United States Patent

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[31] P 19 47 529.7

[54] **FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES**
4 Claims, 2 Drawing Figs.

[52] U.S. Cl. .... 417/293, 123/139 AM, 123/139 BD, 417/300, 417/304, 123/140 FG
[51] Int. Cl. F02m 59/34, F02d 1/06, F04b 19/22
[50] Field of Search .... 123/139 AM, 139 BD, 140 A, 140 FG; 417/300, 293, 302, 303, 304

[56] References Cited

UNITED STATES PATENTS

3,403,629	10/1968	Eheim et al.	417/293
3,320,893	5/1967	Koster et al.	417/293

FOREIGN PATENTS

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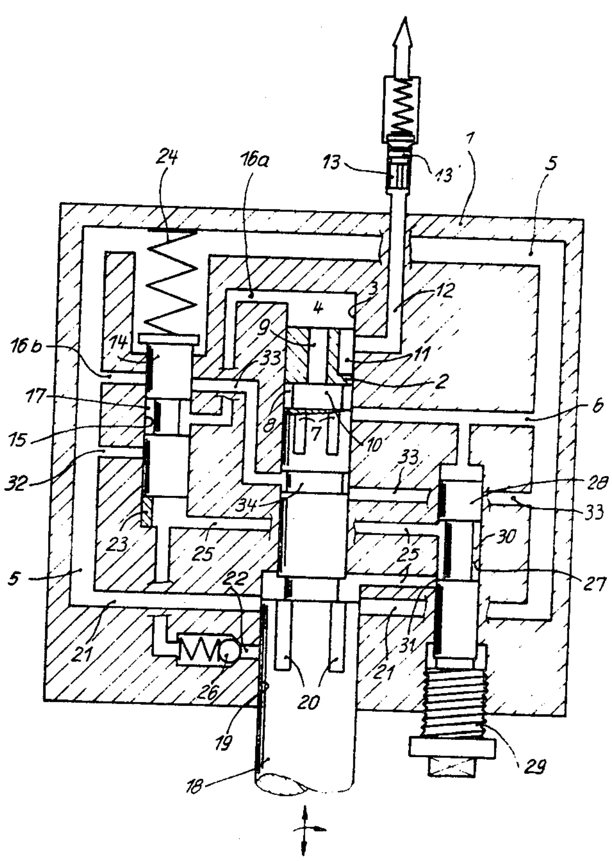
ABSTRACT: A fuel injection system having a reciprocating control member driven in synchronism with the injection pump for opening a fuel and interrupting the injection process. The control member, during its return stroke, drives the fluid through a controllable throttle channel to create a fluid abutment," i.e., it does not return to the initial position. A second bypass is provided subject to control by the control member as well as by a slide valve; also synchronous with the main pump, the characteristic feature being the coordination of the control member with the slide valve in dependence on the variable position of the fluid abutment.



