United States Patent [19]

Chapuis

[11] **3,722,801**

[45] **Mar. 27, 1973**

[54] **FUEL INJECTOR**

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[22] Filed: **Sept. 11, 1970**

[21] Appl. No.: **71,597**

[52] **U.S. Cl.** **239/533,** 239/584, 251/282, 308/5

[51] **Int. Cl.**.....**F16k 21/10**

[58] **Field of Search** 308/5; 92/165; 251/318, 324, 251/282, 214; 137/237

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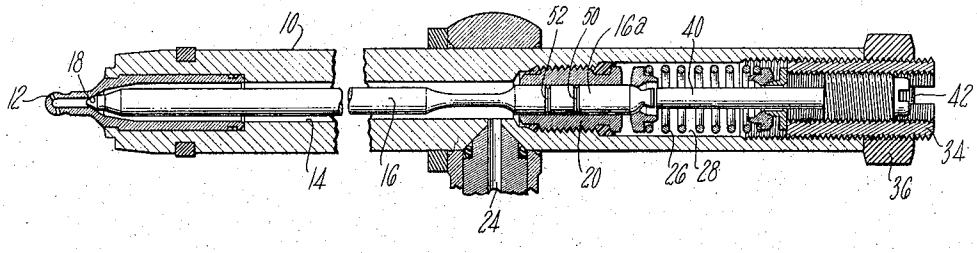
[57] **ABSTRACT**

An inwardly opening pressure actuated liquid fuel injector is provided with a valve mounted in an apertured valve guide for reciprocation. The bearing portion of the valve is provided with a pair of longitudinally spaced V-shaped peripheral grooves which are closed by the mating bearing surface of the aperture of the guide and serve to hydraulically center the valve in the aperture and minimize mechanical friction during reciprocation.

4 Claims, 2 Drawing Figures



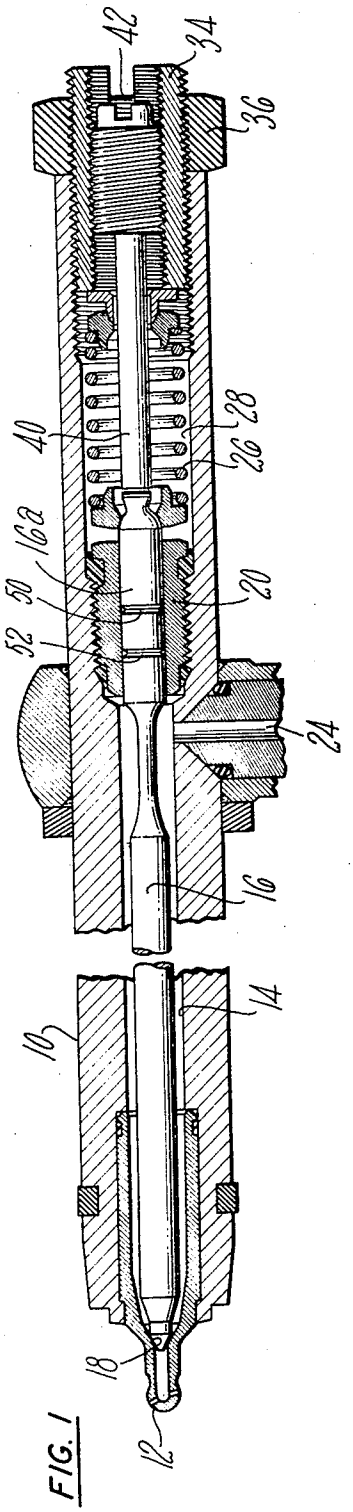


FIG. 1

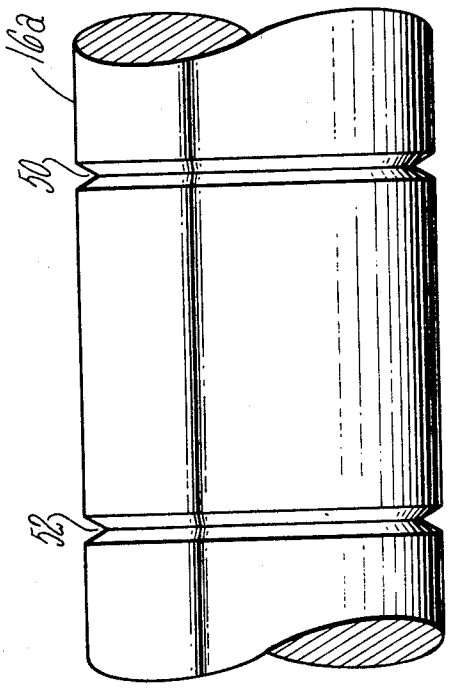


FIG. 2

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FUEL INJECTOR

This invention relates generally to fuel injectors for internal combustion engines and is more particularly concerned with an improvement in the injector described in U.S. Pat. No. 3,224,684 issued Dec. 21, 1965 and entitled "Fuel Injection Nozzle".

