United States Patent

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[72] Inventors **Willi Voit; Ulrich Aldinger, both of Stuttgart, Germany**

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[73] Assignee **Robert Bosch GmbH Stuttgart, Germany**
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[33] **Germany**
[31] **P 19 19 707.0**

[54] **FUEL INJECTION PUMP FOR MULTICYLINDER INTERNAL COMBUSTION ENGINES**
2 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **417/505**
[51] **Int. Cl.** **F04b 7/00**
[50] **Field of Search** .... 417/505, 485, 385, 387, 521, 533; 123/139 E

[56] **References Cited**

UNITED STATES PATENTS

3,476,050 11/1969 Kemp et al. .... 417/385 X
3,482,519 12/1969 Nicolls .... 417/387 X

Primary Examiner—Robert M. Walker
Attorney—Edwin E. Greigg

ABSTRACT: In a fuel injection pump including a rotary distributor with radially operating pump pistons, in order to increase the total number of delivery strokes, said distributor houses two radial pump assemblies supplied by a sole suction chamber and operating with a phase shift of 90°.

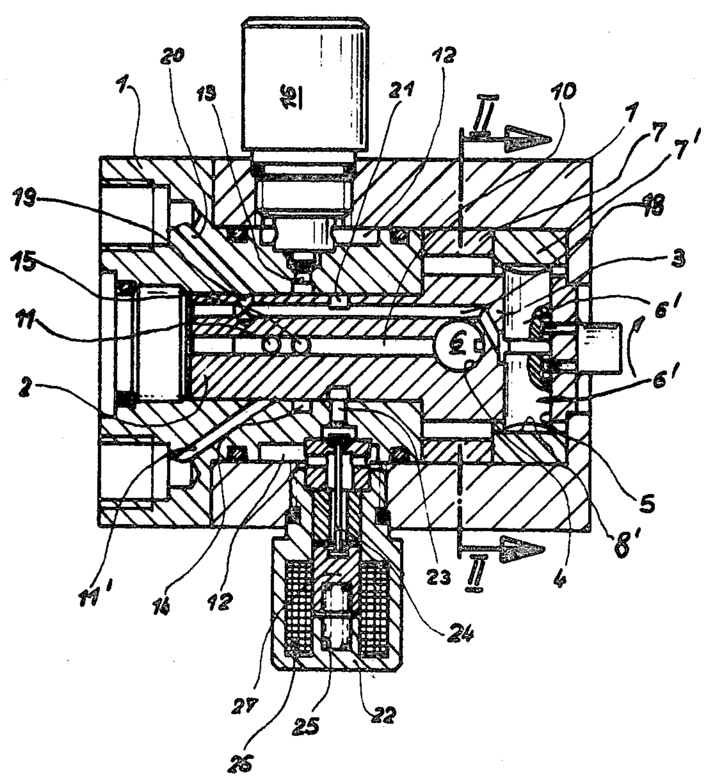

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Fig 1

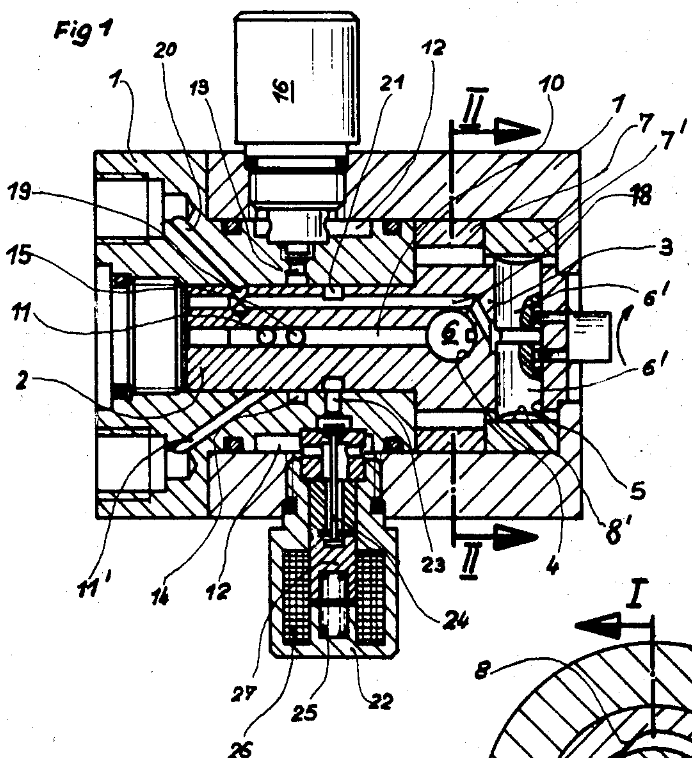


Fig 2

