DEVICE FOR CONTROLLING THE  
PRE-INJECTION

Frank Thoma, Stuttgart, Germany, assignor to Daimler-Benz Aktiengesellschaft, Stuttgart-Unterturkheim, Germany

Filed Mar. 17, 1966, Ser. No. 535,244
Claims priority, application Germany, Mar. 17, 1965, D 46,812
12 Claims. (Cl. 123—139)

ABSTRACT OF THE DISCLOSURE

An intermediate relief device for the control of the pre-injection of fuel in an internal combustion engine comprising a cylinder disposed between an injection pump and an injection nozzle, a control piston adapted to reciprocate within the cylinder, the piston being acted upon, on one side thereof, by the impulse of the injection pump and, on the opposite side thereof, by the force of a coil spring, wherein the cylinder is provided with a relief groove which communicates with a discharge outlet so as to effect intermediate relief from the outlet side of the cylinder through a control groove provided in the piston to the discharge outlet. Accordingly, according to an alternative embodiment of the present invention, a pressure valve may be arranged within the relief discharge outlet so as to effect a braking of the intermediate relief operation.

The present invention relates to a device for the control of the pre-injection by an intermediate relief, especially for motor vehicle internal combustion engines. It is known in the prior art for purposes of achieving a pre-injection to provide the plunger and cylinder of an injection pump with corresponding control cross sections bringing about an intermediate relief or discharge of the fuel. These known injection pumps have the disadvantage that the pre-injection and main injection impulses controlled by the cams thereof are falsified by different known influences with the result that the pre-injected fuel quantity is not constant under all operating conditions. Additionally, the end of the pre-injection may approach the beginning of the main injection or even coincide with the same. Furthermore, the disadvantage exists with the prior art constructions that the pre-injection pulse may suffer falsifications on its way to the injection nozzle as a result of reflections. For the purpose of avoiding an excessively delayed termination of the pre-injection, it has already been proposed that in an injection pump the control edge at the pump plunger for the termination of the pre-injection, extends over a longer circumferential line which is disposed in a plane perpendicular to the cylinder axis and to the plunger movement and therewith is parallel to the plunger edges. However, this prior art measure is not able to eliminate all the disadvantages.

The present invention avoids the disadvantages of the known injection pumps described above in that the device interconnected between an injection pump and an injection nozzle includes a control piston which is displaced in one direction by the supply pulse of the injection pump and in the other direction by a spring force and/or the fuel supply pressure which control piston effects the intermediate relieving or discharging operation in this manner there is assured that with every injection pulse a completely predetermined fuel volume dependent on the dimensioning of the control device is pre-injected and thereafter an injection pause, dependent on an also predetermined fuel volume lead off into the intermediate relief line, is maintained up to the beginning of the main injection.

Accordingly, it is an object of the present invention to provide a fuel injection system operable to produce a pre-injection which avoids by simple means the aforementioned shortcomings and drawbacks encountered in the prior art constructions.

Another object of the present invention resides in a control device for an injection system of internal combustion engines producing a pre-injection and main injection which effectively protects the proper operation of the injection processes from all external influences.

A further object of the present invention resides in a control mechanism for fuel injection systems of internal combustion engines which assures a constant pre-injection fuel quantity under all operating conditions.

Still another object of the present invention resides in a control device for controlling the pre-injection and main injection of fuel in internal combustion engines which accurately controls the timing, i.e., beginning and termination of the pre-injection and main injection under all operating conditions, especially in such a manner that a predetermined pause is maintained between the termination of the pre-injection and the beginning of the main injection.

Another object of the present invention resides in a fuel injection control device for fuel injection systems, especially of internal combustion engines which safeguards the proper operation and timing of the injection mechanisms from any cause, internal or external, which might lead to false timing and/or improper injection quantities.

A further object of the present invention resides in a control device for injection systems of fuels which produces a particularly accurate control of the pre-injection.

Still another object of the present invention resides in a control device for fuel injection systems, especially for internal combustion engines which greatly simplifies the manufacture, reduces the cost in material and labor and also greatly facilitates servicing and installation thereof.

These and further objects, features and advantages of the present invention will become more obvious from the following description when taken in connection with the accompanying drawings which shows, for purposes of illustration only, two embodiments in accordance with the present invention, and wherein:

FIGURE 1 is a partial axial cross-sectional view through a first embodiment of a control device in accordance with the present invention with the control piston shown in the normal rest position;

FIGURE 2 is a partial axial cross-sectional view similar to FIGURE 1, illustrating the parts thereof during pre-injection;

FIGURE 3 is a partial axial cross-sectional view, similar to FIGURE 2, illustrating the parts thereof in the intermediate relief position;

FIGURE 4 is a partial axial cross-sectional view, similar to FIGURES 2 and 3, illustrating the position of the parts during main injection;

FIGURE 5 is a partial axial cross-sectional view through a second embodiment of a control device in accordance with the present invention with the control piston thereof in the normal rest position;

FIGURE 6 is a partial axial cross-sectional view of the device of FIGURE 5, with the parts thereof in the position during pre-injection;

