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FUEL INJECTION PUMP

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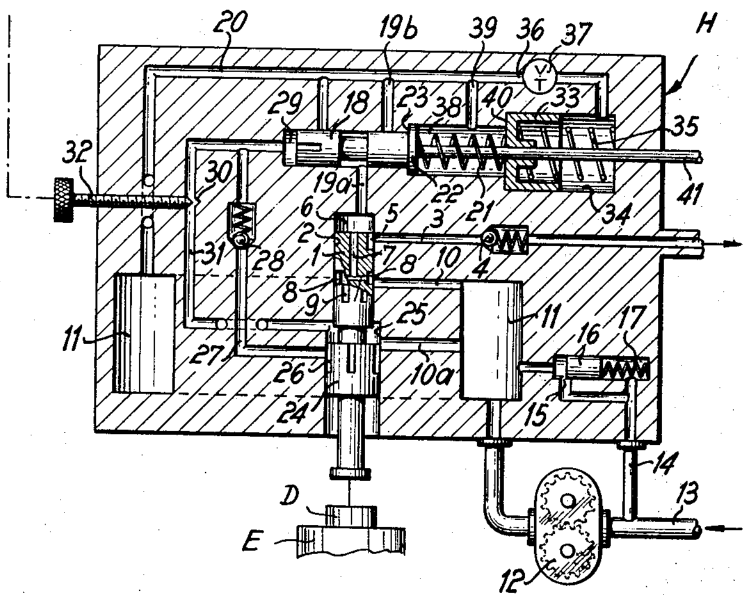

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FUEL INJECTION PUMP

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The present invention relates to fuel injection pumps for internal combustion engines wherein the amount of fuel delivered is varied as a function of the engine speed.

U.S. Patents Nos. 3,044,404 and 3,122,100 to Bessiere disclosed fuel injection pumps wherein the fuel delivery during each delivery stroke is terminated by means of a reciprocable shuttle piston acting as a valve spool controlling a spill passage, which shuttle piston is driven during the forward delivery stroke of the pump piston by the pressure fluid of an auxiliary pump, operating in synchronism with the injection pump, and is braked during its return stroke, which is effected by a spring, in that it must force at least a part of the fuel which has caused its forward stroke through at least one variable regulating throttle, until, at a predetermined cross-section of the throttle, when a certain speed is reached, the shuttle piston no longer returns to its starting position, owing to the so-called "liquid stop." The average force of the regulating spring changes after the occurrence of the liquid stop from a minimum value to a higher value, which increases with the increase of the liquid stop, until a stable speed has been reached for the corresponding opening of the control throttle and the vehicle load. The change in the mean spring force corresponds to a certain degree of non-uniformity. In order to produce a satisfactory regulation, i.e., to reach quickly a stable speed under load or regulating throttle changes, this degree of non-uniformity should be as small as possible. However, it must not be too small, because in this case the regulation will be unstable.

The invention has the object of improving the degree of non-uniformity so that the regulation period between two stable speeds is as short as possible and so that the regulation remains stable at these speeds.

According to the invention, this object is realized in that the abutment supporting the side of the regulating spring remote from the regulating spool is displaceable by the regulating spring against an elastic means, and in that this displacement is hydraulically damped. This elastic means comprises preferably a biased return spring.

According to a further feature of the invention, a particularly good control may be obtained in that the abutment rests, under the bias of the return spring, against a stop until such time, as the liquid stop and with it the rise in the mean force of the regulating spring occurs.

The invention is further described, by way of example, with reference to the accompanying drawing which is an axial section of a fuel injection pump constructed in accordance with the invention.

Referring to the drawing, in a housing H a piston 1 of a fuel injection pump operates in a cylinder 2 and is actuated by a variable speed drive D operated by the internal combustion engine E so that it carries out a reciprocating axial movement and a rotating movement about its axis. During its rotational movement, the piston serves as distributor by supplying fuel during the delivery stroke successively to individual conduits 3, arranged in equidistant spacing about the cylinder 2. Each conduit 3, of which only one is shown in the drawing, contains a nonreturn valve 4. The peripheral surface of the piston 1 is provided with a distributing groove 5 which during

each successive delivery stroke of the piston connects the pump chamber 6 to a corresponding one of the delivery conduits 3. This pump chamber is supplied with fuel through a passage 7, an annular groove 8, one of several longitudinal grooves 9 in the peripheral surface of the piston 1 and a supply bore 10 from a suction chamber 11. This suction chamber 11 is supplied with fuel by a feed pump 12, for example, a gear pump, driven by the engine supplied with fuel by the injection pump.

In order to obtain a speed-dependent pressure in the suction chamber 11, the suction chamber 11 is connected to the inlet conduit 13 of the feed pump by a by-pass passage 14, which is provided with a restriction 15, the cross-section of which is controlled by a valve spool 16. The valve spool 16 is subjected on one side to the fuel pressure in the suction chamber 11 and is displaced with increasing speed against the pressure of a return spring 17, causing the flow cross-section of the restriction 15 to be increased.

A regulating spool 18 serves for the quantity regulation of the fuel delivered to the engine during each delivery stroke of the piston 1. This regulating spool controls the connection between the two sections 19*a* and 19*b* of a spill passage leading from the pump chamber. The section 19*b* of the spill passage communicates through a passage 20 with the suction chamber 11. A spring 21 (regulating spring) tends to hold the regulating spool 12 in the inoperative position, determined by a flange 22 of the regulating spool and a fixed abutment stop 23. In this inoperative position, the regulating spool closes the spill passage 19*a*, 19*b*.