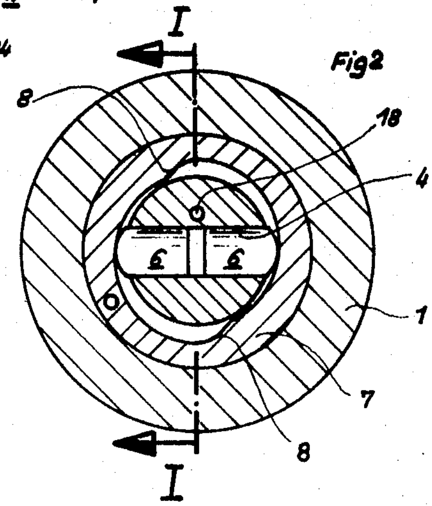
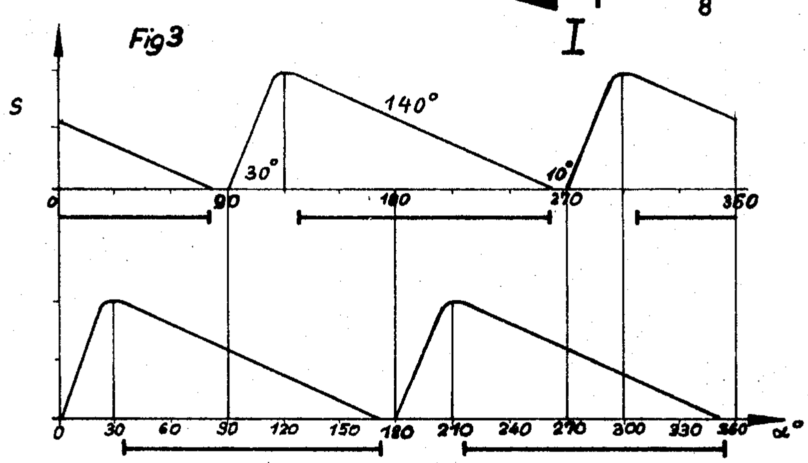


Fig 3



INVENTOR.

Willi VOIT and
Ulrich ALDINGER

BY Erwin E. Greigg

FUEL INJECTION PUMP FOR MULTICYLINDER INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to a fuel injection pump for multicylinder internal combustion engines and is of the type wherein the infection of fuel is effected by at least one reciprocating pump piston disposed in a radial bore of a rotary pump body which simultaneously serves as a distributor. For executing a delivery or pressure stroke, the piston is urged inwardly by a cam and, for executing its suction stroke, the piston is exposed to fuel pressure generated by an upstream arranged delivery pump forcing fuel through a controlled channel associated with said cylinder bore.

In a known fuel injection pump of the aforenoted type (such as disclosed in German Pat. No. 1,288,359), the fuel quantities to be injected are determined by means of a throttle which, dependent upon the pressure and the flow passage section, allows a certain fuel quantity per time unit to flow through.

Further, fuel injection pumps are known, wherein the fuel quantities to be injected are controlled by means of a solenoid valve which operates on electronic command.

