Nov. 13, 1956 J. DICKSON 2,770,500

FUEL INJECTION DEVICE

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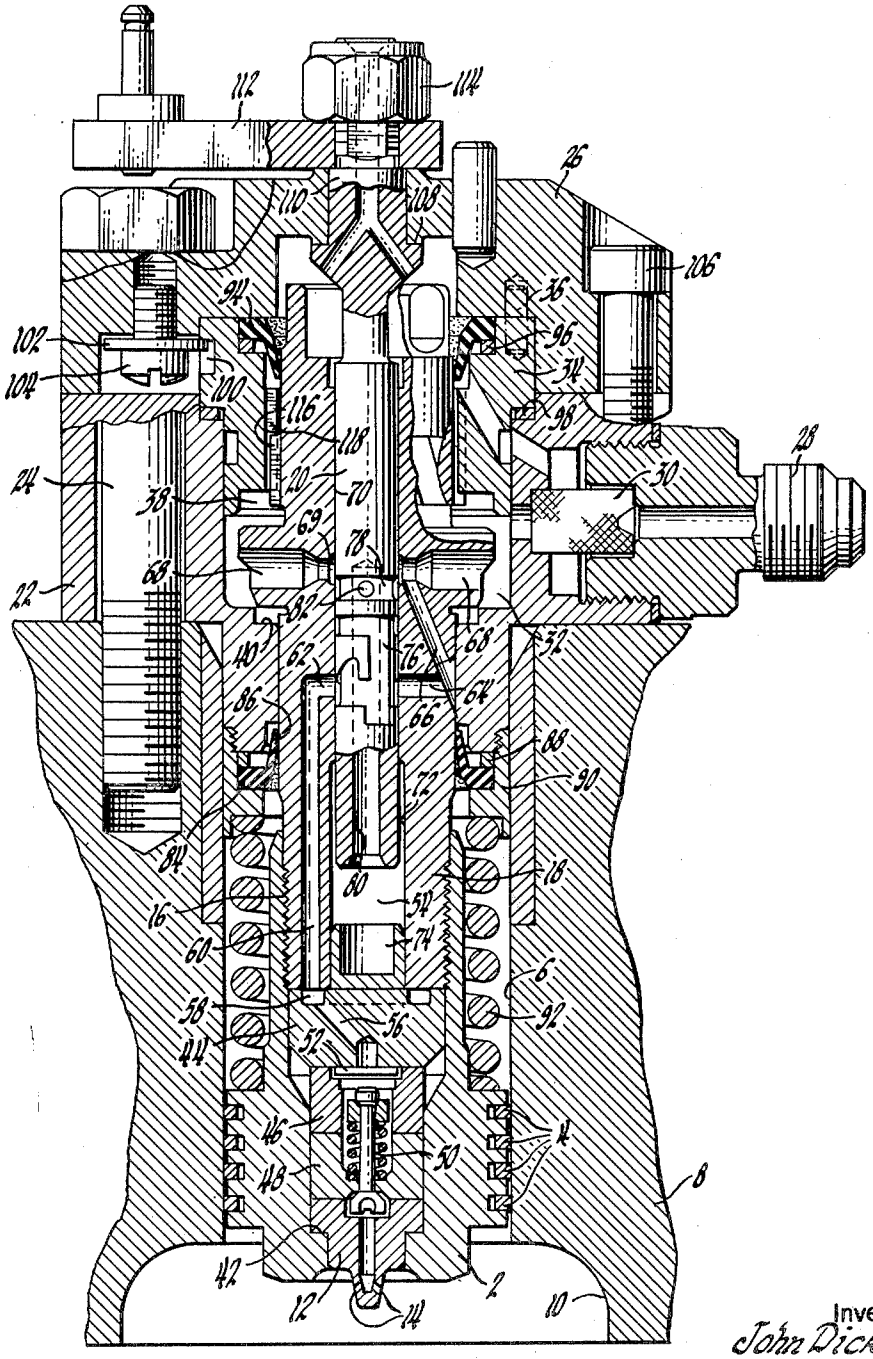


