April 17, 1934. J. F. HERMANN 1,955,383

INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 1, 1932 4 Sheets-Sheet 1

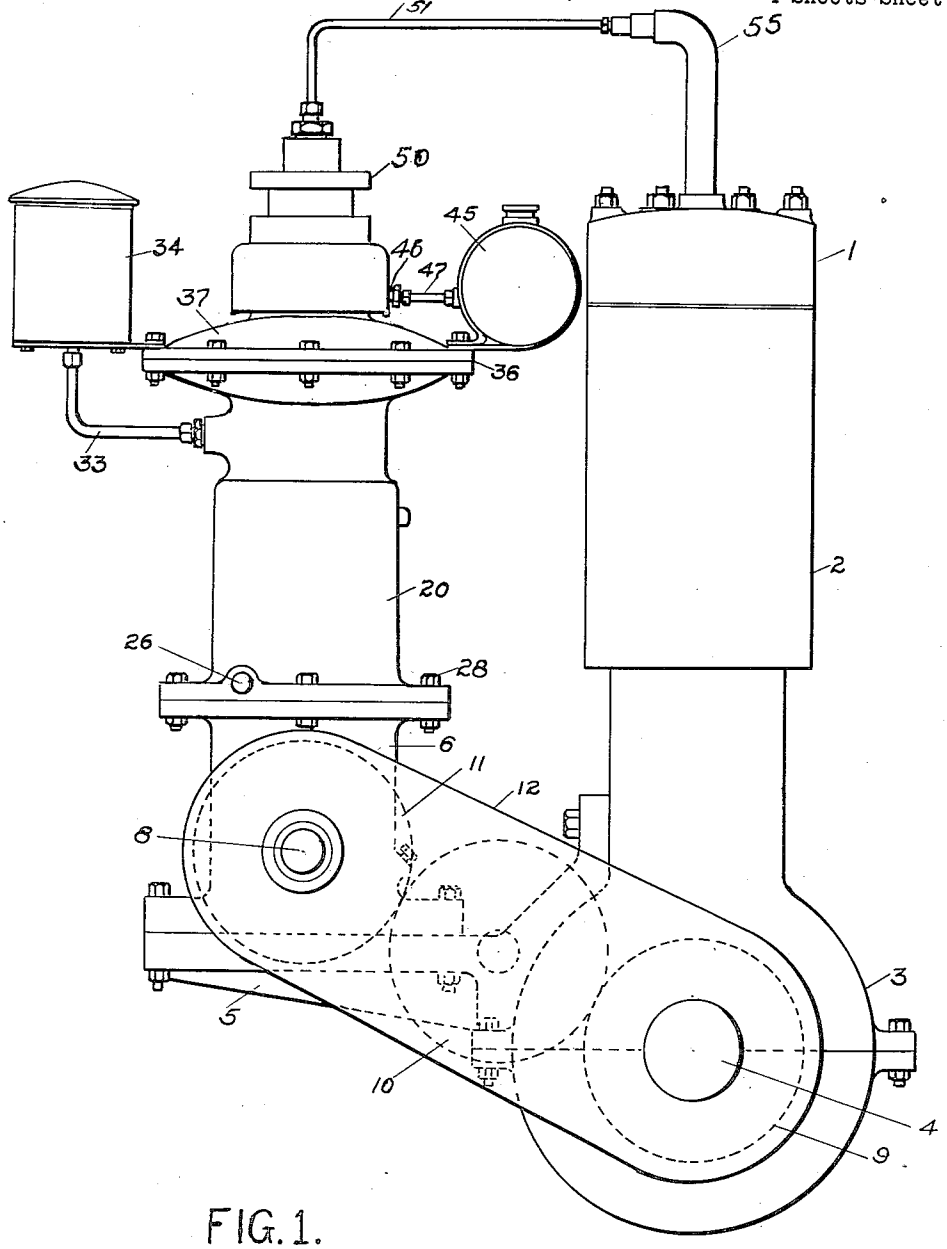


FIG. 1.

J. F. Hermann INVENTOR.

BY C. C. Hermann.

ATTORNEYS.

April 17, 1934. J. F. HERMANN 1,955,383

INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 1, 1932 4 Sheets-Sheet 2

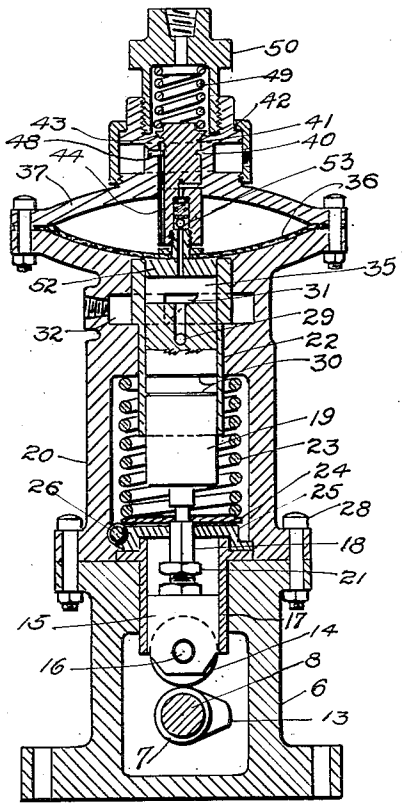


FIG. 2.

