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[54] **FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES AND METHOD OF FUEL CONTROL**

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[51] **Int. Cl.**..........**F02d 1/04**

[58] **Field of Search**........123/140 J, 140 A, 140 FG, 123/140 AS, 139 AM, 140; 417/293

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[57] **ABSTRACT**

In a fuel injection pump, in order to prolong the duration of fuel injection during each pressure stroke of the pump piston in the idling or low load rpm range, there is provided a bypass channel extending from the pump work chamber for continuously discharging part of the fuel displaced by the pump piston. Said bypass channel contains a valve means which closes the bypass channel when the engine rpm exceeds the idling or low load rpm range.

10 Claims, 3 Drawing Figures

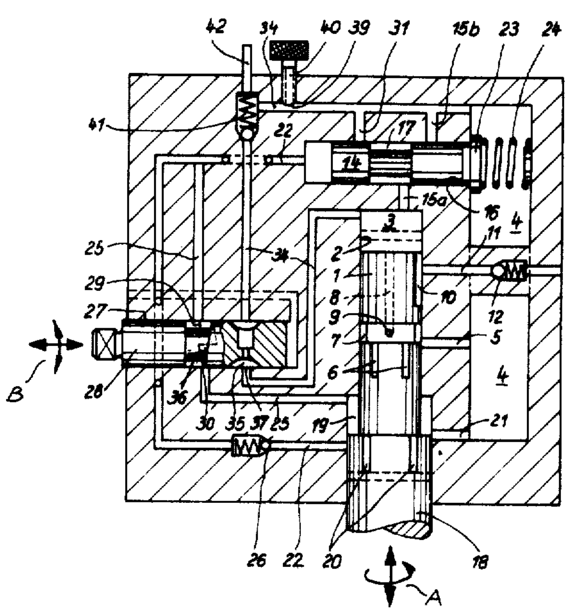

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Fig. 1

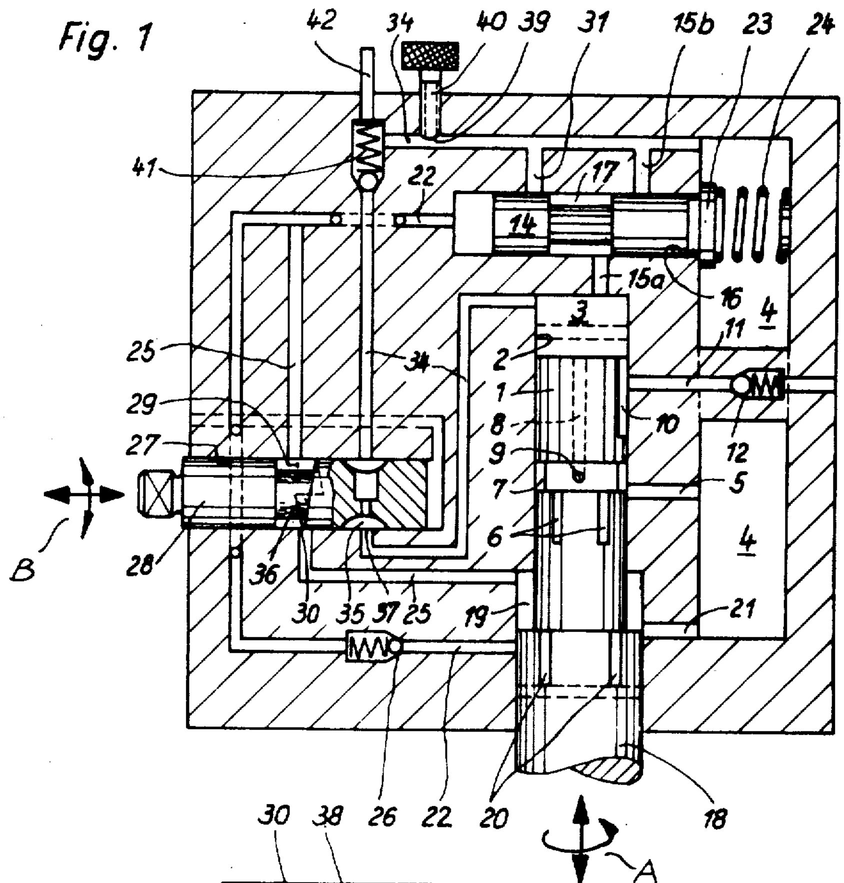
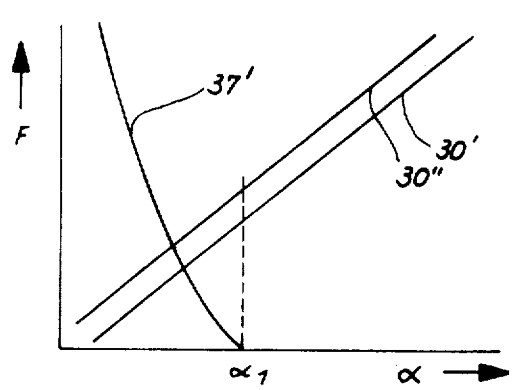


