

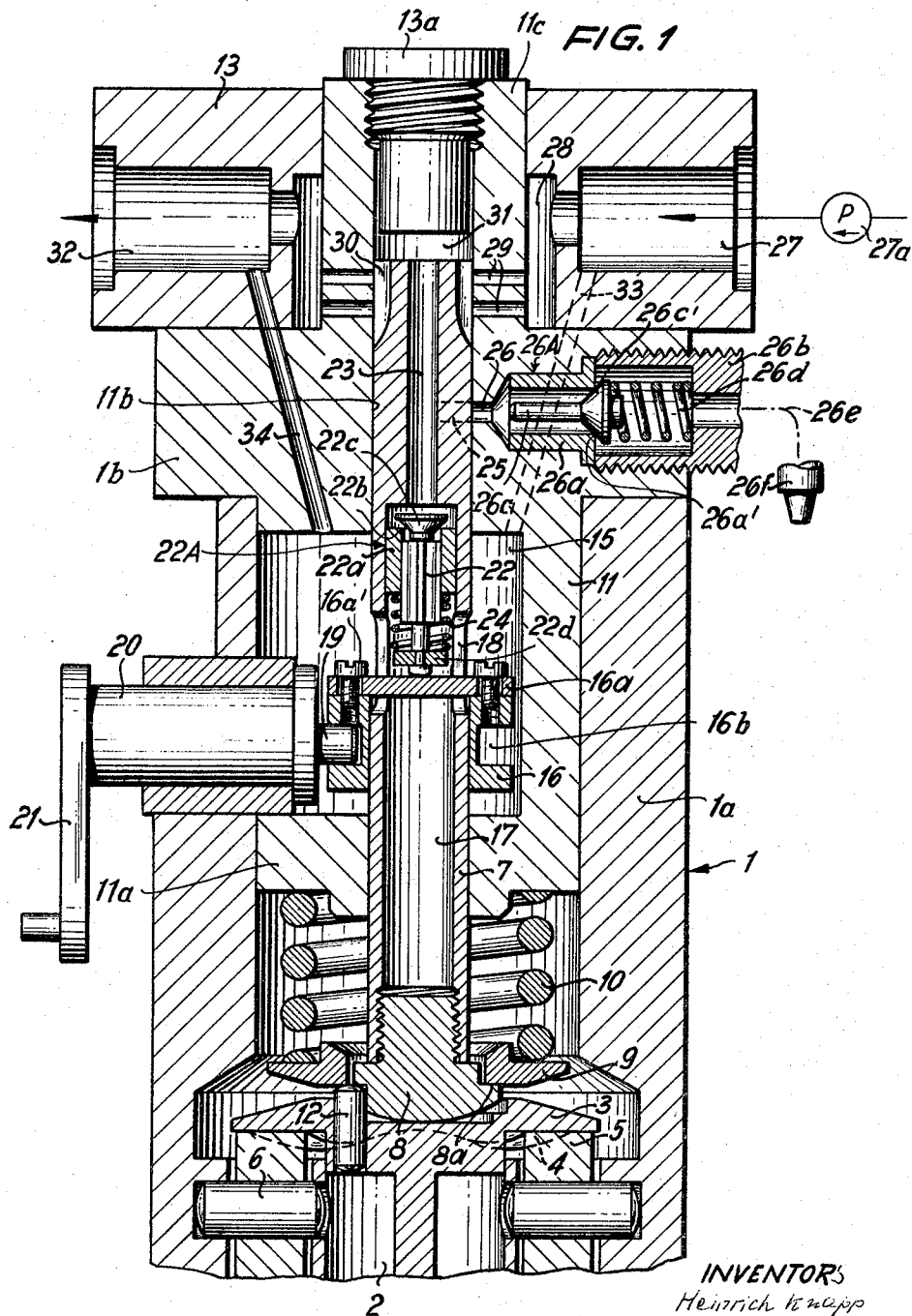
March 28, 1967

H. KNAPP ET AL
FUEL INJECTION PUMP

3,311,062

Filed June 2, 1965

2 Sheets-Sheet 1



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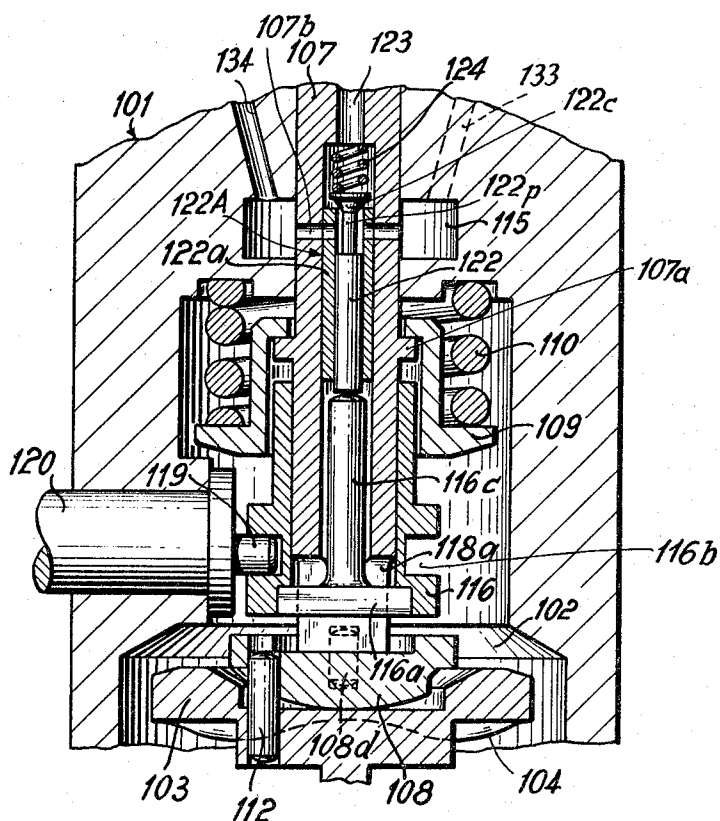
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FIG. 2



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FUEL INJECTION PUMP

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Filed June 2, 1965, Ser. No. 460,740

Claims priority, application Germany, July 10, 1964, B 77,613

7 Claims. (Cl. 103—2)

The present invention relates to fuel injection pumps for multi-cylinder internal combustion engines. More particularly, the invention relates to improvements in fuel injection pumps which are especially suited for feeding accurately metered quantities of light fuel to the injection nozzles of internal combustion engines. Still more particularly, the invention relates to improvements in fuel injection pumps of the type comprising a single pump chamber.

It is an important object of our invention to provide a fuel injection pump wherein the pump chamber is invariably filled with fuel when the distributor of the pump performs that part of its working stroke during which an accurately metered quantity of fuel is delivered to an injection nozzle.

Another object of the invention is to provide a fuel injection pump wherein that quantity of fuel which is being fed to consecutive injection nozzles of an internal combustion engine may be varied with utmost accuracy, in a very simple way, and while the pump is in operation.

A further object of the invention is to provide a fuel injection pump wherein the effective length of working strokes performed by the distributor may be changed and regulated in a very simple way and wherein the distributor is constructed, mounted and configured in such a manner that it facilitates the flow of fuel from the inlet to the pump chamber.

Another object of our invention is to provide a novel regulating device for controlling the effective working stroke of the distributor.

A concomitant object of the invention is to provide a novel fuel metering valve which may be utilized in a fuel injection pump of the above outlined characteristics.

An additional object of the invention is to provide a metering valve which, in cooperation with the improved regulating device, determines the length of effective working strokes of the distributor in a fuel injection pump for multi-cylinder internal combustion engines.

A further object of the invention is to provide a valve which, in addition to metering the fuel that is being admitted to the injection nozzles, also prevents uncontrolled leakage of fuel into that part of the pump which accommodates the drive unit for the distributor.

Another object of our invention is to provide an exceptionally compact fuel injection pump which may be readily installed in many types of known internal combustion engines, which will operate properly even if its parts are not machined with utmost precision, and which may be utilized for injection of many types of fuel, particularly gasoline and other light fuels.

