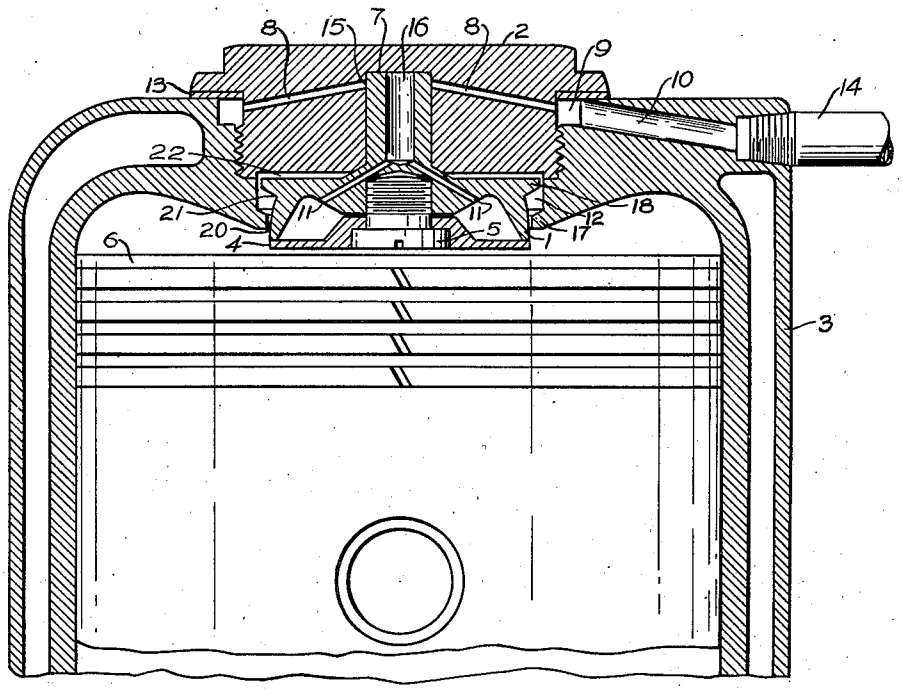
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FUEL INJECTION DEVICE

Filed Oct. 18, 1929



INVENTOR

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FUEL INJECTION DEVICE

Application filed October 18, 1929. Serial No. 400,556.

The invention relates to internal combustion engines of the fuel injection type, and in particular to the means for injecting liquid fuel into the cylinder of an internal combustion engine.

The fuel injection device of this invention operates on the pneumatic displacement principle. The compression pressure in an engine cylinder operates a differential or stepped plunger to inject fuel under a pressure which will bear a similar relation to compression pressure to that which the area of the larger portion of the plunger bears to the area of the smaller portion.

The plunger, in reciprocating, bears only on the fuel chamber walls. There it is well lubricated by the fuel, and there is no side-thrust, so that wear will be slight.

A clearance between the plunger and the larger chamber in which it operates automatically controls the timing of injection to suit the speed of the engine.

The larger part of the stepped plunger, which is operated by gas pressure, is divided into parts of different diameters, as is the corresponding part of the stepped chamber, in such a manner that the plunger will be retarded on the later part of its return or fuel-charging stroke by compression between opposite parts of the plunger and the chamber.

Other objects and advantages will appear from the following description taken in connection with the drawing, in which the invention as applied to the cylinder of a two-stroke-cycle engine is shown in section.

In the drawing, the numeral 3 designates an engine cylinder which is made integral with the cylider head, and 6 a piston, all of conventional design. In the center of the head 3 a large bore is provided, in which a stepped plunger 1 operates. 2 designates the retaining member, in which is contained the fuel pressure chamber 7. 2 is threaded into the head to secure the assembly. The chamber 9 is formed by the head 3, the member 2 and the gasket 13. It is connected with the fuel supply pipe 14 by a passage 10, and with the chamber 7 by several passages 8 which act as ports when uncovered by the plunger at 15.

A description of the operation of the injector at full engine speed, starting with the plunger in the position shown in the drawing, follows.

The pressure in the main cylinder will decrease on the working stroke, until the gas pressure in the space 22 above the plunger 1 is sufficient to move the plunger downward. The fuel plunger will pass the ports 15, so that fuel may enter chamber 7. This downstroke of the plunger 1 will be hereafter referred to as the "return stroke."