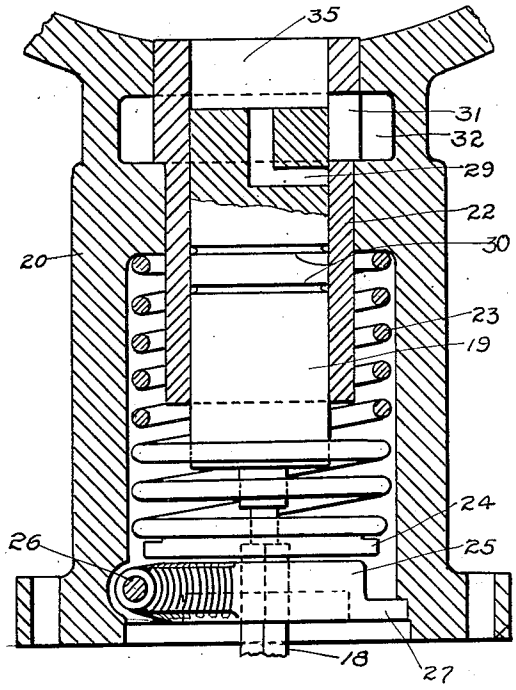


FIG. 3.

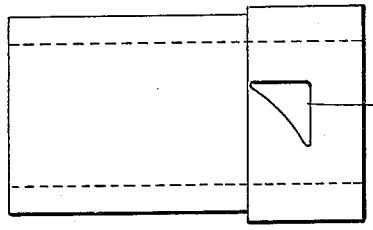


FIG. 4.

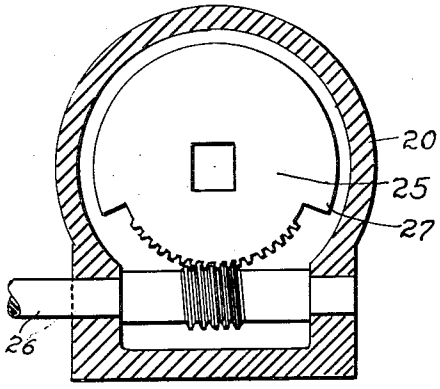


FIG. 5.

J. F. Hermann Inventor

By P. C. Hermann.

Attorney

April 17, 1934. J. F. HERMANN 1,955,383

INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 1, 1932 4 Sheets-Sheet 3

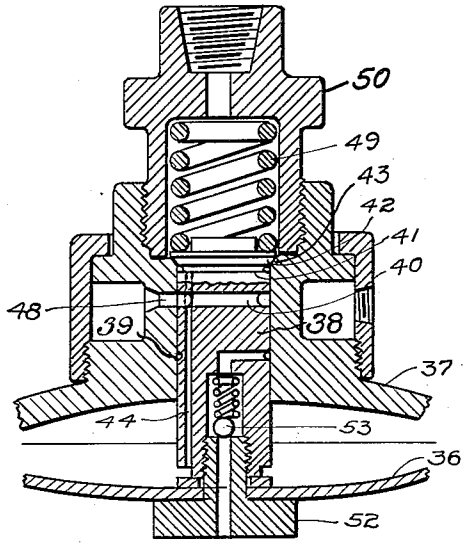


FIG. 6.

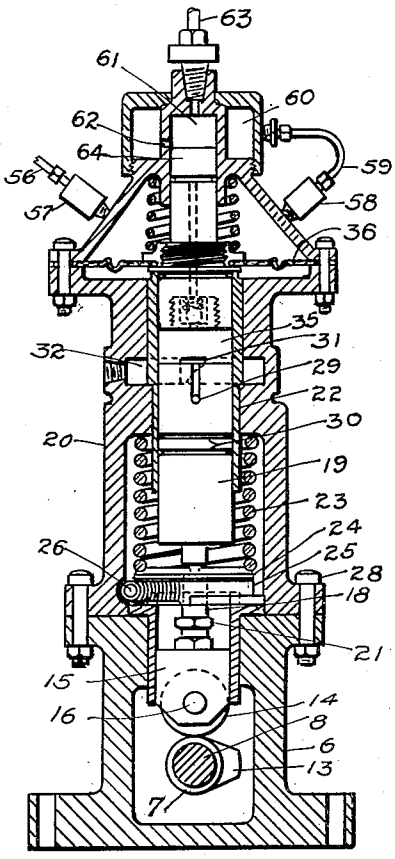


FIG. 7.

J. F. Hermann. Inventor

By C. C. Hermann.