FIGURE 7 is a partial cross-sectional view, similar to FIGURE 6, showing the parts thereof in the intermediate relief position; and

FIGURE 8 is a partial cross-sectional view, similar to FIGURES 6 and 7, and illustrating the parts thereof in the position of main injection.
Referring now to the drawing wherein like reference numerals are used throughout the various views to designate like parts, and more particularly to FIGURE 1, reference numeral 1 designates therein a cylinder which accommodates therein a control piston 2 within the cylinder 1. The control piston 2 subdivides from each other a cylinder space 4 disposed at the inlet side and provided with an inlet 3 and a cylinder space 6 of larger diameter disposed at the outlet side of the cylinder 1. The cylinder space 4 with an inlet 3 at the outlet side is connected in any conventional manner by way of a pipe line with an injection pump (not shown) and the cylinder space 6 at the outlet side by way of a short line with a conventional injection nozzle (not shown). A collar 7 of the control piston 2 abuts in the upper rest position thereof as abutment against the outlet end face 8 of a liner or bushing of the cylinder 1. In the lower end position, the end of the control piston 2 disposed at the outlet side rests against an abutment 9 arranged in the outlet cylinder space 6. A helical coil spring 10 normally seeks to press the control piston into the upper rest position thereof.

The end of the control piston 2 at the inlet side is provided with a throttle bore 11 which terminates in an axial bore 12 of the control piston 2 which, in turn, is in constant communication with the cylinder space 6. The control piston 2 is provided slightly below the throttle place 11 thereof with a number of cross bores 13 terminating in the axial bore 12. The liner of the cylinder 1 accommodating the control piston 2 is provided within the area of the inlet end of the control piston 2 with an annular groove 14 which is controlled, i.e., opened up in the lower end position of the control piston by the inlet end thereof which still overlaps with the cross bores 13 of the control piston.

The control piston 2 is provided with an annular groove 15 at the outlet end thereof and the liner of the cylinder 1 with an annular groove 16 at the outlet end thereof which both form cooperating control cross sections. A discharge 17 terminates in the annular groove 16, and an intermediate relief line (not shown) is connected in any conventional manner with the discharge 17 and leads to a fuel tank.

**Operation**

The operation of the control device described hereinabove is as follows:

The control piston 2 initially assumes the rest position illustrated in FIGURE 1 into which it is urged by the spring 10, and the cylinder 1 is filled completely with fuel. If a fuel injection impulse now arrives from the injection pump (not shown) by way of the inlet 3, then the control piston 2 moves rapidly in the downward direction as viewed in FIGURE 1 and the pre-injection begins. During the rapid movement, the throttle 11 acts practically as a closed connection so that the fuel quantity flowing through the inlet 3 corresponds at all times to the cylinder volume traversed by a piston cross section. Fuel is ejected to the injection nozzle by way of the outlet 5 for such length of time until, as shown in FIGURE 2, a control edge 18 located at the outlet side of the annular groove 15 of the control piston 2, which is still in communication with the annular groove 16 of the cylinder 1, overruns a control edge 19 near the outlet end 8 of the liner of the cylinder 1 and establishes a connection 20 from the outlet cylinder space 6 to the discharge 17. The intermediate relief effect thereby terminates the pre-injection of a fuel quantity which corresponds accurately to the volume determined by the cross section of the control piston and by the mutual spacing of the control edges 18 and 19.

The duration of the now following injection pause depends on the flow velocity of the fuel volume which further depends on the control piston 2 into a position in which an upper control edge 21 of its annular groove 15 overruns a lower control edge 22 of the annular groove 16 of the cylinder 1. In this position the connection 20 of the outlet cylinder space 6 to the discharge 17 is again interrupted so that during the movement of the control piston 2, as illustrated in FIGURE 3, the main injection commences whose duration and injection quantity is determined in a known manner by the injection pump of conventional construction.

After the beginning of the main injection, the inlet end of the control piston 2 engages the annular groove 14 with respect to the inlet cylinder space 4 and the control piston 2 abuts in lower end position, illustrated in FIGURE 4, against the abutment or stop 9 limiting the stroke of the piston so that the fuel volume, which continues to flow into the control device after the main injection, causes no further movement of the control piston. After the end of the injection impulse supplied by the injection pump, the spring 10 again moves the control piston 2 relatively slowly in the upward direction into the rest position thereof illustrated in FIGURE 1 whereby the throttle 11 provides a sufficiently small resistance for such slow movement.

The control piston 2 of the first embodiment illustrated in FIGURES 1 to 4 may, as shown in dash line in FIGURE 1, be provided with a second throttle bore 23 downstream of the throttle bore 11, which throttle bore 23 connects the axial bore 12 with the annular groove 15 of the control piston 2. The second throttling bore 23 permits, in case of a very slow operation of the internal combustion engine, a corrective volume of fuel to enter into the discharge line 17 during the pre-injection which corresponds approximately to a leakage quantity entering into the bore 12 through the throttle bore 11, which leakage quantity does not contribute to the downward displacement of the control piston 2 so that without the throttle 23 it might lead to an undesirable increase of the pre-injection quantity.

