

jection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including a pivoted arm and a follower operatively engaging said cam and a second pivoted arm operatively connected to said pivoted arm and means operatively connected to said supply pump means for adjustably displacing the pivot of said pivoted arm and including a cylinder and an actuator piston, said actuator piston being urged by fluid under pressure from said supply pump means.

12. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means comprising a poppet valve formed on the upper end of said piston.

13. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means comprising a poppet valve formed on the upper end of said piston and of greater diameter than said piston.

14. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

15. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively con-

necting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including supply pump means for supplying fuel to said bore, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

16. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including gear means forming supply pump means for supplying fuel to said bore, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

17. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said means including a pivoted arm and a follower operatively engaging said cam, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

18. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, supply pump means for supplying fuel to said hydraulic head, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including a pivoted arm, and means operatively connected to said supply pump means for adjustably displacing the pivot of said pivoted arm, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

19. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, supply pump means for supplying fuel to said hydraulic head, said hydraulic head having

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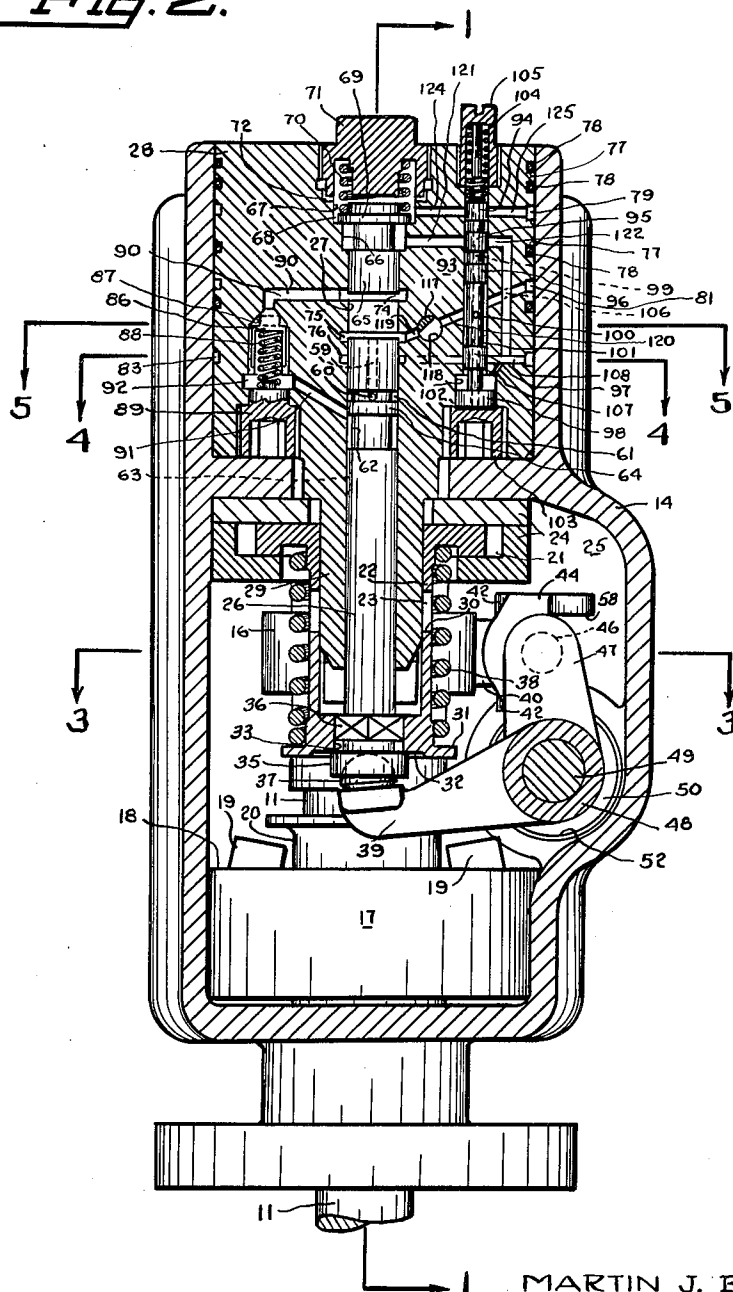
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VERTICAL INJECTION PUMP

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Fig. 2.



