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Feb. 3, 1970 T. O. PAINE 3,492,947

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FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

Filed Feb. 10, 1969 3 Sheets-Sheet 1

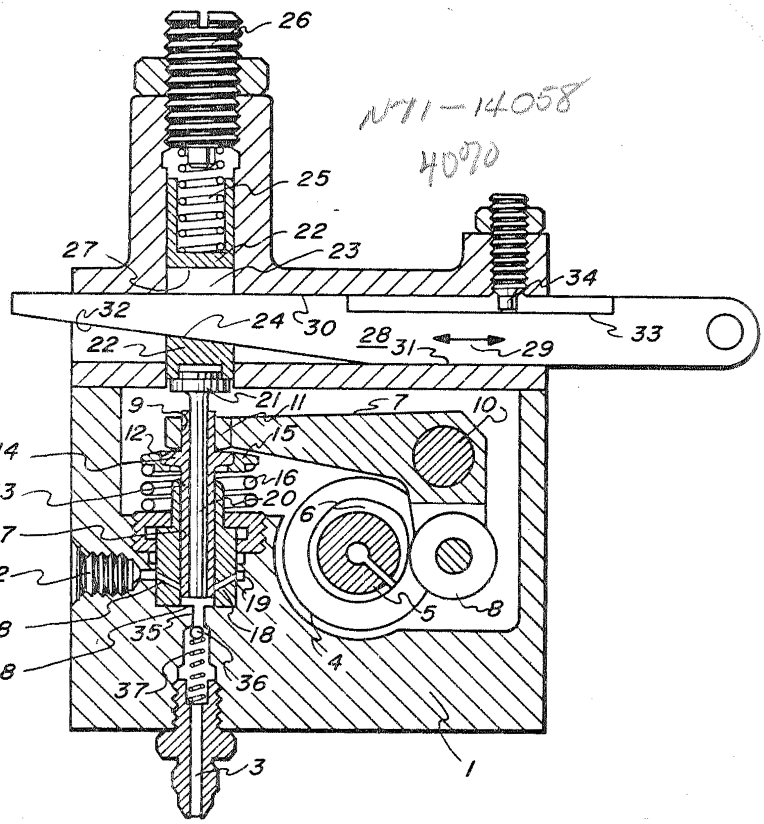

FIG. 1

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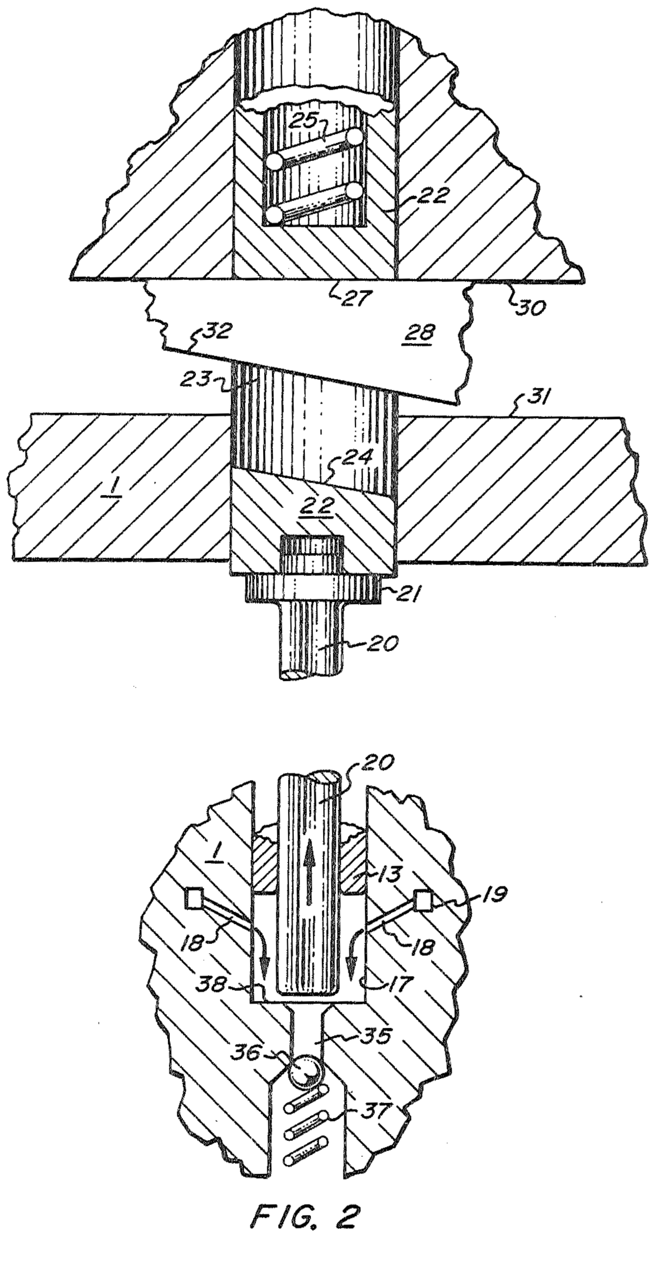

