Dec. 18, 1962 J. N. MORRIS ET AL 3,068,794

FUEL-INJECTION PUMPS FOR COMPRESSION-IGNITION INTERNAL COMBUSTION ENGINES

Filed Aug. 7, 1959

FIG. 1A.

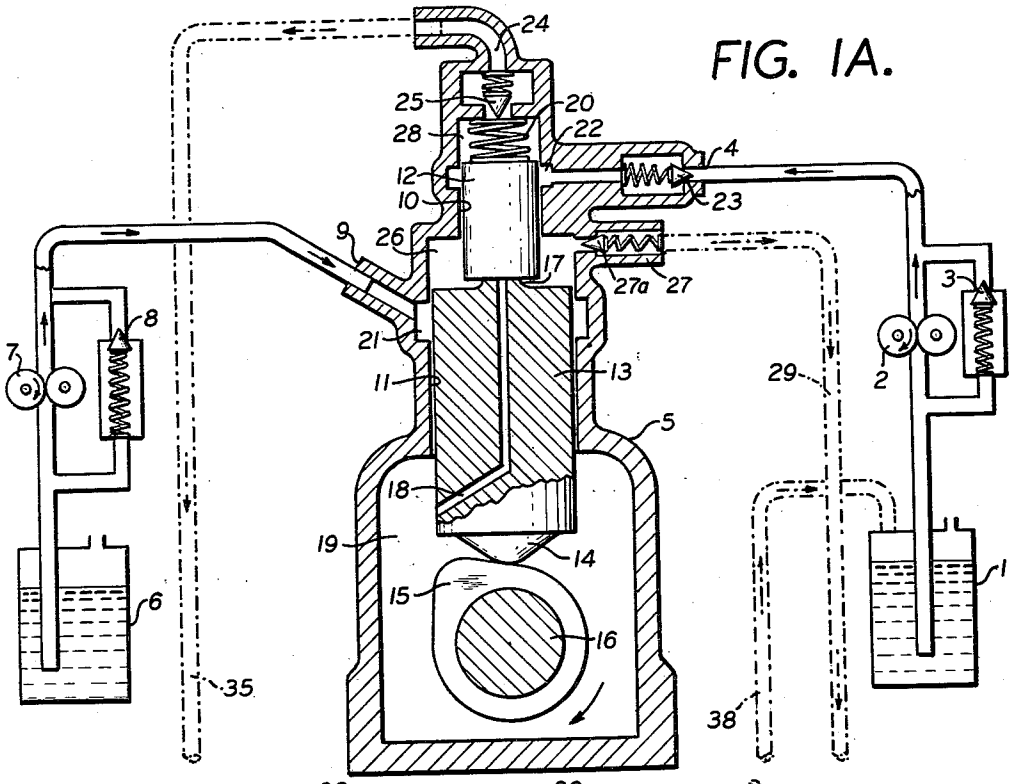
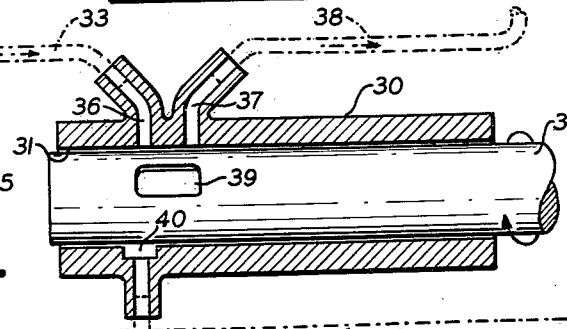


FIG. 1B.



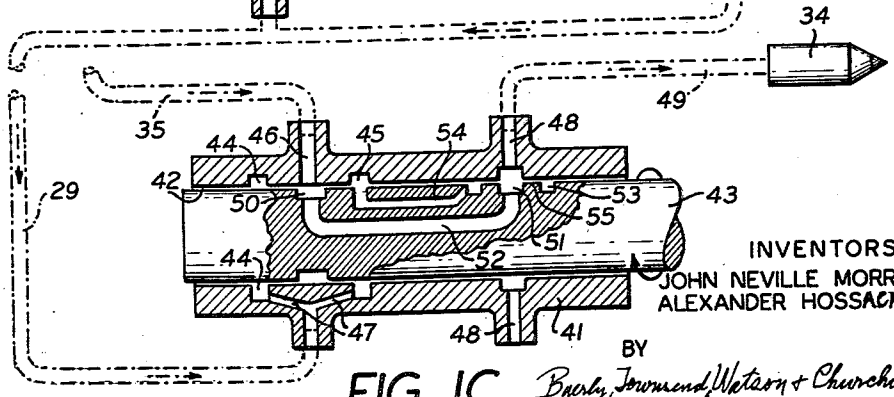


FIG. 1C.

