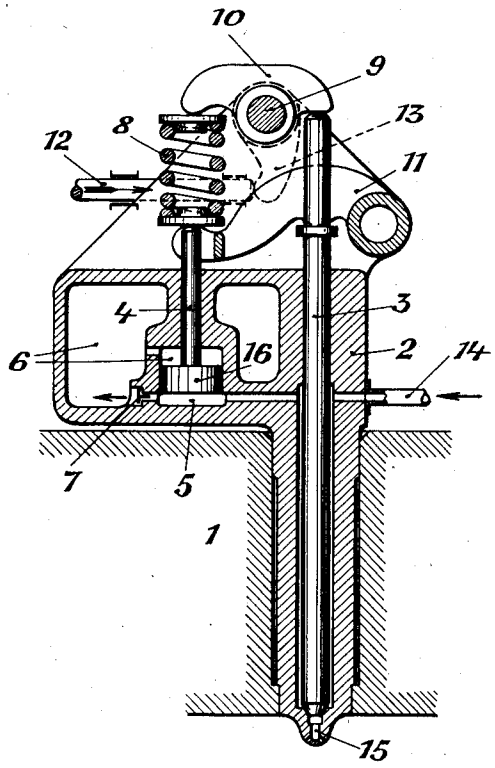
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FUEL INJECTION DEVICE FOR LIQUID FUEL INJECTION INTERNAL COMBUSTION ENGINES

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FUEL INJECTION DEVICE FOR LIQUID FUEL INJECTION INTERNAL COMBUSTION ENGINES

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This invention relates to fuel injection devices for liquid fuel injection internal combustion engines and more particularly to fuel injection devices of the kind comprising a valve which is normally maintained on its seat mechanically but is released when fuel injection is to take place whereupon the valve is opened automatically by the pressure of fuel previously stored under pressure in a pressure accumulator or storage chamber.

In such fuel injection devices which deal with high fuel pressures and large injections quantities it has previously been necessary to use a powerful spring for normally maintaining the fuel valve on its seating with the result that not only was this spring of large dimensions so that it occupied an undesirably large amount of space, but it was impossible to ensure reliable operation of the valve under light load conditions when smaller pressures and fuel injection quantities were employed. In order to overcome these difficulties it has been proposed to reduce the elasticity of the pressure accumulator—that is to say, to reduce the ratio of the pressure exerted by the pressure accumulator to the quantity of fuel stored therein—when the load on the engine increases but such a construction necessitates separate control apparatus.

The object of the present invention is to simplify fuel injection devices of the above general type while at the same time enabling the sum of the forces acting on the piston of the pressure accumulator to be reduced.

To this end in a fuel injection device of the general kind referred to according to the present invention at least a part of the forces acting to move the piston of the pressure accumulator to inject the fuel is derived from a hydraulic spring constituted by the fuel itself. If desired the movement of the piston of the pressure accumulator may be effected not only by the hydraulic spring thus provided but also by a separate spring which determines the fuel injection pressure. In any case the fuel constituting the hydraulic spring is conveniently disposed in a chamber which is separated by a non-return valve from the fuel which is to be injected. Thus conveniently the pressure accumulator has a differentially arranged piston one face of which acts upon the fuel to be injected while its other face is subjected to the action of the hydraulic spring constituted by the fuel under pressure and also to the action of a separate spring determining the injection pressure.

If desired the spring constants, that is, the low governing the variations in pressure exerted on the piston of the pressure accumulator when this piston moves may be the same respectively for the hydraulic spring and for the other spring.

One practical embodiment of the present concept is shown by way of example in vertical, substantially central section in the accompanying drawing.

In the construction shown there is mounted in a bore in the cylinder head 1 of an internal combustion engine a fuel injection device comprising a body part or casing 2 sliding in which is an axially movable fuel injection valve-needle 3 controlling a sprayer opening 15. Pivotally mounted on the upper face of the casing 2 is a lever 11 acting on a collar on the valve 3, and a lever 10 mounted on a rocking shaft 9 and acting on the upper end of the needle 3. A compression spring 8 is interposed between the two levers 10 and 11 so that both of them tend normally to maintain the valve 3 in its closed position. A mechanically operated push-rod 12 acting on an arm 13 also secured to the rocking shaft 9 is however provided whereby the lever 10 can be rocked so that it no longer presses the valve 3 into engagement with its seating.

Also arranged within the casing 2 is a

storage device or pressure accumulator comprising a piston 16 having a piston rod 4 which extends through the casing and bears against the lower end of the spring 8. The piston 16 is arranged within a cylinder the upper end of which communicates with a chamber 6 adapted to contain fuel which constitutes a hydraulic spring acting upon the upper face of the piston. The chamber 6 communicates through a non-return valve 7 with the lower end 5 of the cylinder in which the piston 16 is arranged, the chamber 5 communicating directly with a fuel inlet passage 14 and with the fuel injection nozzle which is normally closed by the valve 3. It will be seen that the piston 16 is of the differential type, the upper face being subject to the pressure in the chamber 6 while the lower face acts on the fuel to be injected.

