Jan. 7, 1969 T. S. CHMURA ET AL 3,420,179

PLUNGER BALANCING ARRANGEMENT FOR FUEL INJECTION PUMPS

Filed June 22, 1967 Sheet 1 of 2

FIG. 1.

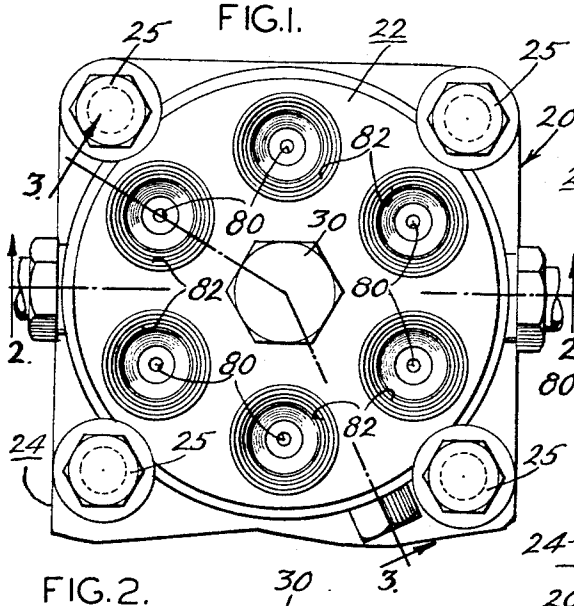


FIG. 3.

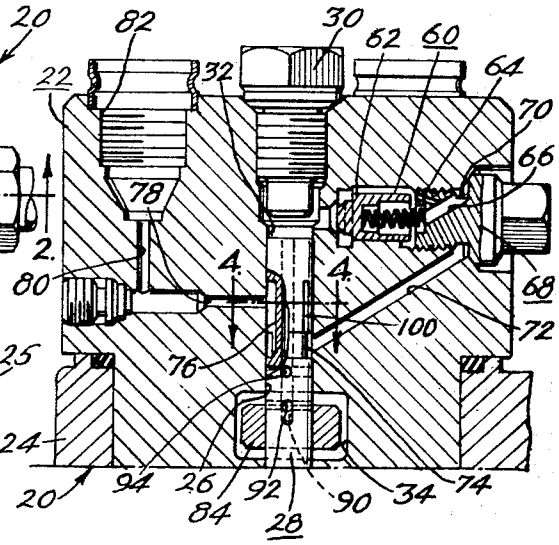


FIG. 2.

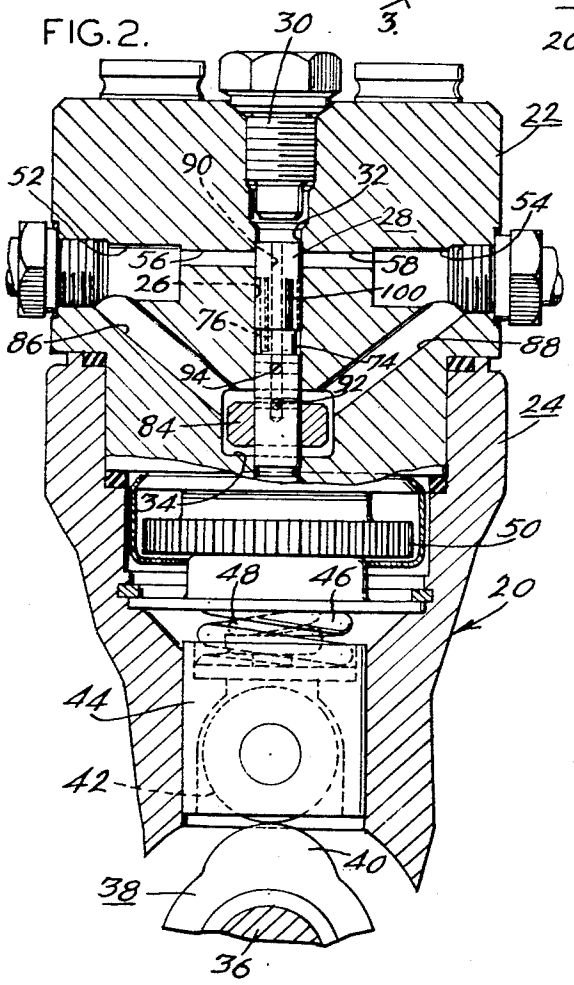
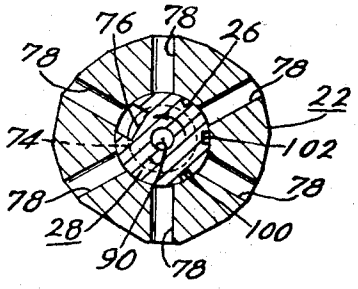


FIG. 4.