Fig. 2

Fig. 3



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FUEL INJECTION PUMP FOR INTERNAL COMBUSTION ENGINES AND METHOD OF FUEL CONTROL

BACKGROUND OF THE INVENTION

This invention relates to a fuel injection pump for internal combustion engines and is of the type which is provided with at least one reciprocating pump piston and with bypass channel means extending from the pump work chamber and including a throttle.

When Diesel engines operate in the lower rpm range, the combustion noises are very substantial, particularly during idling and under low load conditions. Besides thermal effects, the reason therefor is the relatively short duration of injection, corresponding to the small fuel quantities to be injected in this range of engine operation. By prolonging the duration of injection, for example, by extending the effective duration of fuel delivery during each delivery stroke of the fuel injection pump, the combustion noise may be substantially decreased.

An aforenoted prolongation of the injection period is obtained by means of the so-called advance injection methods in which first a small fuel quantity is injected followed by the main fuel quantity. In a known fuel injection pump of the aforenoted type (such as disclosed in French Pat. No. 1,495,537), for practicing such an advance injection, the bypass channel leads into a hydraulic accumulator, the pressure characteristics of which are variable for altering the course of the injection. Such an arrangement, however, is complex and disadvantageous for high partial load or full load conditions since, even when the accumulator piston is blocked in this rpm range, the structurally necessary enlargement of the detrimental space of the pump work chamber has an adverse effect on the course of the injection.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved fuel injection pump and method of the aforenoted type wherein a prolongation of the injection period in the idling and low load rpm range may be achieved by simple means with the elimination of the aforenoted disadvantages.

Briefly stated, according to the invention, the bypass channel is closed beyond the idling rpm by means of a valve which preferably is actuated in unison with the fuel quantity control member of the fuel injection pump.

The invention will be better understood as well as further objects and advantages of the invention will become more apparent from the ensuing detailed specification of a preferred, although exemplary embodiment, taken in conjunction with the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an axial sectional view of a fuel injection pump according to the preferred embodiment;

FIG. 2 is a view of one part shown in FIG. 1 after a 90° turn and

FIG. 3 is a diagram illustrating the function of the flow passage sections F with respect to the angle of rotation α of the fuel quantity control or setting member.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to FIG. **1**, the fuel injection pump shown therein comprises a piston **1** which reciprocates in a cylinder **2**, the upper portion of which, together with the radial terminal face of piston **1**, defines a pump work chamber **3**. The pump piston **1**, which also serves as a distributor, sequentially supplies with fuel the cylinders (not shown) of a multi-cylinder internal combustion engine (also not shown). The pump piston **1** is reciprocated and simultaneously rotated as indicated by arrows A by means not shown. During each suction stroke of the piston **1**, the pump work chamber **3** is supplied with fuel from a suction chamber **4** through a control bore **5**, one of the longitudinal grooves **6**, an annular groove **7**, and an axial bore **8** directly communicating with the pump work chamber **3**. The axial bore **8** is provided in piston **1** and is connected with the annular groove **7** by means of a transversal bore **9**.