In operation fuel is delivered through the pipe 14 and forces the piston 16 upwards against the action of the hydraulic spring constituted by the liquid in the chamber 6 and the action of the spring 8, thus moving the lower end of the spring upwards and relieving the lever 11 of the pressure of this spring. When fuel injection is to take place the rod 12 is operated to rock the shaft 9 and hence the lever 10 so as to permit the valve 3 to lift automatically under the action of the fuel pressure in the chamber 5. The piston 16 then moves downwards under the action of the hydraulic spring constituted by the fuel in the chamber 6 and of the spring 8 to cause injection of fuel. Fuel injection continues until either the rod 12 is moved to release the shaft 9 or until the piston 16 moves downwards to such an extent as to permit the lower end of the spring 8 to come into contact with the lever 11 and thus close the valve 3. The action of the non-return valve 7 is to ensure that if leakage of fuel takes place from the chamber 6, such leakage will be compensated for by a corresponding quantity of fuel being forced through this valve from the chamber 5. The variations in the pressure exerted by the hydraulic spring as the piston 16 moves may follow the same law as the spring 8.

It is to be understood that fuel is injected under pressure from a piston-type fuel pump. It is also to be understood that the injection pressure is dependent on the stroke of the entire piston 4–16, and/or the compressions of the hydraulic spring 6 and the metal spring 8. The pressure in chamber 6, during the below-center position of the piston structure 4–16 levels up to the pressure in the chamber 5. The difference which exists between the upper and lower surface of the piston 16 has no bearing upon the magnitude of the injection pressure, for if, in the case of small loads, the quantity of fuel is reduced, the piston 4–16 will execute a smaller stroke, and both the hydraulic spring 6 and the metal spring 8 will be subject to a lesser strain. A smaller injection pressure therefore is only conditioned by a smaller stroke of the piston 4–16 and independently of the surface ratio above and below the piston 16. Therefore, if the load is reduced after a heavy load, the stem 4 would nevertheless be lifted.

An arrangement according to the present invention makes it possible to reduce the dimensions of the spring of the pressure accumulator to a minimum or even so that the shock of the valve closing is reduced and the risk of the valve-closing lever 11 being broken due to excessive strains is eliminated, whereby a more reliable working of the injection device tends to be obtained.

If as hereinabove stated the spring determining the pressure of injection shall be omitted, the portion 4 of the piston is extended in the highest position of the accumulator piston 4, 16, up to the twin lever 10 and has at the place of the lower spring plate of the spring 8, a lug 20 by means of which it depresses the lever 11 during the descent of the piston 4, 16 and seals the fuel valve 3. In the highest position of the accumulator piston 4, 16, the portion 4 of said accumulator piston presses the twin lever 10 in a direction such as to lock the fuel valve 3, so that the fuel valve is blocked by the fuel itself prior to injection. The injection of fuel is effected in the same way as though there existed a spring 8, in that, by means of the pusher-rod 12 and the lever 12, the twin lever 10 is rotated so as to release the fuel valve 3. As very small distances only are implied, the compressibility of the fuel in chamber 5 is sufficient to make the execution of said movement possible.

I claim:

1. A fuel injection device, comprising a casing, a fuel outlet valve and a fuel accumulator therein, a pressure applying piston in said accumulator, and means for moving said piston to positively inject the fuel from said outlet valve, at least a part of the piston-moving means being constituted by the fuel itself acting as a hydraulic spring on said piston.

2. A fuel injection device, comprising a casing, a fuel outlet valve and a fuel accumulator therein, a pressure applying piston in said accumulator, and means for moving said piston to positively inject the fuel from said outlet valve, at least a part of the piston-moving means being constituted by the fuel itself acting as a hydraulic spring on said piston, the other part of said piston-operating means consisting of a solid spring of predetermined strength acting on said piston to regulate the pressure applied on said fuel to inject same.

3. A fuel injection device comprising a casing, a fuel outlet valve and a fuel accumulator therein, a differential-pressure applying piston in said accumulator, a coiled spring mounted in said casing to act on said piston, a portion of the fuel in the casing acting on said piston whereby said portion of the fuel acts as a hydraulic spring to complement the action of said coiled spring, the other face of said piston being adapted to apply pressure to the other portion of the fuel in said casing to inject same.

4. A fuel injection device, comprising a casing, a fuel outlet valve and a fuel accumulator therein, a differential-pressure applying piston in said accumulator, a coiled spring mounted in said casing to act on said piston, a portion of the fuel in the casing being in communication with one face of said piston whereby said portion of the fuel acts as a hydraulic spring to complement the action of said coiled spring, the other face of said piston being adapted to apply pressure to the other portion of the fuel in said casing to inject same, the spring constants of said coiled spring and of said hydraulic spring acting on the face of said piston, being alike.

5. A fuel injection device, comprising a casing, a fuel outlet valve therein, a closed chamber in said casing, said chamber having communication with said fuel-inlet valve, a piston in said closed chamber acted on by a hydraulic spring constituted by a portion of said fuel and in turn acting on the rest of said fuel, and means for separating the fuel in said first chamber from the fuel in said second chamber.

6. A fuel injection device, comprising a casing, a fuel outlet valve therein, a closed chamber in said casing, said chamber having communication with said fuel inlet valve, a piston in said closed chamber acted on by a hydraulic spring constituted by a portion of said fuel and in turn acting on the rest of said fuel, means for separating the fuel in said first chamber from the fuel in said second chamber, said means being adapted to permit passage of inlet fuel from said second chamber to said first chamber and to prevent the reverse passage thereof.

In testimony whereof I have affixed my signature.

ERNST SCHAEREN.