An electronic regulator permits a more accurate matching of the fuel quantities to be injected with the torque characteristics of the engine and is less expensive than a mechanical or hydraulic regulator Fuel injection pumps of this type are disadvantageous in that the opening and the closing periods of the magnetic valve are relatively long (approximately 1 millisecond each). In a 3,000 r.p.m. pump during each such period the driving cam rotates approximately 18°, or 36° for an opening and successive closing step. It follows that for each revolution of the distributor only two pressure strokes may be performed if a sufficiently large regulating range is to remain available.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved fuel injection pump of the aforenoted type which has a simplified structure particularly adapted for incorporating electronically operated solenoid valves to control the fuel quantities to be delivered.

It is another object of the invention to provide an improved fuel injection pump of the aforenoted type which permits more than two pressure strokes per revolution.

Briefly stated, according to the invention, the rotary distributor of a radial fuel injection pump houses at least two pump units operating with a phase shift. Each pump unit has a pump work chamber and channel means connecting said pump work chamber with a common fuel supply means, such as a sole suction chamber. Each channel means is opened or closed by a solenoid valve, one associated with each pump unit.

The invention will be better understood and 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 section view of a radial fuel injection pump according to the invention taken along line I–I of FIG. 2;

FIG. 2 is a sectional view along line II–II of FIG. 1; and

FIG. 3 is a diagram showing the displacement of the pistons as a function of the angular position of the pump drive shaft.

DESCRIPTION OF THE EMBODIMENT

In a two part pump housing 1 there is disposed a distributor 2 which rotates in tune with an internal combustion engine (not shown) associated with the fuel injection pump. The distributor 2 has an enlarged portion serving as a distributor head

3 in which there are provided, in different planes, two transversal, hydraulically separated cylinder bores 4 and 5, the axes of which cross at an angle of 90°. In bore 4 there operate two radial pump pistons 6 associated with a stationary cam ring 7. In bore 5 there are disposed two radial pump pistons 6′ which, in turn, are associated with a stationary cam ring 7′ disposed immediately adjacent the cam ring 7. As the distributor 2 rotates, cams 7 and 7′ cause the respective piston pairs 6 and 6′ to execute their inwardly directed pressure or delivery strokes. Following each delivery stroke, the outward motion of the pistons 6, 6′ towards cam rings 7, 7′ (suction stroke) is caused by centrifugal forces and by the pressure of the fuel flowing into the pump work chamber of pistons 6 and 6′. Each cam ring 7, 7′ has two rising cam face portions 8, 8′ so that each piston pair 6, 6′ executes two pressure strokes and two suction strokes for each revolution of the distributor 2. The first pump unit formed of bore 4 and pistons 6 is hydraulically completely separated from the second pump unit formed for bore 5 and pistons 6′. The pump work chamber of the first pump unit is, during its pressure stroke, connected with a pressure channel 11′ through an axial bore 10 and a distributor bore 11, both provided in the distributor 2. To the pressure channel 11′ there is connected a pressure conduit (not shown) leading to the internal combustion engine. During the suction stroke of pistons 6, fuel under pressure flows from a suction chamber 12 across a bore 13 into an annular groove 14 provided in the housing 1. The annular groove 14 is in continuous communication with the pump work chamber of the first pump unit through a radial bore 15 of the distributor 2 and the axial bore 10. The suction chamber 12, provided in the pump housing 1, is supplied with fuel by means of a delivery pump, not shown. The bore 13 is controlled by a solenoid valve 16. As long as the solenoid valve 16 is open, the fuel may flow from the suction chamber 12 into the pump work chamber of the first pump unit 4, 6.

Similarly to the first pump unit 4, 6, the pump work chamber of the second pump unit 5, 6′ is connected by means of a longitudinal channel 18 provided in the distributor 2 with a distributor bore 19 which, during the pressure stroke of the pump pistons 6′, communicates with a pressure channel 20 to which there is attached a pressure conduit (not shown) leading to the internal combustion engine.