The second embodiment, illustrated in FIGURES 5 to 8 in the same operating phases as the first embodiment, in which similar parts are designated by corresponding primed reference numerals, differs essentially from the first embodiment in that the cylinder 24 is provided with an annular groove-shaped control cross section 26 connected with a lateral discharge 25 to the injection nozzle (not shown) and in that the end of the control piston 27 at the outlet side thereof is constructed as blocking piston 28 which covers or overlaps with the control cross section 26 connected with the outlet 25 during the pre-injection. The blocking of the outlet 25 leading to the nozzle during the pre-injection may prove necessary if, as indicated in dash line in FIGURE 5, a pressure valve 29 is arranged at the outlet 17 of the control cross section 16’ of the cylinder 24 serving as intermediate relief means, which pressure valve 29 serves for the purpose of “braking” of the intermediate relief operation. In case of the presence of a pressure valve 29 or of a nozzle, a slight fuel injection may occur also during the pause between the pre- and main injection as a result of an incomplete intermediate relieving. A “braking” of the intermediate relieving may be necessary in order to prevent emptying appearances occurring under certain operating conditions during the intermediate relief operation in the control device and in the injection line.

The second embodiment differs furthermore from the first embodiment in that instead of the throttles 11 and 23 of the first embodiment it comprises a fuel supply line 31 which is continuously under fuel supply pressure and leads to the outlet cylinder space 6’ by way of a check valve 30 whereby the outlet cylinder space 6’ is filled with fuel by way of the fuel supply line 31 after termination of the main injection during the return movement of the control piston 27.

Otherwise, the operation of the embodiments of FIGURES 5 through 8 is the same as that of FIGURES 1 through 4 and is believed obvious from the foregoing description when taken in connection with the drawing.
so that a further detailed explanation thereof is dispensed with herein.

A particularly accurate control of the pre-injection results if the control device is connected directly ahead of the injection nozzle. Significant savings in material and labor expenditures are obtained during the manufacture if the control device forms a structural unit together with the injection nozzle, i.e., is made unitary therewith.

While I have shown and described two embodiments in accordance with the present invention, it is understood that the same is not limited thereto but is susceptible of numerous changes and modifications as known to a person skilled in the art, and I therefore do not wish to be limited to the details shown and described herein but intend to cover all such changes and modifications as are encompassed by the scope of the appended claims.

I claim:

1. A device for controlling injection advance, particularly for automotive internal combustion engines provided with an injection pump and an injection nozzle, by means of intermediate relief, comprising cylinder means disposed between the injection pump and the injection nozzle, said cylinder means having an axial inlet from the injection pump and an axial outlet to the injection nozzle, control piston means reciprocally arranged within said cylinder means, spring means positioned within said cylinder means and engaging said control piston means in a direction opposed to the force exerted by the impulse of the injection pump, wherein said control piston means is provided with an axial bore having throttle means serving for filling of the outlet space of said cylinder means and a control cross section, and said cylinder means is provided with a first control cross section and an intermediate relief discharge line in communication therewith, said control piston means closing said first control cross section in said cylinder means in the initial and final positions of the piston means, while operatively connecting, in an intermediate position of the piston means, the first control cross section of the cylinder means with the outlet space of said cylinder means.

2. The device according to claim 1, wherein said control piston means is returned to its initial position by the combined effect of said spring means and the fuel supply pressure.

3. The device according to claim 1, further comprising second throttle means within said control piston means, disposed downstream of the first-mentioned throttle means and operatively connecting the axial bore with the control cross section of the control piston means, said second throttle means permitting the passage of a corrective volume of fuel during low rotational speed of the engine.

4. The device according to claim 1, wherein said cylinder means is provided with a further control cross section and said control piston means is provided with a transverse bore which communicates with said axial bore, said transverse bore cooperating with said further control cross section to provide communication between the inlet space of said cylinder means and the outlet to the injection nozzle when said control piston means is in its final position.

5. The device according to claim 1, wherein a fuel supply line, under supply pressure and provided with a check valve, communicates with the outlet space of said cylinder means.

6. The device according to claim 3, wherein a fuel supply line, under supply pressure and provided with a check valve, communicates with the outlet space of said cylinder means.

7. The device according to claim 2, wherein the intermediate relief discharge line includes throttle means at the inlet thereof.

8. The device according to claim 2, wherein the intermediate relief discharge line includes pressure valve means arranged at the inlet thereof.

9. The device according to claim 5, wherein the intermediate relief discharge line includes throttle means at the inlet thereof.

10. The device according to claim 5, wherein the intermediate relief discharge line includes pressure valve means arranged at the inlet thereof.

11. The device according to claim 2, wherein the control device is a self-contained structural unit connected directly ahead of the injection nozzle.

12. The device according to claim 5, wherein the control device is a self-contained structural unit connected directly ahead of the injection nozzle.

References Cited

UNITED STATES PATENTS
2,090,350 8/1937 Heinrich et al. ... 123—139 XR
2,173,814 9/1939 Bischof 123—139

FOREIGN PATENTS

LAURENCE M. GOODRIDGE, Primary Examiner.