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UNIT FUEL INJECTOR WITH MODULATED INJECTION

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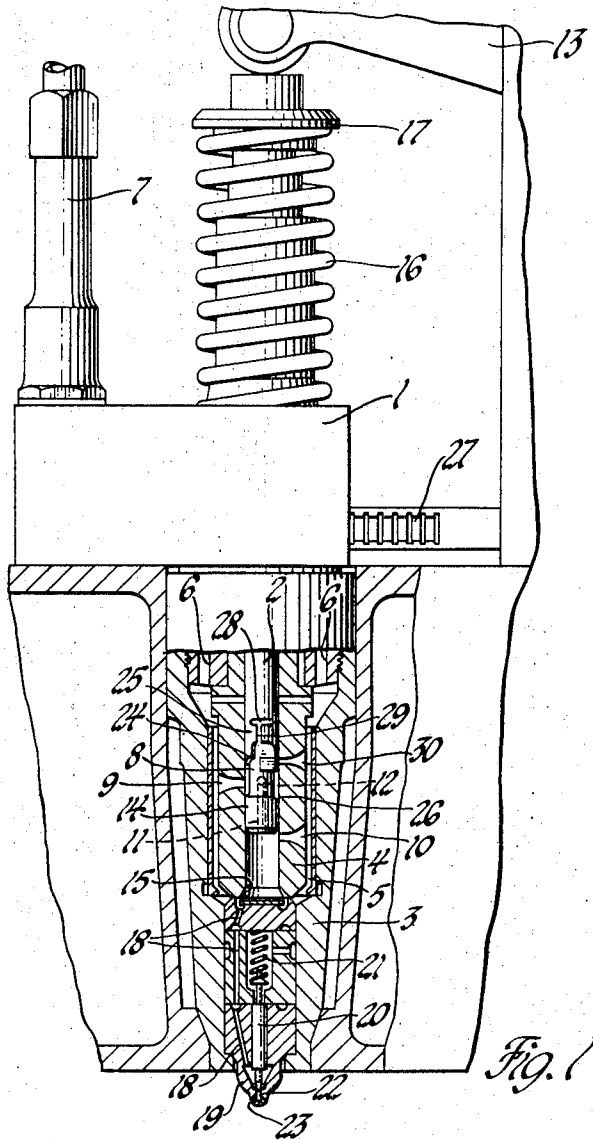