The plunger 1 is provided with a flange 18 which clears the bore slightly, but which has the partial effect of dividing the bore into two sections, 22 and 12. As the plunger moves down, the pressure in 22 will decrease, while that in 12 will increase by compression of the plunger flange 18. The plunger is thus accelerated and retarded. As it nears the end of its return stroke, the pressure in 12 is relieved by the effect of narrowing the plunger at 21, thus increasing the small existing clearance 20, and allowing passage into the main cylinder. The plunger is made light to reduce inertia.

With the piston 6 on the upstroke, the cylinder pressure will increase, and the plunger will be pushed upward. The clearance 20 will again become narrow. Because the plunger moves easily until it is opposed by the fuel in chamber 7, there will be little difference in pressure between the main cylinder and 12, so that little air will pass at 20.

The amount of fuel in 7 will depend on the pressure of the fuel-supply system and the time allowed for charging. The fuel supply may be at atmospheric pressure and regulated by a valve, or a fuel pump may be used.

As the piston nears the proper position for the start of injection, the fuel pressure will become sufficient to open the injection valve 4. This valve consists of a disc or diaphragm held by the adjusting cap-screw 5 at its center, and seating against the plunger on the outside edge. The fuel pressure forces the disc to leave its seat by distortion. The discharge

is radial and very fine atomization is secured.

During injection only a small amount of gases will pass at 20 and around the flange 18, because of the shortness of the time allowed at this speed and the narrowness of the clearance. Such gases as do get into 22 are largely removed after injection, on and after the return stroke of the plunger, by passage back into the combustion chamber of the engine.

At full engine speed the clearances at 20 and around 18 affect the operation of the injector but little, since the time allowed for passage is small. As the speed of the engine is reduced, however, more and more time is allowed for the passage. Consequently, more gases will pass on each stroke from the combustion chamber into 22. It is seen that the pressure back of the plunger will thus be greater at low speeds than at higher speeds.

It is well known that in internal combustion engines, time is required to complete the combustion of the charge. In addition, in fuel injection engines, time is required to complete injection and to initiate combustion. The time required to complete the process from the start of injection to the end of combustion is partially independent of the speed of the engine. It is common practise, in high speed engines, to allow a substantial advance in injection before top center on the compression stroke. Should the engine be operated at varying speeds, it becomes necessary, for proper operation, to reduce the angle of advance at reduced engine speeds. This is the main purpose of the plunger clearances at 20 and around 18. Since, as previously shown, they control the pressure back of the plunger, they also control injection advance, by making necessary a higher compression pressure to cause injection at low speeds than at high speeds, and hence a more advanced degree of compression, which means that the compression stroke of the piston must be more nearly finished.

When the fuel charge is less than the full amount, the plunger will be in a more advanced position at the start of injection, with the result that the gases in 22 will be compressed by the motion of the plunger to a greater degree than at full fuel charge for the start of injection. The resulting effect of increased pressure in 22 can be compensated for by reducing the clearance at 20 or around 18 for advanced injection positions; this is done by varying the plunger or chamber diameters over the amount of travel. The compensation is least at high speeds, when the effect of compression in 22 is the least.

A particular embodiment of the invention which is thought to be desirable has been illustrated and described, but I desire it to be understood that the invention is not limited to the form disclosed.

I do not claim as my own invention the pneumatic displacement principle of the stepped plunger, but I claim:

1. In a fuel injection device of the class described, a stepped plunger, and a stepped chamber in which said plunger reciprocates, said plunger clearing the larger portion of said chamber by a small amount, whereby gases may pass around the larger portion of said plunger into that portion of said chamber which is back of the larger portion of said plunger.

2. In the combination as defined by claim 1, the clearance between said plunger and said chamber being variable with respect to the position of said plunger.

3. In a fuel injection device of the class described, a stepped chamber, a stepped plunger operated by compression pressure on the larger end of said plunger, and a passage connecting the clearance space in the cylinder head with that portion of said chamber which is back of the larger end of said plunger, whereby the action of said plunger will be controlled by back-pressure on the larger end of said plunger, said pressure being regulated by gases which may proceed through said passage.

4. In a fuel injection device of the class described, a stepped plunger and stepped chamber, an enlargement in the diameter of the larger portion of said stepped chamber, and a similar enlargement or flange on the larger part of said stepped plunger, so placed as to form an annular chamber, the pressure in which operates in a direction to retard said plunger during the later part of its return stroke.

In testimony whereof I affix my signature.

ROBERT E. NELSON.