The pump piston **1** delivers fuel through a longitudinal distributor groove **10** and through one of pressure channels **11**, each of which contains a check valve **12**. Each pressure channel **11** extends from the cylinder **2** and is connected with associated pressure conduits, not shown, which, in turn, extend to the individual fuel injection valves (also not shown), mounted in the internal combustion engine. The longitudinal distributor groove **10**, the annular groove **7**, as well as the longitudinal grooves **6** are provided in the lateral face of the piston **1**. The longitudinal distributor groove **10** terminates on the radial face of the piston **3** and thus merges into the pump work chamber **3**. The longitudinal grooves **6**, of which only two are shown in the drawing, and the pressure or delivery channels **11**, of which only one is shown, are arranged uniformly spaced about the circumference of piston **1** and cylinder **2** and their number equals that of the cylinders of the engine with which the fuel injection pump is associated.

The fuel quantity control of the fuel injection pump is effected by means of a regulator shuttle **14** which is disposed between a bypass channel portion **15a** merging into the pump work chamber **3** and a bypass channel portion **15*b*** communicating with the suction chamber **4**. The regulator shuttle **14** controls the hydraulic communication between the bypass channel portions **15*a*** and **15*b***. When such communication is established, the delivery of fuel to the engine is interrupted although the pressure stroke of the pump piston is still in progress.

To control the afore-defined hydraulic communication by means of the regulator shuttle **14**, the bypass channel portions **15a** and **15b** open into a cylinder **16** in which the regulator shuttle **14** reciprocates. The latter is provided with an annular groove **17** which is in continuous communication with the bypass channel portion **15*a***, but, as shown in FIG. **1**, is separated from the bypass channel portion **15*b*** when the regulator shuttle **14** is in its position of rest determined by an abutting relationship between the pump housing and a flange **23** forming part of the regulator shuttle **14**.

An enlarged portion of the piston **1** forms an auxiliary piston **18** operating in a cylinder **19**. The liquid displaced by the piston **18** shifts the regulator shuttle **14** in a direction of its forward motion. At the frontal face of the piston 18 there terminate longitudinal grooves 20 which are disposed on the lateral face of the piston 18 and which equal the number of the longitudinal grooves 6. During the suction stroke of the auxiliary pump 18, 19, fuel is admitted from the suction chamber 4 through a control bore 21 and longitudinal grooves 20 into the work chamber of the auxiliary pump 18, 19. During its pressure stroke, the auxiliary piston 18 forces fuel substantially through the channel 22 into the cylinder 16 to affect the adjacent radial face of the regulator shuttle 14.

The regulator shuttle 14, when displaced from its position of rest by the fuel forced into cylinder 16 by the piston 18, shortly before the end of its possible path of travel, establishes communication between the bypass channel portions *15a* and *15b*. At least one part of the fuel that caused the forward motion of the regulator shuttle 14, is forced by the latter, during its return motion caused by spring 24, through a channel 25 back into the cylinder 19 of the auxiliary pump. During this occurrence the channel 22 is closed by a check valve 26.

The channel 25 passes radially through a cylinder bore 27 in which there is disposed a setting member 28 which is axially reciprocable and rotatable as indicated by arrows B. In the lateral face of the latter there is provided a circumferential control groove 29 which has an oblique control edge 36 to vary, during angular displacement of the setting member 28, the flow passage section of a throttle 30 of the channel 25. The diametrically opposite continuation of the channel 25 freely merges into the control groove 29. Dependent upon the magnitude of the flow passage section of throttle 30, the return motion of the regulator shuttle 14 is braked to a greater or lesser extent.

