Oct. 23, 1951 J. DICKSON 2,572,118

FUEL INJECTOR

Filed Feb. 28, 1944 2 SHEETS—SHEET 1

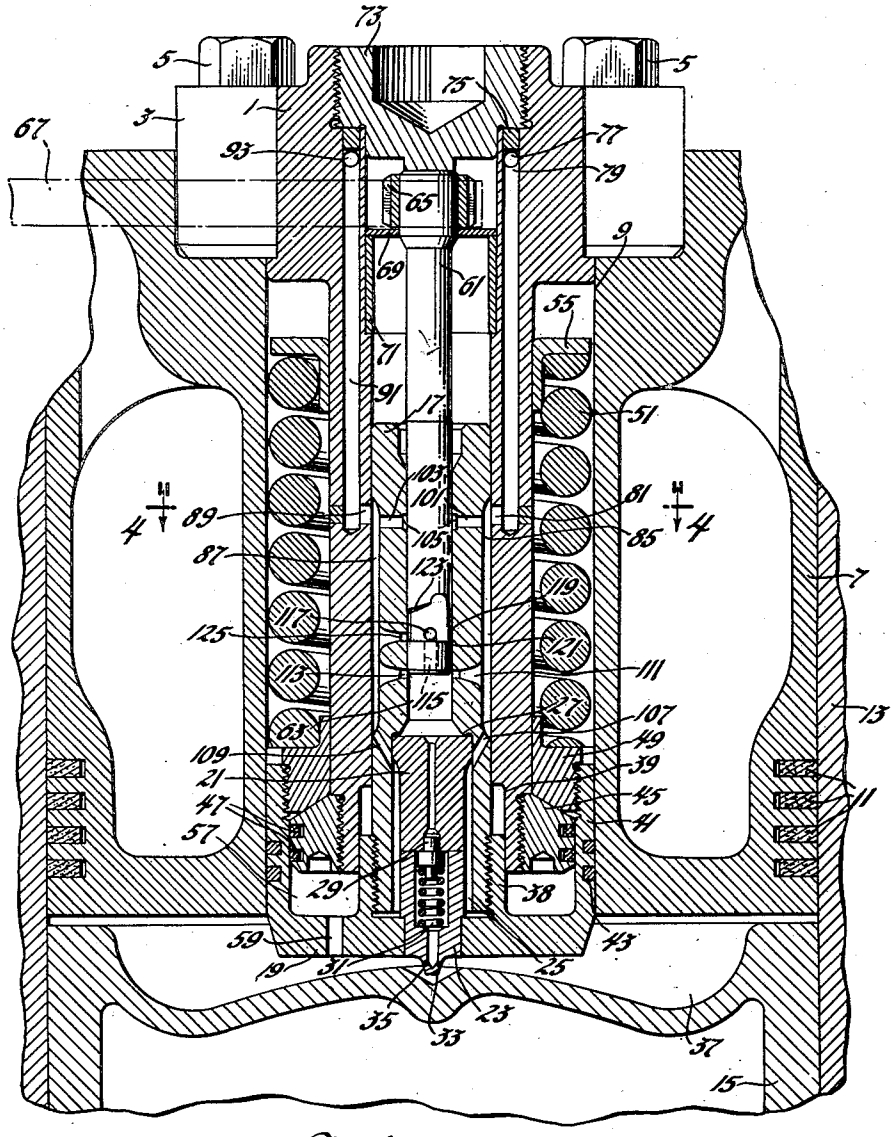


Fig. 1

Inventor
John Dickson

By Blackmore, Spencer & Hunt
Attorneys

Oct. 23, 1951 J. DICKSON 2,572,118

FUEL INJECTOR

Filed Feb. 28, 1944 2 SHEETS—SHEET 2

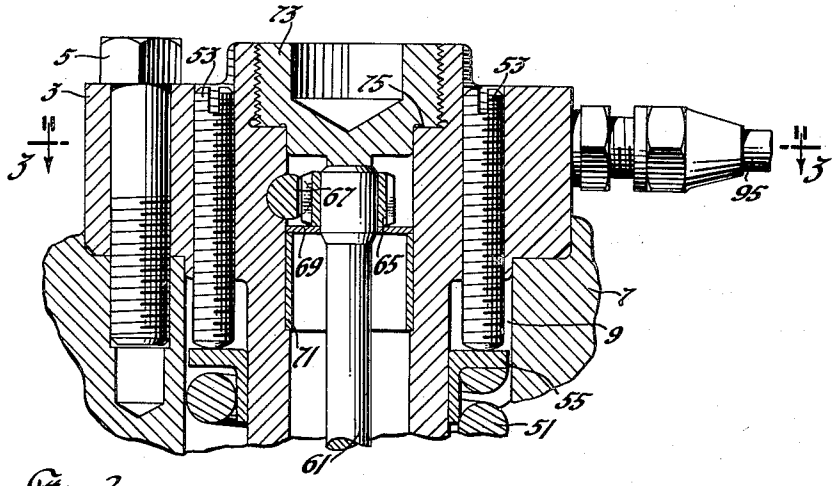


Fig. 2

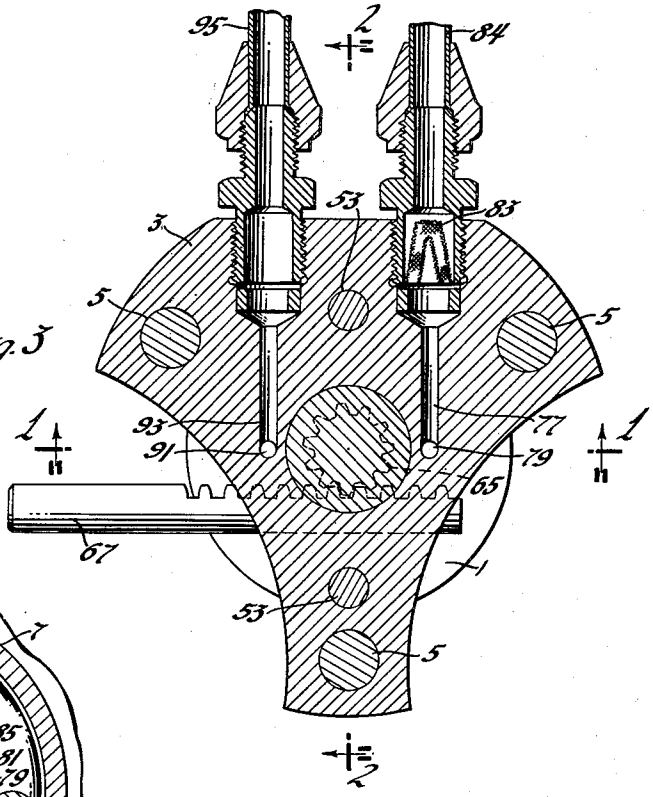


Fig. 3

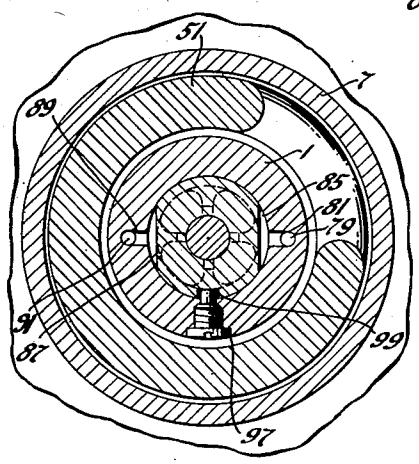


Fig. 4

Inventor
John Dickson
By Blackmore, Spencer & Flint
Attorneys

Patented Oct. 23, 1951 2,572,118

UNITED STATES PATENT OFFICE

2,572,118

FUEL INJECTOR

John Dickson, Huntington Woods, Mich., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Application February 28, 1944, Serial No. 524,217

8 Claims. (Cl. 123—32)

1

The present invention generally relates to fuel injection means for internal combustion engines and more particularly relates to a fuel injector which is operated by changes in pressure within the engine cylinder.

The principal object of the present invention is to provide a simple and compact fuel injection unit adapted to be readily mounted in an engine cylinder head for direct actuation by pressure variations in the cylinder.

Another object is the provision of compensating means in the fuel injection unit for preventing too early injection of fuel at low engine speeds in order to maintain substantially constant start of fuel injection for all speeds of the engine.