Corresponding to the two pressure strokes executed per revolution by each pump unit, there are provided two pressure channels 20 and two pressure channels 11 (only one of each shown). The longitudinally extending bore 18 is connected with an annular groove 21 provided in the outer lateral face of the distributor 2. The annular groove 21 is in continuous communication with a bore 23 leading to the suction chamber 12 and controlled by a solenoid valve 22.

The solenoid valves 16 and 22 are so designed that they are open when unenergized. Their movable valve member (designated at 24 in solenoid valve 22) is pressed against its valve seat into a closed position by the fuel pressure prevailing in the pump work chambers during pressure strokes. On the other hand, during suction strokes, the fuel flowing from the suction chamber 12 to the pump work chamber, aids the valve opening spring 25 of each solenoid valve in displacing the valve member 24 into an open position. Thereafter, as soon as an electronic control device (not shown) energizes the coil 26 of the solenoid valve, the valve member 24 is pulled into its seat by means of an armature 27.

Turning now to FIG. 3, there is graphically shown the operation of the fuel injection pump described hereinabove. In the diagram, the displacement s of the pump pistons 6, 6′ (ordinate) is shown as a function of the rotational angle α of the distributor 2 (abscissa). In the upper graph there is shown the displacement of the pistons 6 operating in the bore 4 (first pump unit) while in the lower graph there is depicted the displacement of the pistons 6′ operating in the bore 5 (second pump unit). A comparison of these graphs shows that the two pump units operate with a phase shift of 90°. **Expressing one pumping cycle in degrees of distributor rotation, it is thus seen**

that one pumping cycle is divided into 30° for a delivery stroke, 140° for a suction stroke and 10° for changing channels. Thus, the solenoid valves **16** and **22** may open the respective bores **13** and **23** connecting the suction chamber **12** with the pump work chambers of the pump units, immediately after closing the pressure channels **11** and **20**, respectively. In this manner, the solenoid valves are already open when the suction stroke begins. Consequently, the fuel quantities to be delivered by the pump are affected only by the closing characteristics of the solenoid valve and not by the opening characteristics thereof. The periods, during which fuel quantity control may take place by virtue of closing the channels **13** and **23** by the solenoid valves **16** and **22**, are represented by lines drawn parallel below the two abscissae in FIG. **3**.

What we claim is:

1. In a fuel injection pump associated with a multicylinder internal combustion engine and being of the known type that includes (A) a rotary distributor, (B) radial pump means contained in said distributor and (C) stationary cam means operatively connected with said radial pump means to cause it to perform pressure strokes, the improvement comprising,

A. a first pump unit including
  1. a first radial cylinder bore provided in said distributor,
  2. at least one first pump piston reciprocably disposed in said first radial cylinder bore,

B. a first cam associated with said first pump piston to cause periodic inward displacement thereof upon rotation of said distributor,

C. a fuel source,

D. a first channel connecting said first radial cylinder bore with said fuel source,

E. a first solenoid valve associated with said first channel to control the flow of fuel therethrough,

F. at least one second pump unit including
  1. a second radial cylinder bore provided in said distributor, said second radial cylinder bore extending spaced from said first radial cylinder bore, the axes of said first and second radial cylinder bores lying in parallel planes,
  2. at least one second pump piston reciprocably disposed in said second radial cylinder bore,

G. a second cam associated with said second pump piston to cause periodic inward displacement thereof upon rotation of said distributor,

H. a second channel connecting said second radial cylinder bore with the same said fuel source,

I. a second solenoid valve associated with said second channel to control the flow of fuel therethrough and

J. means causing said first pump piston to reciprocate out-of-phase with respect to said second pump piston.

2. An improvement as defined in claim **1**, wherein the axes of said first and said second radial cylinder bores are disposed at an angle of 90° with respect to one another.