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SHEET 1 OF 2

Fig. 1

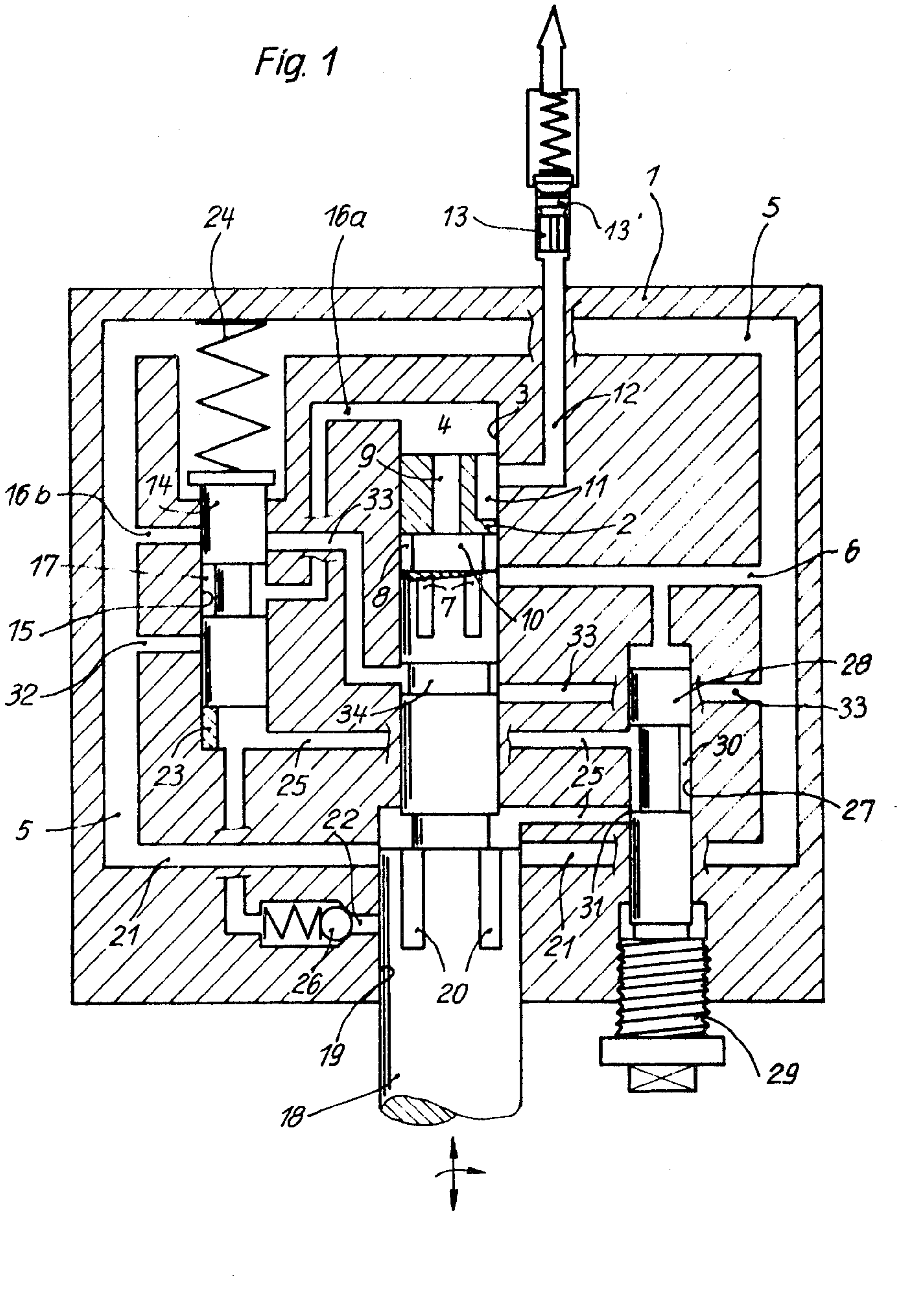

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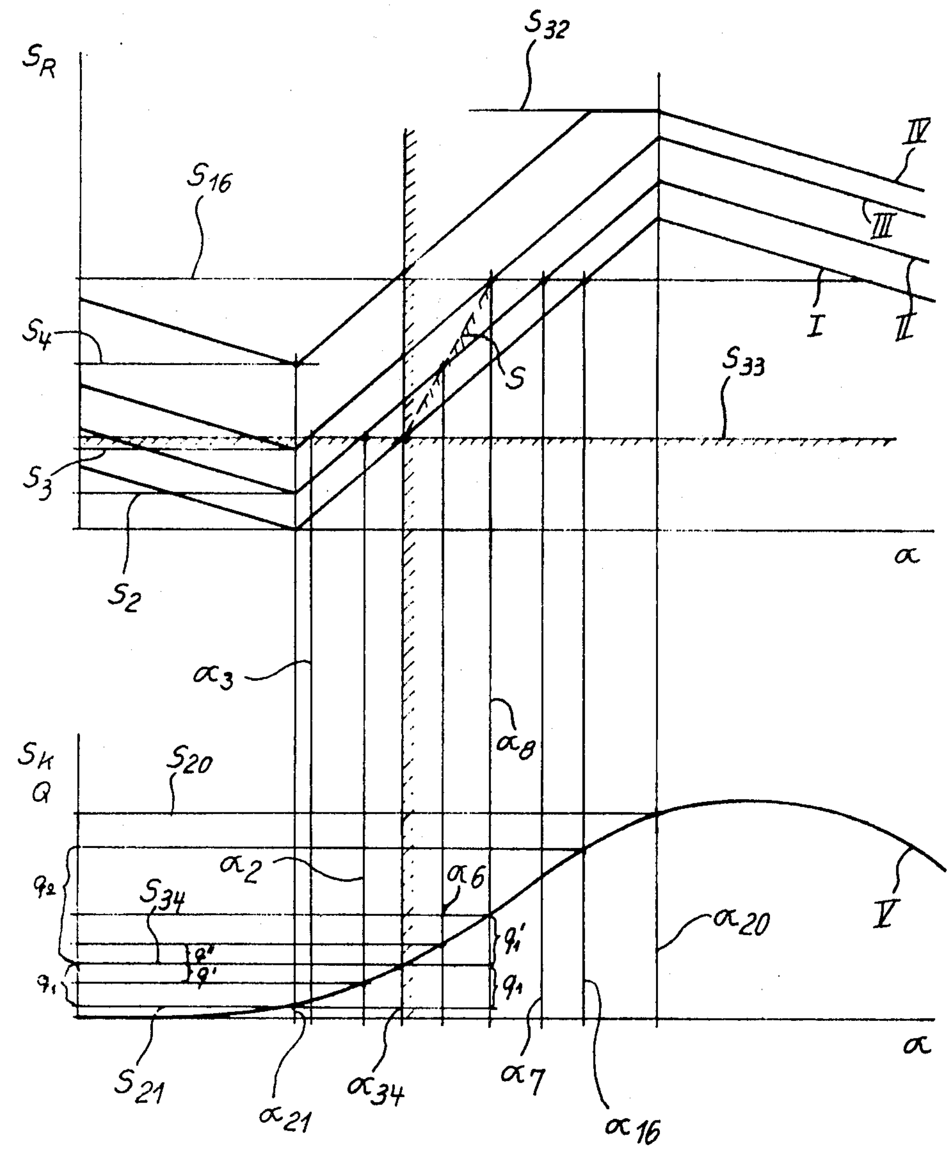
Fig. 2


S_R
S_{32}
S_{16}
S_4
S_3
S_2
S
S_{33}
IV
III
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I
α
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S_K
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S_{20}
α_2
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S_{21}
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FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

FIELD OF THE INVENTION

The invention relates to a fuel injection system for internal combustion engines.

BACKGROUND OF THE INVENTION

A system of this type is known in which the amount or rate of fuel supply is variable in dependence on the r.p.m. by interruption of the delivery at least upon attainment of the maximum r.p.m. owing to the opening of a first bypass of the injection pump work chamber during the pressure stroke of the pump piston by means of a reciprocating control member, which is driven during its pressure stroke by the pressure liquid supplied from an auxiliary pump operating in synchronism with the injection pump, and which is decelerated during the return stroke thereof by means of a throttle channel having a restriction through which at least a portion of the liquid supplied during the pressure stroke is made to flow during the return stroke, whereby the control member upon the attaining of a predetermined r.p.m. and at a certain value of the cross-sectional area of the restriction owing to the occurrence of the "fluid abutment" does not return to the initial position on a fixed stop provided therefor, a second bypass conduit being provided for the work chamber and which is controlled by the control member and by a slide valve operating in synchronism with the injection pump and with the auxiliary pump.

A fuel injection system of this type is known from German Pat. No. 1,286,804, in which the second bypass is blocked by the control member during the starting process and also as long as the control member returns to its initial position or the fluid abutment has not reached a predetermined level, the second bypass conduit is opened up by the pump piston before the control member opens the first bypass. With such a control of the second bypass a means is provided in the known fuel injection system for preventing the pressure liquid supplied by the auxiliary pump and flowing off through a release channel serving to supply an additional amount of fluid during the starting process from disturbing the control process within the range of r.p.m. corresponding to full loading.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide a supplementary preinjection by simple means or to obtain a control of the initiation of the injection in dependence on the loading conditions by providing a release space in the fuel injection line, whereby upon a decrease in loading the start of the injection process is retarded without any detrimental influence on the fluid abutment control.