Fig. 1

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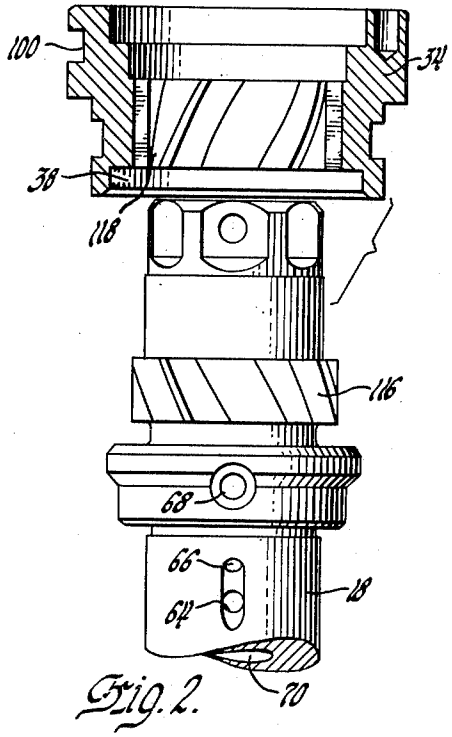


Fig. 2.

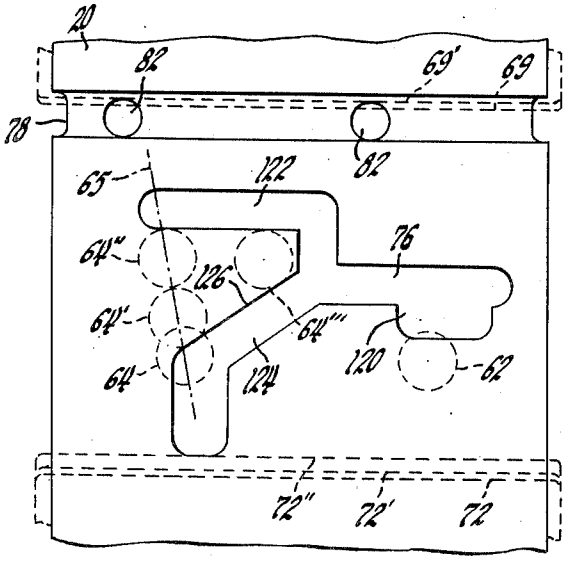


Fig. 3.

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FUEL INJECTION DEVICE

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7 Claims. (Cl. 299—107.2)

This invention relates to fuel injection pumps for internal combustion engines, and particularly to such pumps of the unit pump and nozzle type.

The principal object of the invention is to provide such a pump wherein the fuel discharge from the nozzle will have a rotary motion to effect a better distribution and atomization of the fuel with the combustion air in the engine cylinder.

A more specific object of the invention is to provide such a rotating nozzle discharge in a unit fuel injection pump of the automatic or compression operated type.

Although I appreciate it is not broadly new to provide a fuel injection pump in which the nozzle is rotated during fuel injection, there being a U. S. Patent No. 1,995,459 to Olsen disclosing this idea, it is believed the pump of my present invention has a number of important advantages over such prior constructions. Among such advantages are the fact that the injection period is timed by the relative movement of the pump plunger in its cylinder, rather than by external separately actuated timing valves; that my pump is adapted for controlling the start, finish and duration of the injection period by axial rotative adjustment of the pump plunger during operation, unaffected by the nozzle rotation; and that the design of the pump and nozzle unit with its injection control adjusting means and nozzle rotative drive means are all combined into a single compact organization of parts of rugged design which can be economically manufactured and has great dependability in service.

These and other objects and advantages of the invention will be more readily apparent from the following description of one preferred structural embodiment, having reference to the drawings wherein:

Figure 1 is a fragmentary sectional view through an engine cylinder head incorporating the improved fuel injection pump, with parts broken away and in section.

Figure 2 is an exploded view showing portions of the pump chamber cylinder and its embracing seal carrier member to illustrate their helically inter-splined relation.