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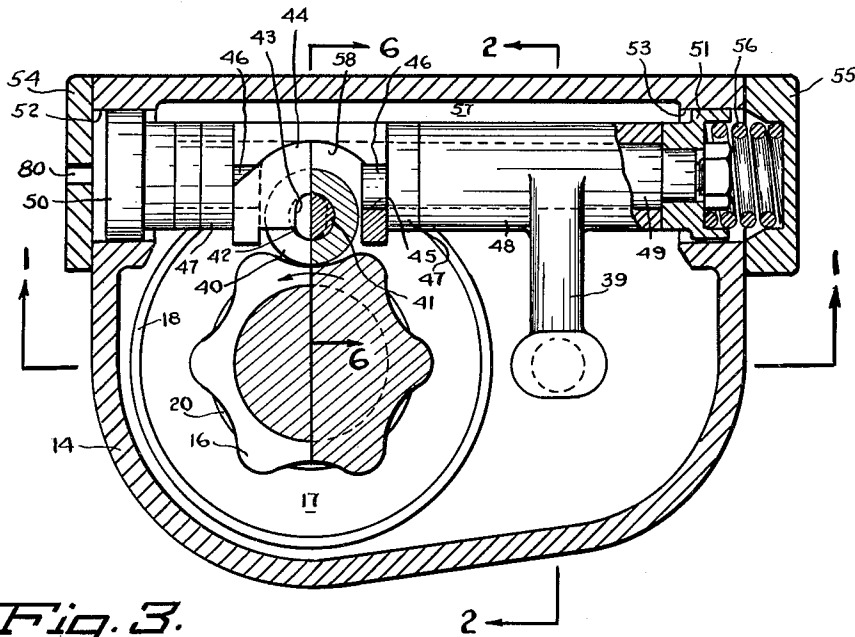


Fig. 3.

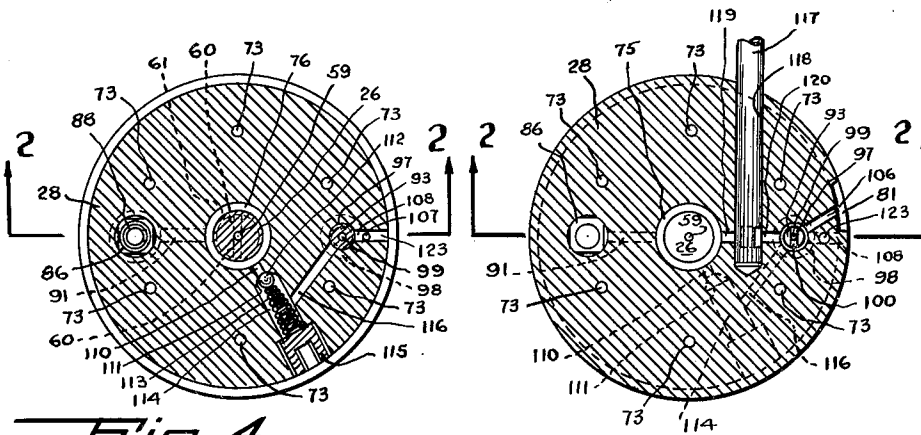


Fig. 4.

Fig. 5.

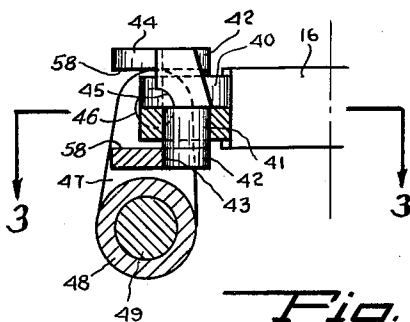


Fig. 6.