Beyond an rpm determined by the flow passage section of the throttle 30, the auxiliary pump 18, 19 begins a new pressure stroke before the regulator shuttle 14 is able to return to its initial position in which flange 23 abuts the pump housing. By virtue of the so-called fluid abutment which appears under these conditions, the regulator shuttle 14 begins its forward motion from an advanced initial position. As a result, the bypass channel portions *15a* and *15b* are interconnected with one another at an earlier moment during the pressure stroke. In this manner, the injected fuel quantities are decreased and, consequently, the rpm of the internal combustion engine, with which the fuel injection pump is associated, also decreases.

A release bore 31 connects the cylinder 16 of the regulator shuttle 14 with the suction chamber 4 and is closed by the lateral face of the regulator shuttle 14 during normal operation. The release bore 31, as a safety means, determines the extreme position which the regulator shuttle 14 may assume during its forward motion subsequent to hydraulically connecting the bypass channels 15a, 15b with one another.

From the pump work chamber 3 there extends a bypass channel 34 to the suction chamber 4. The channel 34 passes radially through cylinder 27 and is controlled by the setting member 28. For this purpose, the setting member 28 is provided with a longitudinal groove 35 which has a bounding edge 38 extending parallel to the axis of the setting member 28 and determines, dependent on the angular position of the setting member 28, a flow passage section of throttle 37 of the channel 34 (FIG. 2). When the setting member 28 is rotated, the edge 38 of the groove 35 passes over the discharge channel 34 and closes the latter. The control edge 38 is so arranged with respect to the oblique control edge 36 of the groove 29 of the setting member 28 that the bypass channel 34 is closed at the moment when the rpm of the engine exceeds the low load rpm range. By virtue of an axial displacement of the setting member 28 effected by means of an adjusting screw not shown, this mechanism may be pre-set. In FIG. 2 a second, adjusted axial position of the setting member 28 is shown in broken lines.

It is thus seen that in the low rpm ranges the fuel displaced by the piston 1 while the bypass channel 15a, 15b is closed, is divided into two simultaneous flows: the first flow is injected into the engine through one of the pressure channels 11, while the second flow passes through the bypass channel 34 and is returned to the suction chamber 4. In this manner the duration of the injection of fuel during each pressure stroke of piston 1 is prolonged because it takes longer to deliver the required fuel quantity by a partial fuel stream (i.e. by the aforedescribed second flow) than by a single flow. This effect is eliminated by closing the throttle 37 of the bypass channel 34 when the engine rpm exceeds the low rpm range.

In order to better adapt to the engine characteristics the fuel discharged through the bypass channel 34, there is provided a second throttle 39 associated with the bypass channel 34. The flow passage section of the throttle 39 is variable by means of a setting screw 40. Also for the flow control, there is provided a check valve 41 disposed in the bypass channel 34 and having a closing spring, the force of which may be varied by means of an adjusting mechanism 42.

Turning now to the diagram shown in FIG. 3, the ordinate indicates the free flow passage section F of the throttle 30, while the abscissa indicates the angle of rotation α of the setting member 28. The curves 30′ and 30″ characterize the function of the flow passage section of throttle 30 in two different axial positions of setting member 28. The curve 37′ relates to the flow passage section of the throttle 37. As it is seen from the diagram, when the setting member 28 is rotated in the direction α, the throttle 30 is widened and the throttle 37 is sharply narrowed. The throttle 37 is closed when the setting member 28 is turned through an angle α_1. Thus, when the setting member 28 is rotated beyond the angle α_1, the engine operates over the low load rpm range in which the bypass channel 34 is closed.

It is to be understood that the valve means controlling the bypass channel 34 may be actuated electromagnetically or by hydraulic pressure that increases with increasing rpm, or by other suitable means.

What is claimed is:

1. In a fuel injection pump for an internal combustion engine, said pump being of the type that includes a pump work chamber and at least one reciprocating pump piston associated with said chamber, the improvement comprising,

A. a bypass channel extending from said pump work chamber to a space in which there prevails a pressure that is lower than the pressure in said pump work chamber at any time during each delivery stroke of said reciprocating pump piston,

B. movable valve means disposed in said bypass channel to assume an open position for maintaining communication between said pump work chamber and said space through said bypass channel and to assume a closed position for blocking said bypass channel, said movable valve means being in continuous communication with said pump work chamber through said bypass channel at least for the entire duration of each delivery stroke and being in said open position for said entire duration at the idling rpm and

C. means for moving said valve means into and maintaining it in said closed position when said engine operates over the idling rpm.