Fig. 1

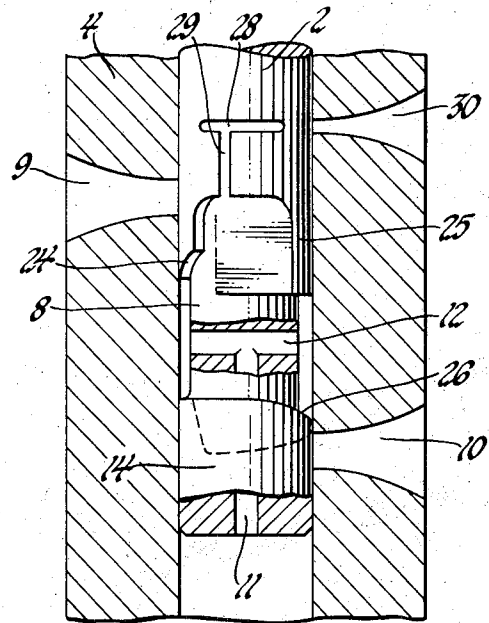


Fig. 2

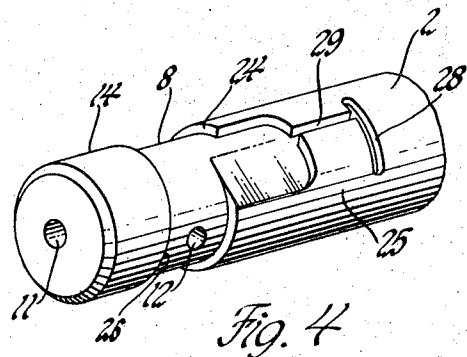


Fig. 4

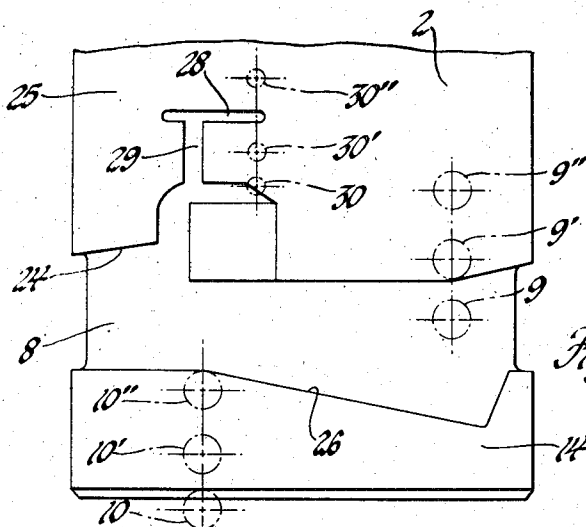


Fig. 3

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UNIT FUEL INJECTOR WITH MODULATED INJECTION

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2 Claims

ABSTRACT OF THE DISCLOSURE

A jerk-type fuel injector-pump unit having a rotatively adjustable plunger and upper and lower main fill and by-pass ports in the pumping cylinder, each sequentially closable and openable by spaced helical lands on the plunger to effect beginning and ending of injection during the pumping stroke of the plunger, the groove between the lands being in continuous communication with the pumping cylinder inwardly of the plunger and also having relatively brief communication with a separate by-pass port in the pumping cylinder while both main ports are closed and the plunger is rotatively adjusted for maximum pump output.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to pressure fluid injectors, and particularly those of the so-called "jerk" type for the injection of liquid fuel into the cylinders of internal combustion engines.

It is a well known disadvantage of such injectors that the maximum output per cycle tends to reduce with increase in operating speed of the pump plunger, this apparently being due to higher pressures developed in the pumping and injection valve chambers with consequent greater opportunity for leakage past the plunger and valve at the higher speeds. Also, this characteristic is more pronounced in those injectors employing the more favored needle type injection valves than those with poppet type valves, and many efforts have been made in the past to overcome this problem because of its deleterious effect on engine fuel consumption under low speed, full throttle operation.

The present invention overcomes this problem in a novel and simple manner which adds relatively little to the cost of the injector, and which adds no moving parts that are likely to get out of order throughout the life of the injector. The idea basically involves the addition of a second bypass means operative during the effective pumping stroke of the plunger, i.e. before the main by-pass opens to relieve the pumping chamber for terminating injection. This additional bypass provision is such that the amount of fuel it withdraws from the charge which would otherwise be injected into the engine on each cycle is very closely dependent upon the operating speed, being less at high speed than at low speed, and thereby operates to compensate for the aforementioned normal tendency of a "jerk" type injector to deliver a greater charge as the speed is reduced.

(2) Description of the prior art

The prior U.S. Pat. No. 3,006,556 to Shade et al. shows

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the basic arrangement of such a jerk-type fuel injector-pump including a needle-type injection valve, but not having the means of our invention to compensate for the effect of operating speed on the quantity of fuel injected per cycle. An earlier U.S. Pat. to Rogers, No. 2,551,053, is of interest in that it proposes to effect such result by controlling the pressure build-up in the pumping chamber, rather than the quantum charge of fuel. In Rogers, a small pressure control or relief port in the pumping cylinder operates in conjunction with a shallow relief area or band on the plunger periphery adjacent a helically shaped groove therein which registers with a separate outlet or discharge port during the plunger pumping stroke when injection is to begin. Thus, his shallow relief band is intended to control pressure build-up both prior to injection, when communicating with the small relief port; and during the start of actual injection, i.e. when the relief band begins to uncover the discharge port. Apart from the reliance on pressure relief in Rogers to obtain the desired fuel charge modulation, his arrangement of cylinder ports and plunger grooving is such that his shallow relief band prevents obtaining precise initiation and termination of injection timing.

(3) Summary of the invention

In our invention, the bleed-off of fuel does not begin until after the main plunger groove moves out of registry with the upper main port in the pumping cylinder to effect the start of injection, and the bleed-off is fully completed before the main groove uncovers the main lower port in the pumping cylinder to terminate injection. We accordingly obtain the desired modulation of the fuel charge per cycle in relation to operating speed without loss of precise injection timing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view partly in longitudinal section and partly in elevation of our improved injector mounted on an internal combustion engine, the plunger being shown in its position at the start of the pumping stroke.

