July 31, 1962 C. W. DAVIS 3,046,905

FUEL INJECTION PUMP

Filed Dec. 27, 1957 2 Sheets-Sheet 1

Fig. 1.

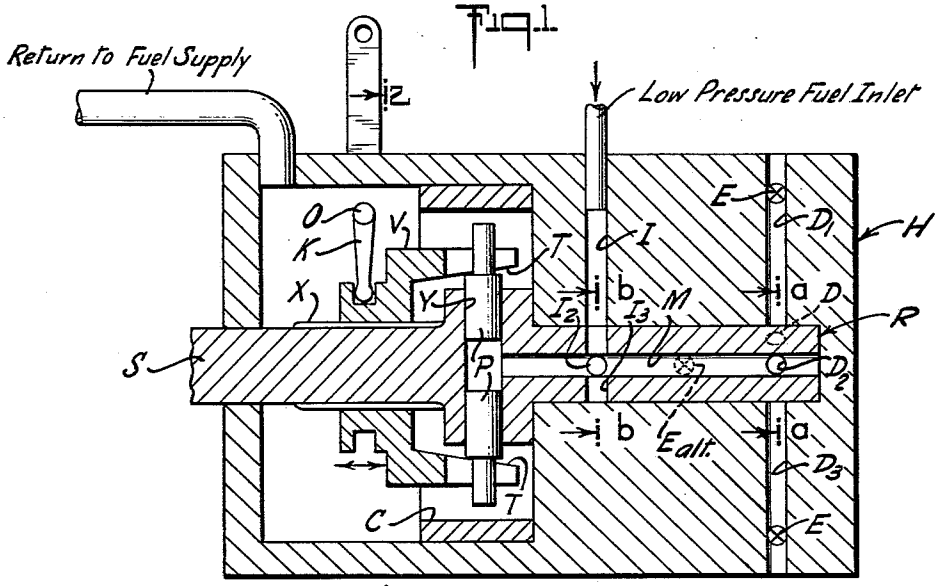


Fig. 3a.

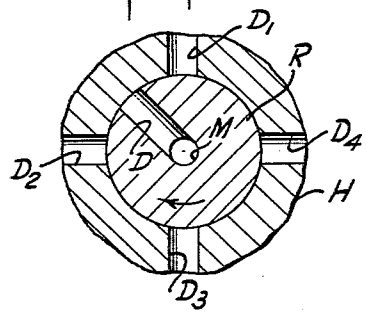


Fig. 3b.

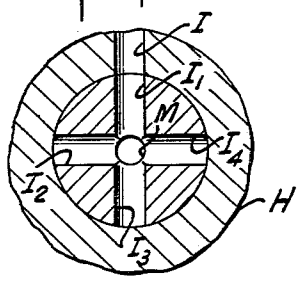


Fig. 2.

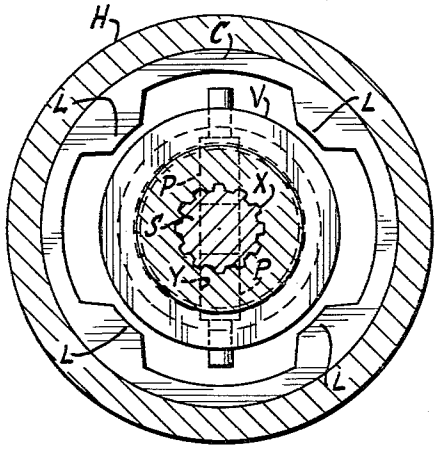
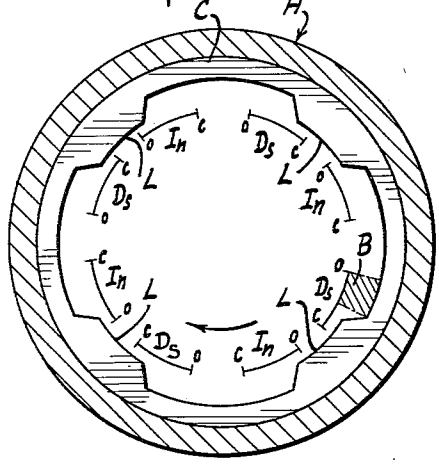


Fig. 7.



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Fig. 5a.

