(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 055 083**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **81305926.8**

(51) Int. Cl.³: **F 02 M 51/04**

(22) Date of filing: **17.12.81**

(30) Priority: **22.12.80 US 219109**

(43) Date of publication of application: **30.06.82**
Bulletin 82/26

(84) Designated Contracting States: **DE FR GB**

(71) Applicant: **FORD MOTOR COMPANY LIMITED, Eagle Way, Brentwood Essex CM13 3BW (GB)**
(84) Designated Contracting States: **GB**

(71) Applicant: **FORD-WERKE AKTIENGESELLSCHAFT, Ottoplatz 2 Postfach 21 03 69, D-5000 Köln 21 (DE)**
(84) Designated Contracting States: **DE**

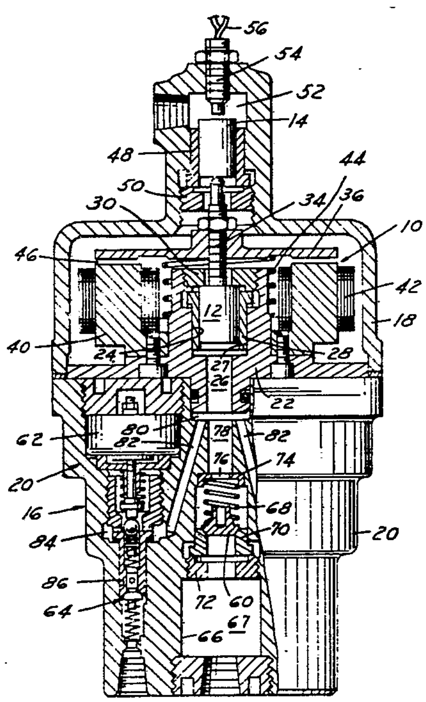
(71) Applicant: **FORD FRANCE SOCIETE ANONYME, 344 Avenue Napoléon Bonaparte B.P. 307, F-92506 Rueil Malmaison Cedex (FR)**
(84) Designated Contracting States: **FR**

(72) Inventor: **Schechter, Michael Moses, 27686 Sutherland, Southfield Michigan 48076 (US)**

(74) Representative: **Drakeford, Robert William et al, 15/448 Research & Engineering Centre, Laindon Basildon Essex SS15 6EE (GB)**

(54) Fuel injection pump.

(57) An electromagnetically actuated fuel injection pump has a primary plunger (12) operated by a solenoid (10), and a booster plunger (14) actuated by fuel pressure to supplement the force of the solenoid (10) and thereby permit the use of a smaller solenoid.



EP 0 055 083 A2

DESCRIPTION

FUEL INJECTION PUMP

This invention relates to fuel injection pumps.

In a known fuel injection pump for a spark ignition type engine, each engine cylinder is provided with a separate fuel injection pump of the plunger type actuated by a solenoid surrounding the plunger. In each case, the output required of the injector is relatively small. Therefore, the size of the plunger and correspondingly the size of the solenoid to drive it also is small since the pressures required for injection are at a relatively low level as compared to that for a diesel engine application. For example, fuel injection pressures of approximately 750 psi would be suitable for a spark ignition type fuel injection system, whereas for diesel engine application, an injection pressure of 2000 psi is more common. To attain the higher pressure level with the use of an electromagnetically controlled plunger type pump generally requires a very large solenoid. The increase in size of the solenoid, however, not only can result in an increased cost, but also a slower response time for actuation of the plunger.

According to the present invention, there is provided a fuel injection pump comprising a primary plunger , and a solenoid for driving the primary plunger through a fuel pumping stroke, characterised by a booster plunger in series with the primary plunger and arranged for actuation simultaneously with the energization of the solenoid whereby the booster plunger moves concurrently with the primary plunger to supplement the driving force of the primary plunger .

The inclusion of a booster plunger in series with the solenoid actuated fuel pumping plunger can provide the higher fuel pressures necessary for diesel engines while permitting reduction in size and, therefore, force of the main actuating solenoid to that comparable to one that would be used in connection with spark ignition type engines. The booster plunger is preferably arranged for actuation by fluid pressure, especially by fuel pressure.

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a cross-sectional view of a fuel injection pump unit embodying the invention; and

Figure 2 is an enlarged view of a detail of Figure 1.