Figure 3 is a diagrammatic developed view of a portion of the plunger periphery, showing the fuel injection timing and fill grooves with the cooperating ports and control edges of the pump cylinder superimposed thereon in broken outline.

As shown in Figure 1, the fuel injection pump includes a piston 2 which is fitted by sealing rings 4 to a bore 6 in an engine cylinder head 8. The piston 2 is exposed through the lower end of the bore 6 to the pressures developed in the engine combustion chamber 10 formed by the cylinder head 8, and carries a fuel injection nozzle 12 having a number of circumferentially spaced downwardly and transversely directed fuel discharge or spray orifices 14. Threaded as at 16 or otherwise secured to the piston for movement therewith is a bushing 18 which forms the pump cylinder for a pump plunger member 20. Slidably fitting the exterior of the bushing or cylinder member 18 is a housing including an open ended body 22 which is fixedly secured to the

head as by bolts 24 and has its upper end closed by a cap 26 which longitudinally supports and rotatably journals the upper end of the plunger 20. A suitable inlet 28 is provided in the body 22 for the admission of fuel, which inlet is connected through a fuel strainer 30 to a fuel reservoir chamber 32 formed between the body and the pump cylinder. An outlet (not shown) identical to the inlet 28 and similarly connected through a filter to the reservoir chamber 32 is provided for returning the excess fuel to its source of supply. The upper end of the reservoir chamber 32 is defined by a seal carrier 34 which is pinned as at 36 to the cap 26. The lower end of the carrier member 34 is counterbored at 38 to form a dash pot, and a similar dash pot forming counterbore 40 is provided in the body 22. The pump cylinder 18 is enlarged intermediate its ends within the reservoir chamber 32 to closely fit these dash pot chambers 38 and 40 so as to trap fuel therein and cushion the strokes of the piston 2 in each direction.

Clamped between the lower end of the pump cylinder 18 and the nozzle 12 which is seated on a shoulder 42 within the piston, is a fuel transfer block 44 and two spacer blocks 46 and 48 which support and house a check valve assembly 50 and provide a passageway for fuel to the nozzle orifices 14. An anti-blowback valve of wafer-like form is inserted as shown between the upper spacer block 46 and the transfer block 44 to prevent combustion gases being blown upwardly into the pump in the event the check valve 50 should be stuck open. Connecting this wafer valve 52 to the pump chamber 54 is a diagonal passage 56 in the transfer block whose upper end communicates with an annular groove 58, which in turn communicates with a "tip" passage 60 drilled longitudinally through the wall of the pump cylinder 18 and terminates at its upper end in a transverse "tip" port 62 controlled by the pump plunger 20. Diametrically opposite this port 62 is a "by-pass" port 64 extending transversely through the pump cylinder wall and connecting at its radially outer end with a diagonally drilled passage 66. Through the enlarged portion of the pump cylinder are provided a plurality of radially drilled "fill" ports 68, to one of which is connected the upper end of the diagonal passage 66. The inner ends of these fill ports communicate with an annular groove 69 in the cylinder bore 70, and their outer ends communicate with the reservoir chamber 32. The pump plunger 20 has very close sliding fit in the bore 70 of the pump cylinder except in the lower portion thereof which is counterbored to a larger diameter 72 having a substantial clearance about the plunger. An upright cup 74 closely fits this counterbore 72 and rests on the fuel transfer block 44 to form a fluid pressure seal closing the lower end of the pump chamber 54.

The pump plunger 20 has its periphery relieved by a metering or injection timing groove 76 and an annular groove 78, the latter of which is in continuous communication with the pump chamber 54 through an axial passage 80 and a plurality of radial connecting passages 82.