Attorney

April 17, 1934. J. F. HERMANN 1,955,383

INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 1, 1932 4 Sheets-Sheet 4

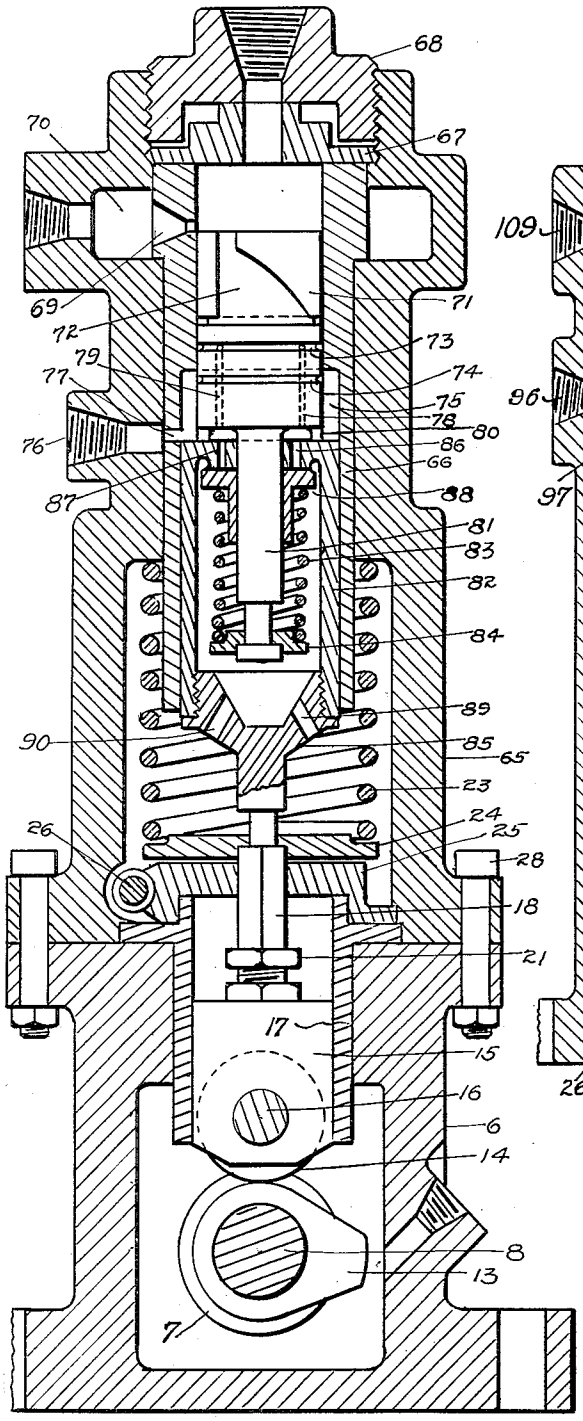


Fig. 8

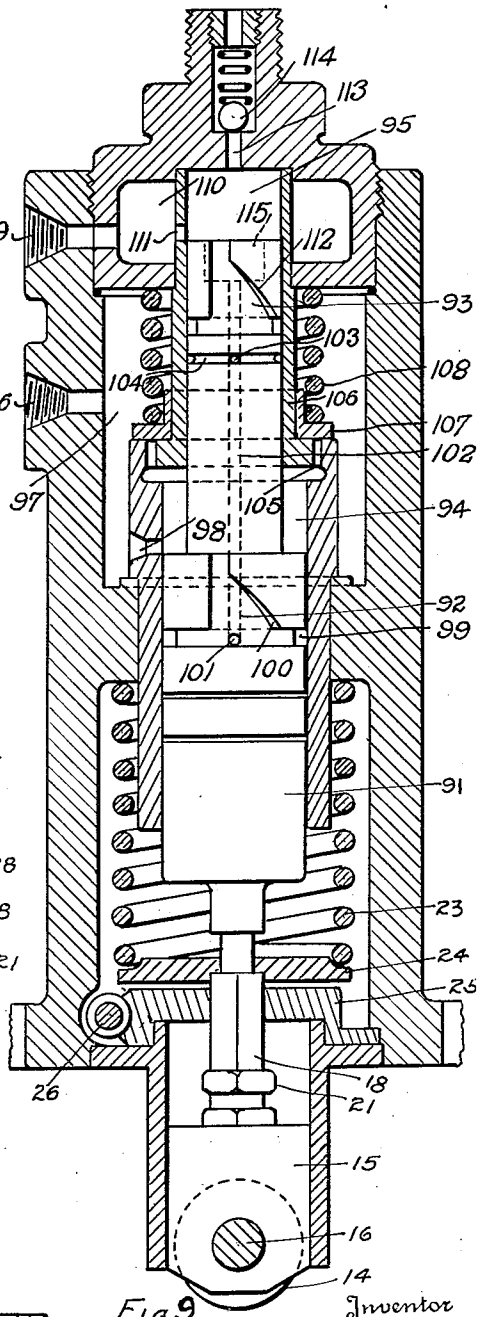


Fig. 9.

Inventor

J. F. Hermann.

By C. C. Hermann.

Attorney

Patented Apr. 17, 1934 1,955,383

UNITED STATES PATENT OFFICE

1,955,383

INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

John Frederick Hermann, Havana, Ill.

Application December 1, 1932, Serial No. 645,253

17 Claims. (Cl. 103—44)

My invention relates to injection pumps which deliver fuel to the spray nozzle commonly used on high-speed, solid-injection engines. A special requirement of such device is that the fuel must be delivered to the combustion chamber of the engine at an accurate time and the fuel so delivered must be accurately measured with regard to volume. Such pump must draw the liquid fuel from the fuel tank at atmospheric pressure and deliver it to the combustion chamber of the engine under a pressure ranging from sixty to six-hundred atmospheres. To cover the entire range of fuels such pump must handle gasoline, distillate or the heavier fuel oils as the engine may require or as may prove economical in the territory in which the engine is to function. The pump must deliver the fuel in varying amounts dependent upon the load on the engine. The amount may vary from a very small charge at no load to a very appreciable charge at full load and each charge must be accurately measured and delivered to the engine at the precise time required.