The fuel injection pump shown in Figure 1 consists essentially of three parts, namely, a main solenoid 10 for driving a primary plunger 12, a booster plunger 14, and a solenoid actuated fuel distibutor unit 16. The three above-named units are arranged in a compact manner within a housing consisting essentially of upper and lower parts 18 and 20. Secured within upper housing portion 18 is a main pump casing 22 having a stepped diameter bore 24. The smallest diameter portion of the bore constitutes a fuel inlet passage 26 to a larger bore portion 27 within which is a sleeve 28 located by a stop nut 30. Reciprocably slideable within sleeve 28 is the pumping plunger 12 having a stem 34. The latter is threadably engaged with a large annular armature 36 of the main solenoid 10. The latter includes a stationary annular core 40 that is screwed to the main pump casing 22 as shown. The core 40 surrounds the primary plunger 12 and is spaced radially therefrom, with suitable coils 42 being wound around the core as shown. The armature 36 is biased by a spring 44 away from core 40 to provide the conventional gap 46 between the two.

The upper part 18 of the housing contains the booster plunger 14 that is reciprocable and slideable within a stationary sleeve 48. The latter is located against a shoulder of the housing by a stop nut 50. The stem 34 of plunger 12 is extended, as shown, and is in engagement with one end of the booster plunger 14, the opposite end of which is under the influence of fuel pressure admitted to a chamber 52 in the upper part of the housing. The fuel pressure in this chamber is the same supply fuel pressure as that in inlet passage 26 located on the opposite side of plunger 12. Also located in the chamber 52 is a position sensor 54, such as a proximity sensor, connected by wiring 56 electrically to a microprocessor or similar device, not shown. The sensor establishes a feedback signal indicative of the position of the booster plunger 14 for comparison with a desired position signal determined in accordance with a predetermined schedule of operation of the engine.

The solenoid actuated fuel distributor unit 16 contained in the lower portion 20 of the housing consists in general of an inlet check valve 60, and a number of small solenoids 62 each controlling fuel flow past fuel delivery valves 64 to individual engine cylinder fuel injectors, not shown. The small solenoids 62 are clustered in a circular pattern around the axis of the pump and equally spaced circumferentially from one another.

More particularly, housing part 20 has a step diameter central bore that constitutes a fuel inlet 66 from a source of fuel under a low pressure, not shown. The larger diameter portion of the bore also constitutes a recess 67 for reception of an electrical harness that provides the electrical connection to the main solenoid 10 and the cluster of small individual solenoids 62 to be described. The inlet 66 also contains the one-way check valve 60 seatable by a spring 68 against a mating portion of a sleeve member 70. The latter is located against a shoulder of the bore by a stop nut 72. A second sleeve 74 containing an orifice 76 connects fuel to a passage 78 that opens into a fuel pressurisation chamber 80. The latter also communicates with the primary plunger 12 via the inlet passage 26. Chamber 80 in turn is connected by a number of spoke-like passages 82 to an equal number of fuel annulii 84 shown more clearly in Figure 2.

The lower part 20 of the housing contains a number of secondary stepped diameter bores 86 corresponding in number to the number of engine cylinders and the number of fuel injectors required for the engine. More particularly, the lower portion of each bore contains a fuel delivery valve 64 of the retraction type having a conical surface 90 adapted to seat against a mating surface 92 on a sleeve type valve body 94. Within the valve body adjacent fuel delivery valve 64 is a slideable sleeve 96 having a spherically formed axially slotted end portion 98 cooperating with a ball valve member 100. The ball valve member, when seated as shown, blocks the passage of fuel from the annulus 84 through sleeve 96 to the fuel delivery valve 64. Sleeve 96 is biased against ball valve member 100 by light spring 102.

Ball valve member 100 is maintained in its closed position by the plunger-like armature 104 of a small solenoid 62 threadably mounted into the lower part 20 of the housing. The armature 104, in this case, is biased by a spring 108 against ball valve member 100 to maintain it seated as shown. A large nut 110 locates the sleeve-type valve body 94 in position.