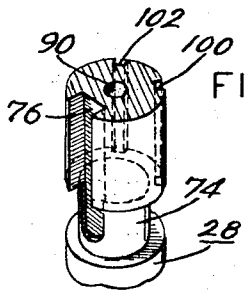


FIG. 5.

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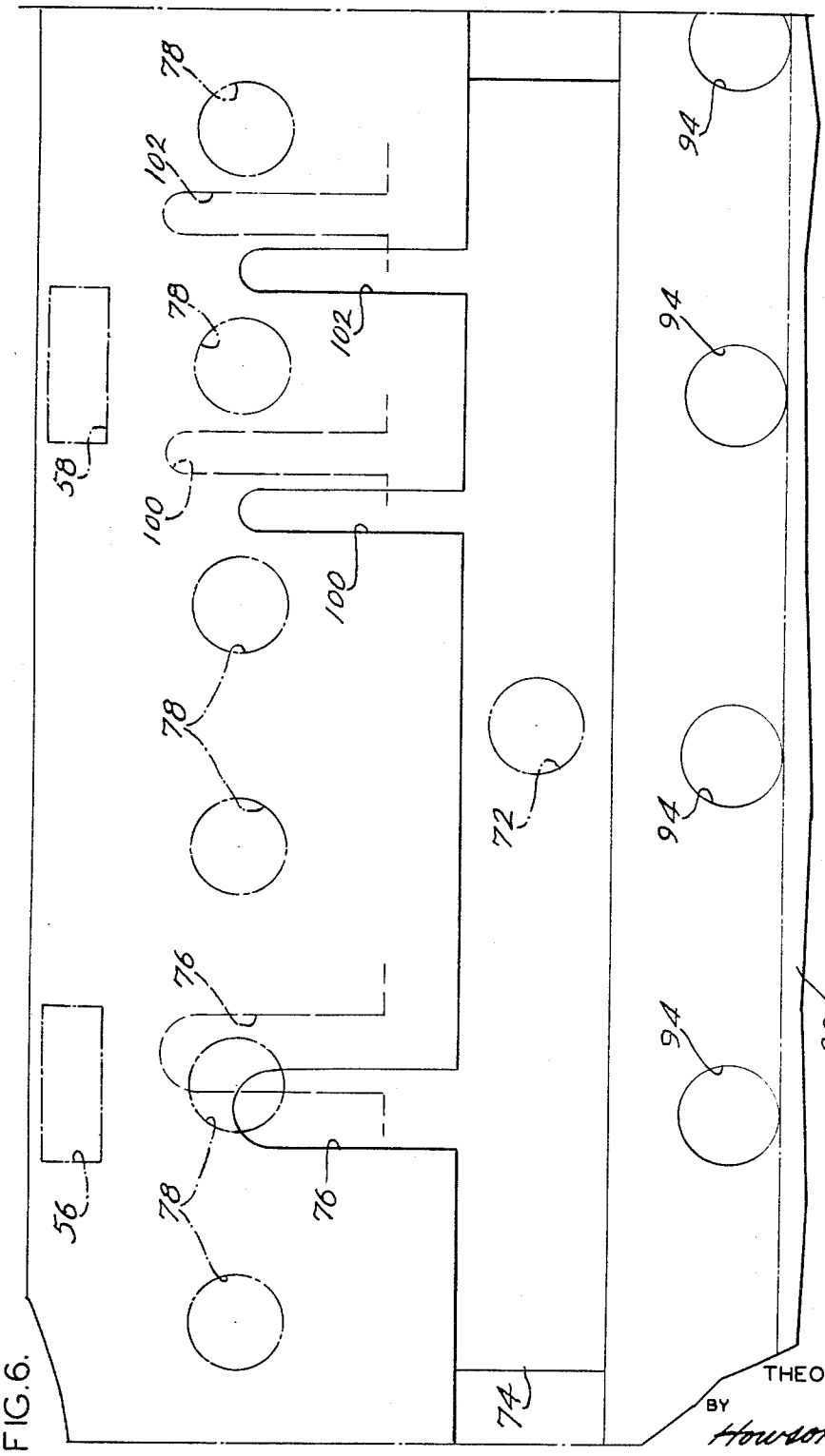

FIG. 6.