Briefly stated, one feature of our invention resides in the provision of a fuel injection pump which comprises a housing defining a pump chamber and an overflow chamber, a bore connecting the two chambers, a fuel-admitting inlet communicating with the two chambers, a plurality of discharge ports communicating with the bore between the two chambers, a rotary distributor which is received in the bore between the two chambers and is provided with an axially extending overflow channel which communicates with both chambers, an outlet port extending radially from the overflow channel in the distributor and located substantially at the level of the

discharge ports, means for supplying fuel to the inlet so that such fuel normally fills both chambers and the overflow channel, drive means for rotating and for simultaneously reciprocating the distributor so that the latter performs alternating working and suction strokes of predetermined length and its outlet port comes in short lasting communication with each discharge port during each revolution of the distributor, a normally closed fuel metering valve provided in the distributor to control the flow of fuel between the overflow channel and the overflow chamber, and adjustable regulating means arranged to open the valve for intervals of variable length. Each such interval includes the last portion of a suction stroke and the first portion of the next-following working stroke so that the distributor discharges fuel from its overflow channel during the remainder of each working stroke and while its outlet port communicates with one of the discharge ports. The discharge ports deliver fuel through suitable discharge valves and into the individual injection nozzles of a multi-cylinder internal combustion engine.

The inlet preferably delivers fuel to an annular space which surrounds the pump chamber, and the pump housing is provided with suitable ducts which connect the annular space with the aforementioned bore so that fuel which is to enter the pump chamber, without flowing through the overflow channel, must flow through special flow-enhancing passages or grooves provided in the periphery of the distributor at that end thereof which is adjacent to the pump chamber.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved fuel injection pump itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is an axial section through a fuel injection pump which embodies one form of our invention; and

FIG. 2 is a fragmentary axial section through a modified fuel injection pump.

The fuel injection pump which is shown in FIG. 1 serves to deliver metered quantities of fuel to a four-cylinder internal combustion engine. The pump comprises a housing or cylinder 1 one end of which receives a rotary crown cam 3 forming part of a drive unit. The drive unit further includes rollers 5 which track the face 4 of the cam 3, a threaded plug-shaped insert 8 which is screwed into and seals the lower end portion of a rotary tubular fuel distributor or plunger 7, and a pin 12 which transmits rotary motion from the cam 3 to the plug 8 and hence to the distributor 7. The cam 3 is driven by a cam shaft, not shown, and the face 4 of this cam is provided with four equidistant lobes which cause the cam to perform a compound movement including a rotary movement about its own axis and a reciprocatory axial movement through strokes whose length is determined by the configuration of the cam face 4. The rollers 5 are mounted on shafts 6 which extend radially with reference to the axis of the cam 3 and are journaled in the housing 1. The underside of the plug 8 is rounded and extends into a depression provided in the upper side of the cam 3. The upper side of the plug 8 is provided with an annular shoulder 8a serving as a stop for an annular spring retainer 9 which surrounds with clearance the lower end portion of the distributor 7 and is engaged by the lowermost convolution of a strong helical expansion spring 10. This spring also forms a part of the drive unit, and its function is to maintain the cam face 4 in abutment with the peripheries of the rollers 5. The housing 1 comprises a lower section 1a and an upper

section 1b which includes an extension 11 projecting into the lower section 1a and having a lower transverse end wall 11a which constitutes an abutment or stop for the uppermost convolution of the spring 10. The end wall 11a is provided with a bore which receives a portion of the distributor 7 in such a way that the latter is free to rotate with and to share axial reciprocatory movements of the cam 3. The upper transverse end wall of the section 1b overlies the open end of the lower section 1a and is provided with a bore 11b which receives the upper portion of the distributor 7. Thus, the distributor is rotatably and axially movably journaled in the end walls of the section 1b.