In overall operation, fuel is scheduled to be delivered to only one engine cylinder at a time so as to coincide with the firing order of the engine. As a result, only one of the small solenoids 62 will be energized at any one particular time, and in a particular sequence, to retract the armature 104. This will permit spring 102 to move sleeve 96 and ball valve member 100 upwardly to permit entry of fuel from the annulus 84 to the fuel delivery valve 64. More particularly, as stated previously, the fluid under pressure for actuating the booster plunger 14 will be the same or at the same supply fuel pressure level as that in the fuel pressurisation chamber 80 and inlet passage 26. When the main solenoid 10 is energised, therefore, retraction of the armature 36 downwardly will cause a downward movement of the primary plunger 12 through a pumping stroke to pressurise the fuel in the inlet passage 26 and pressurisation chamber 80 that previously has been filled by a flow of supply fuel past the check valve 60. At the same time, the supply of fuel under pressure to chamber 52 will cause the booster plunger 14 to follow the motion of the primary plunger 12, adding its force to that of the primary solenoid 10, and thus reducing the magnitude of force required by the primary solenoid 10 to provide the desired pressure level. At substantially the same time, the microprocessor unit, not shown, will activate one of the small solenoids 62 to retract the armature 104 and permit the ball valve member 100 to move upwardly to an open position. This will allow the fuel under pressure in the pressurisation chamber 80 to flow through the passages 82 to the annulus 84 and past the open ball valve member 100 to the fuel delivery valve 64. As soon as the force of the spring 114 of the delivery valve is overcome, the delivery valve will move downwardly out of the valve body 94 until the intersecting supply passages 116 permit a free flow of fuel into the injector passage 118.

The duration and magnitude of fuel injected during each operation will vary as a function of the current impulses to each small solenoid 62 and to the main solenoid 10. This will be determined by the microprocessor unit, not shown, in accordance with a predetermined schedule of flow for the particular engine operating conditions at that time. The stroke of the main plunger 12 and the booster plunger 14 will be sensed by the proximity sensor 54, and if the volume of fuel injected as determined by the stroke varies from the predetermined schedule, the feedback signal provided by sensor 54 will cause the micro-processor to change the duration or magnitude of voltage to the solenoids to thereby vary the fuel flow to conform it to the desired schedule.

Therefore, when fuel injection is terminated by termination of voltage to the small solenoids 62, the residual pressure in the injector passage 118 will drop. When it is below the level of the force of spring 114, the delivery valve 62 will begin to move upwardly into the bore of the valve body 94. The first effect will be to cut off fuel communication between injector passage 118 and the annulus 84. The second effect will be, upon continued upward movement, for the delivery valve 64 to retract a portion of its body into the bore of the valve body 94, thereby decreasing the mass in the injector passage 118 and thereby decreasing the pressure, to prevent after-dribbling and other known secondary injection effects. Once the delivery valve has retracted, deenergisation of the particular solenoid 62 activated at that time will cause or permit the spring 108 to move the armature 104 and ball valve member 100 to its lower position seated against the valve body 94 and thereby block off communication of fuel between the annulus 84 and the injector line 118. Injection is now terminated. Simultaneously, the spring 44 will cause the armature 36 to move upwardly as seen in Figure 1 to return the primary plunger 12 as well as the booster plunger 14 to their intake positions shown. This latter movement will also cause an unseating of the inlet check valve 60 and permit a fresh supply of fuel to flow into the passages and pressurisation chamber 80 for injection on the next stroke of the primary plunger 12.

Figure 1 indicates a construction in which only two injector lines are indicated. However, it will be clear that any number of smaller solenoid controlled injector lines can be provided, as desired, merely be circumferentially spacing the same in a circular cluster around the primary fuel supply passage 26.

From the foregoing, it will be seen that the invention provides an electromagnetically operated fuel injection pump that is particularly suitable for diesel application and yet is operable with small solenoid assemblies instead of the conventional large ones normally employed to provide the high fuel pressure necessary to operate a diesel type injector. It will be seen that this is made possible by the use of a booster plunger that is actuated by supply fuel pressure and therefore compliments the force of the main actuating pump solenoid so that a smaller main solenoid may be used.

CLAIMS

1. A fuel injection pump comprising a primary plunger (12), and a solenoid (10) for driving the primary plunger (12) through a fuel pumping stroke, characterised by a booster plunger (14) in series with the primary plunger (12) and arranged for actuation simultaneously with the energisation of the solenoid (10) whereby the booster plunger (14) moves concurrently with the primary plunger (12) to supplement the driving force of the primary plunger (12).

2. A pump according to claim 1, wherein the booster plunger (14) is arranged for actuation by fluid pressure.

3. A pump according to claim 1 or claim 2, wherein the primary plunger (12) has a stem (34) projecting therefrom along the axis of reciprocation of the primary plunger, the solenoid (10) includes an armature (36) secured to the stem (34) and the booster plunger (14) is axially aligned with the stem (34) with one end of the booster plunger (14) in driving engagement with the stem, and means (52) for applying fluid pressure to the opposite end of the booster plunger (14).