Sealing the exterior of the pump cylinder 18 against leakage of fuel into the combustion chamber from reservoir chamber 32 is an annular nylon ring 84 having an upwardly directed sealing lip 86 as shown. The body portion of this annular nylon ring is clamped between a spacer ring 88 and a gland nut 90 threaded to the lower end of the body 22. This gland nut 90 additionally serves as an upper spring seat for the piston return spring 92 whose lower end abuts the piston. Similarly sealing the external periphery of the pump cylinder adjacent its upper end against escape of fuel oil into the cap 26 is a second nylon ring 94 of the same design but having its sealing lip projecting downwardly. This sealing ring 94 is

clamped between the spacer ring 96 and the cap 26 by the seal carrier member 34 whose upper end is externally flanged to seat on a gasket 98 in a counterbore formed in the upper end of the body 22. The periphery of this flanged portion of the carrier member has a recess 100 to provide for its engagement by a key in the form of a flat washer 102 which is anchored to the cap by a retaining screw 104, thereby enabling the seal carrier and its seal ring 94 to be removed as a unit with the cap 26 when the retaining studs 106 are removed.

The upper end of the plunger 20 is provided with a shoulder 108 which abuts the under side of the cap 26, and with a journal portion 110 extending through the cap 26 and secured by a crank arm 112 and a retaining nut 114. The arm 112 is fixed against rotation on the pump plunger whereby the plunger can be axially rotated relative to the cap, body, pump cylinder and piston during reciprocation of the piston and cylinder.

Below the upper seal 94 and the enlarged portion of the pump cylinder its external periphery is provided with helical splines 116 which slidably engage helical internal splines 118 formed integrally with the sealed carrier member 34. As a result, reciprocation of the pump cylinder 18 during operation produces a simultaneous oscillatory motion about its axis and about the plunger 20, which oscillation or rotation is also imparted to the nozzle 12 by reason of their connection through the piston 2. During each upward stroke of the pump piston, therefore, the fuel discharged through the orifices 14 into the combustion chamber 10 has a rotary component of movement. This rotary component is preferably made of sufficient extent (through selection of a proper pitch of the splines 116, 118 in conjunction with the length of stroke) to equal or exceed the circumferential spacing of the orifices 14 from each other, whereby a full 360° sweep of the combustion chamber is obtained during each injection stroke.

As best shown in Figure 3, the plunger metering groove 76 has a laterally extending portion 120 which cooperates with the tip port 62, and oppositely extending connecting portions 122 and 124 which are spaced longitudinally of each other axially of the plunger and cooperate with the by-pass port 64. One of these groove portions, and preferably that indicated at 124, has at least one of its edge extremities disposed helically of the plunger axis as indicated at 126, whereby its registration with the port controlled thereby can be adjusted and timed by axial rotation of the plunger. In the arrangement illustrated in Figure 3, the tip port designated at 62 and the by-pass port designated at 64 are shown in the positions they occupy in Figure 1 wherein the pump cylinder and the piston 2 are at their lowermost positions and the plunger 20 is rotatively set at its maximum fuel position. Also indicated in broken outline in Figure 3 are the upper end of the pump cylinder counterbore 72 and the lower edge of the pump cylinder fill groove 78 when the piston is at its bottom stroke position. Fuel may then flow from the reservoir chamber 32 (Figure 1) into the annular groove 69 in the cylinder bore 70, thence through the fill ports 82 and down through the axial passage 80 to completely fill the pump chamber 54. As the pump cylinder rises with the piston in response to increased compression chamber pressure at the beginning of each injection stroke the lower edge of the pump cylinder annular groove 69 moves out of registry with the plunger fill groove 72 to the position indicated at 69′ prior to the upper end of the pump cylinder counterbore 72 overlapping the lower end of the plunger groove portion 124. Beginning with this counterbore upper end reaching the position indicated at 72′, a period of fuel precompression takes place within the pumping chamber, with no fuel being injected nor by-passed therefrom until the counterbore upper end reaches a position of registry with the groove portion 124 as indicated at 72″. During both these "fill" and "precompression" portions of the piston injection stroke just described the tip port 62 and the by-pass port 64 are both in registry with their respective portions of

the metering groove 76. Upon the pump cylinder counterbore reaching the position 72″ the pumping chamber pressure is relieved by the groove 76 to the by-pass 64, and the fuel is then by-passed during further upward movement of the pump cylinder until the by-pass port reaches the position indicated at 64′, whereupon no further by-passing can then take place and the fuel being displaced from the pump chamber is forced through the tip port 62 and passage 60 to the check valve 50, which opens under the fuel pressure applied, and injection takes place through the spray orifices 14. As stated, by reason of the rotation of the cylinder and piston, due to the camming effect of the helical splines 116, 118, the nozzle 12 also rotates, causing the sprayed fuel to sweep circumferentially about an arc equal to the circumferential spacing of the orifices 14 from each other.