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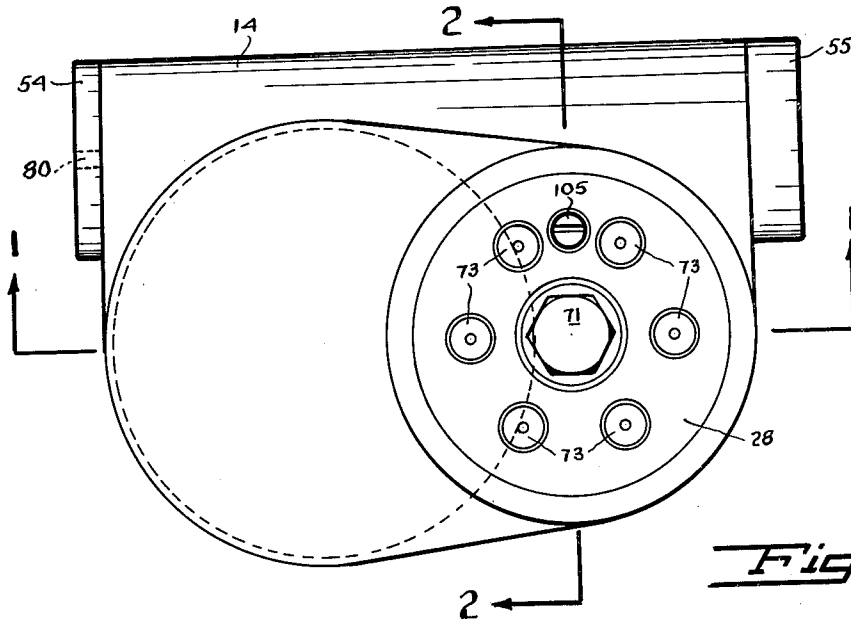
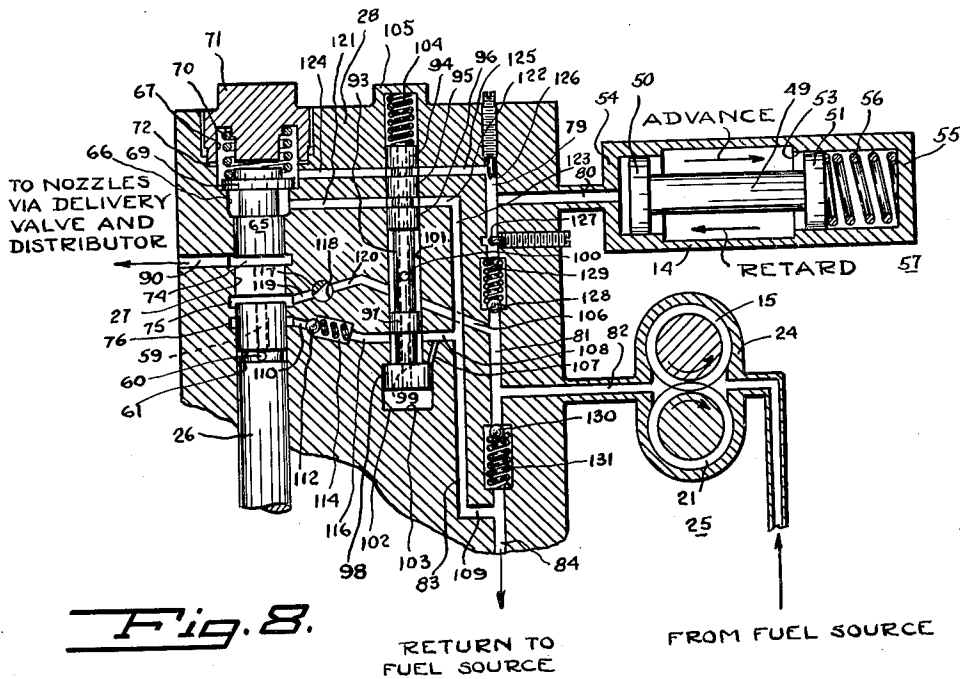
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VERTICAL INJECTION PUMP

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This invention relates to fuel injection pumps for multi-cylinder internal combustion engines such as Diesel engines for trucks, buses, earth-moving equipment, marine propulsion and the like.

More particularly the pump according to this invention is of the distributor type having throttled intake control.

In order to meet the requirements of the market, fuel injection pumps for high-speed internal combustion engines must possess an exacting combination of functional characteristics, yet must not be costly to manufacture.

The novel plunger-actuating mechanism, injection timing control means and excess starting fuel device of the injection pump according to this invention provide, in one combination, all the desirable attributes of injection pumps for high speed multicylinder internal combustion engines.

An object of this invention is to provide an injection pump suitable for fueling engines of the type requiring high injection pressures.

Another object is to provide an injection pump which automatically maintains correct timing of the beginning of injection in all regimes of engine operation.

Another object is to provide an injection pump which automatically delivers, for starting purposes, fuel quantity considerably in excess of normal full-load quantity.

Another object is to provide a pump readily adaptable to a variety of engine types and which may readily be executed for either direction of rotation of its drive shaft.

Other objects are to provide an injection pump of compact, simple and robust construction, and which is inexpensive to manufacture.

FIG. 1 is a sectional elevation in the common plane of the axes of the camshaft and the pump plunger;

FIG. 2 is a sectional elevation in the plane of the axis of the pump plunger at right angles to the plane of FIG. 1;

FIG. 3 is a median section through the cam in a plane at right angles to the planes of FIGS. 1 and 2;

FIG. 4 is a section through the hydraulic head in the plane of the spill check valve and is indicated by 4-4 of FIG. 2;

FIG. 5 is a section through the hydraulic head in the plane of the throttling control valve and is indicated by 5-5 of FIG. 2;

FIG. 6 is a fragmentary and partial section as at 6-6 of FIG. 3 and shows the features of the stirrup carrying the cam roller which are not apparent in FIGS. 2 and 3;

FIG. 7 is a plan view of the pump assembly; and

FIG. 8 is a partial schematic for elucidation of the injection timing and excess starting fuel functions of the pump.

Camshaft 11 is journaled in upper bearing 12 and lower bearing 13 in housing 14. Camshaft 11 carries primary gear 15, cam 16 and a governor indicated generally at 17. Governor 17 includes a spider 18, pivoted governor weights 19 and a governor sleeve 20. Primary gear 15

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meshes with secondary gear 21 which has a sleeve-like hollow hub 22 formed with parallel slots 23 which are open at their lower ends.

Primary gear 15 and secondary gear 21, having equal numbers of teeth, are contained in a casing 24 and so form a fuel transfer pump as indicated generally at 25.

Plunger 26 is adapted to be both reciprocated and rotated in bore 27 of hydraulic head 28 of which the lower extension 29 is of reduced diameter.

Hollow hub 22 of secondary gear 21 is journaled for rotation on lower extension 29 of hydraulic head 28 and slots 23 of hollow hub 22 receive corresponding parallel fingers 30 in reciprocating engagement.