The essential feature of the invention, by which this object is attained, consists in a dimensioning of the system, whereby the second bypass is opened up by the control member before the first bypass, and, when no fluid abutment is present, is closed by the slide valve before the opening in response to the control member, whereas in the presence of a fluid abutment it is opened up by the control member at an increasingly earlier time relative to the closing thereof by the slide valve as the level of the fluid abutment rises.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal section through an embodiment of the fuel injection system according to the invention.

FIG. 2 shows diagrams illustrating operation of the system of FIG. 1.

DESCRIPTION OF THE EMBODIMENT

In FIG. 1, numeral 1 represents the housing of a fuel injection pump. Provided in housing 1 is a cylinder 3 with a combined slide valve and piston 2 reciprocable therein and delimiting therewith a work chamber 4. Piston 2 is reciprocated and at the same time rotated about its axis by means known per se and not shown in the drawing. During each suction stroke of piston 2, work chamber 4 is supplied with fuel from a suction chamber 5 via a suction boring 6 and one of a number of longitudinal notches 7 on piston 2, an annular notch 8, an axial boring 9, which communicates with annular notch 8 and a transverse boring 10.

Piston 2 supplies fuel via a distributing notch 11 successively to supply conduits 12, in each of which there is provided a nonreturn valve 13 with a pressure release piston 13', conduits 12 being connected to pressure lines not shown, which connect with the individual injection valves of the engine. The release and nonreturn valve 13 prevents in known manner the occurrence of a spurious delayed injection due to pressure variation or elasticity in the pressure line or to the compressibility of the fuel, and which might otherwise tend to occur after the termination of the actual injection process. Longitudinal notches 7, only two of which are shown, and supply conduits 12, of which only one is shown, are spaced uniformly about the circumference of piston 2 and boring 3 in a number equal to that of the cylinders of the engine. While suction boring 6 and supply conduit 12 are disposed in one plane, distributing notch 11 and longitudinal notches 7 are staggered, relative to each other since distributor notch 11 should open up one of the supply conduits only when longitudinal notches 7 are shut off from suction boring 6 and vice versa.

The control of the rate of delivery of the pump occurs with the aid of a control member 14 in the form of a slide valve. Control member 14 operates in a cylinder 15 and controls the connection between a bypass channel section 16*a* connecting work chamber 4 with cylinder 15, on the one hand, and a bypass channel section 16*b* connecting cylinder 15 with suction chamber 5, on the other hand. Control member 14 has an annular notch 17 which is in continual connection with channel section 16*a* and in the inoperative position of control member 14 shown in FIG. 1 is disconnected from section 16*b*.

A section of larger diameter of piston 2 forms the piston 18 of an auxiliary pump. Piston 18 operates in a cylinder 19. The liquid displaced by piston 18 displaces control member 14 during its operative stroke. Connecting with the end surface space of piston 18 are longitudinal notches 20 provided on the cylindrical surface thereof in the same number and in the same planes as longitudinal notches 7. Via suction borings 21 fuel flows from suction chamber 5 into longitudinal notches 20 during the suction stroke of the auxiliary pump and thence into the work chamber of auxiliary pump 18, 19. During the subsequent pressure stroke piston 18 displaces fuel substantially via longitudinal notches 20 and a channel 22 into cylinder 15 below control member 14. Channel 22 and suction borings 21 are disposed in staggered arrangement.

As control member 14 is displaced by the fuel supplied from the auxiliary pump just before the end of its operative stroke it interconnects bypass channel sections 16*a* and 16*b*. The inoperative position of control member 14 is determined by a stop 23 disposed at the lower end of cylinder 15. During the return stroke, control member 14 is driven by a return spring 24 and displaces at least a portion of the liquid which was supplied during the operative stroke via a channel 25 back into cylinder 19, channel 22 being held closed by a nonreturn valve 26. Interposed in channel 25 is a cylinder 27, in which a slide valve 28 is axially displaceable by means of a screw 29. Slide valve 28 has a peripheral notch 30, in which terminates the section of channel 25 connected with the cylinder of piston 15, whereas the section connecting with cylinder 19 can be throttled at 31 by slide valve 28.