FIG. 2 is an enlarged fragmentary view similar to FIG. 1, but showing the pump cylinder and plunger parts in their relative positions at the end of the pumping stroke.

FIG. 3 is a diagrammatic representation of a 360 degree development of the grooving adjacent the lower end of the plunger, with the pumping chamber ports indicated in broken outline in their respective positions corresponding to plunger advancement from the start of its stroke, to start of injection and end of injection.

FIG. 4 is a perspective view of the lower portion of the plunger.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the drawing, and first to FIG. 1, the upper portion of the unit 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 is a nut 3, within which is supported a bushing 4 forming the pump cylinder for the plunger 2. An annular space 5 surrounds the bushing 4 within the nut and is supplied with fuel via passages 6 in the housing from an external connection 7. The plunger has the

usual external metering groove 8 adjacent its lower end 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 pump cylinder 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 pumping stroke of the plunger from its position shown (effected as by means of the engine rocker 13), fuel is initially bypassed to the fuel space 5 from the cylinder below the plunger, but after the groove 8 has moved out of registry with the upper port 9 and the lower port 10 is closed by the land 14 of the plunger, fuel is displaced under high pressure through the lower open end 15 of the cylinder until the groove 8 moves into registry with the lower port 10 to again bypass the fuel and end injection. Upon the plunger thereafter reaching its lowermost position and during retraction of the rocker arm 13, return of the plunger is effected by a spring 16 which, as shown, may be interposed for this purpose between the housing 1 and a retainer washer 17 carried by the plunger. Such fuel charge delivered from the pump cylinder flows through a tip passage 18 into the lower end or spray tip 19 of the injector where it acts upwardly against the injection valve 20 to raise the latter against its spring 21 and open the fuel outlet 22 for injection of the fuel charge into the engine cylinder via the spray orifices 23. Other details of the injector below the lower end 15 of the pump bushing are not important to the present invention, and are common to the construction shown and described in the Pat. No. 3,006,556 to Shade et al.

Also in accordance with conventional practice, the plunger metering groove 8 has that portion 24 of its upper land 25 which traverses the upper port 9 inclined helically of the plunger axis and that portion 26 of the lower land 14 which traverses the lower port 10, helically inclined to the same extent in the opposite direction, and the plunger is axially rotatable by means of a rack 27 and a pinion (not shown) on the plunger, thereby enabling regulation of the fuel charge per cycle. In other words, by rotating the plunger in the direction such that the upper helical edge 24 closes the upper port 9 later, and the lower helical edge 26 opens the lower port 10 earlier in the pumping stroke, the bypassing of fuel through the ports 9 and 10 before and after the effective pumping stroke begins and ends is prolonged, and the quantity of fuel charge per stroke is thereby reduced.

Located above the metering groove 8 on the plunger is a second groove 28 of relatively narrow width but of substantial depth and extending a short distance circumferentially about the plunger (see FIGS. 2 and 4). This groove is in constant communication, as by a longitudinal external passage 29 on the plunger, with the metering groove 8, and hence also in constant communication with the cylinder outlet 15 via the plunger internal passages 11 and 12. Cooperating with this groove, when the plunger is rotatively adjusted by the rack 27 for maximum fuel rate per stroke, is a relatively small diameter bleed port 30 in the bushing, in constant communication with the inlet and bypass ports 9 and 10 via the annular fuel space 5. This port 30 and upper plunger groove 28 are so located relative to each other that the port 30 is traversed by the groove 28 during a brief interval while the plunger is undergoing its effective pumping stroke, i.e. after the ports 10 and 9 have been closed by the lands 14 and 25, respectively, and prior to the main groove 8 uncovering the lower port 10. When the plunger is rotated to the position shown, in which the effective pumping stroke (and hence the quantum of fuel injected per cycle) is less than maximum, this upper groove is unable to register with the bleed port 30 and is thus rendered ineffective.