Parallel fingers 30 are formed on the upper side of lower spring seat 31 which is formed with a lower face 32 and a centrally located square hole 33.

The lower end of plunger 26 is provided with a square section 36 which engages the square hole 33 of lower spring seat 31 and is also provided with a cylindrical foot 35 the flat upper surface of which is in abutting engagement with the lower face 32 of lower spring seat 31.

The underside of the foot 35 of plunger 26 is provided with a hemispherical socket in which a hemispherical tappet 37 is fitted for rotation and oscillation.

Surrounding hub 22 of secondary gear 21 and fingers 30 of lower spring seat 31 is plunger spring 38. Secondary gear 21 acts as the upper seat for spring 38.

Plunger 26 is moved upwards by tappet lever 39 by way of tappet 37 and is returned by spring 38 while being rotated (in the opposite direction to the rotation of camshaft 11) by way of primary gear 15, secondary gear 21, engagement of slots 23 of hub 22 with fingers 30 of spring seat 31, and the engagement of square section 36 of plunger 26 in the square hole 33 in spring seat 31.

Engaging cam 16 is roller 40 which is journaled on roller pin 41 which is provided with an oval-section extension 42 at each end.

Oval extension 42 of roller pin 41 are fitted into suitably formed slots 43 in trunnioned stirrup 44 which is provided with semicircular seats 45 to receive trunnions 46 which are fixed to the ends of roller-levers 47 on hollow rockshaft 48. As can be seen in FIG. 6, the axial width of roller pin 41 and is also less than the distance between the cheeks 58 of stirrup 44, thus roller 40 can follow the cam contour with true rolling motion and with no lateral skidding notwithstanding the arcuate path of trunnions 46 due to oscillation of roller-levers 47 about the axis of hollow rockshaft 48.

Hollow rockshaft 48 oscillates on coaxial shaft 49 one end of which carries piston 50 and the other end of which carries crosshead 51.

Piston 50 is reciprocable in bore 52 of housing 14. Crosshead 51 is reciprocable in bore 53 of housing 14. Bore 52 is closed by cover 54 and bore 53 is closed by cover 55.

Cover 54 is provided with duct 80 for leading fuel under pressure from transfer pump 25 to bore 52. Cover 55 houses return spring 56 which urges crosshead 51 towards piston 50.

Collectively, shaft 49, piston 50, crosshead 51, bores 52 and 53, covers 54 and 55 and spring 56 constitute

the injection timing servomotor as indicated generally at 57.

Plunger 26 is provided with an axial spill duct 59 and radial spill ducts 60 communicating from the top surface of plunger 26 to plunger spill annulus 61.

Plunger 26 is also provided with distributor annulus 62 and distributor slot 63.

Land 64 separates plunger spill annulus 61 from distributor annulus 62.

Displacer piston 65 is a pressure sealing sliding fit in the upper portion of the bore 27 of hydraulic head 28 which is provided with a first counterbore 66 and a second and larger counterbore 67. At the junction of counterbores 66 and 67 there is a face 68 which serves as a seat for the poppet head 69 of displacer piston 65. A spring 70 urges poppet head 69 against face 68. Threaded plug 71 serves as a closure for counterbore 67 also as an abutment for the end of spring 70 remote from poppet head 69 and as a lift-limiting stop for displacer piston 65. Adjustment of the amount by which poppet head 69 can lift off face 68 is made by altering the thickness of shim 72.

Hydraulic head 28 is provided with a plurality of discharge ducts 73 (one for each engine cylinder served by the injection pump) each of which in succession receives fuel under injection pressure from distributor slot 63, since cam 16 has as many lobes as there are discharge ducts 73 and plunger 26 rotates once for every revolution of cam 16; this is to say that, for a six-cylinder engine, the pump has six discharge ducts 73 and cam 16 has six lobes and plunger 26 makes six pumping strokes for each revolution of cam 16.

Plunger bore 27 is provided with discharge undercut 74, filling undercut 75 and spill undercut 76.

Hydraulic head 28 is provided with circumferential grooves 77 around its periphery for accommodation of sealing rings 78.

With particular reference now to FIGS. 1, 2 and 8, hydraulic head 28 is provided with circumferential groove 79 which communicates with duct 80 of cover 54 of injection timing servomotor 57. Hydraulic head 28 is also provided with circumferential groove 81 which communicates with discharge duct 82 of fuel transfer pump 25. Hydraulic head 28 is also provided with circumferential groove 83 which communicates with return duct 84 (FIG. 8) to the fuel source. Duct 85 (FIG. 8) leads from the fuel source (not shown) to the inlet side of fuel transfer pump 25.

With more particular reference now to FIGS. 2, 4, 5 and 8, delivery valve 86 is urged on to its seat 87 in hydraulic head 28 by spring 88. The end of spring 88 remote from delivery valve seat 87 abuts delivery valve plug 89.

