed-off precludes fuel trapped between the check valve and needle valve from interfering with closure of the needle valve, or from reopening the needle valve, which would result in "after-dribble" of fuel beyond the normal ending of injection.

Preferably the lower inlet and bypass port 18 is made sufficiently small to restrict its flow capacity such that dissipation of the injection fuel pressure in the pump cylinder is delayed upon the plunger groove 16 uncovering this port to terminate injection (FIGURE 3). As a result fuel pressure in the pump cylinder at the end of the injection yieldingly opposes further downward movement of the plunger. Were it not for this feature, too rapid a decrease in fuel pressure opposing such downward movement of the plunger could result in initiating a surging action in the plunger return spring 5, and its

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possibility of breakage. The extent of the restriction of the size of port 18 must, of course, be selected in accordance with the pumping displacement, operating speed and plunger return spring loading in the particular fuel injector unit to be used, but in general it is desirable that the restriction be such as to maintain sufficient pressure in the pump chamber to minimize the increase in the downward velocity of the pump plunger at the uncovering of port 18.

While only a single preferred embodiment of the invention has been disclosed, it is appreciated that numerous minor changes in the construction and arrangement of the parts may be made without departing from the spirit and scope of the invention as defined in the following claims.

I claim:

1. In a unit fuel injector-pump, a relatively low pressure fuel supply connection, a pumping cylinder, a pump plunger reciprocable in the cylinder, said cylinder having two side ports each sequentially closable and openable by the plunger during its pumping stroke and an opening for fuel displaceable by the plunger during the portion of said stroke when both said ports are closed, a fuel delivery passage connected to said opening and terminating with an outlet, an injection valve normally closing said outlet but movable to open the same in response to a predetermined relatively high fuel pressure developed in the cylinder by the plunger during said portion of its pumping stroke, a chamber separate from said passage, said valve being exposed to pressure in said chamber acting thereon in the direction toward closure of said outlet, said plunger having bypass means connected to said opening and connectable to said ports in response to opening of said ports by the plunger, one of said ports being connected to said supply connection for venting said relatively high fuel pressure developed in the cylinder to the supply connection in response to connecting said bypass means to said one port, the other of said ports being connected to said chamber for applying said relatively high fuel pressure thereto from the cylinder to bias the valve closed in advance of said venting of the cylinder to the supply connection, said chamber being in direct fluid communication solely with said other port.

2. The invention of claim 1, wherein opening movement of said injection valve is in the direction toward said chamber, and a spring is provided in said chamber and acts on the valve to bias it closed.

3. The invention of claim 2, together with check valve means in said passage between said opening and injection valve, said check valve means being closable toward said opening.

4. The invention of claim 3, wherein said check valve means includes a check valve, a seat therefor, and means defining a restricted leakage path for flow past the check valve when seated.

5. The invention of claim 4, together with a plunger return spring, and wherein said one port is of restricted flow capacity relative to the flow capacity of said other port for slowing dissipation of fuel pressure in the cylinder below the plunger upon opening of said one port.

6. The invention of claim 1, wherein said one port is located for opening by the plunger subsequently of opening of said other of said ports.

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