In inwardly opening pressure actuated liquid fuel injectors of the type contemplated by this invention, the plunger or valve is lifted from its seat by the pressure of the fuel delivered to the injector from an associated high pressure pump in measured quantities or charges. Each measured charge of pressurized fuel is discharged from the injector into a combustion chamber of an associated engine to operate the engine at the desired speed and torque, and the delivery of fuel to the injector, and its discharge therefrom, is timed to take place at a predetermined time during the compression stroke of the piston in the associated cylinder.

It is important that the injector discharge the fuel in a fine atomized spray. To produce such an atomized spray, the valve of the injector must be free to "chatter", that is, to reciprocate rapidly and frequently between an open and closed position during each injection period. In order to accomplish this, it is essential that the valve be free floating in its guide to avoid seizure or erratic operation of the valve in its guide under all operating conditions and throughout the entire life of the injector.

Accordingly, a primary object of the present invention is to provide an improved injector of the type described having reduced susceptibility to seizure of the valve and related malfunctions under all operating conditions. Included in this object is the provision of means to minimize variations in the mechanical friction acting on the valve during reciprocation.

A further object of this invention is the provision of a precision fuel injector of the reciprocating valve type which is economical to manufacture and reliable in use.

A still further object of this invention is to provide an injector for a compression-ignition engine wherein the valve is hydraulically centered in its supporting guide. Included in this object is the provision of means for assuring a film of lubricant around the entire periphery of the guide portion of the valve.

Another object of this invention is the provision of an injector design resulting in consistent "chatter" between different injectors and between injectors used with different supply pumps and engines.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth.

In the drawing:

FIG. 1 is a cross-sectional view of a portion of a fuel injector embodying the present invention; and

FIG. 2 is an enlarged fragmentary view of the guide portion of the valve of the injector of FIG. 1.

Referring to the drawing, in which like numerals refer to like parts throughout the several views, the exemplary injector shown herein and embodying the present invention is generally similar to that illustrated in the aforementioned U.S. Pat. No. 3,224,684 and includes an elongated generally tubular body **10** having

an apertured tip **12** fixed at one end thereof and a central longitudinal bore **14** extending throughout its length. Located within the central bore **14** is a plunger or valve **16** having a conical tip which cooperates with a conical valve seat **18** formed in the tip **12** to control the discharge of fuel from the injector. A valve guide **20** is shown as being fixedly positioned within the bore **14** of the body **10** at a position remote from the valve seat to slidably mount the valve **16** and position it in coaxial alignment with the valve seat **18**.

The injector is provided with a fuel inlet **24** communicating with a bore **14** of the tubular body **10** for delivery of discrete measured charges of high pressure fuel thereto from a source (not shown). A spring **26** disposed in a spring chamber **28** above valve guide **20** biases the valve **16** downwardly against the seat with a pressure which may be adjusted by a threaded retainer sleeve **34** received within the end of the tubular body **10** and locked in adjusted position by a lock nut **36**. An adjustable lift stop **40** is also provided for limiting the lift of the valve **16** from the valve seat **18**.

When each discrete charge of pressurized fuel delivered to the inlet **24** of the injector increases the pressure of the fuel within the bore **14** to a level to overcome the bias of spring **26**, the valve **16** is moved upwardly away from the valve seat **18** and the charge of fuel is discharged through the orifices in the valve tip **12**.

As mentioned above, it is important for the smooth operation of the fuel injector that the plunger **16** be free at all times during the injection period to reciprocate rapidly so as to produce the proper chatter of the valve and the consequent desired atomized spray of fuel into the firing chamber of the associated engine. This operation is initially made possible through the alignment of the valve **16** with the valve seat **18** and by providing a lapped fit of the surfaces of the bore of the valve guide **20** and the portion of the valve **16** received therein to minimize friction and lateral forces which may cause binding or seizure of the valve **16** in the valve guide **20**.