Delivery duct 90 connects discharge undercut 74 with delivery valve seat 87. Delivery duct 91 connects delivery valve counterbore 92 of hydraulic head 28 with distributor annulus 62 of plunger 26.

A baulk valve generally designated 93 is provided with lands 94, 95, 96 and 97 also with an integral piston 98 at its lower end and with a through axial duct 99 and radial ducts 100 intersecting axial duct 99 between lands 96 and 97.

Lands 94, 95, 96 and 97 are a fluid-sealing sliding fit in baulk valve bore 101 of hydraulic head 28 and baulk valve piston 98 is a fluid-sealing sliding fit in counterbore 102 of hydraulic head 28. Threaded plug 103 closes baulk valve counterbore 102. Spring 104, enclosed in spring housing 105, urges baulk valve 93 towards plug 103.

Fluid pressure from transfer pump 25 is communicated via duct 82 (FIG. 8) to groove 81 (FIG. 2) and duct 106 to the bore 101 in which baulk valve 93 is fitted, thence the fluid pressure is communicated via radial ducts 100 to axial duct 99 and is applied to the area delineated by the top surface of land 94 and to the area delineated

by the under surface of piston 98 generating a net axial upward force sufficient to overcome the downward force of spring 104 so that baulk valve 93, shown at the lower limit of its travel in FIG. 2, moves to the upper limit of its travel as shown in FIG. 8.

Hydraulic locking of piston 98 in its upward movement is prevented by venting duct 107 which drains fluid by way of duct 108 to groove 83 and thence via ducts 109 and 84 (FIG. 8) to the fuel source.

Duct 110 (FIGS. 4 and 8) leads from spill undercut 76 to check valve seat 111 on to which check valve 112 is urged by spring 113 which is housed in spring chamber 114 which is closed by threaded plug 115 (FIG. 4). Duct 116 leads from spring chamber 114 to the bore 101 containing baulk valve 93.

Throttle valve 117 is a fluid sealing fit for oscillating motion in bore 118 (FIG. 5) of hydraulic head 28.

Duct 119 leads from filling undercut 75 (FIGS. 5 and 8) to bore 118 containing throttle valve 117. Duct 120 leads from bore 118 to bore 101 containing baulk valve 93.

Duct 121 leads from counterbore 66 of hydraulic head 28 (FIGS. 2 and 8) to bore 101 containing baulk valve 93. Duct 122 leads from bore 101 to vertical duct 123 which at its lower end joins duct 108.

Duct 124 leads from counterbore 67 of hydraulic head 28 (FIGS. 2 and 8) to bore 101 containing baulk valve 93. Duct 125 leads from bore 101 to circumferential groove 79.

Now, with particular reference to FIG. 8, adjustable construction 126 is located in the fluid circuit between duct 80 and duct 125; adjustable constriction 127 is located in the fluid circuit between check valve 128 and duct 80. Check valve 128 is urged on to its seat by spring 129 and is arranged to open when fluid flows in the direction from transfer pump 25 towards injection timing servo 57 and to close against flow towards transfer pump 25.

Transfer pump pressure regulating valve 130 is urged on to its seat by spring 131. Fuel passing valve 130 returns to the fuel source via return duct 84. Neither check valve 128 nor regulating valve 130 is in the direct fluid path from transfer pump discharge duct 82 to duct 106 which feeds duct 120 and throttle valve 117.

By reference to FIGS. 1, 2, 3 and 6, the actuation of plunger 26, whereby it is reciprocated for pumping and rotated for distribution, may readily be understood.

The use of such compound motion, of itself, is old in the art, but the novel means provided by this invention for effecting this compound motion are exceptionally compact, robust and simple.

Another novel and improved feature of the injection pump, according to this invention, is the means for controlling the timing of the beginning of injection whereby the timing is automatically compensated for the tendency (in pumps of the type employing throttled-intake control) to retarded injection at light load and whereby the timing of injection may also be made automatically speed-responsive, with more advance at higher engine speed.

From FIG. 3 it is evident that translation of shaft 49 to the right (carrying to the right also the hollow rockshaft 48 and roller 40) advances the injection while translation to the left retards the injection. Obviously, for clockwise rotation of the cam shaft 49 would have to be shifted to the left for advance and to the right for retard; for clockwise cam rotation, therefore piston 50 and crosshead 51 would be transposed, also covers 54 and 55 and spring 56.

Now by reference to the schematic, FIG. 8, the functioning of the automatic timing control feature may be understood.

When transfer pump 25 is delivering fuel under pressure, baulk valve 93 is maintained at its upper limit of travel, as shown in FIG. 8; this is its normal running

position. It has no effect upon injection timing and will not be referred to again in this connection.

Plunger 26, at the lowest part of its stroke, uncovers filling undercut 75 and fuel flows from transfer pump 25, via duct 82, groove 81, duct 106, bore 101, duct 120, throttle valve 117 and duct 119 into bore 27.