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PLUNGER BALANCING ARRANGEMENT FOR FUEL INJECTION PUMPS

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U.S. Cl. 103—2 4 Claims

Int. Cl. F04b *13/00;* F04b *15/00;* F02m *39/00*

ABSTRACT OF THE DISCLOSURE

A plunger balancing arrangement for distributor type fuel injection pumps having a rotating and reciprocating plunger which includes a fuel distributor slot communicating with a plunger annulus into which high pressure fuel is intermittently pumped by the reciprocation of the plunger. By the present invention, the unbalanced side loading of the plunger normally caused during injection by the high pressure fuel in the distributor slot is eliminated by the provision of one or more balancing slots in the plunger communicating with the plunger annulus and having a combined area and location sufficient to provide a radial force equal and opposite that produced by the pressurized fuel in the distributor slot. The balancing slots are positioned so as to be out of communication with the fuel distributor passages during the injection phase of the plunger stroke.

The present invention relates generally to fuel injection pumps of the type having a single reciprocating and rotating plunger to provide a pumping and distribution of the fuel and which includes a fuel distributor slot on the plunger for successive communication with spaced fuel distributor passages. More particularly, the invention is directed to an arrangement for balancing the radial force produced during injection by the high pressure fuel in the plunger distributor slot.

Fuel injection pumps of the type having a single reciprocating and rotating plunger for sequentially pumping and distributing fuel to a plurality of outlet ports by means of a distributor slot in the plunger have enjoyed widespread usage in recent years. A pump of this type is illustrated and described in U.S. Patent 2,518,473, issued Aug. 15, 1950. In some applications, the fuel pressure peaks in such pumps may reach extremely high values, in the order of 16,000 to 20,000 p.s.i. The pump plunger is subjected intermittently to the high injection pressures in the plunger annulus and the communicating distributor slot. Since the plunger annulus is of a uniform width around the circumference of the plunger, the net radial force of the high pressure fuel in the annulus tending to move the plunger radially against the pump head bore is zero. However, the high pressure fuel in the distributor slot provides a substantial and undesirable radial or side loading of the plunger, particularly when the fuel pressure peaks reach the extremely high values indicated above. This side loading of the plunger not only causes rapid wear of the plunger but, in addition, can cause plunger seizure during high pressure pump operation. The unbalanced condition of the plunger during the injection phase of the cycle can thus affect the efficient operation of the pump as well as substantially shorten the pump life under high pressure operating conditions.

In the present invention, the unbalanced plunger condition during injection is corrected by the provision of one or more pressure balancing slots in the plunger opposed from the distributor slot. The pressure balancing slots communicate with the plunger annulus and are axially coextensive with the distributor slot. The area and location of the balancing slots is selected to provide a combined radial force equal and opposite to the radial force produced by the distributor slot during the fuel injection period. The locations of the pressure balancing slots are selected to avoid communication with the fuel distributor passages during the injection phase of the plunger stroke. The communication of the pressure balancing slots with the fuel distributor passages at other times is of no conecrn since the slots and passages will at such times contain only fuel at low residual line pressures.

It is accordingly a primary object of the present invention to provide a plunger balancing arrangement for distributor type fuel injection pumps which will effectively eliminate the undesirable unbalanced side loading of the plunger caused by high fuel injection pressures in the plunger distributor slot.

A further object of the invention is to provide a plunger balancing means as described to eliminate the excessive wear of the plunger and pump head bore caused by unbalanced side loading of the plunger during the injection cycle.

Another object of the invention is to provide a plunger balancing arrangement as described which eliminates the unbalanced side loading of the plunger as a cause of plunger seizure during high pressure operation of the pump.

Additional objects and advantages of the invention will be more readily apparent from a consideration of the following detailed description of an embodiment thereof when taken together with the accompanying drawings in which:

FIG. 1 is a partial plan view of a fuel injection pump embodying the present invention showing the hydraulic head thereof;

FIG. 2 is a partial sectional view taken along line 2—2 of FIG. 1 showing details of the pump hydraulic head;

FIG. 3 is a partial sectional view taken along line 3—3 of FIG. 1 showing further details of the hydraulic head;

FIG. 4 is an enlarged partial sectional view taken along line 4—4 of FIG. 3 and showing the position of the balancing ports in the plunger with respect to the distributor port;

FIG. 5 is a partial perspective view partly in section of the plunger of the pump of FIGS. 1–4; and

FIG. 6 is a development of the plunger and hydraulic head bore.

Referring to the drawings and particularly FIGS. 1–3 thereof, a fuel injection pump generally designated **20** is partially shown and includes a hydraulic head **22** secured to a main pump housing **24** by bolts **25**. The hydraulic head **22** includes a central vertical bore **26** within which a plunger **28** is slidably disposed, the plunger in conjunction with a threaded bore plug **30** defining a fuel distribution chamber **32** in the upper end of the bore. The plunger passes through a sump or spill chamber **34** in the lower part of the hydraulic head and is rotatably and reciprocally driven for delivering fuel to cylinders of an internal combustion engine (not shown).