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FUEL-INJECTION PUMPS FOR COMPRESSION-IGNITION INTERNAL COMBUSTION ENGINES

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4 Claims. (Cl. 103—9)

This invention relates to fuel-injection pumps of the reciprocatory plunger type for compression-ignition internal combustion engines, designed to meter liquid fuel and to deliver it at relatively high pressures, that is to say, at pressures in the region of 5,000 p.s.i. or upwards. More specifically, it is concerned with certain improvements of the invention that forms the subject of co-pending application of John Neville Morris, Serial No. 757,731 filed August 28, 1958.

According to the earlier invention referred to, a fuel-injection pump of the type shown herein is enabled to provide automatically a supply of unmetered fuel and, therefore, in a limited sense, expendable fuel at a pressure approximately equal to that of the metered fuel, this supply of expendable fuel remaining available for a variety of sealing purposes throughout the duration of the high pressure phase of the main metered fuel pumping action.

The object of the present invention is to enable a fuel-injection pump of the character set forth to provide automatically, in addition to its metered fuel output, a supply of auxiliary fluid, other than fuel, at a pressure approximately equal to that of the metered fuel, this supply of pressurized auxiliary fluid being rendered available for use throughout the duration of the high-pressure phase of the metered fuel pumping action.

According to this invention a fuel-injection pump of the reciprocatory plunger type has a plunger which is associated with a pumping chamber for delivering metered quantities of fuel at high pressure. The metering plunger is operable in conjunction with, and under the control exercised by, another plunger of larger effective cross-sectional area working in an auxiliary pumping chamber. The auxiliary pumping chamber receives fluid other than fuel, which may conveniently be designated auxiliary fluid, the arrangement being such that at an early stage of the working stroke of the plungers, owing to their differential pumping action, the auxiliary fluid becomes pressurized at the moment at which delivery of the metered fuel commences, and simultaneously therewith means become effective to maintain the supply of auxiliary fluid, rendered available in the auxiliary pumping chamber, at a pressure which varies instantaneously with, and remains approximately equal to, that of the metered fuel.

Although the pressurized auxiliary fluid may be used for other purposes, its primary function is to effect high-pressure sealing of ducts, ports and so forth in liquid-fuel supply systems. The auxiliary fluid may, for example, be a lubricant such as ordinary engine lubricating oil. This possibility renders the invention especially useful for application to pumps which operate on fuels having exceptionally poor lubricating properties, such as gasoline.

The invention is applicable to fuel-injection pumps of the non-distributing type as well as to those of the distributing type, namely, in which either a single reciprocating plunger or a system of such plungers meters and delivers fuel under high pressure to distributing means arranged to supply a multiplicity of engine cylinders.

Further objects and advantages of the invention will become apparent from the following description when considered in conjunction with the accompanying drawing wherein:

FIG. 1A is a diagrammatic elevational view, partly in section, depicting a fuel injection pump in accordance with the practice of the invention;

FIG. 1B is a fragmentary plan view, partly in section, and shows the practice of the invention in control means used in conjunction with the pumps of FIG. 1A;

FIG. 1C is a view similar to FIG. 1B and depicts the practice of the invention in distributor means used in conjunction with the pumps of FIG. 1A.

The invention will now be described with reference to FIG. 1A. Liquid fuel is taken from a supply tank 1 by a feed pump 2, provided with the usual relief valve 3, and is delivered to an inlet 4 of a casing 5 of a fuel-injection pump. An auxiliary fluid, which may conveniently be lubricating oil, is taken from a reservoir 6 by a feed pump 7, having the usual relief valve 8, and is delivered to an inlet 9 of the fuel-injection pump casing 5. The casing, which constitutes the main body of the fuel-injection pump, is formed with a pair of coaxial communicating bores 10 and 11 in which are mounted plungers 12 and 13 respectively. The bores 10 and 11 are of unequal diameter, and one end of the larger plunger 13 protrudes from the inner or as herein shown the lower end of its bore and is shaped at its lower end 14, to co-operate with a cam 15 mounted on a pump drive shaft 16.