Another object is to provide suitable fuel passages in the injector unit in order to provide adequate cooling thereof and to quickly discharge any vapor in or leakage of fuel into the passages and thereby enable the amount of fuel injected into the engine cylinder to be accurately controlled.

These and other objects will become apparent by reference to the following detailed description of the present invention and accompanying drawings illustrating the details of the injector unit.

Figure 1 of the drawings is a partial vertical mid-sectional view of an engine cylinder, piston and cylinder head with certain parts thereof broken away to show a mid-sectional view of the fuel injection unit and the mounting details thereof taken on line 1—1 of Figure 3.

Figure 2 of the drawings is a partial mid-sectional view of the upper portion of the injector unit taken at right angles to the view shown in Figure 1, and

Figures 3 and 4 of the drawings are cross sectional views taken on lines 3—3 and 4—4 of Figures 2 and 1 respectively.

As best illustrated in Figure 1, the fuel injection unit includes a hollow cylindrical injector body 1 provided with an external mounting flange 3 which is clamped by means of studs 5 to an engine cylinder head 7 for holding the injector body centrally in an enlarged central bore 9 extending through the engine cylinder head. The cylinder head is provided with packing rings 11, shown in contact with an engine cylinder sleeve 13. The upper portion of an engine piston 15 is shown in the upper dead center position within the cylinder sleeve 13. Any conventional arrangement of inlet and exhaust ports and/or valves may be provided in the cylinder sleeve or cylinder head to control inlet of air for scavenging and charging the cylinder sleeve and to control exhaust of gas therefrom.

2

A hollow cylindrical fuel injection plunger 17 is slidably mounted in the lower end of the injector body 1. A plunger actuating piston 19 is secured to the lower end of the plunger for movement by pressure variations in the engine sleeve. A hollow check valve seat 21 and a fuel injection nozzle 23 are located in a counterbore 25 of the lower portion of the plunger 17 and are clamped between the plunger piston 19 and an internal shoulder 27 of the plunger counterbore 25. A check valve 29 and spring 31 for holding the valve upwardly on the seat 21 are located in the nozzle 23 which is pressed in a central opening in the plunger piston 19. The nozzle 23 is provided with a tip 33 having fuel spray openings 35, projecting into the engine combustion chamber 37. The plunger piston 19 is provided with a central portion 38, slidable in a counterbore 39 in the lower end of the injector body 1, and a piston skirt portion 41 provided with external packing rings 43 which are slidable in the lower end of the cylinder head bore 9. An annular abutment 45 is secured on the lower end of the body 1. This body abutment is provided with external packing rings 47 on which the inner surface of the plunger piston skirt portion 41 slides. A cooperating annular abutment 49 is secured to the skirt 41 of the plunger piston. The piston abutment 49 is slidably mounted on the body 1 for engagement with the body abutment 45 in order to limit downward movement of the plunger 17 and plunger piston 19 with respect to the injector body 1. A compression spring 51 is placed between the piston abutment 49 and the body mounting flange 3 which, as best shown in Figure 2, is provided with threaded openings in which are placed spring adjusting screws 53 for the spring 51. The lower end of these screws engage a collar 55 slidably mounted on the body 1 and in engagement with the upper end of the spring 51. It will be evident that the spring 51 normally urges the plunger piston abutment 49 downwardly into contact with the body abutment 45 in order to hold the plunger piston in the normal position adjacent the engine combustion chamber, as shown in Figure 1. With the plunger piston 19 in this position a compensating pressure chamber 57 is formed between the inner face of the plunger piston and the body abutment 45. A compensating orifice 59 is provided between the inner and outer faces of the plunger piston to permit passage of air and gas between the engine combustion chamber 37 and injector compensating pressure chamber 57. The area of the compensating orifice 59 is select-

ed so that a sufficient amount of air will pass from the engine combustion chamber 37 to the compensating chamber to partially counter-balance the pressure on opposite sides of the plunger piston in order to sufficiently delay upward movement thereof in order to delay the start of fuel injection into the engine combustion chamber by an increase in the compression pressure therein for slow speeds of the engine and slow upward movement of the engine piston 15 on the compression stroke. The compensating orifice 59 permits more air to pass from the combustion chamber to the compensating chamber at lower engine speeds than at higher speeds, and therefore the pressure in the compensating chamber 57 and force opposing upward movement of the plunger piston 19 on the fuel injection stroke is greater at lower engine speeds than at higher speeds to provide substantially constant start of fuel injection for all engine speeds. The compensating orifice 59 also permits the passage of gas between the engine combustion chamber 37 and injector compensating chamber 57 upon compression ignition of the fuel and the resulting increase in pressure in the compensating chamber cushions upward movement of the plunger piston and thereby prevents violent contact between the plunger piston 19 and the body abutment 45, which contact limits the maximum upward movement of the plunger piston and plunger on the fuel injection stroke.