FIG. 2

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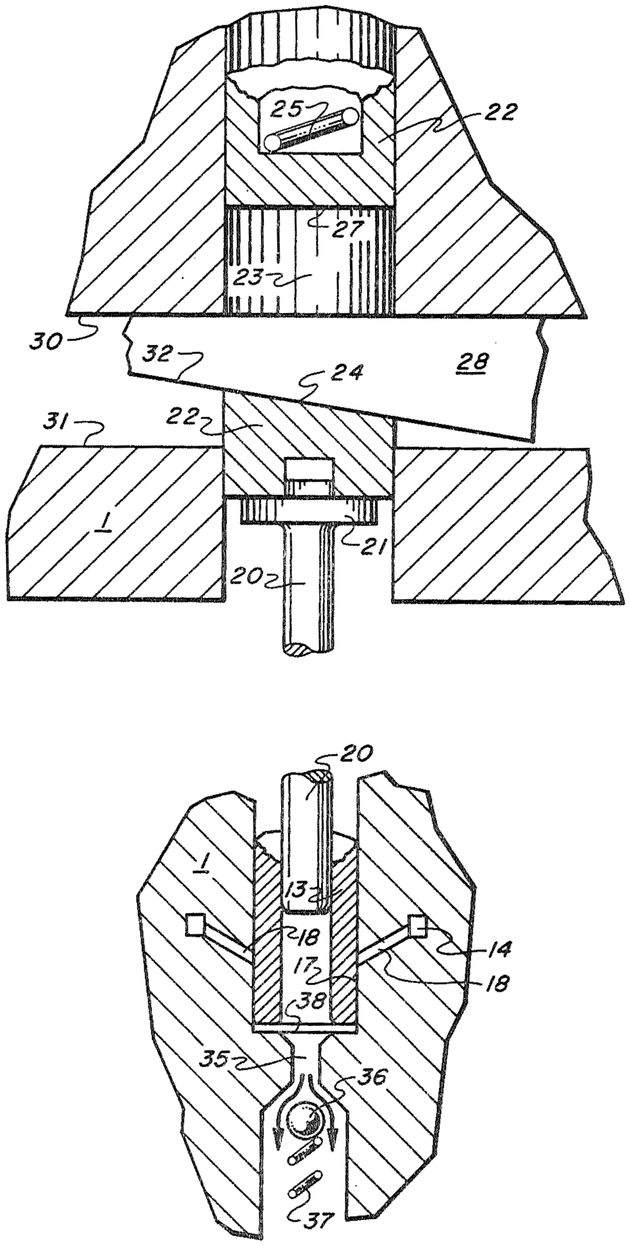

Fig. 3

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United States Patent Office

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3,492,947

FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES

T. O. Paine, Acting Administrator of the National Aeronautics and Space Administration, with respect to an invention of John H. Danskin, Northridge, Calif.

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Int. Cl. F04b *49/00, 19/02*
U.S. Cl. 103—37 4 Claims

ABSTRACT OF THE DISCLOSURE

A variable displacement volume fuel injection pump for internal combustion engines comprises an axially reciprocating tubular displacement plunger (d.p.) having an axial through-bore. The pump cylinder head end of the d.p. is resiliently biased to a constant first position remote from the pump cylinder head and is driven against the force of said resilient bias by an engine cam driven rocker arm to a constant second position more proximate of said cylinder head. Reciprocally disposed within said d.p. through-bore is a cylindrical volume control plunger (v.c.p.) that is resiliently biased to a constant first position proximate of said cylinder head and is extruded against the bias thereof through said through-bore to a variable second position, determined by the position of a selectively variable abutment surface, by the pressure force of a charge of fuel in said cylinder displaced by said d.p. upon moving from said first to said second respective positions. The volume of fuel displaced by said d.p. in moving from said first to said second respective positions equals or exceeds the volume evacuated by said v.c.p. upon extrusion from the first to the second positions respective thereto. The excess fluid volume displaced by said d.p. is discharged from the pump cylinder past a resiliently biased check valve into a pump discharge conduit.