The requirements of the solid-injection engine with regard to fuel are very exact and pumps, to serve the purpose, must be produced with a very high degree of accuracy in their moving parts, clearance must be at a minimum and lubrication of the moving parts must be positively assured. Because of the high pressures present the slightest wear in the pump results in considerable slip and the quantity of fuel delivered becomes less than should be the case for the setting or timing and the power delivered by the engine decreases. Replacement cost on the injection pump is therefore a considerable item of expense in the operation of solid-injection engines and until my invention was disclosed it was impractical to handle gasoline, distillate, kerosene and other light fuels unless such fuel was premixed with from five to ten percent of lubricating oil to insure lubrication of the moving parts of the pump. Also up to the time of this disclosure solid-injection engines were comparatively low in speed and consequently relatively heavy per indicated horse-power; however, with my invention it is possible to use much higher speeds of piston travel of the pump and therefore the weight of engine per indicated horse-power may be materially reduced as compared with previous practice. This feature of my invention is of considerable importance to the art since it broadens the field of use of the solid-injection engines to include every use now supplied by the internal combustion engine of any description.

My invention eliminates the use of the usual carburetor and intake system of the ordinary gasoline engine fuel system making such engines capable of operation independent of fuel levels and therefore of great practical use on aircraft engines.

The principal objects of the present invention may be said to comprise the following:

First: To provide an improvement in injection pumps which enables the pump to operate at high piston speeds and thereby provide a direct increase in the speed of the engine of which it is a part.

Second: To provide a device which will accurately measure the volume of fuel injected into the engine of which it may be a part even after considerable wear has taken place in the moving parts of said pump.

Third: To provide a device which will pump fuel to the combustion chamber of an internal combustion engine under high pressure and maintain lubrication of such device, the lubricant being at or near the same pressure as the fuel.

Fourth: To provide a device in which the lubricant for such device is maintained at or near the same pressure as the fuel being pumped thereby insuring constant lubrication of the device and at the same time utilizing the volume of lubricant as the means of measuring the volume of fuel injected into the combustion chamber of the engine.

Fifth: To provide a fuel injection pump with a minimum of moving parts, minimum of wear in the moving parts and economical of manufacture.

Sixth: To provide a fuel injection pump which will function with gasoline, distillate or other light volatile fuels without the necessity of diluting such fuels with lubricating oil for the purpose of lubrication of the device.

Seventh: To provide a fuel injection pump which will be far more economical in operation than fuel pumps heretofore produced by virtue of the conservation of the lubricant used therein.

Eighth: To provide a fuel injection pump which uses the lubricant over and over until the full lubricating qualities of such lubricant have been exhausted.

Ninth: To provide a fuel injection pump having complete separation between the fuel being pumped and the lubricant used to lubricate the pump.

Tenth: To provide a fuel injection pump and fuel system for internal combustion engines which may be utilized to replace the carburetor

and intake manifolding system of the ordinary internal combustion engines now in use.

With these objects in view my invention consists in the novel features and advantages of construction and the arrangement of parts which will be more fully understood from the following specifications, reference being had to the accompanying drawings in which:—

Fig. 1 shows a side elevation of my invention and a fragmentary view of an internal combustion engine.

Fig. 2 is a sectional elevation of my invention showing the working parts thereof.

Fig. 3 shows the lower piston in side elevation and in greater detail than shown by Fig. 2.

Fig. 4 shows the cylinder lining or sleeve 22 in greater detail.

Fig. 5 shows the worm and wheel 26 and 25 in enlarged detail.

Fig. 6 shows the fuel cylinder, piston and cooperating elements of the fuel section of the pump.

Fig. 7 is a sectional elevation of a modification of my invention.

Fig. 8 is another sectional elevation of a modification of my invention.

Fig. 9 is still another sectional elevation of a modification of my invention.

It is intended that a practical embodiment of my invention be disclosed in the accompanying drawings, forming a part of this specification in which similar numerals of reference indicate corresponding parts throughout the several views.

Referring to Fig. 1, the cylinder head 1, cylinder 2, crankcase 3 are elements of the conventional internal combustion engine. Within the cylinder 2, not shown, however, is the piston and connecting rod, same being connected to the crankshaft 4. At one side of the crankcase 3, a bracket 5 is mounted extending the full length of the engine and parallel with the crank-shaft in a multiple cylinder engine. On the bracket 5, I mount an auxiliary fuel pump comprising my invention there being one pump for each cylinder of the engine. Since all pumps for a given engine would be duplicates only one such unit will be shown and described.

On the bracket 5, a base casting 6, is secured. At each end of the base 6, are located bearings 7 in which a cam shaft 8 is mounted. The cam shaft 8 is driven in timed relation to the engine crank shaft 4 by the gear train comprising gears 9, 10 and 11 shown in dotted lines in Fig. 1 and enclosed in the gear case 12.

Referring to Fig. 2, which shows the device in sectional elevation, the cam shaft 8 has mounted thereon a cam 13 disposed to engage the cam roller 14, which latter is secured to the cross-head 15 by the pin 16. The cross-head 15 works slidably in the cross-head guide 17 and has secured to its upper end a piston 19 by means of the connecting rod 18. The piston 19 reciprocates in the sleeve 22 secured in the cylinder 20. The connecting rod 18 is adjustable in length by the adjusting nut 21 in the conventional manner of valve tappet adjustment. The upper portion of the part 20 is bored out to receive the sleeve 22, the latter member being bored to receive the piston 19. The cylinder 20 is also bored out in its lower portion, such bore being concentric with the upper portion, to receive the compression spring 23, the spring washer 24, and the piston rotating gear 25. The piston rotating worm 26, is also contained in this portion of the cylinder casting 20. The connecting rod 18 is square in cross section as shown in Fig. 5 and the rotating gear wheel 25 is provided with a square hole to receive the square portion of the connecting rod mentioned. The connecting rod 18 may therefore slide up and down in the gear wheel 25 under action of the cam 13 and the spring 23. The gear wheel 25 is held in position and against movement corresponding to the connecting rod 18 by having a lip 27, which fits into a corresponding groove in the base of the cylinder casting 20. The gear wheel 25 is provided with worm-gear teeth on one side only as shown in Fig. 5 it being intended to turn this element only through ninety degrees by means of the worm-gear 26. The extended shaft of the worm-gear 26 is revolved by an auxiliary means which need not be described here but obviously may take the form of a slidable throttle lever since it is this element which controls the amount of fuel delivered to the engine as will be more fully understood from the following:

Any rotating movement applied to the worm-gear shaft will cause the worm-gear 26 to rotate and transmit rotation to the worm wheel and therefore the piston 19 will turn through the same number of degrees as the wheel 25.