When plunger 26 has risen to the level where its top edge passes the top edge of filling undercut 75 the fuel in bore 27 is compressed. Before the fuel pressure in bore 27 has achieved a value high enough to open an injection nozzle, the force acting on displaced piston 65 lifts it until poppet head 69 abuts threaded plug 71. Upon further upward movement of plunger 26 the fuel pressure in bore 27 rises to the value necessary to expel fuel from the nozzle via duct 90 (FIGS. 8 and 2) delivery valve 86, duct 91, distributor slot 63 (FIGS. 2 and 1) and duct 73 (FIG. 1).

Towards the end of upward travel of plunger 26, spill annulus 61 uncovers spill undercut 76, the pressure in bore 27 drops because fuel escapes by way of axial duct 59, radial ducts 60, spill annulus 61, spill undercut 76, duct 110, spill check valve 112, duct 116, bore 101, duct 108, groove 83 and ducts 109 and 84 to the fuel source.

As soon as the fuel pressure in bore 27 drops, displacer piston 65 is forced downwards by spring 70 until poppet head 69 seats on face 68 thereby blocking communication between ducts 124 and 121.

It is evident that duration of the opening of communication between ducts 124 and 121, expressed in degrees of cam rotation, is a function of the volume of fuel delivered per cycle to the nozzle. When poppet head 69 is lifted off face 68, fuel may be discharged from bore 52 by piston 50 (FIG. 8) by way of duct 80, groove 79, adjustable constriction 126, duct 125, bore 101, duct 124, counterbore 67, counterbore 66, duct 121, bore 101, duct 122, duct 123, groove 83, and ducts 109 and 84 to the fuel source.

When poppet head 69 is seated on face 68, no fuel can leave bore 52 but fuel can enter bore 52 by way of check valve 128, adjustable constriction 127, groove 79 and duct 80.

Thus, for a given fuel pressure in groove 81, the ratio of time for fuel entering bore 52 to time for fuel to leave bore 52 is a function of the quantity per cycle delivered to the nozzle. The more fuel delivered, the greater the ratio leaving time/entering time for fuel acting on piston 50; so that the greater the quantity per cycle of fuel (pumped to the nozzle) the more shaft 49 moves in the "retard" direction, and vice versa.

It will also be apparent that the higher the fuel pressure maintained in duct 82 by pump 25 the more advanced shaft 49 will become for a given quantity per cycle of fuel delivered to the nozzle.

The characteristics of pump 25 and of regulating valve 130 are both such that increased speed of rotation of the pump, for a given quantity per cycle leaving duct 90, results in increased fuel pressure in duct 82 so that automatically advanced injection timing with increased speed is accomplished.

Baulk valve 93 is provided for the automatic delivery to duct 90 of excess fuel for starting the engine. This it achieves as follows:—

When the engine is stationary there is no fuel pressure in transfer pump discharge duct 82 and therefore no net upward force due to fluid pressure on baulk valve 93; the downward force of spring 104 therefore holds baulk valve 93 at its lower limit of travel (FIG. 2), in this position lands 94 and 95 block ducts 124 and 121 respectively, also land 97 blocks duct 116; consequently, displacer piston 65 is hydraulically lock (with poppet head 66 seated on face 68) and spill cannot take place. Except for the amount by which the top edge of plunger 26 falls below the top edge of filling undercut 75 (FIGS. 1, 2 and 8) when plunger 26 is in its lowest position, the amount of fuel per cycle which can be discharged

through duct 90 corresponds with the full displacement-per-stroke of plunger 26.

Transfer pump 25 will not develop significant discharge pressure at engine cranking speed, so baulk valve 93 remains down until the engine fires.

As soon as significant pressure builds up in duct 82, baulk valve 93 rises to the upper limit of its travel, displacer piston 65 is unlocked and the spill function is restored. Under these conditions, the maximum amount of fuel per cycle which can pass through duct 90 is the full displacement-per-stroke of plunger 26, minus the quantity which must always be rejected at filling undercut 75 on initial upward plunger movement, minus the quantity necessary to move displacer piston 65 up to its limit (which depends upon the thickness of shim 72), minus the quantity spilled through duct 110.

The object of check valve 112 in the spill tract is to prevent induction to bore 27, during the filling function, of any fuel not under control of throttle valve 117.

From the foregoing it will be seen that I have provided new and improved means for obtaining all of the objects and advantages of the invention.

I claim:

1. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger.

2. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including supply pump means for supplying fuel to said bore.

3. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including gear means forming supply pump means for supplying fuel to said bore.

4. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively con-

8. In a device of the character described, a casing adapted to be connected to a source of supply pressure, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and lateral-

11. In a device of the character described, a casing supply pump means connected to said casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, supply pump means for supplying fuel to said hydraulic head, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a displacer piston mounted for reciprocation in said bore, valve means carried by said displacer piston, said valve means being adapted to control the timing of in-

jection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including a pivoted arm and a follower operatively engaging said cam and a second pivoted arm operatively connected to said pivoted arm and means operatively connected to said supply pump means for adjustably displacing the pivot of said pivoted arm and including a cylinder and an actuator piston, said actuator piston being urged by fluid under pressure from said supply pump means.

12. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means comprising a poppet valve formed on the upper end of said piston.

13. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means comprising a poppet valve formed on the upper end of said piston and of greater diameter than said piston.

14. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

15. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively con-

necting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including supply pump means for supplying fuel to said bore, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

16. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including gear means forming supply pump means for supplying fuel to said bore, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

17. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said means including a pivoted arm and a follower operatively engaging said cam, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

18. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, supply pump means for supplying fuel to said hydraulic head, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including a pivoted arm, and means operatively connected to said supply pump means for adjustably displacing the pivot of said pivoted arm, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

19. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, supply pump means for supplying fuel to said hydraulic head, said hydraulic head having

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a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a displacer piston mounted for reciprocation in said bore, valve means carried by said displacer piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including a pivoted arm, and means operatively connected to said supply pump means for adjustably displacing the pivot of said pivoted arm and including a cylinder and an actuator piston, said actuator piston being urged by fluid under supply pressure, said valve means limiting the downward travel of said displacer piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said displacer piston.

20. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, supply pump means for supplying fuel to said hydraulic head, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a displacer piston mounted for reciprocation in said bore, valve means carried by said displacer piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including a pivoted arm and a follower operatively engaging said cam and means operatively connected to said supply pump means for adjustably displacing the pivot of said pivoted arm and including a cylinder and an actuator piston, said actuator piston being urged by fluid under pressure, said valve means limiting the downward travel of said displacer piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said displacer piston.

21. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means comprising a poppet valve formed on the upper end of said piston, said valve means limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston.

22. In a device of the character described, a casing, a rotary camshaft journaled for rotation in said casing, a right cylindrical external cam carried by said camshaft, a first pivoted arm in said casing, a cam follower operatively connected to said first pivoted arm, said cam follower engaging said cam and normally constrained by said first pivoted arm to move along a path substantially radial with respect to the base circle of said cam, means

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for adjustably displacing the pivot of said first pivoted arm to effect lateral displacement of said path in the plane of rotation of said cam, a second pivoted arm pivoted in said casing and operatively connected to said first pivoted arm, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis parallel with, and laterally offset from, the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion, said plunger being adapted to be moved axially in one direction by said second pivoted arm and in the opposite direction by spring means, toothed gearing whereby rotation is transmitted to said plunger by said camshaft, a housing enclosing said gearing to form a gear pump for delivering fuel to said bore, a piston reciprocable in said bore, a poppet valve formed on the upper end of said piston and of greater diameter than said piston, said poppet valve being adapted to limit the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston, an adjustable abutment adapted to limit the upward travel of said piston, spring means for urging said piston downward, means for adjustably displacing said pivot of said first pivoted arm including a cylinder and a single acting piston in said cylinder, said single acting piston being adapted to be urged by fluid under pressure from said gear pump to laterally displace said path counter to rotation of said cam, said fluid pressure being relieved at each delivery stroke of said plunger by action of said poppet valve.

23. In a device of the character described, a casing, a rotary camshaft journaled for rotation in said casing, a right cylindrical external cam carried by said camshaft, a first pivoted arm in said casing, a cam follower operatively connected to said first pivoted arm, said cam follower engaging said cam and normally constrained by said first pivoted arm to move along a path substantially radial with respect to the base circle of said cam, means for adjustably displacing the pivot of said first pivoted arm to effect lateral displacement of said path in the plane of rotation of said cam, a second pivoted arm pivoted in said casing and operatively connected to said first pivoted arm, hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis parallel with, and laterally offset from, the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion, said plunger being moved axially in one direction by said second pivoted arm and in the opposite direction by spring means, toothed gearing whereby rotation is transmitted to said plunger by said camshaft, a piston reciprocable in said bore, a poppet valve formed on the upper end of said piston and of greater diameter than said piston, said poppet valve limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston, an adjustable abutment adapted to limit the upward travel of said piston, spring means for urging said piston downward, means for adjustably displacing said pivot of said first pivoted arm including a cylinder and a single acting piston in said cylinder, said single acting piston being urged by fluid under pressure from said gear pump to laterally displace said path counter to rotation of said cam, said fluid pressure being relieved at each delivery stroke of said plunger by action of said poppet valve.

24. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a fuel path to said bore for supplying fuel thereto, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion, said plunger being adapted to be moved axially in one direction by said camshaft and in the opposite direction by spring means, toothed gearing whereby rotation is transmitted to said plunger by said camshaft, a housing enclosing said gearing to form a gear pump for delivering fuel to said bore, a piston reciprocable in said bore, a poppet valve formed on the upper end of said piston and of greater diameter than said piston, said poppet valve limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head adjacent the upper edge of said bore when limiting the downward travel of said piston, an adjustable abutment adapted to limit the upward travel of said piston, spring means for urging said piston downward, means for adjustably displacing said pivot of said first pivoted arm including a cylinder and a single acting piston in said cylinder, said single acting piston being urged by fluid under pressure from said gear pump to laterally displace said path counter to rotation of said cam, said fluid pressure being relieved at each delivery stroke of said plunger by action of said poppet valve.