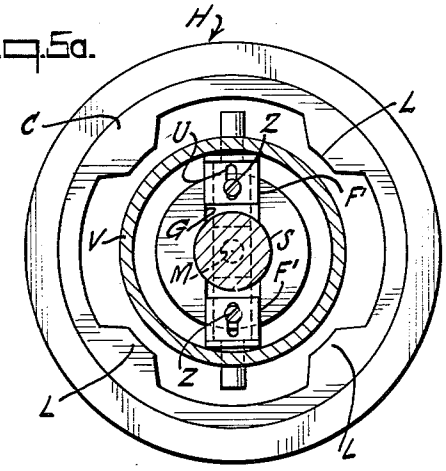


Fig. 5b.

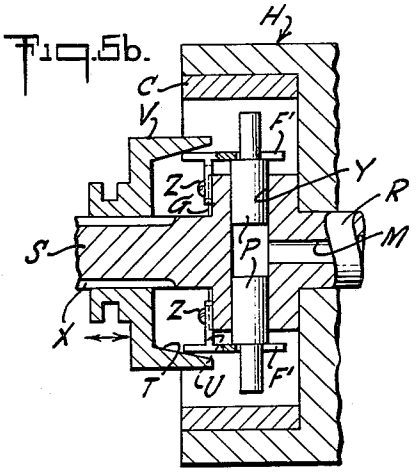


Fig. 4a.

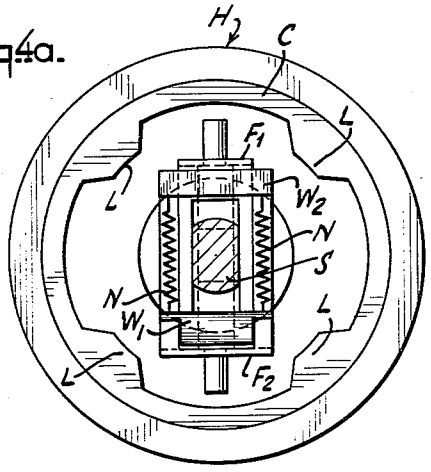


Fig. 4b.

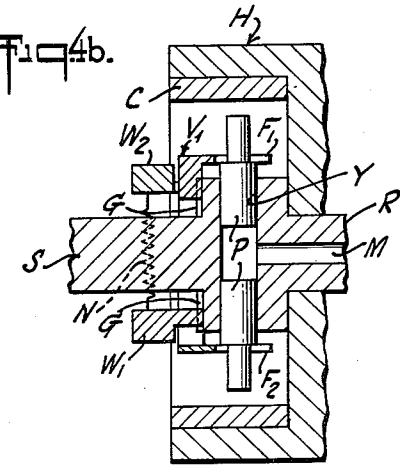


Fig. 6a.

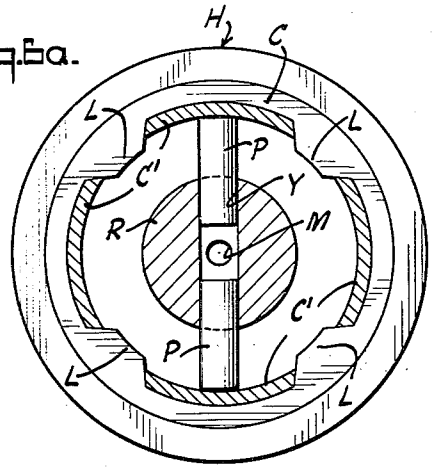
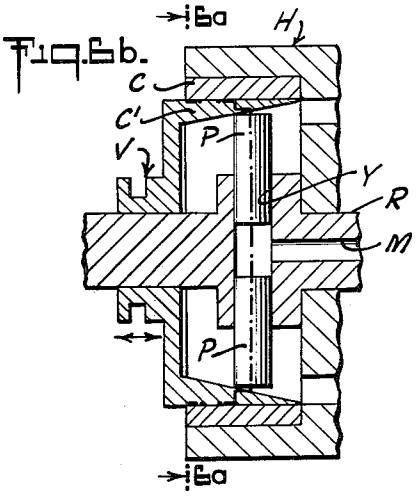


Fig. 6b.



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3,046,905

FUEL INJECTION PUMP

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7 Claims. (Cl. 103—161)

This invention relates generally to a fuel injection system in an internal combustion engine, and specifically, to a fuel injection pump of the single plunger distributor type.

Single plunger or single pumping element distributor type pumps can be classified broadly according to the methods used to control the quantity of fuel injected. These include cut-off control wherein a portion of the constant amount of fuel displaced by the plunger is dumped back to the supply side of the pump, depending on the amount required by the engine. Cut-off control involves short leakage paths and therefore very close and expensive fits to control leakage. Erosion caused by the sudden release of high pressure fuel is also a problem.