The two plungers 12 and 13 contact each other at their adjacent ends through an abutment 17 formed upon the upper end face of the plunger 13. The area of contact of the abutment 17 is substantially less than the cross-sectional area of the smaller plunger 12, and the larger plunger 13 is provided with a duct 18 which debouches at one end within the area of the contacting surface of the abutment 17 and at its other end is in permanent open communication with a region 19 for receiving spillage of the auxiliary fluid. In the upper end of the small bore 10 is a spring 20 which reacts upon the upper end of the smaller plunger 12 and thus urges the two plungers into contact over their abutment area and, additionally, maintains the protruding end of the larger plunger 13 in contact with the cam 15. Rotation of the drive shaft 16 and cam 15 imparts what will be referred to as outward motion of the pair of plungers, while the spring loading applied to the plunger 12 effects their inward motion and insures that the plunger 13 at all times engages and follows the cam.

Formed in the large bore 11 is a circumferential groove 21 which, is in open communication with the auxiliary fluid inlet 9, said groove being designated a filling groove. The groove 21 is located in such a position that the end of the plunger 13 remote from the cam, overruns this groove shortly before the completion of the inward movement of the plungers. The small bore 10 is formed with a similar circumferential filling groove 22 in open communication with the fuel inlet 4 and said groove is overrun by the small plunger 12 simultaneously with the overrunning action described above. The annular filling groove 21 is in permanent communication with a moderately pressurized supply of the auxiliary fluid subsequently to be employed for lubricating and sealing purposes. The annular filling groove 22 communicates via an inwardly opening spring-biased-non-return valve 23 with a moderately pressurized source of fuel supply. The pump casing at its upper end is formed with a metered fuel outlet passage 24, controlled by an outwardly opening spring-biased non-return valve 25.

In open communication with an annular pumping space 26 which is constituted by the difference in areas between the two plungers 12 and 13 within the outer end of large bore 11, there is provided an outlet passage 27 which is arranged to communicate with any regions of the addi-

tional units of the complete injection equipment to which highly pressurized lubricating and sealing fluid is required to be applied. The region above the smaller plunger will be referred to as the main pumping chamber **28** and that constituted by the difference in areas between the two plungers, as the differential pumping chamber **26**.

The operation of the pump is as follows:

Commencing at the outer dead center position of the plungers, rotation of the camshaft **16** permits both plungers to move inwardly under the action of the return spring **20**, the two plungers being maintained in mechanical contact by the intervening abutment **17**. During this phase the non-return valve **25** leading from the main pumping chamber **28** remains closed, and thus a partial vacuum is formed, not only in the main pumping chamber **28** but also in the differential pumping chamber **26**, it being assumed that no inward flow of fluid can occur via the outlet passage **27** leading from pumping chamber **26** by virtue of the check valve **27***a* mounted in the outlet passage **27**. Shortly before the termination of the inward or downward stroke, the two plungers **12** and **13** overrun their respective filling grooves **22** and **21**, and thus the main pumping chamber **28** is enabled to inspire and become replenished with fuel and the differential pumping chamber **26** is enabled to inspire and become replenished with lubricating and sealing fluid.

At an early stage of the ensuing outward or upward stroke of the plungers **12** and **13**, both filling grooves **21** and **22** become cut off simultaneously. The fuel previously inspired into the main pumping chamber **28** now becomes pressurized to the point where the non-return valve **25** opens and fuel delivery commences notwithstanding any degree of back pressure which may be imposed, as, for instance, by the type of nozzle commonly employed for diesel engine injection, to which the fuel outlet **24** of the pump may lead.

Simultaneously with action next hereinbefore recited, the auxiliary fluid contained in the differential pumping chamber **26** momentarily will have no sufficiently rapid means of egress since the outlet passage **27** from said differential pumping chamber **26** is capable of permitting a small rate of flow only, as will subsequently be made apparent. The fluid in said pumping chamber **26** therefore rapidly attains a pressure which, acting upon the differential area existing between the cross-sectional area of the smaller plunger **12** and that of the abutment **17** through which the two plungers contact, hydraulically impels the smaller plunger **12** on its outward stroke. The smaller plunger thus tends to run away from the larger plunger, but, in so doing, it exposes the upper end of the spill duct **18** in the larger plunger. The result of the foregoing action is that the auxiliary fluid pressurized within the differential pumping chamber **26** is permitted to leak away, via the duct **18**, into the region **19** of the pump casing **5** from which it may be returned in any suitable manner to the reservoir **6**. Consequently, a controlled pressure is automatically sustained within the differential pumping chamber **26** throughout the remainder of the outward stroke of the plunger assembly, which pressure varies instantaneously with any variation which may occur within the main pumping chamber **28** and always being somewhat higher than the pressure obtaining in the main pumping chamber in accordance with the relative cross-sectional areas of the smaller plunger **12** and of the abutment **17**. For example, if the cross-sectional area of the smaller plunger **12** were 1 sq. cm. and the effective cross-sectional area of the abutment **17** were approximately 0.1 sq. cm., then the pressure generated in the differential pumping chamber **26** during this phase would be, at any instant, approximately 10% greater than that obtaining in the main pumping chamber **28**.