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cation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, and fuel throttling means in said fuel path to said bore.

25. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a fuel path to said bore for supplying fuel thereto, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including supply pump means for supplying fuel to said bore, and fuel throttling means in said fuel path between said fuel supply pump means and said bore.

26. In a device of the character described, a casing, a rotary camshaft journaled for rotation in said casing, a right cylindrical external cam carried by said camshaft, a first pivoted arm in said casing, a cam follower operatively connected to said first pivoted arm, said cam follower engaging said cam and normally constrained by said first pivoted arm to move along a path substantially radial with respect to the base circle of said cam, means for adjustably displacing the pivot of said first pivoted arm to effect lateral displacement of said path in the plane of rotation of said cam, a second pivoted arm pivoted in said casing and operatively connected to said first pivoted arm, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis parallel with, and laterally offset from, the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion, said plunger being moved axially in one direction by said second pivoted arm and in the opposite direction by spring means, toothed gearing whereby rotation is transmitted to said plunger by said camshaft, a housing enclosing said gearing to form a gear pump for delivering fuel to said bore, a piston reciprocable in said bore, a poppet valve formed on the upper end of said piston and of greater diameter than said piston, said poppet valve limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head at the upper edge of said bore when limiting the downward travel of said piston, and adjustable abutment adapted to limit the upward travel of said piston, spring means for urging said piston downward, means for adjustably displacing said pivot of said first pivoted arm including a cylinder and a single acting piston in said cylinder, said single acting piston being urged by fluid under pressure from said gear pump to laterally displace said path counter to rotation of said cam, said fluid pressure being relieved at each delivery stroke of said plunger by action of said poppet valve, and fuel throttling means in the fuel path between said fuel supply pump means and said bore.

27. In a device of the character described, a casing, a rotary camshaft journaled for rotation in said casing, a right cylindrical external cam carried by said camshaft, a first pivoted arm in said casing, a cam follower operatively connected to said first pivoted arm, said cam follower engaging said cam and normally constrained by said first pivoted arm to move along a path substantially

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radical with respect to the base circle of said cam, means for adjustably displacing the pivot of said first pivoted arm to effect lateral displacement of said path in the plane of rotation of said cam, a second pivoted arm pivoted in said casing and operatively connected to said first pivoted arm, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis parallel with, and laterally offset from, the axis of said camshaft and having an upper edge, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion, said plunger being moved axially in one direction by said second pivoted arm and in the opposite direction by spring means, toothed gearing whereby rotation is transmitted to said plunger by said camshaft, a piston reciprocable in said bore, a poppet valve formed on the upper end of said piston and of greater diameter than said piston, said poppet valve limiting the downward travel of said piston and to effect fluid sealing contact with said hydraulic head at the upper edge of said bore when limiting the downward travel of said piston, and adjustable abutment adapted to limit the upward travel of said piston, spring means for urging said piston downward, said means for adjustably displacing said pivot of said first pivoted arm including a cylinder and a single acting piston in said cylinder, said single acting piston being urged by fluid under pressure to laterally displace said path counter to rotation of said cam, said fluid pressure being relieved at each delivery stroke of said plunger by action of said poppet valve, and fuel throttling means in the fuel path between the fuel supply means and said bore.

28. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, supply pump means for supplying fuel to said hydraulic head, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a fuel path to said bore for supplying fuel thereto, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a displacer piston mounted for reciprocation in said bore, valve means carried by said displacer piston, said valve means being adapted to control the timing of injection, and mechanical means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said mechanical means including a pivoted arm and a follower operatively engaging said cam and means for adjustably displacing the pivot of said first pivoted arm and including a cylinder and an actuator piston, said actuator piston being urged by fluid under pressure from the supply pump means, and fuel throttling means in said fuel path between the fuel supply pump means and said bore.

29. In a device of the character described, a casing, a camshaft journaled for rotation in said casing, a cam carried by said camshaft, a hydraulic head operatively connected to said casing, said hydraulic head having a bore having its axis substantially parallel with and laterally offset from the axis of said camshaft, a fuel path to said bore for supplying fuel thereto, a plunger mounted for reciprocation and rotation in said bore, said plunger having a pumping portion and a distributing portion adapted to deliver fuel to a plurality of outlets successively, a piston mounted for reciprocation in said bore, valve means carried by said piston, said valve means being adapted to control the timing of injection, and means operatively connecting said camshaft and said plunger for effecting rotation and reciprocation of said plunger, said valve means comprising a poppet valve formed on the upper end of said piston, and fuel throttling means in said fuel path to said bore.

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