Such injection continues to take place until the by-pass port reaches the position indicated at 64″ where it initially makes registry with the upper portion 122 of the plunger groove 76, again permitting the fuel displaced from the pump chamber to be by-passed into the reservoir chamber 32. The extreme upward travel of the cylinder and piston is limited by the enlarged portion of the cylinder moving into the upper dash pot 38 in the lower end of the seal carrier 34 and being cushioned by oil trapped in the dash pot 38. On the return stroke, as the engine combustion chamber pressure is relieved to permit the piston return spring 92 to move the piston downwardly to its initial position, fuel is again supplied through the fill ports 82, grooves 69 and 78, plunger passages 80 and 82, with the extreme travel of the piston being limited by the cushioning action of the fuel in the lower dash pot 40 as the cylinder enlargement moves into it.

The timing of the start of fuel injection may be delayed, with resultant decrease in the quantity of fuel injected, by rotating the plunger 20 by means of its lever 112 (Figure 1). Rotation of the plunger to the left from its position shown in Figure 3 has the effect of moving the by-pass and tip ports to the right from their positions indicated at 64 and 62, respectively. At 64‴ in Figure 3 is shown the relative position of the by-pass port when the plunger is in its "no fuel" position, where it will be noted that this port then makes its initial registry with the upper plunger groove portion 122 simultaneously with discontinuing its registration with the lower groove portion 124. Thus, with the plunger so rotated to the "no fuel" position, that portion of the stroke of the pump cylinder and piston remaining after "precompression" produces only a by-passing of fuel from the pump chamber to the reservoir chamber.

The helical control edge 126 of the plunger groove 76 (by which timing of the injection is rendered adjustable) has a different pitch than that of the helical splines 116, 118 which effect the oscillatory rotation of the pump cylinder during reciprocation. This may best be observed from the non-perpendicular relation to this groove edge 126 of the line 65 drawn through the centers of the by-pass port positions 64, 64′ and 64″ in Figure 3. By having these helical pitches of different magnitude, the rotation of the pump cylinder about the plunger does not disturb the injection timing and/or duration as set by the plunger control arm 112 (Figure 1).

It will thus be noted that my pump as above described accomplishes the desired result of rotating the fuel spray during injection in addition to permitting the timing or length of injection to be controlled by axial rotation of the pump plunger, and also provides for precompressing the fuel in the pumping chamber prior to injection whereby the start of injection can be delayed as necessary to render the pump automatically responsive to variation in the combustion chamber.

It is appreciated that minor modifications and rearrangements 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. A fuel injection pump including a longitudinally fixed and axially rotatable plunger, a reciprocating pump cylinder with fuel by-passing means controlled by rotation of said plunger, a fuel discharge nozzle fixed to the cylinder and camming means interposed between the cylinder and plunger operable to rotate the nozzle during reciprocation.

2. A fuel injection pump including a longitudinally fixed and axially rotatable plunger having a peripheral fuel metering groove defined by a helical edge, a reciprocating cylinder forming a pumping chamber therewith having a fuel by-pass port closable by said edge to intiate injection, a fuel discharge nozzle carried by the cylinder, and slidably interengaged helical splines fixed against longitudinal movement relative to the plunger and cylinder, respectively, for imparting oscillatory rotation of the nozzle axially of the plunger and cylinder during its reciprocation with the cylinder.