2. An improvement as defined in claim **1**, including a check valve disposed in said bypass channel.

3. An improvement as defined in claim **1**, including a fuel quantity setting member and means to move said valve means together with said setting member as a rigid unit.

4. An improvement as defined in claim **3**, wherein said movable valve means forms part of a variable throttle in said bypass channel to vary the flow passage section thereof between said open and said closed positions of said movable valve means, said movable valve means and said fuel quantity setting member form a unitary structure.

5. An improvement as defined in claim **4** including

A. hydraulically operated means for determining the injected fuel quantities by interrupting the injection of fuel during one part of each delivery stroke of said reciprocating pump piston,

B. a channel communicating with said pressure-dependent means and carrying hydraulic liquid and

C. an additional variable throttle forming part of said fuel quantity setting member and disposed in the lastnamed channel for varying the flow passage section thereof to control said hydraulically operated means.

6. An improvement as defined in claim **5**, wherein said setting member is rotatably and axially displaceably held in said fuel injection pump; said additional throttle is variable by rotating and axially displacing said setting member; said bypass channel is closable by said setting member upon rotation thereof.

7. An improvement as defined in claim **1**, wherein said movable valve means forms part of a variable throttle in said bypass channel to vary the flow passage section thereof between said open and said closed positions of said movable valve means.

8. An improvement as defined in claim **7**, including an additional throttle disposed in said bypass channel remote from said movable valve means and means for arbitrarily varying said last-named throttle independently from the first-named throttle.

9. In a fuel injection pump for an internal combustion engine, said pump being of the type that includes a pump work chamber and at least one reciprocating main pump piston associated with said

chamber, the improvement comprising in combination,

A. a first bypass channel extending from said pump work chamber,

B. valve means disposed in said first bypass channel and continuously communicating with said pump work chamber through said first bypass channel at least for the entire duration of each delivery stroke of said reciprocating main pump piston, said valve means being in an open position for said entire duration at the idling rpm,

C. means actuating said valve means to close and maintain closed said first bypass channel when said engine operates over the idling rpm,

D. a second bypass channel extending from said pump work chamber,

E. a regulator shuttle reciprocably disposed in said pump for opening and closing said second bypass channel,

F. return means urging said regulator shuttle into an initial position of rest,

G. an auxiliary piston operating synchronously with said main pump piston,

H. a first hydraulic channel establishing communication between said auxiliary piston and said regulator shuttle,

I. a hydraulic liquid driven by said auxiliary pump during the pressure strokes thereof through said first hydraulic channel to exert an engine rpm-dependent force on said regulator shuttle for displacing the latter in a forward motion from its initial position of rest to open said second bypass channel thus interrupting fuel delivery to said engine by said main pump piston during the pressure strokes thereof,

J. a second hydraulic channel extending from said regulator shuttle; said regulator shuttle, displaced by said return means during the suction strokes of said auxiliary piston, forces at least part of the liquid that caused its forward motion, through said second hydraulic channel and

K. a variable throttle disposed in said second hydraulic channel to brake to a predetermined extent the return motion of said regulator shuttle; upon reaching of a predetermined rpm at a given setting of said throttle, said regulator shuttle reciprocates without returning into said initial position of rest.

10. A method of prolonging the period of fuel injection into an internal combustion engine during the idling rpm range by means of a fuel injection pump of the type that includes a pump work chamber and at least one reciprocating pump piston associated with said chamber, comprising the following steps:

A. discharging in said rpm range through a bypass channel extending from said pump work chamber one part of the fuel displaced by said pump piston throughout its pressure strokes and

B. closing said bypass channel by valve means when said engine operates beyond said rpm range.

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