It will therefore be appreciated that with the plunger rotatively adjusted for maximum fuel injection, during such time as the upper plunger groove 28 and the port

30 of the bushing are in registry, fuel is bypassed from the space below the plunger to the external fuel space 5 via the plunger passages 11 and 12, groove 8, passage 29, groove 28 and the bleed port 30 in the bushing. The amount of such fuel thus bypassed would, were it not for the additional plunger groove 28 and bushing port 30, be included in the fuel charge delivered to the engine via the outlet 15, tip passage 18 and spray orifices 23. Of course, the amount of such fuel thus bypassed during the effective pumping stroke of the plunger is dependent upon the speed with which the plunger groove 28 traverses (or, stated in another way, remains in registry with) the bushing port 30. Thus, at low engine operating speeds, the speed of the plunger is relatively slow and the amount of such bypassing of the fuel during the effective pumping stroke in relation to the total fuel charge is relatively large, while at higher engine speeds the amount of such diminution of the charge is relatively small. The necessary capacity of the plunger groove 28 and bushing port 30 will obviously vary for different injectors, depending upon their plunger stroke, diameter, etc., and this may be easily determined to meet the requirements of the particular injector to be used.

The operation should be clearly understood from the description heretofore given, but will be made clearer upon inspection of FIG. 3 which shows a 360° development of the plunger and the relative locations of the upper and lower main ports 9 and 10 and bleed port 30 before, during and subsequent to the bleed-off of the pumping charge when the plunger is in its rotative position for maximum injection. Thus in FIG. 3, circles shown in broken outline at 9, 9' and 9'' represent the upper port in its relative locations corresponding to the positions of the plunger at the top of its stroke, at the beginning of injection, and at end of injection, respectively. Similarly, the circles 10, 10' and 10'' show the same corresponding locations of the lower port; and circle 30, 30' and 30'' show the same for the bleed port. When the plunger is rotated to reduce the fuel rate to less than maximum (visualized in FIG. 3 with plunger 2 moved to the left from its position shown, relative to the port locations 9, 9', 9'', 10, 10', 10'') the bleed groove 28 will not be traversed by the bleed port (30, 30', 30'') and hence no additional bypassing of fuel will occur.

What is claimed is:

1. In a plunger-type fuel injection pump comprising a pump cylinder having a discharge outlet associated with one end, an upper side port spaced from said outlet, and a lower side port located intermediate said upper port and outlet; a fuel supply chamber interconnecting said ports externally of the cylinder; and a plunger axially rotatable and longitudinally reciprocable in the cylinder having upper and lower lands operative to sequentially close the cylinder ends of said lower and upper ports, respectively, during longitudinal movement of the plunger toward said outlet on the pumping stroke; said plunger having a circumferentially extending main groove intermediate of and defined by said lands, and a longitudinal passage connecting said main groove to the remote end thereof of said lower land, whereby during the pumping stroke fuel in the cylinder between the plunger and outlet is bypassed to the supply chamber until the plunger has advanced far enough to effect closure of both said ports by said lands, and thereafter fuel is displaced from the cylinder via said outlet until the plunger has further advanced to effect registry of said main groove with the lower port; said main groove having one of its land defining extremities disposed helically of the plunger axis, whereby the quantity of said fuel displaced during each plunger pumping stroke may be varied over a range of maximum, intermediate and minimum values by rotational adjustment of the plunger; said cylinder having a third side port connected to the supply chamber and said plunger having a bleed groove connected to said main groove

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and located to register with said third port during the pumping stroke of the plunger while said upper and lower ports are both closed and the plunger is rotationally adjusted for substantially maximum fuel displacement.

2. The invention of claim 1, wherein said bleed groove extends circumferentially of the plunger and is located in said upper land in spaced relation to said main groove, the circumferential extent of the bleed groove about the plunger being limited to preclude registry of the bleed groove with said third port during reciprocation of plunger while rotationally adjusted for minimum fuel displacement from the cylinder.

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References Cited

UNITED STATES PATENTS

2,898,051	8/1959	Teichert	239—88
3,006,556	10/1961	Shade et al.	239—533
3,115,304	12/1963	Humphries	239—533
3,282,512	11/1966	Bluhm et al.	234—533

C. J. HUSAR, Primary Examiner

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