During the phase of operation just considered, leakage of the highly pressurized fuel in the main pumping chamber **28** into the annular filling groove **22** rapidly causes the pressure in these two regions to become equalized since the inwardly opening non-return valve **23** provided in the fuel inlet passage **4** precludes any outward flow. One immediate consequence of this approximate equality of pressures between the differential pumping chamber **26**, the main pumping chamber **28**, and the fuel-filled annular groove **22**, is that the tendency for the highly pressurized fuel to leak away from the main pumping chamber **28** into what would, in the case of a conventional construction, be a region at approximately atmospheric pressure, is eliminated. The flow is, in fact, at a now much diminished rate, in the contrary direction. That is to say, some slight flow of the lubricating and sealing fluid takes place into the fuel-filled annular groove **22** and thence, intermixed with fuel therefrom, into the main pumping space **28**. By this provision, it is clear that slight imperfections in plunger/bore fit, due to manufacturing errors or to wear, can be tolerated without serious leakage of the highly pressurized fuel in the main pumping chamber **28** and without serious intermixing of the fuel and the lubricating and sealing fluid.

It will also be clear that the auxiliary fluid contained in the differential pumping space **26** can be led from it by a duct **29** to any further point in the injection system at which it can perform a lubricating and sealing function, analogous to that which it has already been seen to perform in precluding leakage from the main pumping space **28** of the pump. The quantity of this auxiliary fluid available per stroke of the plungers, without disturbing the balance of hydraulic pressures as described above, depends upon the volume of the differential pumping chamber **26**, which is therefore made of sufficient size to accommodate the maximum possible demand for such fluid.

Examples of useful applications of the sealing and lubricating fluid to other parts of a typical high-pressure fuel metering system, will now be described.

Provision for enabling the output per stroke of the pump to be varied, preferably by the abrupt spilling of the metered fuel at a variable point during the outward stroke of the main injection plunger, is a normal requirement in diesel engine operation.

Such a variable spill control may conveniently be afforded by a device shown in FIG. 1B comprising a fixed casing **30** having a cylindrical bore **31** within which is mounted a continuously rotating control shaft **32** driven by the pump drive shaft **16** through drive mechanism (not shown) arranged to permit the two shafts to be phased or relatively rotated to a limited degree. This phasing or relative rotation of the shafts constitutes a means of varying the output per stroke of the pump.

A connecting pipe **33**, additional to that leading from the metered fuel outlet **24** of the pump to an injection nozzle **34**, and arranged in parallel with an injection nozzle feed pipe **35**, terminates in a duct **36** debouching upon bore **31** of the fixed casing **30**, as also does a further adjacent relief duct **37** leading, via a pipe **38**, to a region into which fuel may conveniently be spilled, in this case fuel supply tank **1**. The control shaft **32** is provided with a recess **39** capable of effecting temporary communication between the two ducts **36**, **37**. In its simplest form the device comprises only one such recess, and the control shaft **32** is driven at the same speed as the pump drive shaft **16**. The arrangement is such that rotation of the control shaft **32** effects spillage of the metered fuel at any required interval after the commencement of the injection phase, in accordance with the variable relative rotational positions of the two shafts concerned.

Within bore **31** of the fixed casing **30** and situated approximately diametrically opposite the duct **36** which communicates with the metered fuel outlet **24** from the pump, a port **40** is provided the cross-sectional area of which is somewhat greater than that of the duct **36**. This port **40** is placed in communication, by the duct **29**, with the lubricating and sealing fluid in the differential

pumping chamber 26 from which said fluid is thus able to perform the useful functions of lubrication and of hydrostatically forcing the control shaft 32, to the degree to which this shaft may be fitted with some small clearance in its bore, into intimate mechanical contact with the region at which the metered high-pressure fuel would otherwise tend to cause local separation of the shaft from its bore, and thus leak away. This hydrostatic sealing action automatically commences at the instant of pressure rise in the metered fuel and is automatically sustained throughout the high-pressure phase, namely until the recess 39 formed in the control shaft 32 causes spillage of the metered fuel.