Another control means involves the throttling of the supply of fuel to the pumping element. This results in the creation of low pressures in the pumping element and introduces the problem of fuel flashing into vapor, with resulting deterioration of injection characteristics, if the fuel is sufficiently volatile, and particularly, if the fuel becomes heated. Advantages of the throttled intake pump include long leakage paths with less critical fit of parts and so a cheaper construction.

A third method for control of injection quantity is positive regulation of the stroke of the pump plunger. With this control arrangement, it is possible to obtain most of the advantages of the throttled inlet arrangement while avoiding the fuel vaporization problems that are inherent with inlet throttling control.

Accordingly, it is an object of the present invention to provide a new and improved fuel injection pump of the single plunger distributor type to prevent flash vaporization of fuel into vapor.

It is another object of the invention to provide a single plunger distributor fuel injection pump wherein the quantity of fuel injected is regulated by control of pump plunger travel.

Still another object of the invention is to prevent flashing of fuel in a single plunger distributor type fuel injection pump having plunger travel control and unrestricted filling.

Another object of the invention is to provide a novel fuel injection pump of the single plunger distributor type having the quantity of fuel injection regulated by control of pump plunger travel, and with unrestricted filling and check valves to prevent back flow of fuel from pressurized delivery lines.

These and other objects, features and advantages of the invention will appear from a reading of the specification, detailing a description of the structure illustrated in the accompanying drawings, wherein:

FIG. 1 is a diagrammatic sectional showing of the improved fuel injection pump;

FIG. 2 is an end view taken along line 2—2 of FIG. 1;

FIGS. 3*a* and 3*b* are cross-sectional views taken respectively along lines *a—a* and *b—b* of FIG. 1;

FIGS. 4*a* and 4*b*, respectively, are partial end and cross section views of a modification of the control means of the fuel injection pump;

FIGS. 5*a* and 5*b*, respectively, are partial end and cross section views of a modification of the control means disclosed in FIGS. 1 and 4*a*.

FIGS. 6*a* and 6*b*, respectively, are partial end and cross section views of another modification of the control means of the fuel injector pump; and

FIG. 7 is a diagrammatic showing of the timings for fuel inlet and discharge functions.

In accordance with my invention, positive mechanized control of plunger travel in the pump regulates the quantity of fuel to be injected, with indexing of the intake passages being timed to provide for unrestricted filling, and with the use of check valves in the fuel discharge lines to prevent back flow of pressurized fuel into the pump rotor.

As disclosed in FIGS. 1, 2, 3*a* and 3*b*, the fuel injection pump is for a four cylinder engine and includes a housing H with an axial bore for the rotor R, and a cam ring section for the cam ring C. The housing contains a single inlet passage at I, to which is joined a low pressure fuel inlet, and four discharge passages D_1, D_2, D_3 and D_4, FIG. 3*a*, in communication with the axial bore, and each with a check valve as indicated at E, FIG. 1. The rotor R is driven from its flange end by the drive shaft S and contains an axial passage M and a series of radial inlet passages leading therefrom indicated as I_1, I_2, I_3 and I_4, FIG. 3*b*, and adapted to be indexed with the inlet passageway at I, and another radial passage, indicated at D, to function as an outlet, spaced axially along the shaft from the inlet passages to index with the discharge passages D_1, D_2, etc.

The flange of the rotor R contains a diametral cylindrical pump chamber Y for housing two opposed pump plungers P, which, shown diagrammatically, are actuated simultaneously as their outer ends ride over equally spaced internal cam lobes L in the cam ring C. In practice, cam follower pieces would be interposed between the cam ring and the ends of the pump plungers.

In the housing H, there are as many fuel discharge passages (D_1, D_2, D_3, D_4) as there are cylinders in the engine, but there is only one outlet passageway (D) in the shank of the rotor (R) that can register with them. There are also as many oppositely spaced cam lobes (L) in the cam ring (C) as there are cylinders in the engine.

Mounted on the rotor R at the flange end is a plunger stop control means including sleeve V, which has a tapered inner surface T and rotates with the rotor, being slidable thereon through the spline construction at X, to limit the outward motion of the plungers to any value depending on its axial position. The sleeve is positioned either manually or by governor action and as disclosed herein, by means of the yoke K, which fits in a circular groove on the sleeve, and pivots about O.

A short description of the operation of the fuel pump follows. As the rotor turns, each of the radial inlet passages (I_1, etc.), register in consecutive order with the fuel inlet (or supply) passage I and fuel supplied under pressure by a supply pump (not shown) feeds through to the axial passage M to the pumping chamber Y. When registry takes place, the ends of the pump plungers P are located in the intervals between the cam lobes L of the cam ring C. Outward movement of the pump plungers in the chamber follows due to centrifugal force and fuel supply pressure and fuel is drawn into the pump chamber. The amount of outward plunger movement determines the amount of fuel that is to be injected.