The return movement of control member 14 is braked in dependence upon the cross section of the throttling restriction 31. Above a certain r.p.m. determined by the cross section of restriction 31, the pressure stroke of the auxiliary pump sets in before control member 14 has returned to its initial position abutting stop 23. Due to this "fluid abutment" provided for control member 14, it begins its forward stroke from another initial position, whereby bypass sections 16*a* and 16*b* are interconnected at an earlier time during the displacement stroke. This leads to a decrease in the amount or rate of injection and consequently also in the r.p.m. of the engine supplied from the fuel injector. The operative stroke of control member 14 ends in any event when the lower end thereof opens up a safety bore 32, which connects with suction chamber 5 and through which any further amount of fuel supplied by the auxiliary pump can drain off.

Before the opening of channel 16*b* by control member 14, the latter opens up a second bypass channel 33, which also connects with suction chamber 5, however, bypass channel 33 has interposed therein cylinder 3, in which piston 2 operates. Provided on the cylindrical surface of piston 2 is an annular notch 34 for controlling second bypass channel 33 and holding it open as long as piston 2 is in its lower inoperative position, but disconnecting it therefrom when the piston has gone through a certain portion of its pressure stroke. The length of this portion of the stroke required for blocking channel 33 is selected in such a way that at full loading, i.e., as long as control member 14 returns to its initial position on stop 23, channel 33 is closed by piston 2 before control member 14 has opened up the same. As soon, however, as a fluid abutment is present, channel 33 is opened up by control member 14 before the pump piston has gone through the corresponding portion of its stroke. Therefore, a portion of the fuel displaced by piston 2 flows via bypass section 16*a*, annular notch 17, and second bypass channel 33 into suction chamber 5 until channel 33 is closed by piston 2.

The operation of the resulting regulation of the initiation of the injection in dependence upon the loading will now be explained with reference to the diagrams of FIG. 2.

In FIG. 2 a pair of diagrams are shown one above the other. The upper diagram represents the displacement s_R of control member 14 as a function of the angle of rotation α of the driving means, usually in the form of a cam, causing the reciprocating movement of piston system 2, 18. The lower diagram represents the displacement s_K of piston 2, 18 or the corresponding amount Q of liquid displaced by piston 2, also as a function of angle α.

In the upper diagram, four characteristics I, II, III, IV of the movement of the control member 14 have been drawn. The lower diagram shows a curve V illustrating the sinusoidal movement of piston system 2, 18.

The horizontal line S_{33} indicates the displacement of control member 14 from fixed stop 23 which is required for second bypass channel 33 to open (intersections of line S_{33} with characteristics I to IV). The horizontal line S_{16}, on the other hand, shows the displacement required by control member 14 for first bypass section 16*b* to open up (intersections of line S_{16} with characteristics I to IV). Characteristics I shows the movement of control member 14 as long as it is able on its return stroke to attain the inoperative position on stop 23. Characteristics II to IV show the movement of control member 14 for different increasing levels S_2, S_3, and S_4 of the fluid abutment. The horizontal line S_{21} of the lower diagram shows the position of the pump piston at which the connection of suction borings 6 and 21 is brought about by pistons 2 and 18, respectively, and the forward stroke of control member 14 begins. This position corresponds to the angle α_{21}. At the angular position α_{34}, when the pump piston system is in the position S_{34}, annular notch 34 is disconnected from second bypass channel 33 and the latter is blocked.

As soon as piston system 2, 18 reaches the position S_{20}, suction borings 21 are opened up by longitudinal notches 20 enabling the fuel displaced by piston 18 to flow back into suction chamber 5. As is apparent from the upper diagram, at this moment the return stroke of control member 14 sets in under the influence of return spring 24 and fuel is made to flow through restriction 31, and in dependence upon the cross-sectional area thereof determines the amount of braking action exerted on the control member, the position S_{20} of the piston system corresponds to the angular position α_{20}.

Since the intersection of lines S_{33} and α_{34} is on or immediately above the characteristic, it is apparent that second bypass channel 33 is disconnected from annular notch 34 before control member 14 opens up channel 33 as long as the control member returns to its fixed abutment, i.e., as long as there is not fluid abutment in operation.