3. In a compression operated fuel injector, a piston, a fuel nozzle and a pumping cylinder fixed to the piston, said cylinder having fuel by-pass and discharge ports, fixed guiding means slidably supporting the cylinder for reciprocation with the piston, a plunger axially rotatable in said cylinder and having a helical edge cooperating with one of said ports to control the effective pumping stroke of said cylinder, means supporting the plunger from the guiding means against reciprocation with the cylinder while accommodating its axial rotative adjustment therein, said guiding means including splines helically disposed about the plunger axis, said cylinder having splines slidably interengaging said guiding means, splines whereby the piston, cylinder and nozzle rotate during reciprocation.

4. A fuel injection pump including a plunger member and a cylinder member forming a pumping chamber therewith, one of said members being fixed against longitudinal movement, and the other being reciprocable in operation, said reciprocable member having a transversely directed fuel discharge orifice, passage means for connecting said orifice to the pumping chamber during a portion of each stroke of the reciprocated member, said passage means including a port in one of the members and a groove in the other member registrable with said port, said groove having a control edge defining its limits of registration with the port, means for axially rotating said fixed member to adjustably time the registry of said port and control edge during reciprocation of said reciprocated member, and means operative in response to reciprocation of said reciprocated member to axially rotate the same for varying the transverse direction of said discharge orifice during said registry, said control edge being angularly disposed to the helical direction of movement of the ported member relative to the other member.

5. A fuel injection pump including a plunger member and a reciprocably driven cylinder member forming a pumping chamber therewith, a housing supporting the plunger against longitudinal movement while accommodating its rotary movement, said cylinder member being slidably and rotatably guided in the housing, a nozzle rotatable and reciprocable with the cylinder member and having a transversely directed fuel discharge orifice, means for adjustably rotating the plunger relative to the housing, passage means for connecting said orifice to the chamber including a port in one of said members and a groove in the other member registrable with said port, said groove having a control edge determining its registration with the port, camming means on the housing and cooperative camming means on the cylinder member operative to axially oscillate the cylinder member and thereby vary the transverse direction of said discharge orifice during pump operation, said control edge being angularly disposed to the helical direction of movement of the ported member relative to the other said member whereby the timing of said port registration may be controlled by adjustably rotating said plunger member.

6. A fuel injection pump including a plunger member and a reciprocably driven cylinder member forming a pumping chamber therewith, a housing supporting the plunger against longitudinal movement while accommodating its rotary movement, said cylinder member being slidably and rotatably guided in the housing, a nozzle rotatable and reciprocable with the cylinder member and having a transversely directed fuel discharge orifice, means for adjustably rotating the plunger relative to the housing, passage means for connecting said orifice to the chamber including a port in one of said members and a groove in the other member registrable with said port, said groove having a control edge determining its registration with the port, a seal carrier fixed within the housing having a sealing element extending therefrom into sealing engagement with the outer periphery of the cylinder member, said carrier and the outer periphery of the cylinder member below said sealing element being provided with slidably interengaged helical splines whereby the cylinder member must oscillate about its axis during reciprocation, said control edge extending helically of the plunger axis with a pitch different from the pitch of said splines whereby the timing of registration between said port and groove may be controlled by said plunger rotating means.

7. A fuel injection pump including a plunger and a reciprocably driven cylinder forming a pumping chamber therewith, a housing supporting the plunger against longitudinal movement while accommodating its rotary movement, said cylinder member being slidably and rotatably guided in the housing, a nozzle rotatable and reciprocable with the cylinder and having a transversely directed fuel discharge orifice, means for adjustably rotating the plunger relative to the housing, passage means for connecting said orifice to the chamber including a groove in the periphery of said plunger communicating with said chamber and a port in the cylinder registrable with said groove, said groove having a control edge determining its registration with the port, a seal carrier fixed within the housing having a sealing element in sealing engagement with the outer periphery of the cylinder, said carrier and the outer periphery of the cylinder below said sealing element being provided with slidably interengaged helical splines whereby the cylinder must oscillate about its axis during reciprocation, said control edge extending helically of the plunger axis with a pitch different from the pitch of said splines whereby the timing of registration between said port and groove may be controlled by said plunger rotating means.

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