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435, 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

The efficient operation of internal combustion engines designed to exploit thermodynamic principles embodied in Otto and Diesel cycles, for example, relies upon the ability of the machine to provide the correct ratio of fuel and oxidant to the combustion chamber thereof in quantities proportional to the power demanded from the engine. Furthermore, the respective quantities of fuel and oxidant must be correctly and homogeneously combined within the engine combustion chamber to constitute a combustible charge.

Theoretically, the above objectives are best accomplished in an air breathing engine, naturally inducted or supercharged, by injecting the fuel directly into the combustion chamber under sufficiently high pressure as to cause complete vaporization and mixing.

In practice, these functions are performed by fuel injection pumps usually having a pumping piston and cylinder element respective to each power cylinder in the engine. As an additional complicating factor, each of these pump elements must include some mechanism for regulating the quantity of fuel delivered on each pulse responsive to the instantaneous power demand from the engine. In the case of a multicylinder engine, the calibration of prior art mechanisms so that each element delivers a uniform

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quantity of fuel to each respective engine cylinder under all load conditions becomes quite complex for this purpose.

Accordingly, direct injected fuel delivery systems for I.C. engines have not been widely accepted by the industry due to the manufacturing and maintenance economics associated with fuel injection pumps of the prior art. In lieu thereof, aspirated fuel systems have been adopted by a majority of the I.C. power industry notwithstanding the compromise of operational efficiency incident thereto.

It is, therefore, an object of this invention to teach the construction of a fuel injection pump that is adapted to inexpensive manufacturing and maintenance techniques.

A further object of this invention is to provide a reciprocating element pump in which the fluid discharge quantity may be rapidly and continuously adjusted.

Another object of this invention is to provide a variable discharge volume system for a multielement reciprocating pump that is simple to calibrate and operate.

SUMMARY

To accomplish the foregoing objects, a fuel injection pump cylinder according to the present invention is provided with a tubular displacement plunger (d.p.) having an axial through-bore. The d.p. extends beyond the axial end of the pump cylinder and has a collar disposed about the periphery thereof. A coil spring seated between a portion of the pump housing structure and the proximate side of the d.p. collar urges the d.p. away from the head end of the pump cylinder. On the side of the d.p. collar opposite from the spring seat, an engine cam driven rocker arm forces the reciprocation of the d.p. toward the cylinder head end against the bias of the spring.

Within the d.p. through-bore, a solid cylindrical volume control plunger (v.c.p.) is slidably disposed to axially reciprocate therein. A portion of the v.c.p. projecting beyond the d.p. collar end is provided with an abutment surface which engages a co-operative, selectively positionable, abutment surface to limit the extrusion of the v.c.p. when the pump cylinder pressure becomes sufficiently great as to force the v.c.p. out through the d.p. through-bore against the bias of another spring urging the v.c.p. toward the cylinder head end.

In operation, the fluid admitted to the cylinder pressure chamber from intake conduits is trapped between the fluid end of the d.p. and the cylinder head with the annulus that is formed by the cylinder wall and the outer peripheral wall of the v.c.p. As the d.p. continues its inward stroke, the pressure on the trapped fluid forces the v.c.p. out through the d.p. through-bore with the volume evacuated by the v.c.p. equaling that displaced by the d.p. The extrusion of the v.c.p. continues until the co-operative abutment surfaces engage to halt the extrusion. Depending on the position of the adjustable abutment surface. the d.p. may have a portion of stroking distance remaining whereupon the fluid pressure is further increased to overcome the sealing pressure of a check valve disposed in the fluid discharge conduit for high pressure fluid delivery.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects of the present invention may be more readily seen and understood by reference to the following detailed description of the drawing wherein:

FIGURE 1 is a cross-sectional elevation of a typical pumping unit constructed according to the invention.

FIGURE 2 is a partial view of the pump illustrated in FIG. 1 showing the relative positions of key pump and volumetric control elements at the fluid intake portion of the pumping cycle.

FIGURE 3 is a partial view of the pump illustrated in FIG. 1 showing the relative positions of key pump and volumetric control elements at the fluid discharge portion of the pumping cycle.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, there is shown the cross-section of what may be a single pumping unit of a multiple unit pump. When used as a reciprocating internal combustion (i.c.) engine fuel injection pump, there will usually be a number of pumping units equal to the number of power cylinders in the associate engine.