The amount of fuel injected into the engine combustion chamber 37 is controlled by a rotary metering valve stem 61 which extends downwardly into the hollow plunger 17 to form a pumping chamber 63 in the lower portion of the plunger. A pinion 65 is secured on the upper end of the valve stem. The pinion meshes with a rack 67 which is slidably mounted in a suitable opening in the body for rotating the plunger. The rack 67 may be moved manually or by a conventional engine driven speed governor, as desired. The pinion is rotatably supported in the body 1 between a washer 69, which is supported on a collar 71 secured in a counterbore in the body 1, and a plug 73 screwed in the upper end of the injector body against a shoulder 75. The valve stem 61 is accordingly prevented from moving axially with respect to the plunger and body but is freely rotatable with respect to these parts by means of the rack and pinion.

The injector body, plunger and valve stem are provided with cooperating inlet and outlet fuel connections, passages and ports to permit continuous circulation of fuel therethrough, from and back to a suitable fuel tank, by means of a suitable fuel supply pump, not shown. As best illustrated in Figures 1, 3 and 4, the injector body 1 is provided with connecting fuel inlet passages 77, 79 and 81 in which a fuel filter 83 is located. The inlet passage 77 is connected by an inlet pipe 84 leading to the outlet of the fuel pump, not shown, the inlet of which pump is connected to a suitable fuel tank, not shown. The inlet passage 81 opens into an external inlet plunger groove 85 which extends longitudinally intermediate the ends of the plunger 17 and serves as a fuel inlet chamber. An external fuel outlet plunger groove 87 serving as a fuel outlet chamber extends longitudinally intermediate the ends of the plunger 17 and is positioned diametrically opposite the inlet groove or chamber 85. Connecting fuel outlet passages 89, 91 and 93 are provided in the injector body to cause return of fuel therein to the fuel tank. The outlet passage 89 opens into the plunger outlet groove or chamber 87 and an outlet pipe 95 is connected between the outlet passage 93 and the fuel tank. As best illustrated in Figure 4, a plunger positioning screw 97 is threaded in a radial opening in the body 1. The inner end of this screw extends into a longitudinally extending external plunger slot 99 to permit longitudinal plunger movement and prevent rotation thereof with respect to the body 1 in order to keep the body fuel inlet and outlet openings 81 and 89 in alignment with the plunger inlet and outlet grooves or chambers 85 and 87.

The plunger is provided with diametrically aligned cross passages 101 and 103 opening into the upper extremities of the fuel inlet and outlet grooves 85 and 87, as best shown in Figures 1 and 4. The passages 101 and 103 are connected at their inner extremities by an internal plunger leakage groove 105 surrounding the valve stem 61 to permit continuous circulation of fuel through these passages in order to cause the return to the fuel tank of any leakage of fuel or vapor between the valve stem and plunger or any vapor in the upper extremity of the inlet or outlet plunger chambers.

The plunger is also provided with cooling passages 107 and 109 leading from the lower extremities of the plunger inlet and outlet chambers to the counterbore 25 in the plunger adjacent the plunger piston 19 and surrounding the fuel injection nozzle 23 and check valve seat 21 for cooling these parts by continuous circulation of fuel past these parts.

The plunger inlet and outlet grooves or chambers 85 and 87 are also connected intermediate the extremities thereof by an external circumferential groove 111 in the plunger. Fuel inlet and pressure relief ports 113 extend radially inwardly from the bottom of the plunger groove 111 through the walls of the plunger. When the plunger 17 is in the normal position, the plunger ports 113 open into the upper extremity of the pumping chamber 63 adjacent the lower face of the valve stem 61. With the ports 113 in this position fuel circulates between the plunger inlet and outlet grooves or chambers 85 and 87 through the plunger ports 111 and pumping chamber 63 to cause this chamber to be completely filled with fuel and any vapor in the upper extremity of the pumping chamber is carried back to the fuel tank with the circulating fuel.