The sections 1a, 1b of the housing 1 define between themselves an overflow chamber 15 which is located at a level between the end walls of the section 1b. This overflow chamber 15 accommodates an axially adjustable regulating member here shown as a short sleeve 16 which is slidably telescoped onto the central portion 17 of the distributor 7. The sleeve 16 has an annular peripheral groove 16b which receives an eccentric pin 19 forming part of a crank shaft 20 which is mounted in the lower section 1a and is turnable by a manually operated crank arm 21. It is clear that the crank arm 21 may be replaced by an automatic adjusting device which can turn the shaft 20 in dependency on the operation of the engine which receives fuel from the pump. The shaft 20 extends radially with reference to the distributor 7, and the top face of the sleeve 16 is detachably connected with a bridge-like stop plate 16a (see the screws 16a'), this stop plate 16a extending through a pair of diametrically opposed slots or cutouts 18 provided in the central portion 17 of the distributor 7. Thus, the sleeve 16 is compelled to rotate with the distributor 7 but its axial position with reference to the distributor may be changed in response to angular displacement of the shaft 20. The stop plate 16a regulates the length of intervals during which a normally closed bypass valve 22A in the distributor 7 remains open. The valve 22A is a poppet valve and comprises a cylindrical casing 22a which is telescoped into the central portion 17 of the distributor 7 and defines an annular seat 22b which may be engaged by a conical head 22c provided at the upper end of a reciprocable winged valve member 22. The lower end portion of the valve member 22 carries a spring retainer 22d for a helical valve spring 24 which seeks to keep the tip at the lower end of the valve member 22 in permanent abutment with the stop plate 16a. The spring 24 operates between the lower end face of the casing 22a and the retainer 22d and thus cooperates with the stop plate 16a to open or close the bypass valve 22A. The stop plate 16a will open the valve 22A by moving the head 22c away from the seat 22b when the distributor 7 performs the last part of a suction stroke and the first part of the next working stroke. The numeral 23 denotes an axial bore in the upper portion of the distributor 7, and this bore 23 performs the function of an overflow channel by connecting the overflow chamber 15 with a pump chamber 31. The pump chamber 31 is provided in an annular attachment 13 which constitutes a third section of the housing 1 and surrounds a hub 11c extending upwardly from the top end wall of the section 1b.

The upper end portion of the distributor 7 is provided with a radial outlet port 25 which can feed fuel to four discharge ports 26 machined into the section 1b. The discharge ports 26 extend radially outwardly from the bore 11b in the section 1b. FIG. 1 shows only one of the discharge ports 26, and each of these discharge ports registers with the outlet port 25 during a fraction of each revolution of the distributor 7. The discharge ports 26 extend radially from the distributor and are equidistant from each other.

Each discharge port 26 feeds fuel to a discharge valve 26A including a fixed casing 26a defining an annular seat 26a', a valve member 26c having a conical head 26c',

and a valve spring 26d which tends to maintain the head 26c' in sealing engagement with the seat 26a'. The casing 26a is held in the position shown in FIG. 1 by a threaded nipple 26b which is fitted into a radially extending tapped bore provided in the upper end wall of the section 1b. The nipple 26b has an internal shoulder which constitutes a stop for the valve spring 26d. A conduit 26e connects the nipple 26b to a fuel injection nozzle 26f. There are four discharge valves 26A and four nozzles 26f, each such nozzle discharging into one of the four cylinders of the internal combustion engine.

The attachment 13 defines a fuel admitting inlet 27 which discharges into an annular space 28. The annular space 28 communicates with four pairs of parallel ducts 29 which deliver fuel into the bore 11b for the upper end portion of the distributor 7 just below the pump chamber 31. The upper end portion of the distributor 7 is formed with four axially extending or helical flow-enhancing peripheral grooves or passages 30 which allow fuel to flow from the ducts 29 into the pump chamber 31 when the distributor 7 is driven by the insert 8. Surplus fuel is discharged through an outlet 32 which is located diametrically opposite the inlet 27. FIG. 1 shows only two pairs of ducts 29 and only two flow-enhancing passages 30.