Advance of the regulating spool 18 is obtained by a piston 24, working in synchronism with the piston 1, and being preferably constructed as a stepped piston of the piston 1, and a cylinder 25 which receives fuel from the suction chamber 11 through a passage 10*a* whose opening into the cylinder is controlled by the piston 24. The piston displaces fuel from its cylinder 25 through one of several longitudinal grooves 26 formed in the periphery of the piston 24 and through a passage 27 containing a non-return valve 28 into a cylinder 29. The cylinder 29 contains the regulating spool 18 which is advanced against the force of the spring 21 by the fuel displaced by the auxiliary pump 24, 25 to interconnect the sections 19*a* and 19*b* of the spill passage.

During the period between two delivery strokes of the piston 24, the regulating spool 18 returns into its inoperative position. During this return movement, the regulating spool, acted upon by the regulating spring 21, displaced a part of the fuel from the cylinder 29 through a throttle 30 (regulating throttle), provided in a passage 31 so that the return movement of the regulating spool is braked. The flow cross-section of the regulating throttle 30 is preferably adjustable by means of a throttle needle 32.

Above a predetermined driving speed of the pump, there occurs the liquid stop, i.e., the regulating spool no longer has time to return to its starting position and the extremities of its to and fro movement move in the direction of the regulating spring 21. In this way, the amount of fuel delivered with each delivery stroke of the pump to one of the injection nozzles is reduced. This displacement of the starting and finishing points of the travel of the regulating spool towards the regulating spring has the result that the mean force of the regulating spring 21 is increased. This also increases the degree of non-uniformity. In order to reduce this degree of non-uniformity, the end of the regulating spring 21 remote from the regulating spool 18 rests against an abutment piston 33, arranged in a cylinder 34 to be displaceable against the force of a return spring 35. The cylinder 34 is connected by a passage 36 to the passage 20, terminating in the suction chamber **11**. In the passage **36**, there is a throttle (damping throttle) through which the abutment piston **33** forces fuel during its movement, so that its movement is damped. The blow cross-section of the damping throttle **37** is preferably adjustable (by means not shown in the drawing) whereby the damping throttle is adjusted as a function of the adjustment of the regulating throttle **30**. At low speeds, the damping throttle **37** is closed so that the abutment piston **33** is retained in its initial position illustrated.

The chamber **38**, which contains the regulating spring **21** and accommodates flange **22** of the regulating spool **18**, communicates through a passage **39** with the passage **20**.

The bias of the return spring **35** and the diameter of the abutment piston **33** are so chosen that the abutment piston **33** rests on an abutment stop **40** at low speeds, i.e., prior to the occurrence of the liquid stop, that is, so long as the mean force of the regulating spring **21** is at a minimum.

When the liquid stop occurs, the mean force of the regulating spring **21** changes and the abutment piston **33** is shifted to the right until a new equilibrium position has been reached. In this new equilibrium position, the degree of non-uniformity of the regulation is reduced, because the mean force of the regulating spring **21** has almost returned to its minimum. The more predominant the liquid stop becomes the more the abutment piston **33** is moved towards the right. Thus, after a certain transitional period, during which a temporary larger regulation deviation occurs, a substantially smaller regulation deviation (degree of non-uniformity) is obtained than if the abutment piston were fixed. For each degree of the liquid stop, there is a certain equilibrium position of the abutment piston **33**.

The abutment piston **33** has preferably a larger diameter than the regulating spool **18** so that the return spring can be made soft and the cross-section of the damping throttle **37** can be comparatively large.

The stiffness of the return spring **35** determines the reduced degree of non-uniformity, and the cross-section of the damping throttle **37** determines the period of time which expires until the degree of non-uniformity has adjusted itself to a new value.

For the case wherein the regulating spool is to be rotated for starting and stopping the engine, it is provided with a shaft **41** which, as shown in the drawing, passes through the chamber **38**, the abutment piston **33** and the chamber **34** towards the outside. Instead of this arrangement, the shaft may alternatively be mounted on the other end of the regulating spool.

What is claimed as new and desired to be protected by Letters Patent is:

1. A fuel injection pump for an internal combustion engine having an injection piston and a regulating spool for terminating each fuel delivery stroke of said piston by advancing until it opens a spill passage, an auxiliary pump adapted to operate in synchronism with said piston for advancing the regulating spool during each pumping stroke against the force of a regulating spring, the regulating spring resting against an elastically yieldable abutment whose movement is hydraulically damped, and a throttle through which fuel is displaced by the regulating spool upon its return movement, said throttle braking such return movement so that when a certain speed is reached the regulating spool is prevented from returning to its initial position prior to beginning of the subsequent pumping stroke of said injection piston owing to the "liquid stop" phenomenon, and the amount of fuel delivered by the injection piston during each working stroke is reduced.

2. A fuel injection pump as claimed in claim **1**, in which said abutment is yieldable against a pre-stressed return spring.

3. A fuel injection pump as claimed in claim **1**, in which the abutment comprises a second piston which displaces liquid through a damping throttle to effect the hydraulic damping.

4. A fuel injection pump as claimed in claim **3**, wherein the cross-section of the damping throttle is adjustable simultaneously with that of the regulating throttle.

5. A fuel injection pump as claimed in claim **3**, in which means are provided for closing the damping throttle at slow engine speeds.

6. A fuel injection pump as claimed in claim **3**, in which the effective cross-sectional area of said second piston is larger than the effective cross-sectional area of the regulating spool.

7. A fuel injection pump as claimed in claim **1**, further comprising a housing for said regulating spool, said spool having a portion extending from said housing.

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