The body 1 of the pump is provided, for each pumping unit, a fuel inlet conduit 2 which may communicate with a pressurized distribution manifold not shown. Also provided for each pumping unit is a discharge conduit 3 which may communicate at the terminal end thereof with injector nozzles for discharging a precisely metered quantity of fuel directly into the engine combustion chamber in a fine mist conducive of rapid mixing and vaporization with an air charge. Bearing journals 4 are provided to rotatively support an engine driven cam shaft 5 having lobes 6. Cam shaft lobes 6 cause the oscillation of bell crank 7 by turning against the cam follower 8 rotatively supported at one bell crank end.

The other end of the bell crank 7 is provided with an aperture 9 for reasons to become obvious subsequently. The internal bore of aperture 9 should be crowned to avoid structural interference between the aperture walls and the driving end 11 of the displacement plunger 13 as the bell crank oscillates about the axis of rocker shaft 10. Hammer surface 12 is also crowned and hardened for striking displacement plunger collar 14.

A spring seating collar 15 is provided to abut the under surface of collar 14 and act as a seat and reaction surface for displacement plunger biasing spring 16.

The pump cylinder 17 is provided with a plurality of intake conduits 18 emanating radially inward from a manifold ring 19 which is in fluid communication with fuel inlet conduit 2. The penetration point by intake conduits 18 of cylinder wall 17 is determined by the cylinder fill rate at maximum pump operational speed. Co-operatively, said penetration point determines the maximum extracted position of the fluid end-face of displacement plunger 13.

Slidably disposed within the hollow interior of displacement plunger 13 is a solid cylindrical rod-like volume control plunger 20. The volume control plunger projects axially beyond the driving end 11 of displacement plunger 13 and is provided with an end collar 21. The upper face annulus of end collar 21 is engaged by the co-operative end of metering plunger 22.

Metering plunger 22 is constructed with a stirrup opening 23 having an inclined abutment surface 24. Spring 25 serves to bias metering plunger 22 into firm engagement with the upper face annulus of end collar 21. Set screw 26 provides an adjustable seating surface for spring 25 to regulate the biasing force thereof.

To limit and control the reciprocatory displacement of metering plunger 22 between abutment surfaces 24 and 27, a metering wedge 28 is provided to project through stirrup opening 23. Movement of the metering wedge 28 is restricted by parallel surfaces 30 and 31 of the pump body 1 to reciprocatory motion in the direction indicated by arrow 29. Inclined abutment surface 32 of metering wedge 28 is constructed with approximately the same slope as that of metering plunger inclined abutment surface 24.

In order to limit the reciprocatory motion of metering wedge 28, a limiting slot 33 may be provided in wedge 28 to co-operate with limiting pin 34.

Referring finally to the discharge orifice 35 from cylinder 17, a resiliently biased check valve obturating element 36 is provided to seal the cylinder against a predetermined pressure. The preset tension in spring 37 determines the cracking pressure at which obturating element 36 will move away from its associate seat to allow fluid to flow from cylinder 17 into discharge conduit 3.

OPERATION

It will be readily seen from a cursory purview of FIG. 1 that the linear displacement of bell crank 7 hammer end 12 is determined by the product of the radial differential between the cylindrical surface of cam 5 and lobe 6 multiplied by the length ratio of bell crank follower arm 8 length to the hammer arm length. This linear displacement will dictate the reciprocating stroke of displacement plunger 13 and hence, the volume of cylinder 17 displaced thereby.

A typical pumping cycle is initiated by cam follower 8 contacting the cylindrical portion of cam shaft 6 as illustrated in FIG. 1. Accordingly, hammer surface 12 of bell crank 7 is rotated to the maximum clockwise direction thereby allowing the bias of spring 16 to push displacement plunger 13 to the maximum withdrawn position relative to cylinder head 38. See FIG. 2. In this position, the intake conduit 18 penetration points of cylinder 17 are open to allow fluid to flow into and fill the cylinder void.

Simultaneously, the biasing force of metering plunger spring 25 prevails over the cylinder 17 pressure force acting on the cross-sectional area of volume control plunger 20 thereby pushing the fluid end face of volume control plunger 20 to the maximum inward position relative to cylinder head 38.

Because of the presence of volume control plunger 20 in cylinder 17, the maximum cylinder void to be filled by incoming fluid is essentially limited to the annular space between the fluid end face of displacement plunger 13 and the cylinder head 38.