The overflow chamber 15 communicates with inclined bores 33, 34 which respectively connect this chamber with the inlet 27 and outlet 32. The upper end of the pump chamber 31 is sealed by a removable plug 13a.

The plug-like insert 8 serves to seal the lower end portion of the distributor 7 and to thus prevent leakage of fuel from the interior of the distributor into the compartment 2 which accommodates the drive unit. This compartment is preferably filled with oil or another suitable lubricant. Proper sealing of the compartment 2 is important when the fuel is a light fuel, such as gasoline.

The operation of the injection pump shown in FIG. 1 is as follows:

In the illustrated position, the distributor 7 has just completed a suction stroke. During such suction stroke, fuel delivered by a supply pump 27a flows from the inlet 27 and into the annular space 28 to pass through the ducts 29 and passages 30 prior to entering the pump chamber 31. At the same time, fuel also flows through the bore 33, into the overflow chamber 15 and through the bore 34 on its way to the outlet 32. Of course, some fuel will pass through the bypass valve 22A (which is open), through the bypass channel 23 and will enter the pump chamber 31.

The bypass valve 22A opens during the last part of the suction stroke, and this valve remains open during the first part of the compression or working stroke when the distributor 7 moves upwardly, as viewed in FIG. 1, to reduce the volume of the pump chamber 31. At the same time, the outlet port 25 reaches the intake end of one of the four discharge ports 26 so that the corresponding discharge valve 26A receives fuel during the interval following the closing of the bypass valve 22A and terminating when the distributor 7 reaches the end of its working stroke.

By turning the crank shaft 20, the operator can adjust the axial position of the sleeve 16 to thereby change the length of the interval during which the bypass valve 22A remains open. The shorter that portion of the interval during which the valve 22A is open while the distributor performs a working stroke, the greater is the quantity of fuel which is delivered to one of the injection nozzles 26f. In other words, the valve 22A actually constitutes a metering valve which controls the quantity of fuel entering the conduits 26e during upward movement of the distributor. When the valve 22A is open, the bias of the springs 26d suffices to keep the discharge valves 26A closed, and the fuel then flows through the valve seat 22b, overflow chamber 15, bore 34 and into the outlet 32.

The pump chamber 31 is invariably filled with fuel

when the distributor 7 performs a working stroke because, during the preceding suction stroke, the chamber 31 receives fuel not only through the ducts 29 and flow-enhancing passages 30 but also through the overflow channel 23 (during the interval when the bypass valve 22A remains open).

The bore 33 and the chamber 15 together constitute an overflow passage which connects the inlet 27 with the lower end of the bore 11b.

Referring to FIG. 2, there is shown a portion of a modified fuel injection pump which is more compact than the pump of FIG. 1 because the bypass valve 122A is installed in the lower end portion of a relatively short rotary tubular distributor or plunger 107. Also, the regulating sleeve 116 is placed in immediate proximity of the cam 103. Thus, the overflow chamber 115 is also nearer to the cam 103 so that the height of the pump housing 101 is only a fraction of the height of the housing 1 shown in FIG. 1. The compartment 102 in the lower part of the housing 101 accommodates the drive unit including the cam 103, the pin 112 and the rollers (not shown) which track the face 104 of the cam 103. The driving connection between the cam 103 and distributor 107 comprises a cap-shaped insert 108, a first eccentric pin 112 which transmits motion from the cam 103 to the insert 108, a second eccentric pin 108d which transmits motion from the insert 108 to the distributor 107, and a strong helical spring 110 which maintains the insert 108 in abutment with the cam 103 and with the distributor 107 and at the same time insures that the cam face 104 engages the rollers. The spring 110 operates between an annular retainer 109, which is engaged by an annular flange 107a of the distributor 107, and an internal shoulder of the housing 101. The pins 108d, 112 are angularly spaced with reference to each other, preferably through an angle of 90 degrees.