The pump is driven by the engine by means of the cam shaft **36** which is journaled in the pump housing **24**. A cam **38** on the cam shaft having a plurality of cam lobes **40** coacts with roller **42** of tappet **44** and, in conjunction with the helical return springs **46** and **48**, effects a reciprocating vertical stroke of the plunger. Rotation of the plunger is effected by means of a vertical quill shaft (not shown) geared to the cam shaft and having a gear at the upper end thereof meshing with the sliding gear **50** on the

plunger. The rotation of the cam shaft **36** thus causes both a reciprocation and rotation of the plunger.

The hydraulic head **22** includes fuel inlet ports **52** and **54** on opposite sides thereof to which fuel under pressure is supplied by a suitable fuel supply pump (not shown). The inlet ports **52** and **54** communicate respectively with the fuel supply passages **56** and **58** which in turn open into the fuel distribution chamber **32** when the plunger is in a lowered position. The pressurized fuel passes through the passages **56** and **58** into the fuel distribution chamber when the plunger exposes the passages to the chamber and is pumped sequentially to the cylinders of the engine by the upward strokes of the plunger, the fuel in the chamber being forced through fuel delivery check valve **60** shown in FIG. 3. Fuel flowing through the check valve passes around the valve plunger **62** and through passages **64** and **66** in the plug **68** to an annulus **70** in the plug. The fuel passes from the annulus **70** through passage **72** in the hydraulic head into annulus **74** of the plunger and then into the plunger distributor slot **76**, which sequentially communicates with spaced distributor passages **78** in the pump head during rotation of the plunger. Each distributor passage **78** communicates with an outlet passage **80** from which fuel is discharged through an outlet port **82** to a cylinder of the engine, the cylinder being connected thereto by means of suitable tubing. The number of ports **82** corresponds with the number of engine cylinders, six in the present instance.

The amount of fuel delivered by the pump is regulated by the position of a control sleeve **84** slidably located on the plunger in the sump **34**. The control sleeve is vertically positioned on the plunger by means of a conventional stub shaft and eccentric pin connected with the pump control linkage, none of which is shown in the present drawings in view of its conventional character. A pair of downwardly inclined fuel conduits **86** and **88** extend from the fuel inlet ports **52** and **54** to connect the inlet ports with the sump **34** and thus provide the fuel supply pressure in the sump. The plunger includes an axial bore **90** which extends from the upper end of the plunger to the radial spill ports **92** communicating with the sump **34**. When the spill ports **92** are covered by the control sleeve **84**, fuel cannot pass from the fuel distribution chamber through bore **90** to the sump. However, when the spill ports clear the sleeve toward the end of the plunger pumping stroke, the pressure in the fuel distribution chamber is reduced to the sump pressure, permitting the check valve **60** to close and stopping further fuel delivery. By adjustment of the vertical sleeve position, the duration of the pumping action and hence the amount of fuel delivered may be accurately controlled. Radial ports **94** in the plunger spaced above the spill ports **92** permit the plunger bore **90** to communicate with the sump during the lower part of the plunger stroke to assist in filling the fuel distribution chamber.

In the conventional pump structure described thus far, the extremely high fuel injection pressures, which may reach 16,000 to 20,000 p.s.i. as indicated above, cause severe unbalance of the plunger during the injection phase of the cycle, resulting in excessive wear of the plunger and hydraulic head bore and an increased possibility of plunger seizure. To correct this imbalance, in the present invention one or more balancing slots are provided in the plunger communicating with the plunger annulus and having a combined area and position sufficient to produce a radial force equal and opposite to the force produced by the distributor slot.

As shown in the drawings, and particularly FIGS. 4 and 5 thereof, in the embodiment illustrated the plunger **28** is provided with a pair of balancing slots **100** and **102** which extend from the plunger annulus **74** axially along the plunger. The balancing slots are the same length as the distributor slot **76** and have a combined area sufficient considering their location on the plunger to provide a combined force during the injection phase of the plunger

cycle to fully counteract the radial force developed in the distributor slot **76**.

As shown in the plunger and hydraulic head bore development of FIG. 6, the balancing slots **100** and **102** do not communicate with any of the distributor passages **78** during the injection phase of the plunger cycle. As shown in FIG. 6, the distributor slot during the injection phase is in communication with one of the distributor passages **78** at which time the balancing slots **100** and **102** are located between ones of the distributor passages **78**. At the end of the injection phase as illustrated in broken lines in FIG. 6, the distributor slot is still in communication with the distributor passage **78** while the balancing slots have not yet come into communication with the distributor passages. At such time the balancing slots **100** and **102** do communicate with the distributor passages **78**. The balancing slots may thus traverse the distributor passages between the injection phases of the plunger stroke without in any way affecting the pump operation.

The operation of the pump with the improvement of the present invention is the same as that of the conventional pump, the balancing slots in communication with the plunger annulus being filled with fuel at the same high injection pressures as the distributor slot during the injection phase of the plunger cycle. As described above, the balancing slots are of the proper size and location to provide a combined force equal and opposite to that produced by the distributor slot during the injection phase to balance the plunger and accordingly reduce friction and the chance of plunger seizure.

Should the pump be designed for an engine having an odd number of cylinders, a single balancing slot would suffice since the distributor passages would then not be diametrically opposed in the bore of the hydraulic head. The usual pump, however, is designed with an even number of distributor passages and the passages are thus normally in diametrically opposed relation so that the use of at least two balancing slots as illustrated in the present embodiment is necessary.

Manifestly, changes in details of construction can be effected by those skilled in the art without departing from the spirit and the scope of the invention as defined in and limited solely by the appended claims.

We claim:

1. In a fuel injection pump including a hydraulic head having a bore therein, a plunger rotatably and slidably disposed within the bore, a closed end of the bore defining a fuel distribution chamber in conjunction with one end of the plunger, means for introducing fuel into the fuel distribution chamber, means for providing a reciprocating and rotation motion of the plunger, means connecting the fuel distribution chamber with a distributor slot in the plunger, said means providing reciprocating and rotating motion of the plunger effecting a pumping of fuel into said distributor slot by said plunger from the fuel distribution chamber when said distributor slot is sequentially indexed with equally spaced fuel distribution passages in the bore, the improvement comprising slot means in the plunger opposed from the plunger distributor slot, said slot means communicating with said means connecting the fuel distribution chamber with the distributor slot, said slot means being located on said plunger to avoid communication with any of said distributor passages during the injection phase of the plunger stroke, the area and location of said slot means providing a radial force equal and opposite to that provided by said distributor slot during the injection phase of the plunger stroke to thereby provide a radial balance of the plunger during fuel injection.

2. In a fuel injection pump including a hydraulic head having a bore therein, a plunger rotatably and slidably disposed within the bore, a closed end of the bore defining a fuel distribution chamber in conjunction with one end of the plunger, means for introducing fuel, into the

fuel distribution chamber, means for providing a reciprocating and rotating motion of the plunger, passage means in the hydraulic head connecting the distribution chamber with an annulus in the plunger, a plurality of distributor passages in the hydraulic head radially intersecting the bore at equally spaced circumferential intervals, and a distributor slot in the plunger communicating with the plunger annulus and adapted to sequentially connect the annulus and hence the fuel distribution chamber with the distributor passages during rotation and reciprocation of the plunger, the improvement comprising at least one balancing slot in said plunger opposed from the plunger distributor slot, said balancing slot being located on said plunger to avoid communication with any of said distributor passages during the injection phase of the plunger stroke, said balancing slot extending axially along said plunger and communicating with the plunger annulus, the area and location of said balancing slot providing a radial force equal and opposite to that provided by said distributor slot during the injection phase of the plunger stroke to thereby provide a radial balance of the plunger during fuel injection.

3. The invention as claimed in claim 2 wherein said balancing slot is axially coextensive with the plunger distributor slot.

4. In a fuel injection pump including a hydraulic head having a bore therein, a plunger rotatably and slidably disposed within the bore, a closed end of the bore defining a fuel distribution chamber in conjunction with one end of the plunger, means for introducing fuel into the fuel distribution chamber, means for providing a reciprocating and rotating motion of the plunger, passage means in the hydraulic head connecting the fuel distribution chamber with an annulus in the plunger, a plurality of distributor passages in the hydraulic head radially intersecting the bore at equally spaced circumferential intervals, and a distributor slot in the plunger communicating with the plunger annulus and adapted to sequentially connect the annulus and hence the fuel distribution chamber with the distributor passages during rotation and reciprocation of the plunger, the improvement comprising a plurality of balancing slots in said plunger opposed from the plunger distributor slot, said balancing slots extending axially along said plunger coextensive with said distributor slot and communicating with the plunger annulus, the location of said balancing slots on said plunger preventing communication of said balancing slots with any of said distributor passages during the injection phase of the plunger stroke, the area and location of said balancing slots providing a radial force equal and opposite that provided by the distributor slot during the injection phase of the plunger stroke to thereby provide a radial balance of the plunger during fuel injection.

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