Fuel and vapor in the upper extremity of the pumping chamber 63 is also by-passed to the fuel tank through the following passages provided in the lower end of the valve stem and a by-pass port provided in the plunger. Axial and radial by-pass passages 115 and 117 extend from the lower face of the valve stem 61 to a fuel metering groove 119 provided in the valve stem adjacent the lower face thereof. The metering groove 119 has a lower circumferential edge 121 adjacent the lower end face of the stem and an upper helical edge 123. A by-pass port 125 is provided in the plunger 17 and this port cooperates with the edges of the metering groove and is aligned with the plunger fuel outlet groove or chamber 87. When the plunger 17 is in the normal position, the plunger by-pass port 125 is adjacent the lower edge 121 of the valve stem metering groove 119 and when the by-pass port is in this position or any position between the edges of the metering groove fuel and any vapor in the upper extremity of the pumping chamber 63 is by-passed to the fuel tank through the valve stem by-pass passages 115—117, metering groove 119 and plunger by-pass port 125.

With the fuel circulating through the injector unit in the above described paths the parts of the unit are adequately cooled and any vapor in the fuel passages and pumping chamber is returned to the tank so that the pumping chamber is completely filled with fuel. Upon upward movement of the plunger piston 19 from the normal position the ports 113 and 125 in the plunger 17 are moved relative to the valve stem 61 to cause the start of injection of fuel into the engine combustion chamber 37 and the amount of fuel injected is controlled by rotation of the valve stem 61 relative to the plunger 17. It has been found that where no compensating orifice 59 is provided in the plunger piston 19 the start of fuel injection is advanced more at low speeds of the engine piston 15 than at high speeds. This is an inherent fault of fuel injectors operated by the compression pressure in the engine cylinders as the pressure cycle is obtained in the compression chamber 37 during each up and down stroke of the engine piston 15, irrespective of the speed of the engine piston, although the actual time that the pressure cycle is maintained is reduced as the speed of the engine piston is increased. By providing a compensating orifice 59 in the injector plunger piston 14 the higher the speed of the engine piston 15 the less time will be available for air to pass through this orifice from the combustion chamber 37 to the compensating chamber 57 and the lower resulting pressure on the back of the plunger piston 14. The lower the speed of the engine piston 15, the more time will be available for air to pass from the compression chamber 37 to the compensating chamber 57, and the higher the resulting pressure on the back of the plunger piston 14. By proper proportioning of the compensating orifice 59, the pressure and the resulting retarding force on the back of the plunger piston 19 is made higher at low engine speeds and lower at high engine speeds and as the plunger piston 19 travels a definite distance to cause the start of fuel injection, the start of fuel injection can be made to occur at substantially the same number of crank angle degrees of the engine piston 15 before top dead center throughout the engine speed range. The start of fuel injection can accordingly be made substantially constant throughout the engine speed range.

Initial upward movement of the plunger 17 by the plunger piston 19 causes the plunger ports 113 to move past the lower face of the valve stem 61. This cuts off circulation of fuel through the ports 113 and pumping chamber 63 and upon further upward movement of the plunger, fuel is bypassed from the pumping chamber to the tank through the by-pass passages 115 and 117 and metering groove 119 in the valve stem 61 and through the plunger by-pass port 125 until this port moves past the upper helical edge 123 of the metering groove. Movement of the plunger bypass port 125 past the helical edge of the metering groove cuts off the by-pass of fuel to the tank and the resulting pressure rise in the pumping chamber causes the check valve 29 in the injection nozzle 23 to be unseated and cause the start of fuel injection into the engine combustion chamber 37 through the nozzle spray openings 33. It will be evident that the start of fuel injection can be controlled by rotation of the valve stem 61 by the pinion 65 and rack 67 to cause different portions of the helical edge 123 of the valve stem metering groove to be positioned adjacent the plunger by-pass port 125. Fuel injection continues until the plunger ports 113 move past the lower circumferential edge 121 of the valve stem metering groove 119. When the plunger ports 113 are opened by moving upwardly past the lower edge 121 of the valve stem metering groove 119, fuel in the pumping chamber passes through the ports 113 to the plunger outlet groove or chamber 87 and the pressure in the pumping chamber is relieved. This causes the check valve 29 to be reseated and to cause the end of fuel injection. It will be evident that by varying the start of fuel injection with reference to the end of injection by rotation of the valve stem 61, variable amounts of fuel are injected into the engine combustion chamber 37 for upward movement of the plunger 17 by the plunger piston 19. For an angular setting of the plunger 61 to obtain slow engine speed the start of fuel injection will be delayed more than for an angular setting to obtain high engine speed by the provision of the compensating orifice 59 of proper area for the reasons previously stated.