The regulating sleeve 116 is axially movably supported by the distributor 107 and its bridge-like stop plate 116a extends through a diametrical cutout 113 provided in the lower end portion of the distributor so that the parts 107, 116 must rotate at the same speed as soon as the cam 103 begins to rotate. In this embodiment of our invention, the stop plate 116a is provided at the lower end of the sleeve 116 and is integral with an upwardly extending bolt-shaped projection 116a which constitutes the actual stop means for the valve member 122 of the bypass valve 122A. The peripheral groove 116b of the sleeve 116 receives an eccentric pin 119 which extends from the inner end face of a radially extending crank shaft 120 serving to adjust the axial position of the projection 116c and to thereby select the length of intervals during which the bypass valve 122A remains open.

The bypass valve 122A further comprises a cylindrical casing 122a which is press-fitted into the axial bore of the distributor 107 and defines an annular valve seat which may be sealed by the conical head 122c of the valve member 122 when the latter is free to follow the bias of a pre-stressed valve spring 124. The valve member 122 also prevents leakage of fuel from the overflow chamber 115 toward the diametrical cutout 113a. Bores 133, 134 respectively connect the chamber 115 with the inlet and outlet (not shown) of the pump housing 101.

The operation of the pump shown in FIG. 2 is the same as that of the pump which is illustrated in FIG. 1. The bypass valve 122A will seal the overflow chamber 115 from the overflow channel 123 during a certain part of each working stroke of the distributor 107, and the length of intervals during which the valve 122A remains open can be regulated by the shaft 120 and sleeve 116. When the valve 122A is closed, the channel 123 can be said to form part of the pump chamber.

The flow of fuel from the chamber 115 to the channel 123 takes place through radial bores 107b of the distributor 107, around a reduced-diameter neck portion 122p

of the valve member 122, and through the valve seat of the casing 122a. The valve spring 124 operates between the head 122c and an internal shoulder of the distributor 107.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a fuel injection pump, a housing defining a pump chamber and an overflow chamber, said housing having a bore connecting said chambers, two inlets each communicating with and arranged to supply fuel to one of said chambers, and a plurality of discharge ports communicating with said bore; a rotary distributor received in said bore and having an axially extending channel communicating with said chambers and outlet port means communicating with said channel; means for feeding fuel to said two inlets through which the fed fuel is supplied to both chambers; a drive for rotating and for simultaneously reciprocating said distributor so that the latter performs alternating working and suction strokes and said outlet port means is in short-lasting communication with each discharge port during each revolution thereof; a metering valve provided in said distributor to control the flow of fuel through said channel in a first direction from one of said chambers toward the other chamber and in a second direction from said other chamber toward said one chamber; and adjustable regulating means arranged to open said valve for intervals of variable length, each such interval including the last part of each suction stroke and the first part of the next working stroke so that said distributor expels fuel during the remainder of each working stroke and while said outlet port means communicates with one of said discharge ports.

2. In a fuel injection pump, a housing defining a pump chamber and an overflow chamber, said housing having a bore connecting said chambers, two inlets each communicating with and arranged to supply fuel to each of said pump chambers and said overflow chamber, fuel supplying duct means connecting said two inlets with said bore, and a plurality of discharge ports communicating with said bore; a rotary distributor received in said bore and having an axially extending channel communicating with said chambers and outlet port means communicating with said channel, said distributor comprising an end portion adjacent to said pump chamber and provided with peripheral flow-enhancing passage means connecting said duct means with said working chamber when the distributor rotates in said bores; means for feeding fuel to said two inlets through which the fed fuel is supplied to both of said chambers; a drive for rotating and for simultaneously reciprocating said distributor so that the latter performs alternating working and suction strokes and said outlet port means is in short-lasting communication with each discharge port during each revolution thereof; a metering valve provided in said distributor to control the flow of fuel through said channel from said pump chamber to said overflow chamber and from said overflow chamber to said pump chamber; and adjustable regulating means arranged to open said valve for intervals of variable length, each such interval including the last part of each suction stroke to admit fuel from the overflow chamber to the pump chamber and the first part of the next working stroke to admit fuel from the pump chamber to the overflow chamber so that said distributor expels fuel during the remainder of each working stroke and while said outlet port means communicates with one of said discharge ports.