The cylinder casting 20 is secured to the base 6 by bolts 28.

The spring washer 24 rests on the shoulder of the connecting rod 18 and under the compression spring 23. Under the compression of the spring 23, the piston 19, connecting rod 18 and cross-head 15 are held downward with the cam roller 14 in contact with the cam 13 on the cam-shaft 8 at all times. The upper end of the piston 19 is provided with an L channel 29, as shown in Fig. 3. One end of the channel 29 comes out on the side of the piston 19 and the other end comes out on the head surface of said piston. The piston 19 is also provided with oil grooves 30, the exact purpose of which with the L channel 29 will be more fully explained later.

The cylinder sleeve 22 is provided with an orifice 31, as shown in Fig. 4, having one side formed to a helical curve for reasons which will be presently apparent.

The cylinder casting 20 is provided with a cavity 32, concentric with the bore of same and in the same horizontal plane as the orifice 31 in the cylinder sleeve 22. In fact the width of this cavity 32 is the same dimension as the height of the orifice 31. At one side of the cylinder casting 20, and connecting with the cavity 32, is a copper tube 33 adapted to conduct liquid, at atmospheric pressure, from the vessel 34, to the cavity 32. This liquid, preferably a lubricant having a very low cold test and a relatively high lubricating value, flows from the vessel 34 into the cavity 32, and when the piston 19 is lowered so that it uncovers a portion of the cavity and orifice 31, the liquid also fills the cavity 35 above the piston. Assuming that the space above the piston is filled with the liquid and that the piston has reached its lower point and begins to ascend it is obvious that there will be a tendency to compress the liquid. However, this compression of the liquid in the space 35 may be relieved by rotating the piston 19 by means of the worm-gear 26 and the worm wheel 25 until the L channel 29, lower end, progresses past the helical side of the orifice 31. As soon as the piston 19 is turned thus far the liquid escapes through the channel 29 back to the cavity 32 and back to the vessel 34.

The foregoing description of the flow, counter-flow and by-passing of the liquid is of great im-

portance as it is by virtue of this arrangement that I am able to accomplish the objects set forth. The liquid entrapped in the cavity 35 comprises a hydraulic means for the transmission of power from the lower piston 19 to the fuel injection elements and fuel pump of my invention comprising the upper portion of the device which will now be explained.

Referring to Fig. 2 and more particularly to Fig. 6, the upper end of the cylinder casting 20 forms a hollow bowl for the reception of a diaphragm 36 which is clamped between the part mentioned and the casting 37 forming the cylinder for the fuel piston 38. The piston 38 is provided with an oil groove 39, fuel grooves 40 and 41 and a bevel seat 42 which latter engages a corresponding bevel seat 43 in the cylinder casting 37. A vertical fuel groove 44 is also provided in the piston 38, this groove connecting the fuel grooves 41 and 42 with the space above the diaphragm 36.

At one side of the upper cylinder 37 is mounted a fuel tank 45, see Fig. 1, which connects with a fuel cavity 46 in the cylinder casting 37 by a copper tube 47. The fuel cavity 46 connects with the fuel grooves in the piston 38 by the circular orifice 48. The piston 38 is held in contact with its seat 43 by means of the compression spring 49 contained within the casing 50 which latter part is screwed into the cylinder casting 37. A copper tube 51, see Fig. 1, conducts the fuel to the engine combustion chamber.

The piston 38 is secured to the diaphragm 36 by the plug 52 which screws into the lower end of the piston mentioned after having first been inserted in a central hole in the diaphragm. This plug 52 is provided with an elongated head which fits the bore of the lower cylinder casting sleeve 22. The length of the head is such that it never leaves the bore of the sleeve even during a maximum length of stroke of the lower piston. The plug 52 is provided with a hole through its center which is intended to conduct liquid, preferably a lubricant, from the cavity 35 past the check valve 53 and through the oil hole 54 and to the oil groove 39 in the piston 38.

In operation the compression of the liquid in the cavity 35 will tend to raise the diaphragm 36 and plug 52 thereby forcing the piston 38 upward. As long as the piston 38 is in its down position the fuel groove 40 coincides with the fuel orifice 48 allowing fuel to flow into the space above the diaphragm 36 by way of the vertical groove 44. Now as soon as the piston 38 begins to rise it closes off the fuel orifice 48 and opens the way for the fuel to flow from the fuel groove 41 past the valve seat 43 and directly into the space around the compression spring 49 and from this space through the copper tube 51 to the combustion chamber of the engine.

The amount of fuel delivered by the pump is dependent upon the length of the stroke of the piston 38 and the length of the stroke of the piston 38 is dependent upon the cut-off of the liquid flowing from the vessel 34 into the cavity 35. It is obvious therefore that the fuel delivered to the engine may be varied through a very wide range. The injector 55 is set at a predetermined pressure and fuel is prevented from returning to the supply tank 45 by the valves 42 and 43. The pump will therefore, deliver the fuel to the engine at the injector pressure.