As previously explained, the passage of exhaust gas from the combustion chamber 37 into the compensating chamber 57 through the plunger piston compensating orifice 59 prevents violent contact of the plunger piston with the body abutment 45. Upon exhaust of gas from the cylinder sleeve 37 the spring 51 and pressure in that compensating chamber 57 causes downward movement of the plunger piston 19 and plunger 17 to the normal position so that the pumping chamber is again completely filled with fuel.

The above arrangement of injection unit parts, fuel passages and ports therein and therebetween provides controlled amounts of fuel to be injected into the engine combustion chamber with greater delay of the start of fuel injection at low speed than at high speeds to give substantially constant start of fuel injection for all engine speeds upon changes in the pressure in the engine cylinder throughout the speed range of the engine and also provides adequate cooling of the injector parts and elimination of vapor in the fuel passages by permitting fuel to be continuously circulated through certain passages and intermittently circulated through and by-passed from the injector pumping chamber.

I claim:

1. A pressure operated fuel injection device for an engine comprising a hollow injector body, a hollow fuel plunger slidable into one end of said body, an actuating piston attached to said plunger, cooperating abutments on said piston and said body for limiting outward movement of said piston and forming a compensating space between said piston and body, a compensating orifice in said piston to partially equalize the pressure on opposite sides of said piston, a spring between said body and piston for opposing inward movement thereof, a metering valve stem supported by said body and extending into one end of said plunger to form a pumping space in the other end thereof and a check valve and fuel injection nozzle between said pumping space and outer working face of said piston, said orifice being of a size which will regulate the flow of pressure therethrough to said compensating space at such rates that the same pressure cycle will be imposed on the outer working face of said piston at all engine speeds to give a constant point of the beginning of injection.

2. A pressure operated fuel injector device comprising a hollow injector body adapted to be mounted in an opening in an engine, an actu-

ating piston slidable in said opening and operable by the pressure therein, a hollow plunger operable by said piston, said plunger extending into the hollow body, a fuel injection nozzle including a check valve located in the hollow plunger, said nozzle projecting through an opening in said piston into the engine opening, a valve stem rotatably mounted in said body and projecting into said hollow plunger to form a fuel pumping chamber, pressure sealing means between said body and piston to form a compensating chamber therebetween, an adjustable spring between said body and piston and a compensating orifice in said piston to cause partial equalization of pressure on opposite sides of said piston, said orifice being of a size which will regulate the flow of pressure therethrough to said compensating chamber on one side of the piston at such rates that the same pressure cycle will be imposed on the other or pressure side of the piston at all engine speeds to give a constant point of the beginning of injection.

3. A pressure operated fuel injection device comprising a hollow injector body adapted to be mounted in an opening in an engine, a hollow plunger in the inner end of said body, a piston slidable in the inner end of the opening and secured to said plunger, a fuel spray nozzle extending through said piston, a check valve located between said nozzle and plunger, a fuel metering valve rotatably mounted in said body and extending into said plunger to form a pumping chamber therein adjacent the inner end of said valve stem, body and piston abutments cooperating to limit inward and outward movement of said piston and plunger and to provide a compensating pressure space between said body abutment and piston, said piston having a pressure equalizing orifice extending between said compensating chamber and engine opening and adjustable spring means between said body and piston for opposing inward movement of said piston, said compensating orifice being of a size which will regulate the flow of pressure therethrough to said compensating chamber at such rates that the same pressure cycle will be obtained in the engine opening at all engine speeds to give a constant point of the beginning of injection.