3. In a fuel injection pump, a housing defining a pair

of chambers and having a bore connecting said chambers; a rotary distributor provided in said bore and defining an axially extending channel communicating with said chambers; drive means for rotating and for simultaneously reciprocating said distributor so that the latter performs alternating working and suction strokes; a normally closed metering valve provided in said distributor to control the flow of fuel between said channel and one of said chambers, said valve comprising a casing defining an annular seat, a valve member reciprocably received in said casing and having a head at one end thereof, and means for biasing said head against said seat to thereby close said valve; and adjustable regulating means arranged to open said valve for intervals of variable length in response to reciprocation of said distributor, each such interval including the last part of a suction stroke and the first part of the next-following working stroke of said distributor, said regulating means comprising a sleeve rotatably mounted on said distributor and including a stop member extending through cutout means provided in the distributor adjacent to the other end of said valve member so as to move said head away from said seat during each of said intervals and in response to reciprocation of said distributor.

4. In a fuel injection pump for multi-cylinder internal combustion engines, a housing defining a pump chamber and an overflow chamber, said housing having a bore connecting said chambers, two inlets communicating with and arranged to supply fuel to each of said chambers, and a plurality of equidistant discharge ports communicating with said bore; a rotary distributor received in said bore and having an axially extending channel connecting said chambers, said distributor further having a radially extending outlet port located substantially at the level of said discharge ports and communicating with said channel; means for feeding fuel to said two inlets so that such fuel fills said chambers and said channel; a drive for rotating and for simultaneously reciprocating said distributor so that the latter performs alternating working and suction strokes and said outlet port comes in communication with each discharge port during each revolution of the distributor; a normally closed poppet valve provided in said distributor to control the flow of fuel through said channel from said overflow chamber into said pump chamber and from said pump chamber into said overflow chamber; and adjustable regulating means arranged to open said valve for intervals of variable length in response to reciprocation of said distributor, each such interval including the last part of a suction stroke to admit fuel from said overflow chamber into said pump chamber and the first part of the next working stroke to admit fuel from said pump chamber into said overflow chamber so that said distributor expels fuel from said channel during the remainder of each working stroke and while said outlet port communicates with one of said discharge ports.

5. A structure as set forth in claim 4, wherein said distributor comprises a first end portion adjacent to said pump chamber, a second end portion operatively connected with said drive, and a central portion adjacent to

said overflow chamber, said regulating means including a member connected for rotation with said central portion and received in said overflow chamber.

6. A structure as set forth in claim 4, wherein said distributor comprises a first end portion adjacent to said pump chamber and a second end portion operatively connected with said drive, said regulating means comprising a member connected for rotation with the second end portion of said distributor.

7. In a fuel injection pump for multi-cylinder internal combustion engines, a housing defining a pump chamber and an overflow chamber, said housing having a first bore connecting said chambers, an inlet communicating with said pump chamber via said first bore, an outlet, a second bore connecting said inlet with said overflow chamber, a third bore connecting said overflow chamber with said outlet, and a plurality of equidistant discharge ports communicating with said first bore; a rotary distributor received in said first bore and having an axially extending channel connecting said chambers, said distributor further having a radially extending outlet port located substantially at the level of said discharge ports and communicating with said channel; means for supplying fuel to said inlet so that such fuel fills said overflow chamber, said distributor having an end portion adjacent to said working chamber and provided with flow-enhancing peripheral passages for admission of fuel from said inlet to said pump chamber and to said channel in response to rotation of the distributor; a drive for rotating and for simultaneously reciprocating said distributor so that the latter performs alternating working and suction strokes and said outlet port comes in communication with each discharge port during each revolution of the distributor; a normally closed metering valve provided in said distributor to control the flow of fuel between said channel and said overflow chamber; and adjustable regulating means arranged to open said valve for intervals of variable length in response to reciprocation of said distributor, each such interval including the last part of a suction stroke and the first part of the next working stroke so that said distributor expels fuel from said channel during the remainder of each working stroke and while said outlet port communicates with one of said discharge ports.

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