As rotation of the rotor continues, the inlet passages cease to be indexed, the discharge passages will become indexed and pumping will begin with the inward motion of the pump plungers as their outer ends ride up and over the cam lobes, with fuel being discharged to the respective passages (D_1, etc.) in turn, as they register with the discharge passage D in the rotor.

Additional modifications of the plunger variable stop means are disclosed in FIGS. 4*a*, 4*b*, 5*a*, 5*b*, 6*a* and 6*b*, with the elements of the structures identical to those previously disclosed in FIGS. 1, 2, 3*a* and 3*b* bearing the same numeration.

Referring to FIGS. 4*a* and 4*b*, the variable stop control means V_1, comprises a pair of interconnected stop pieces having fingers F_1 and F_2 at one of their ends, which overlap the ends of the pump plungers P, and weight portions W_1 and W_2 on their opposite ends. The stop pieces ride in a diametral groove G on the outer face of the rotor flange and are joined to each other by spring means N, N, which draw the weight portions toward each other.

In this modification, the weighted stop pieces act also as a governing device. To control the speed of the engine, the tension on the springs is regulated by manual means and the mechanism will operate to control fuel flow as necessary to maintain the speed, regardless of load, as in the case of any flyball governor. If the engine speeds up, the weight portions will move outwardly causing the fingers on the opposite ends of the pieces to stop the plungers at lesser outer travel and hence reduce fuel quantity. If the engine slows down, the weight portions will move inwardly to cause the fingers to move outwardly and increase the fuel capacity of the pump. It is apparent that the weighted sections can be discarded and the finger sections moved either manually or by other governor arrangement.

FIGS. 5*a* and 5*b* disclose a combination of the stop control means disclosed in FIGS. 1 and 4*a* and 4*b*, wherein the tapered inner surface T controls the position of the fingers F', F' (instead of weight portions), as the sleeve V moves axially. As in the structure shown in FIG. 4*b*, the fingers slide in a groove G on the outer face of the rotor flange, being held in position by the screw means Z, which project through the slot U in the fingers, thereby restricting the fingers to radial movement.

Another approach to the problem of limiting plunger travel positively is to have a cam ring design with adjustable sections between the cam lobes. This modification is disclosed in FIGS. 6*a* and 6*b* showing an adjustable base circle cam section or piece C_1, which moves axially with respect to the cam ring, i.e., inwardly or outwardly, by manual or governor action (neither disclosed). If the adjustable base circle cam section is moved to the right of FIG. 6*b*, the plungers will be limited to a small outward travel, and vice versa. It is quite evident that the quantity of fuel injected will be regulated by the axial position of the cam section of piece C_1.

To further reduce the chances of vapor formation in the rotor passages, I propose to have the inlet passages become indexed prior to the time the pump plungers start their contact with the back side of the cam lobes. If this does not occur, low pressure in the rotor passages will occur until such times as the inlet passages are indexed.

Proper timing sequence of inlet and discharge passage indexing related to the time of plunger travel over the cam lobes is illustrated in FIG. 7 for a four cylinder engine fuel pump. The indexed periods of intake and discharge parts are shown as a polar diagram drawn on a plan view of the cam ring, with plunger motion indicated by the profiles on the cam ring. Intake and discharge porting events are noted by I_n and D_s, respectively, with opening and closing denoted by *o* and *c* respectively.

FIGURE 7 also discloses a cross hatched area, indicated at B, showing the time during which high pressure fuel previously pumped into the discharge passages may spill back into the rotor passages. The sudden release of pressure and resulting back flow is detrimental to injection characteristics, particularly at small injection quantities and in addition may cause flashing of the fuel in the discharge passages. To prevent such an occurrence, since it is not possible to relocate the discharge passages so that they do not open until pumping begins, because the beginning of pumping is variable depending on the load, it is proposed to insert a check valve in each of the discharge passages leading to the nozzles, placed as close to the rotor R as possible. This valve is shown at E in FIG. 1. Alternately, one check valve may be placed in the central rotor passage M between the inlet and outlet passages, and is shown dotted at $E_{alt.}$ in FIG. 1.

Thus there has been shown and described a single pumping element distributor type fuel injection pump which has improved injection characteristics, particularly when operating with volatile fuels.