Another example of a useful application for the high-pressure auxiliary fluid is represented by a distributing device, which is employed when the output from a single pumping unit has to be distributed to a plurality of engine cylinders in sequence. This device as shown in FIG. 1C comprises a fixed casing 41 having a cylindrical bore 42 which contains a rotatable distributor shaft 43. The shaft 43 is driven at some finite fraction of the pump shaft speed, in accordance with the number of engine cylinders to be served. Two circumferential grooves 44, 45 are provided in the bore 42 of the fixed casing 41. Bore 42 also has a fuel supply duct 46 spaced intermediately between grooves 44, 45. Communication, by way of the duct 29 and passages 47, is permanently established between the two grooves 44, 45 and the high-pressure auxiliary fluid in the differential pumping chamber 26. A further permanent communication, by the pipe 35, is established between the fuel supply duct 46 and the metered fuel outlet 24 from the pump.

In the normal application of the distributing device, in which a variable spill control 30, such as that already shown in FIG. 1B is required to be incorporated in the system, two passages are provided from the metered fuel outlet 24 from the pump; one, represented by the branch pipe 33, leading to such variable spill control 30 and the other, represented by the continuation of the pipe 35, to the distributing device 41. Within the fixed casing 41 of the distributing device, in addition to the two grooves 44, 45 and the supply duct 46, there are also provided, in a plane longitudinally displaced therefrom, a plurality of equally spaced radial outlet ducts 48 debouching upon the bore of the casing, and each connected by a pipe 49 to the corresponding injection nozzle 34, their number being in accordance with the number of injection nozzles to be supplied.

The distributor shaft 43 has a circumferential groove 50 and a distributing port 51 spaced apart longitudinally and interconnected by a duct 52. Surrounding the distributing port 51 there is in the distributor shaft 43, a continuous or annular groove 53 such as can conveniently be formed by the operation of trepanning. A duct 54, which will be designated, the pressurizing duct, debouches at one end upon the surface of the distributor shaft 43 and at its other end communicates with the groove 53 surrounding the distributing port 51. The arrangement is such that, upon assembly, the circumferential groove 50 in the distributor shaft 43 registers with the fuel supply duct 46 in the casing, the distributing port 51 in the shaft falls within the plane containing the radial outlet ducts 48 of the casing, and the pressurizing duct 54, where it debouches upon the surface of the shaft, registers with the circumferential groove 45 in the bore of the fixed casing which communicates with the source 26 of high-pressure lubricating and sealing fluid.

The bores of the distributing port 51 and of the individual outlet ducts 48, at their intersection with the surface of the distributor shaft 43 and the bore of the casing 41 respectively, are such that, whatever the timing of the pump and spill control in their effect upon the duration of the injection dwell, free communication is maintained between distributing port 51 and one of the outlet ducts 48 throughout the duration of each injection dwell. The land 55 provided between the distributing port 51 and the inner periphery of the annular groove 53 surrounding it is, moreover, of sufficient width to insure that this groove under no circumstances comes into communication with any of the outlet ducts 48 during the injection phase through that particular duct.

The metered fuel, at the commencement of the injection phase, passes by way of supply duct 46, into the associated circumferential groove 50 of the distributor shaft 43 and thence through the corresponding duct 52 in the shaft to the distributing ports 51, the relative rotational position of the distributor shaft 43 with respect to the main pump shaft 16 is such that the fuel then enters one of the outlet ducts 48 and passes to one of the injection nozzles 34. Supply to that particular nozzle then continues until such time as the injection phase is terminated, as by means of the spill device 30 previously described.

In the absence of a supply of high-pressure auxiliary fluid coinciding in time with the injection dwell, or in the absence of a commercially impracticable closeness of fit between the distributor shaft 43 and its bore 42, serious leakage of metered fuel would occur in the vicinity of the supply duct 46 and its associated groove 50 in the shaft, and also in the vicinity of the distributing port 51. Such high-pressure auxiliary fluid is, however, rendered available by the invention and is active from the moment of the commencement of the injection phase until the moment of its termination. The presence of expandable fluid during this time, within the two circumferential grooves 44, 45 in the casing 41 and within the annular groove 53 surrounding the distributing ports 51, serves incidentally, to reverse the direction of such leakage since this fluid is at somewhat higher pressure than the fuel, and, in particular, serves substantially to diminish the extent of such leakage.