As the cam 5 rotates such that the follower 8 is contacted by lobe 6, hammer surface 12 acts against displacement plunger collar 14 to force the displacement plunger inwardly toward cylinder head 38 against the bias of spring 16. The consequence of this displacement of plunger 13 is to seal the intake conduits 18 as the plunger moves inwardly (FIG. 3) and displace the fluid trapped in the annulus between displacement plunger fluid end face and cylinder head 38. To accommodate the fluid displaced by this action, the bias force of metering plunger spring 25 is exceeded and volume control plunger 20 is extruded from the cylinder 17. Such extrusion continues until the inclined abutment surface 24 of metering plunger 22 contacts the inclined abutment surface 32 of metering wedge 28. When this occurs, the continued inward advance of displacement plunger 13 raises the pressure of the fluid trapped in cylinder 17 sufficiently to overcome the sealing force exerted by spring 37 on the obturating element 36 in the discharge orifice 35. Accordingly, a quantity of fluid equal to the volumetric displacement of displacement plunger 13 after the abutment of metering plunger 22 with wedge 28 is discharged into conduit 3 under high pressure.

As will be observed from FIG. 1 the extent to which volume control plunger 20 is extruded from cylinder 17, thereby determining the quantity of fluid discharged into conduit 3, is a function of where, along the length of inclined surface 32, metering plunger 22 strikes the wedge 28. This relation is regulated by the selective positioning of wedge 28 along the line indicated by arrow 29. Such regulation of the wedge 28 position is executed by the engine throttle mechanism.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. For example, the throttling mechanism including the metering wedge 28 and plunger 22 may be supplanted by other mechanisms which will provide a selectively positionable abutment surface for limiting the extruded displacement of volume control plunger 20. The term reciprocation, as used in the following claims, is intended to also encompass the technical definition of oscillation. Furthermore, such geometrically descriptive terms as cylindrical are intended to encompass other shapes such as elliptical and toroidal that are compatible with the spirit of the invention.

What is claimed is:

1. A fuel injection pump for internal combustion engines comprising:

pump body means;

cylinder means in said body having an open bore end and head end;

inlet fluid conduit means communicating with said cylinder intermediate of said ends;

discharge fluid conduit means communicating with said cylinder proximate of said head end;

first tubular plunger means having an axial through-bore disposed for axial reciprocation within said cylinder means and extending beyond said bore end;

second cylindrical plunger means disposed for axial reciprocation within the through-bore of said tubular plunger means, said second plunger means extending beyond the bore end of said first plunger means;

first resilient biasing means urging the head end of said first plunger means to a first position most remote from said cylinder head end;

second resilient biasing means urging the head end of said second plunger means to a first position most proximate of said cylinder head end;

powered stroking means forcing said first plunger means to a second position most proximate of said cylinder head end;

selectively positionable abutment means limiting the withdrawal of said second plunger means to a variable second position remote from said cylinder head end; and

resiliently biased unidirectional flow control means disposed in said dicharge fluid conduit means whereby the fluid pressure force imposed on a fluid fuel charge in said cylinder by said first plunger means in moving from first to second respective positions exceeds the fluid pressure force required to move said second plunger from first to second respective positions against the force of said second biasing means but is less than the fluid pressure force required to open said unidirectional flow control means until said second plunger means strikes said seletcively positionable abutment means whereupon substantially all fluid displaced by said first plunger means after said abutment means striking is discharged into said discharge conduit means.

2. Apparatus as described by claim 1 wherein said first tubular plunger means is provided with radially projecting abutment surface means having annular face means, the approximate plane of said annular face means disposed substantially perpendicular to said first plunger axis, said annular face means being positioned between said cylinder bore end of said first plunger means and said cylinder bore end of said cylinder.

3. Apparatus as described by claim 2 wherein said powered stroking means comprises cam means, said cam means acting upon said annular face means to force said first plunger means to said second position;

said first resilient bias means acting upon said annular face means to urge said first plunger to said first position.

4. Apparatus as described by claim 3 wherein said cam means comprises substantially cylindrical aperture means and annular striking face means, the approximate plane of said striking face means disposed substantially perpendicular to the axis of said cylindrical aperture means;

a portion of said first plunger means between the cylinder bore end thereof and said first plunger annular face means being slidably disposed within said cylindrical aperture means.

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U.S. Cl. X.R.

103—158