As shown in FIG. **1**, a pair of annular recesses are provided between the bearing surfaces of the valve guide **20** and those of the guide portion **16***a* of the valve **16**. As shown, the recesses are provided by forming a pair of longitudinally spaced peripheral grooves **50, 52** on the external surface of the valve **16** with the grooves being disposed intermediate the ends of the valve guide **20** so that the mating bearing surface of valve guide **20** overlies the grooves at all times during operation.

Referring particularly to FIG. **2**, the grooves **50, 52** are shown as being substantially V-shaped in cross section with an included angle of about 60°. A valve provided with such grooves **50, 52** spaced longitudinally about 100 mils apart with the grooves being about 5–15 mils deep has proven to be satisfactory in carrying out the principles of this invention.

With the grooves disposed so as to be covered at all times during operation by the mating surface of the valve guide **20**, they are protected from debris damage and debris accumulation which might otherwise occur as a result of solid particulate contaminants in the fuel.

It has been found that the provision of the double groove construction as described results in valves which will meet the requirements for chattering with a

high degree of uniformity from injector to injector and from engine to engine with the result that the rejection rate of injectors provided with such grooves is one-sixth or less than the rejection rate of identical injectors not provided with the grooves.

In a 4-cycle compression ignition engine, the period generally available for the injection of the charge of fuel during each compression stroke is approximately 20° out of every 720° of crank shaft rotation. When such an engine is operating at, say, 3,000 rpm, the period of time for injection of a charge of fuel is about 0.0111 second. It will be readily apparent that the high, short-term pressures encountered within the bore **14** of the injector during the injection period for such an engine create high differential pressure relative to the pressure in spring chamber **28** which is vented by a bleed passage **42**. While the guide portion **16***a* of the valve **16** and the mating surface of the guide **20** are precision sized to minimize leakage into the spring chamber **28** during the injection period, it is apparent that a small amount of leakage will occur. Moreover, the rapidity of the build-up and dissipation of high pressure within the bore **14** during the injection period will also create transient differential pressures within the bore **14** due to hydraulic shock waves and hydraulic inertia. Such transient differential pressures adjacent the guide **20** may establish lateral forces on the valve **16** which bias the valve laterally. Such a condition is self-generating since it results in a greater clearance (and less resistance for leakage flow) on one side of the valve than on the opposite side. This invention minimizes the effects of this condition by providing for the relatively unimpeded flow of lubricant around the periphery of the valve guide portion **16***a* through the use of grooves **50**, **52**. This serves to centralize the valve and reduce the mechanical friction between the valve **16** and the valve guide **20** by promoting a uniform layer of lubricant around the valve guide portion **16***a*.

Moreover, the rapid reciprocation of the valve during the injection period to provide the desired chatter, coupled with the tapered shape of the grooves in the direction of reciprocation, establishes an outward component of force on the fuel in the grooves **50**, **52** to bias the fuel against the bearing surface of the guide **20** overlying the grooves **50**, **52**. This assists in promoting the establishment and maintenance of a uniform layer of lubricating film around the entire periphery of the valve portion **16***a* thereby offering additional assurance that any tendency of the binding or seizure of the charge is minimized.

From the foregoing it will be apparent that the present invention provides a new and improved inwardly opening pressure actuated injector which substantially aids in promoting the uniformity in the atomization of the fuel discharged therefrom by reducing the possibility for seizure or increased mechanical friction between the valve and its guide.

As will be apparent to persons skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the teachings of the present invention.

I claim:

1. A liquid fuel injector for injecting into the combustion chamber of an associated engine pulsed charges of liquid fuel received from a high pressure fuel source comprising a tubular body having a bore provided with a valve seat and a discharge tip at one end thereof, a pressure-operated inwardly opening valve disposed in said bore, biasing means for biasing said valve toward said valve seat, an apertured valve guide closing the end of said bore remote from said valve seat, said valve having a bearing portion positioned in the aperture of said valve guide to mount said valve for high speed reciprocating movement toward and away from the valve seat, during each injection period of the valve, and means comprising longitudinally spaced peripheral grooves on said bearing portion of said valve, said grooves being V-shaped in axial cross section to wedge said valve bearing portion to a center position during such high speed reciprocating movement thereby to overcome lateral forces which may cause binding or seizing of the valve.

2. The injector of claim **1** wherein the included angle of said V-shaped grooves is of the order of 60°.

3. The injector of claim **2** in which said grooves are of the order of 10 mils deep.

4. The injector of claim **1** wherein a groove is disposed adjacent each end of the valve guide.

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