Referring to Fig. 7 the diaphragm 36 is so constructed that it may be used for the purpose of pumping the fuel from a remotely located tank under low pressure thus eliminating the auxiliary fuel pump usually found on or in connection with internal combustion engines. The fuel suction line is shown at 56 with its check valve 57. The fuel discharge line is shown at 58 with its check valve at 59. The fuel discharge line 58 conducts the fuel to the chamber 60 from whence it flows into the pressure cylinder 61 of the fuel pump through the orifice 62 and is finally ejected to the injector line 63 by the piston 64.

It is obvious that the lubricant used to lubricate the pistons is subjected to the same pressure as the fuel, therefore, lubrication of the fuel piston is assured, also the lubricant forms a seal which tends to maintain the constant flow of the pump even after considerable wear has taken place. Because of this positive lubricating means the pump may be operated at much higher piston speeds than pumps used thus far. Since the engine speed depends upon the speed of the fuel pump the engine speed may be increased.

Referring to Fig. 8 a modification of this lubricating means is shown. This figure also shows a modification of the fuel pump similar parts bearing the same numerals of reference as used in preceding figures. The cylinder 65 is bored out to receive the sleeve 66 which is held in place by the cylinder head 67 and cap 68, the latter being drilled and tapped for reception of the injector fuel line not shown. The sleeve 66 is provided with an orifice 69 for the entrance of fuel from the cavity 70 in cylinder 65. The fuel is conducted to this cavity 70 by a pipe connecting with a fuel supply tank not shown. The sleeve 66 is provided with two diameter bores, the upper being smaller in diameter than the lower. In the upper bore the piston 71 functions. This piston 71 is provided with a recess 72; said recess having one vertical side and one helical side as shown. In normal operation this recess 72, is turned ninety degrees clockwise so that it coincides with the fuel orifice 69 during a predetermined portion of the stroke of the piston 71 as will soon be apparent. Piston 71 is also provided with oil grooves 73 and 74, which, receive oil in the following manner. The upper portion of the lower bore of the sleeve 66 forms a cavity 75 which is filled with lubricating oil under atmospheric pressure from a supply tank, not shown, through a pipe, not shown, which pipe connects to the cylinder 65 at the point 76 and therefrom flows through the orifice 77 in the sleeve 66. This oil flows directly into the oil groove 74 when the piston 71 is at or near the bottom of its stroke. In order to supply oil to the groove 73, oil channels 78 and 79 are provided in the piston 71. The bottom of the piston 71 is provided with projections 80 which are spaced around the piston and prevent it from sealing off the oil grooves 78 and 79. The piston 71 is provided with a stem 81, which projects downward within a cavity of a second piston 82 and is held in yielding relation thereto by the spring 83 and keeper 84. The piston 82 reciprocates within the lower bore of the sleeve 66 and obtains its reciprocating motion from the connecting rod 18 and related parts as previously explained. The lower part of the piston 82 is closed by the plug 85 attached to the end of the connecting rod 18. The head of the piston 82 is provided with two oil holes 86 and 87, sealed below by the bushing 88 mounted slidably on the stem 81 of the piston 71. Pistons 71 and 82 are rotated by the worm 26 and the worm-wheel 25 in the manner previously described.

In operation the pistons 82 and 71 start up-

ward at the same rate of speed, however since the cavity 75 is filled with oil and upward motion of the piston 82 closes the oil port 77 almost immediately this oil is compressed forcing the piston 71 upward at a higher rate of speed causing a separation of pistons 71 and 82. This separation of the pistons continues until the fuel pressure above the piston is sufficient to cause the high pressure of the oil in cavity 75 to force the bushing 88 downward allowing the oil to escape through the oil holes 86 and 87 into the hollow of the piston 82 from where it escapes through the ports 89 and 90 in the plug 85.

The oil used for lubricating the pistons is therefore placed under pressure equal to and greater than the pressure of the fuel above the piston 71. Lubrication of the pistons and all moving parts is therefore insured at all speeds. The lubricating oil also serves to vary the travel of the respective pistons relative to each other. Cut-off of the fuel is obtained by rotating the piston 71 in the manner described previously.

Figure 9 incorporates the same general features with regard to lubricating the piston under pressure as Fig. 8 with several further modifications. The piston 91 is provided with two diameter sections, one above the other. Each section is provided with a depression 92 and 93 respectively, one side of which is vertical and the other helical. The piston is rotated by the worm 26 and the worm-wheel 25 as previously described. The lubricating oil cut-off occurs at the same instant as the fuel cut-off and the cavity 94 is proportioned so that the same pressure is produced in the lubricating oil as in the fuel in cavity 95.

Referring to Fig. 9, lubricating oil is conducted by piping (not shown) from a supply tank (not shown) to the inlet 96 of the cavity 97 and flows through port 98 to the chambers 94 and 99. The flow of oil is interrupted by the cut-off characteristics of the piston 91 by means of the cam 100 formed therein. Further upward motion of the piston 91 results in pressure being produced in the chambers 94 and 99 causing the oil to flow through the passage 101 and through the vertical passage 102 thence through the passage 103 to the piston groove 104. The oil from chamber 94 is also forced through the holes 105 in the base of the upper cylinder sleeve 106 exerting a lifting force on the cylindrical ring 107. When the pressure reaches a point where the resistance of the compression spring 108 is overcome the oil flows back to chamber 97. The maximum pressure of the oil in chambers 94 and 99 is maintained equal to the maximum pressure of the fuel in chamber 93 and chamber 95 by the compression spring 108 so that lubrication of the piston 91 throughout its length is secured and the clearance between the piston 91 and its cylinder wall is sealed against the fuel.

Fuel enters the pump through piping from a supply tank to the inlet port 109, filling the cavity 110 thence through the inlet port 111 to the cavity 93 in the piston 91 and the cavity 95 above the piston 91. Cut-off is by means of the helical cam 112 closing the inlet port 111 as the piston 91 rises on its upward stroke. The pressure exerted on the fuel by the upward movement of the piston 91 forces the fuel through the outlet port 113, through the ball-check valve 114, thence through the connecting piping to the combustion chamber of the engine. The upper end of the vertical groove 102 is closed by means of a screw plug 115 screwed into the head of the piston 91.

While I have shown and described what I consider to be the preferred form of my invention, it is thought that various other structural modifications may be effected within the spirit and scope of the same and I intend that only such limitations be imposed as may be indicated in the appended claims, in which it is my intention to claim all novelty inherent in my invention as broadly as possible in view of the prior art.

What I claim as new and desire to secure by Letters Patent is:

1. In a fuel injection device of the type described including a cylinder, a pump piston therein, a timed actuating member therefor, a fuel inlet and outlet for same, a second piston within said cylinder positioned above the first piston and having its central axis on the same center line as the first piston, said second piston adapted to reciprocal motion in cooperation with the first piston but separated therefrom by a liquid filled chamber and means for varying the volume of liquid between said pistons for the purpose of varying the length of stroke of said second piston, the liquid between said pistons being distinct and separate from the fuel handled by said injection pump.

2. In a fuel injection device of the type described including a cylinder, a pump piston therein, a timed actuating member therefor, a fuel inlet and outlet in said cylinder, a second piston within said cylinder adapted to movement to and fro in cooperation with the first named piston but separated therefrom by a volume of liquid and means for varying the volume of said liquid between said pistons, the liquid between said pistons being distinct and separate from the fuel handled by said injection pump.

3. In a fuel injection device of the type described including a cylinder, a pump piston therein, a timed actuating member therefor, a fuel inlet and outlet in said cylinder, said cylinder adapted to receive a plurality of pistons therein, a liquid chamber between said pistons and a means for varying the volume of liquid between said pistons, the liquid between said pistons being distinct and separate from the fuel handled by said injection pump.

4. In a fuel injection device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet in said cylinder, said cylinder adapted to contain a plurality of pistons in said cylinder, a liquid chamber between adjacent pistons and a means for varying the volume of liquid between adjacent pistons for the purpose of varying the length of stroke of all pistons above the first, the liquid between said pistons being distinct and separate from the fuel handled by said injection device.

5. In a fuel injection device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet, said cylinder adapted to contain a plurality of pistons in said cylinder above the first named piston, a liquid chamber between adjacent pistons, an inlet and outlet for said liquid chamber and a means for varying the volume of liquid between adjacent pistons for the purpose of varying the length of stroke of all pistons above the first.

6. In a fuel injection device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet, a second piston within said cylinder adapted to movement to and fro in cooperation

with the first named piston but separated therefrom by a volume of lubricating liquid and means for varying the volume of lubricating liquid between said pistons the liquid between said pistons being distinct and separate from said fuel handled by said injection device, an inlet port for said liquid controlled by said pistons respectively and an outlet for said liquid controlled by a plate in a yielding manner when said liquid is subjected to a predetermined pressure, said pistons held in limited relation to each other by a spring and spring retainers, said upper retainer comprising a valve head disposed to close a multiple of orifices in the head of said first named piston, said valve head and orifices comprising a pressure release mechanism for said lubricating liquid between said pistons.

7. In a fuel injection device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet, a second piston and diaphragm attached thereto superimposed over the first named piston on the same axial center line, a liquid chamber between said first named piston and said diaphragm whereby movement of said first named piston is transmitted to said second named piston and diaphragm and means for varying the volume of liquid in said chamber for the purpose of varying the length of stroke of said second piston and diaphragm, the liquid between said pistons and said diaphragm being distinct and separate from said fuel handled by said injection device and inlet and outlet ports provided for said liquid.

8. In a fuel metering device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet, a tortuous passage in said piston with its inlet in the head surface and outlet in the side surface, said cylinder having an orifice in its wall for the admission of a liquid into said cylinder ahead of said piston, said piston adapted to rotary motion for the purpose of bringing its outlet in line with the orifice in said cylinder wall thereby relieving the pressure of said liquid in the cylinder at a predetermined point of its forward stroke, a second piston within said cylinder but separated from said first named piston by said volume of liquid and means for rotating said first named piston for the purpose of varying the pressure of the liquid and thereby the length of stroke of the second named piston.

9. In a fuel metering device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet, a plurality of pistons in said cylinder above said first named piston, a tortuous passage in said first named piston with its inlet in the head surface and outlet in the side surface, said cylinder having an orifice with helical formed side in its wall for the admission of liquid into said cylinder ahead of said first named piston and behind the adjacent piston, said first named piston adapted to rotary motion for the purpose of bringing its outlet in line with the orifice in the wall of said cylinder thereby relieving the pressure of the liquid in said cylinder and between adjacent pistons and means for rotating said first named piston for the purpose of varying the length of stroke of all subsequent pistons relative to the stroke of the first named piston.

10. In a fuel metering device of the type described, including a cylinder, a piston thereon, a timed actuating member therefor, a fuel inlet and outlet, a second piston above said first piston adapted to reciprocations in cooperation with the first piston but separated therefrom by a volume of lubricant, oil grooves cut in the surface of said pistons, channels leading to said grooves and means for varying the pressure applied to said lubricant between said pistons.

11. In a fuel metering device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet, said cylinder of a length to receive a plurality of pistons, a body of lubricant between said pistons, lubricating channels cut in the surface of said pistons, the stroke of the first piston being constant, means for varying the pressure applied to said lubricant by the first piston at a predetermined point in its stroke thereby varying the stroke of subsequent pistons relative to the stroke of the first and means for returning the lubricant to an outside vessel for subsequent use.

12. In a fuel metering device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet, a second piston and diaphragm attached thereto superimposed over the first named piston on the same axial center line, a liquid chamber between said first named piston and said diaphragm whereby movement of said first named piston is transmitted to said second named piston and diaphragm, said diaphragm comprisng a fuel pump for pumping fuel to said second named piston displacement and means for varying the volume of liquid in said liquid chamber between said first named piston and said diaphragm for the purpose of varying the length of stroke of said second named piston and diaphragm.

13. In a fuel pump of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet in said cylinder to permit fuel to enter into and leave the space above said piston, a fuel metering chamber within said cylinder between said piston and a second piston, said second piston comprising a fuel piston, a valve disposed to allow liquid to enter and leave said fuel metering chamber and means for varying the volume of liquid remaining in the fuel metering chamber during the full stroke of the first named piston for the purpose of varying the amount of fuel pumped by the fuel piston.

14. In a fuel metering device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet in said cylinder to permit fuel to enter and leave the space above said piston, a fuel metering chamber within said cylinder, a fuel piston and diaphragm within said cylinder and above said metering chamber, a helical sided orifice in the wall of said cylinder communicating with said metering chamber, a tortuous passage in the head of said first named piston with one end in the side surface of same and adapted to adjustable intersection with the orifice in the cylinder wall, liquid supplied to said metering chamber and means for rotating said first named piston for the purpose of relieving the pressure within said metering chamber thereby varying the stroke of the diaphragm and fuel piston relative to the stroke of the first named piston.

15. In a fuel metering device of the type described, including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet

and outlet in said cylinder to permit fuel to enter into and leave the space above said piston, said piston provided with two holes drilled at right angles to each other, one of said holes in the head surface and extending inward along the central axis of the piston, the other of said holes entering the side of said piston and intersecting the first hole on the center line, a helical sided orifice in the cylinder wall communicating with a cavity in the cylinder wall concentric with the bore of said cylinder, said cavity supplied with liquid from an external source, said piston rotative about its central axis, means to rotate said piston for the purpose of bringing the hole in the side of same in communication with the helical side of said orifice and allow liquid under pressure within the liquid chamber above said piston to flow back into the cavity within said cylinder wall, a second piston disposed within the cylinder bore and separated from the first named piston by a diaphragm and the liquid chamber but adapted to corresponding movement with the first named piston by the pressure of the liquid on the diaphragm, the length of stroke of said second named piston and diaphragm being dependent upon the amount of liquid by-passed due to the angular movement of the first named piston.

16. In a fuel injection device of the type described including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet in said cylinder, a lubricant inlet and outlet in said cylinder, a sleeve in the upper portion of said cylinder, the bore of said sleeve being concentric with the bore in the lower portion of said cylinder, the upper portion of the aforesaid piston being smaller in diameter than the lower portion thereof, a recess in the side of said piston at the upper edge of the larger portion, said recess being provided with the helical sides to form a variable cut-off, a recess in the upper portion of said piston in duplicate of the recess in the lower portion, an annular space around the piston communicating with the aforementioned helical sided recess in the lower portion of the said piston and connected with the inlet for a lubricating medium and having an outlet for the lubricating medium, said piston being provided with channels and grooves for conducting said lubricant to the friction surface between said piston and the cylinder wall, a flange provided on the lower end of the aforesaid sleeve, said flange provided with a series of orifices, a concentric collar on said sleeve held yieldingly against the flange of said sleeve and adapted to close the orifices in said flanged portion of said sleeve, an annular space in the upper portion of said cylinder provided with connection to the fuel supply and in corelation to the inlet orifice aforementioned, and means to rotate said piston to provide variable cut-off on both the lubricating medium and the fuel.

17. In a fuel injection device of the type described including a cylinder, a piston therein, a timed actuating member therefor, a fuel inlet and outlet in said cylinder, a second inlet and outlet in said cylinder for lubricating oil or other liquid, an annular space in said cylinder near the upper end of the piston stroke, communication between said annular space and the space above said piston, an inverted valve in the upper end of said cylinder the head of said valve being in the form of a foreshortened piston, a diaphragm on said valve having its periphery secured to cylinder head, an annular space around said valve communicating with the space above said diaphragm, a vertical channel in said valve terminating at the surface beneath the chamfered edge of the upper valve head and communicating with the space above said valve when the valve is in its upper or raised position, internal channels in said piston and valve corresponding with grooves for the purpose of lubricating the friction surface of same, a helical sided cut-off in the lower piston for the purpose of cutting off the admission of lubricating oil or other liquid to the space above the first named piston and means for rotating said first named piston to obtain variable cut-off for the purpose of varying the length of stroke of the aforementioned valve.

JOHN FREDERICK HERMANN.