4. An injection pump comprising a hollow body, a hollow plunger slidable therein to form a pumping chamber therebetween, said plunger having an enlarged piston slidable on said body to form a compensating chamber therebetween, a compensating orifice in the piston between the compensating chamber and the pressure working face of the piston, said compensating orifice being of a size which will regulate the flow of pressure therethrough to said compensating chamber at such rates that the same pressure cycle will be applied to the pressure working face of the piston at all engine speeds to give a constant point of beginning of injection from the pumping chamber.

5. A pressure operated injection pump comprising a hollow body, a stationary plunger, a hollow plunger slidable on said stationary plunger to form a pumping chamber therebetween, said hollow plunger having an enlarged piston portion slidable on said body to form a pressure compensating space therebetween and an injection nozzle extending from the pumping space through the piston portion, said piston having a compensating orifice therein extending from the pressure compensating space to the pressure working face of the piston, said compensating orifice being of a size which will regulate the flow of pressure therethrough to said compensating space at such rates that the same pressure cycle will be applied to the pressure working face of the piston at all engine speeds to give a constant point of the beginning of injection.

6. A pressure operated injection pump comprising a hollow pump body, a valve stem rotatable therein, a hollow pump plunger slidable on said valve stem to form a pumping chamber therebetween, said plunger having a pressure operated piston portion slidable on said body to form a pressure compensating chamber therebetween and a compensating orifice extending through said piston between the compensating chamber and the pressure working face of the piston, an adjustable spring between said body and plunger normally acting to increase the volume in the pumping and compensating chamber and an outwardly opening check valve and injection nozzle in the plunger, said nozzle extending outwardly of the piston pressure working face and communicating with the pumping chamber, said compensating orifice being of a size which will regulate the flow of pressure therethrough to said compensating chamber at such rates that the same pressure cycle will be applied to the pressure working face of the piston at all engine speeds to give a constant point of the beginning of injection.

7. A fuel injection pump comprising a stationary hollow body member, a fuel control valve stem rotatable therein, a hollow fuel plunger slidable on said valve stem to form a fuel pumping chamber therebetween, said plunger having an enlarged piston portion slidable on said body to form a pressure compensating space therebetween, a pressure compensating orifice extending from the compensating space through said piston portion to the pressure working face thereof, a fuel injection nozzle including an outwardly opening check valve extending from the pumping chamber through the piston portion to the pressure working face thereof, and an adjustable spring between said body and said piston portion for normally urging said piston portion away from said body to increase the volume in said fuel pumping chamber and compensating space and for opposing movement of said piston portion by changes in pressure applied to the opposite face of said piston portion, said compensating orifice being of a size which will regulate the flow of pressure therethrough to said compensating space on one side of the piston portion at such rates that the same pressure cycle will be applied to the opposite side of said piston portion at all engine speeds to give a constant point of beginning of fuel injection.

8. A fuel injection unit comprising an injector body adapted to be mounted in an opening in an engine cylinder, a hollow fuel plunger in the inner end of said body, an actuating piston on the inner end of said plunger and slidable in said cylinder opening and on said body to form a pressure compensating space between said piston and said body, said piston having a pressure compensating orifice extending from said compensating space to the working face of said piston in said engine cylinder, a fuel control plunger carried by said body in cooperating with said hollow fuel plunger to form a fuel pumping chamber adjacent said piston for controlling the effective stroke of said fuel plunger, an injection nozzle extending between said pumping space

and the working face of said piston, a spring between said body and plunger for opposing inward movement of said piston by an increase in engine cylinder pressure, said compensating orifice being of a size which will regulate the flow of pressure therethrough to said compensating space at such rates that the same pressure cycle will be obtained in the engine cylinder.

JOHN DICKSON.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,201,533	Wackenhuth	Oct. 17, 1916
1,856,852	Palisca	May 3, 1932
1,860,865	Le Pul	May 31, 1932
1,925,614	Straussler	Sept. 5, 1933
1,990,714	Skooltvet	Feb. 12, 1935
1,995,459	Olson	Mar. 26, 1935
2,015,887	Eek	Oct. 1, 1935
2,052,459	Geiser	Aug. 25, 1936
2,067,997	White	Jan. 19, 1937
2,135,925	Tuscher	Nov. 8, 1938
2,190,051	Tuscher	Feb. 13, 1940
2,204,570	Butler	June 18, 1940