Obviously, many modifications and variations of the invention as heretinbefore set forth may be made without departing from the spirit and scope thereof, and therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. In a fuel injection system for an internal combustion engine, a fuel injection pump comprising a pump housing having an axial bore with fuel inlet and discharge passages leading therefrom and a fuel distributing and pumping means comprising a rotor having an axial passage with fuel inlet and discharge passages leading therefrom adapted to be placed in communication with the corresponding passages in said housing when said rotor is positioned and rotated in said bore, said rotor having a diametral chamber in communication with said axial passage, a pair of plungers housed in said chamber and forming a fuel pumping means therewith, and internal cam means located in a section of said housing in operative position with the outer ends of said plungers so that when said rotor revolves within said axial bore of said housing said plungers are moved radially outward when said fuel inlet passages in said pump housing and said rotor are in communication with each other and fuel is being admitted to the rotor, and being forced inward when said discharge passages in said pump housing and said rotor are in communication with each other and fuel is being delivered to individual engine cylinders, and means for regulating the quantity of fuel to be injected by the positive control of the displacement of said plungers comprising a sleeve member mounted on said rotor and capable of axial adjustment therealong for effecting contact engagement with each of the outer end portions of said pair of plungers thereby to limit positively the amount of plunger travel and so regulate the quantity of fuel injected.

2. In the fuel injection pump as defined in claim 1, means for preventing back flow of highly pressurized fuel from said discharge passages to said pumping means comprising a check valve therein.

3. In the fuel injection pump as defined in claim 2, said sleeve member having a tapered inner surface in operative contact with said outer end portions of said plungers whereby variable outward movement of said plungers is determined.

4. In the fuel injection pump as defined in claim 3, said means for positive control of the plunger displacement including finger members in contact with said outer end portions of said plungers and with said tapered inner surface of said sleeve member.

5. In the fuel injection pump as defined in claim 3, said sleeve member being part of a base circle cam ring having a tapered internal surface for operative engagement with said outer ends of said plungers and meshing between the cam lobes on said cam ring whereby outward travel of said plungers is controlled positively by mechanical means.

6. In an internal combustion engine, a single pumping unit distributor type fuel injection pump including a pump housing having an axial bore therein and discharge passages for receiving pressurized fuel in communication therewith, a rotor adapted to be positioned within said bore having an axial passage and a plurality of radial passages leading therefrom and serving as the inlet and discharge for pressurized fuel passing through said rotor in said axial bore into said discharge passages, said rotor having a flange portion with a radial chamber therein and pumping means comprising a plunger housed therein for reciprocating movement, said radial chamber being in

communication with said axial passage within said rotor, a cam surface located for operative contact with the external end of said plunger whereby the rotation of said rotor moves said plunger in inward pumping motion to force pressurized fuel from said chamber and axial passage into said discharge passages in said housing, and means for preventing the flash vaporization of fuel in said rotor including means for positive control of outward movement of said plunger comprising a sleeve member mounted on said rotor and capable of axial adjustment therealong for contact with the outer end portion of said plunger and means for preventing return of pressurized fuel from said discharge passages comprising valve means therein.

7. In a single pumping unit distributor type fuel injection pump comprising a pump housing having an axial bore with fuel inlet and discharge passages leading therefrom and a fuel distributing and pumping means comprising a rotor having an axial passage with fuel inlet and discharge passages leading therefrom adapted to be placed in communication with the corresponding passages in said housing when said rotor is positioned and rotated in said bore, said rotor having a diametral chamber in communication with said axial passage, a pair of plungers housed in said chamber and forming a fuel pumping means therewith, and internal cam means located in a section of said housing in operative position with the outer ends of said plunger so that when said rotor revolves within said axial bore of said housing said plungers are moved radially outward when said fuel inlet passages in said pump housing and said rotor are in communication with each other and fuel is being admitted to the

rotor, and being forced inward when said discharge passages in said pump housing and said rotor are in communication with each other and fuel is being delivered to individual engine cylinders, means for preventing deterioration of fuel injection characteristics including fuel flashing comprising, in combination therewith, means for positively limiting outward movement of said pump plungers comprising rotor mounted means including a sleeve member for operative engagement with the outer end portions of said plungers, means for continuously filling of fuel, and means for preventing back flow of fuel from discharge passages of said pump comprising valve means positioned therein, said sleeve member of said rotor mounted means being adapted for axial movement therealong and having a tapered inner surface, said means for positively limiting outward movement of said pump plunger including finger members in contact with said outer end portions of said plungers and with said tapered inner surface of said sleeve member.

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