The amount of fuel delivered by injection pump piston 2 can be thought of as consisting of two portions, namely, the quantity q_1 which is delivered between positions α_{21} and α_{34}(intersection α_{34}- S_{35}) and the quantity q_2, delivered between positions α_{34} and α_{16}(intersection α_{16}- S_{16}). The pump is designed in such a manner that the first quantity q_1 delivered between S_{21} and S_{34}, which is comparatively small, serves to compensate for the loss of volume occurring when the fuel pressure line is drained through piston 13' of nonreturn valve 13, whereas the second quantity is the effective amount of fuel injected. In the entire range of r.p.m. corresponding to full loading, the ratio of these quantities is maintained constant. However, as soon as a fluid abutment is present, for instance, at the level S_2 and at position α_{21}, the second bypass channel is opened up by control piston 14 at angular position α_2(intersection α_2- S_{33}), whereby the flow of fluid into supply conduit 12 is interrupted and the quantity q' is drained off to suction chamber 5 (idling output). Not until second bypass channel 33 is closed by piston 2 at position α_{34} does the delivery to conduit 12 set in again. Therefore, only at position α_6 is the bypass space in the pressure line filled by such a quantity q''- q', that the actual injection can begin, which is then interrupted at position α_7 owing to control member 14 opening up section 16*b* of the first bypass channel (intersection S_{16}- α_7). Apart from the decreased amount of fuel injected, there is a displacement of the moment at which injection begins in accordance with the characteristic shown in broken lines and designated S.

As soon as the fluid abutment has reached the level S_3, the idling delivery through second bypass channel 33 between positions α_3 and αA α_8 bypass section 16*b* is opened so as to terminate the injection (intersection of characteristic III with S_{16}), whereby the fuel delivered by piston 2 serves only to fill the bypass space and on injection takes place. If the fluid abutment rises further, no injection takes place anymore. From a certain level on, for instance, that of the fluid abutment, control member 14 opens up safety bore 32 at S_{32}, which controls the maximum stroke thereof. After the opening of safety bore 32, characteristic IV is horizontal and then drops, just extent the other characteristics, from position α_{20} on.

As has been explained with reference to the diagrams, through the control according to the invention, the initiation of the injection is retarded within the range of downward regulation, and this takes place to a greater extent as the load decreases, i.e. the r.p.m. increases.

If nonreturn valve 13 with its release piston 13' is replaced with a nonreturn valve without such piston, there takes place in the region of partial loading or idling a preinjection by the quantity q_1, which may contribute to smooth running in the idling state.

What is claimed is:

1. A fuel injection system for internal combustion engines having a variable rate of fuel supply in dependence on the r.p.m. comprising,

a fuel injection pump having a cylinder and a pump piston in said cylinder delimiting therewith a work chamber,

a first bypass for said work chamber, a reciprocable control member for interrupting the delivery of said pump at least at maximum r.p.m. by opening up said first bypass during the pressure stroke of the said pump piston,

an auxiliary pump for operation in synchronism with said injection pump and supplying pressure liquid to said control member during the pressure stroke thereof,

means for exerting a return force on said control member,

a stop for limiting the return stroke of said control member and defining a fixed initial position therefor, a throttle channel having a controllable restriction therein and connected to receive a portion of the liquid displaced during the return stroke of said control member, thereby to decelerate said return stroke,

whereby said control member upon the attaining of a predetermined r.p.m. and at a certain value of the cross-sectional area of said restriction is subjected to a fluid abutment and does not return to said initial position,

a second bypass connected with said work chamber and means on said control member for controlling said second bypass,

a slide valve driven in synchronism with said injection pump and said auxiliary pump for controlling said second bypass,

characterized by a dimensioning of said system, whereby said second bypass (**33**) is opened up by said control member (**14**) before said first bypass (**16*b***), and said second bypass (**33**) is closed by said slive valve (**2**) before the opening up thereof in response to said control member (**14**) when no fluid abutment is present and in the presence of a fluid abutment is opened up by said control member (**14**) at an increasingly earlier time relative to the closing thereof by said slide valve (**2**) as the level of said fluid abutment rises.

2. A fuel injection system according to claim **1**, having a fuel line for connecting to an engine and in which a release space is provided in said fuel line.

3. A fuel injection system according to claim **1**, in which said injection pump piston (**2**) forms said slide valve.

4. A fuel injection system according to claim **1**, in which the pump piston (**18**) of said auxiliary pump forms said slide valve.

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