4. A pump according to any one of claims 1 to 3 including a fuel pressurisation chamber (20) communicating with the primary plunger (12), a fuel inlet (66) to the chamber adapted for connection to a source of fuel at a predetermined pressure lever, and means for connecting the booster plunger (14) to the source of fuel to effect movement thereof with the primary plunger.

0055083

FIG. 1

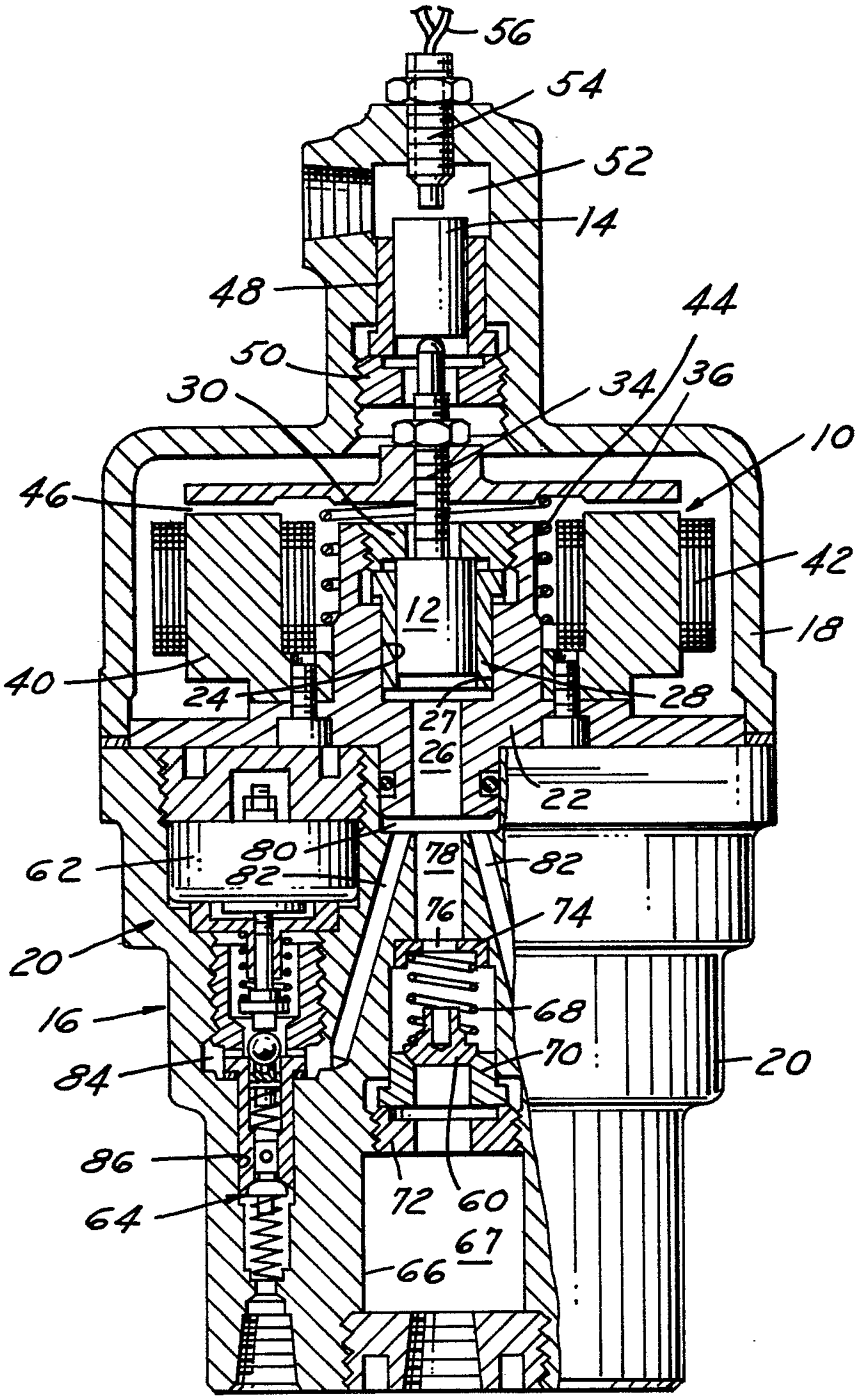


FIG. 2