Since many changes could be made in the above construction and many apparently entirely different embodiments of this invention could be made without departing from the scope thereof, it is to be understood that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What we claim is:

1. A fuel injection pump of the reciprocatory plunger type adapted for delivering metered quantities of liquid fuel at high pressure and rendering available simultaneously a supply of auxiliary liquid, other than fuel, at approximately the same pressure as the metered fuel, comprising a casing having a pair of coaxial communicating bores of different diameters, a pair of coaxial plungers of different diameters, movable in said respective bores and providing therewith pumping chambers for the fuel and the auxiliary liquid respectively, means for charging fuel to one chamber and auxiliary liquid, other than fuel to the other chamber during the intake stroke of the pump, the plungers operating for cutting off said chambers from said sources at an early stage of the working stroke, discharge ports leading from said respective chambers, the plunger of larger diameter working in the auxiliary liquid chamber and the plunger of smaller diameter working in the metered fuel chamber, means including a driving shaft, a cam and a return spring reciprocating said plungers substantially in unison, said plungers at their adjacent ends being unconnected but normally held in liquid tight contact with each other within the auxiliary pumping chamber by said return spring and cam, an abutment provided upon an end face of one of said plungers in contact with the adjacent end face of the other plungers, the contact area of the abutment being substantially less than the cross-sectional area of the smaller plunger, the larger plunger having a spill duct which debouches at one end within the area of the contacting surface of the abutment and at its other end in permanent communication with a region for receiving spillage of aux-

iliary liquid; the end of the smaller plunger remote from the abutment contacting end constituting a movable boundary wall of the metered fuel pumping chamber and the supply of auxiliary liquid being rendered available in the auxiliary pumping chamber in which it becomes pressurized by the differential pumping action of the two plungers, the pressure of the auxiliary liquid being limited by the hydraulic separation of the contacting plungers in said auxiliary pumping chamber and the consequent uncovering of the spill duct.

2. A fuel injection pump according to claim 1 wherein each of the bores in the casing has an annular groove in proximity to the respective inner ends of the pumping chambers, the groove in the smaller bore for receiving a quantity of liquid fuel and the groove in the larger bore for receiving a quantity of an auxiliary liquid, other than fuel.

3. A fuel-injection pump according to claim 1, in combination with means for distributing the metered fuel output of the pump to a plurality of engine cylinders in sequence, the said distributing means comprising a fixed casing having a cylindrical bore containing a rotatable distributor shaft which is driven at some finite fraction of the speed of the pump driving shaft, said distributor casing having its bore formed with a pair of axially spaced circumferential grooves in permanent communication with the supply of auxiliary liquid available in the auxiliary pumping chamber, the distributor casing having a supply duct leading to the bore of the casing in permanent communication with the metered fuel outlet of the pump and situated intermediate the said axially spaced circumferential grooves, the distributor shaft having a circumferential groove registering with the metered fuel supply duct and in permanent communication with a distributing port in the distributor shaft, the distributor casing having a plurality of radial outlet ducts connected respectively to a plurality of injection nozzles for the respective engine cylinders and co-operating individually with the distributing port, and a continuous groove in the distributing shaft surrounding the distributing port and in permanent communication with the supply of auxiliary liquid available in the auxiliary pumping chamber.

4. A fuel-injection pump according to claim 1 in combination with variable spill control means for varying the output of metered fuel per stroke of the pump, the said variable spill control means comprising a fixed casing having a cylindrical bore containing a continuously rotating control shaft driven in variable phase relationship to the driving shaft associated with the pump plungers, said fixed casing having a pair of axially spaced ducts leading to the control shaft therein, one of which ducts receives metered fuel and the other of which leads to a spill outlet, the control shaft having a recess disposed to effect transient communication with the axially spaced ducts in said fixed casing which also has a port leading from the bore connected to the supply of auxiliary liquid available in the auxiliary pumping chamber, the said port being located approximately diametrically opposite the casing duct which receives the metered fuel, and having a greater cross-sectional area than said casing duct.

References Cited in the file of this patent

UNITED STATES PATENTS

1,563,328	Bradbury	Dec. 1, 1925

FOREIGN PATENTS

520,995	Germany	Mar. 14, 1931
661,722	Great Britain	Nov. 28, 1951

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,068,794 December 18, 1962

John Neville Morris et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 63, after "spring" insert -- for --; line 70, for "plungers" read -- plunger --; line 74, after "end" insert -- is --.

Signed and sealed this 24th day of September 1963.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents