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FUEL INJECTION PUMP WITH PNEUMATIC DAMPER

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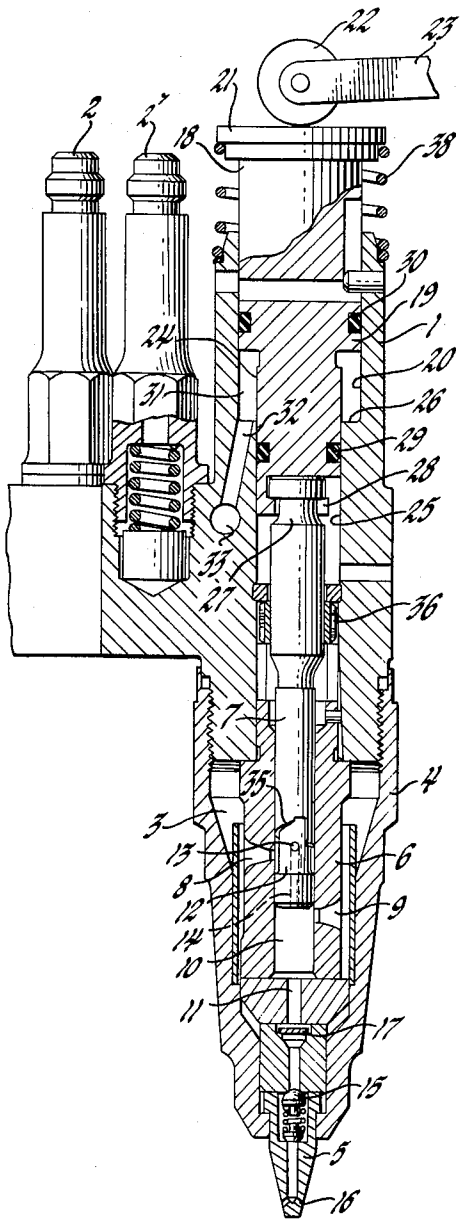


Fig. 1

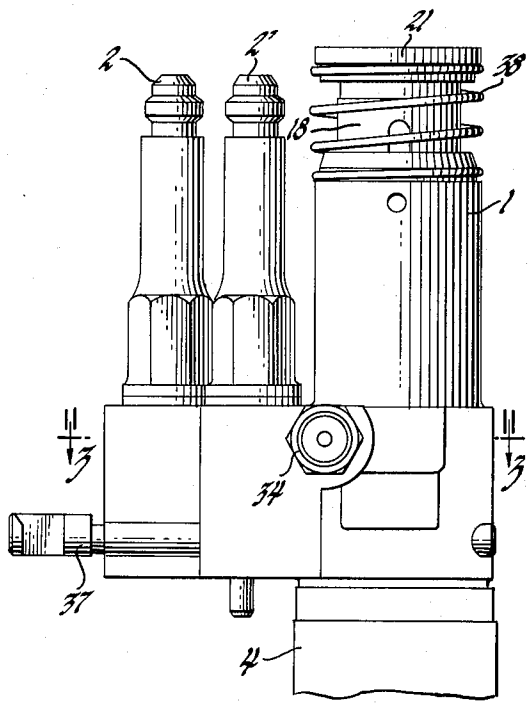


Fig. 2

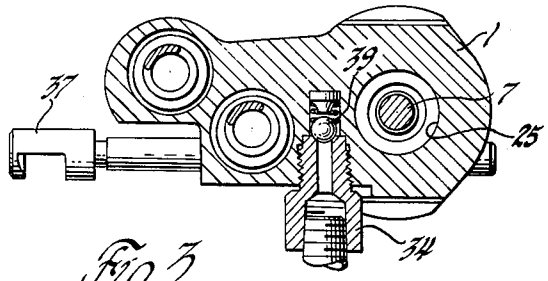


Fig. 3

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FUEL INJECTION PUMP WITH PNEUMATIC DAMPER

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This invention relates to fuel injection pumps, and particularly those of the so-called "jerk" type wherein the injection pressure developed by a spring opposed plunger during its pumping stroke is suddenly dissipated to end the injection by the plunger uncovering a bypass port in the side wall of the pumping chamber.

The principal object of this invention is to provide means to eliminate destructive surge of the pump plunger return spring.

It has been found from experience that in some engine installations the plunger return spring surges at certain engine speeds, and that this surge is caused by the sudden pressure drop in the pump chamber at the end of the injection period. This sudden reduction of hydraulic pressure acting on the lower plunger area, being resisted by the spring-action of the rocker-lever and associated drive train components, excites the plunger spring to vibrate at its natural frequency.

It is the object of our invention to prevent such spring surge by employing expansible fluid under pressure in opposition to the axial movement of the plunger on its pumping stroke. Also, by using such fluid at a sufficiently high pressure in relation to its effective working area, its force tending to return the plunger after the pumping stroke may be made great enough that the conventional metallic return spring need serve only to exert sufficient biasing force to overcome the friction opposing the plunger return stroke.

A better understanding of the invention will be had from the following description with reference to the drawing, wherein:

FIGURE 1 is a longitudinal sectional view through a unit fuel injector pump constructed in accordance with the invention.

FIGURE 2 is a side elevational view of the upper portion of the unit shown in FIGURE 1.

FIGURE 3 is a sectional view taken substantially along the line 3—3 of FIGURE 2, showing the expansible fluid supply connection in greater detail.

Referring now to the drawing in detail, a unit fuel injector pump is illustrated having a pump body **1** to which fuel is supplied under pressure at a fitting **2** and is conducted through internal passages (not shown) to a reservoir chamber **3** formed in a lower extension of nut **4** threadedly secured to the lower end of the body. The nut **4** extends through a suitable opening in the cylinder head or other wall portion (not shown) of an internal combustion engine and terminates in a fuel discharge nozzle **5** within the combustion space of the engine. Suitably supported within the nut and surrounded by the annular reservoir **3** is a bushing **6** which forms the pumping cylinder for a plunger **7** reciprocably slidable therein. It will be understood that the liquid fuel within the reservoir **3** is under relatively low pressure, in the order of 30 to 40 p.s.i., supplied at the fitting **2**. In order that excess fuel may return to the tank or other source, the pump body is also provided with a return fitting **2'** which also is connected by internal passages (not shown) to the reservoir **3**. Fuel inlet and bypass ports **8** and **9** extend through the side of the bushing **6** and are controlled by the plunger so as to admit fuel within the pump chamber **10** below the plunger for delivery at high pressure, in the

order of 20,000 to 30,000 p.s.i., to the nozzle **5** via the pump chamber outlet **11** on each downward or pumping stroke of the plunger.

The plunger is also provided with bypass means to cooperate with the ports **8** and **9** in controlling the start and end of fuel injection during each such downward stroke of the plunger from its position shown. This bypass means includes an external metering groove **12** encircling the plunger at a distance above its lower end, together with transversely and axially drilled passages **13** and **14** which continuously connect the metering groove with the pump chamber **10** and outlet **11**. The fuel inlet and bypass ports **8** and **9** are located in relation to the groove **12** and the lower end of the plunger such that during each pumping stroke of the plunger it first closes off port **9**, then closes off port **8** (as groove **12** moves out of registry therewith), and thereafter reopens port **9** (as groove **12** moves into registry therewith) to relieve the high fuel pressure in the pump chamber **10** and thereby terminate the injection. The usual normally closed injection valve **15** is located in the outlet passage leading to the spray orifices **16** in the lower end of the nozzle, and shown between this injection valve and the pumping chamber is the conventional anti blow-back valve **17** for preventing engine gases entering the pump chamber in the event the injection valve should fail to close after an injection.

Means for reciprocating the plunger **7** include a combined actuator and piston **18** whose upper or piston portion **19** is slidably fitted in an upwardly open bore **20** which is provided in the upper end of the body **1**, coaxially with the plunger **7**. The upper end of the piston **19** extends above the upper end of the body and carries an enlargement or head **21** which is in driven engagement with a suitable operator, illustrated as a roller **22** on a rocker arm **23** of the engine. The lower or actuator portion **24** of the member **18** is of smaller diameter than the piston portion and is slidably guided in a reduced bore **25** extending through the pump body from the bore **20**. A shoulder or end wall **26** is located at the juncture of these bores **20** and **25**. The plunger **7** and the lower end of the actuator **24** are connected for concurrent reciprocation by suitable means, shown in the form of the necked upper end **27** of the plunger received in a U-shaped recess **28** in the lower end of the actuator. Conventional O-rings **29** and **30** are provided to seal against leakage past the actuator and piston portions of the member **18** in the bores **25** and **20**, respectively. Between the enlargement **21** and the upper end of the body is located the usual metallic coil compression spring **38** which yieldingly opposes downward movement of the plunger on its pumping stroke and acts to return the plunger to its position shown after each pumping stroke.

The annular space **31** within the bore **20** between the piston **19** and the end wall **26** serves as an expansible fluid pressure chamber, into which fluid such as air may be introduced via passages **32** and **33** from a pressure supply connection **34** (FIGURES 2 and 3).

As is conventional in unit injector pumps of this type, the metering groove **12** on the plunger has at least one helical control edge **35** which determines the timing of closure of the bushing port **8**, and hence the quantity of fuel injected during each plunger stroke, in accordance with the angular position of the plunger about its longitudinal axis. Likewise, conventional means for rotatively adjusting the plunger is also provided, in the form of a pinion **36** on the plunger and meshing with teeth (not shown) on a fuel control rack **37**. By longitudinally shifting this rack, the plunger is rotated since the pinion **36** is keyed to the plunger.

During operation, the air or other expansible fluid under pressure in the chamber **31** acts to resist downward

movement of the plunger on its pumping stroke and to bias the plunger return stroke, complementing the compressive force exerted by the metallic spring **38**. As described, such air is introduced through the supply connection **34**. Suitable means, shown in the form of a check valve **39** within the connection **34**, serves to retain the pressure in the chamber **31**; which pressure, of course, increases considerably during the pumping stroke of the plunger. Such air pressure may be supplied continuously via the connection **34** during operation of the injector pump unit on the engine, or the chamber **31** may only be charged to a sufficient pressure initially before the unit is put in operation, and at suitable intervals thereafter as necessary to compensate for such leakage as is found to occur past the seals **29** and **30**. Also, by employing such fluid at a sufficiently high supply pressure, it will serve, even in the absence of metallic spring **38**, as the means for returning the plunger to its retracted position shown, after each pumping stroke. For example, with a fluid supply pressure of 90 p.s.i., the effective piston area (annular area of chamber **31**) may be kept relatively small, in the order of ⅜ square inch, for an injector pump in which the plunger **7** has a diameter and stroke in the order of ⅜ inch and ½ inch respectively. In such case, the metallic spring **38** need have a deflection rate of only about 6 lbs./in. instead of the conventional rate of some 200 to 230 lbs./in., with the important advantage that the natural frequency of such lower rate spring will be considerably less, say 13,000 c.p.m. as compared to approximately 18,000 c.p.m. for the conventional higher rate spring. Such lower natural frequency serves to inhibit any tendency of the spring **38** to surge in operation as the result of the sudden relief of fuel pressure in the pump chamber when the plunger groove uncovers the lower bushing port **9** during the pumping stroke. Such a relatively weak spring **38** may be used, therefore, which has only sufficient strength to return the plunger to its retracted position shown, against friction forces imposed by the sliding parts. It thus serves to keep the plunger retracted prior to installation of the injector pump unit on the engine, and to facilitate injector timing after such installation.

It is appreciated that numerous minor changes in the construction and arrangement of the parts may be made without departing from the spirit and scope of the invention as hereinafter claimed.

We claim:

1. In a fuel injection pump having a fuel pump chamber, means including a fuel reservoir chamber and a pump chamber inlet connected to said reservoir chamber for introducing fuel at relatively low pressure to said pump chamber, a pump chamber outlet, a plunger reciprocable in said pump chamber and operative during its pumping stroke therein to sequentially block and re-establish communication between said inlet and outlet, whereby fuel is discharged from the pump chamber via said outlet while said communication is blocked and thence fuel is bypassed to said reservoir chamber via said inlet when said communication is re-established, and means including return spring means for reciprocating said plunger, the improvement wherein said spring means comprises a guide part and an air cylinder of larger diameter than said guide part located in tandem relation at one end of said pump chamber and forming an air chamber coaxial with the plunger, a piston slidably fitting said air chamber having an axially extending guide plunger slidably fitting in said guide part, said air chamber having an end wall between said cylinder and said guide part facing said piston, means connecting said guide plunger and said piston to said pump plunger for movement therewith toward and away from said end wall during reciprocation of said plunger, and means connected to said air chamber for introducing air under pressure to said air chamber between said end wall and piston and means in said guide part for retaining said air under pressure developed in said air chamber by said piston during the pumping stroke of the plunger.

2. The invention of claim **1**, wherein said spring means also includes a metallic spring operatively connected to the plunger and yieldably opposing movement thereof in the pumping direction with a force sufficiently ample only to exceed frictional forces opposing movement of the plunger on its return stroke.

3. In a unit fuel injection pump, a pump body having a bore defining an air chamber, a bushing secured to said body coaxially of said air chamber bore, a pump plunger reciprocable in said bushing, means for driving said plunger on its pumping stroke, a spring operatively biasing said plunger into engagement with said driving means, said bushing having a fuel inlet closable and openable by the plunger during its reciprocation and an outlet for fuel displaceable from the bushing by the plunger during its pumping stroke after closing said inlet port, said plunger having a bypass passage connected at one end to said outlet and connected to said inlet in response to said plunger completing a predetermined portion of its pumping stroke after closing said inlet whereby pumping resistance to the driving means ceases, a piston carried by said plunger for reciprocation therewith and slidably fitting said air chamber bore, said bore having an end wall facing the plunger-adjacent end of said piston and means connected to said bore for introducing air under pressure to said bore between said piston and end wall for compression therebetween throughout the pumping stroke of the plunger, whereby upon completion of injection when the resistance of said pump to said driving means decreases, the force of said compression complements the biasing force of said spring in maintaining the operative engagement of the plunger with said driving means.

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