April 21, 1964 T. V. ARBANAS 3,129,702

VARIABLE DELIVERY PUMP

Filed June 26, 1962 2 Sheets-Sheet 1

Fig. 1.

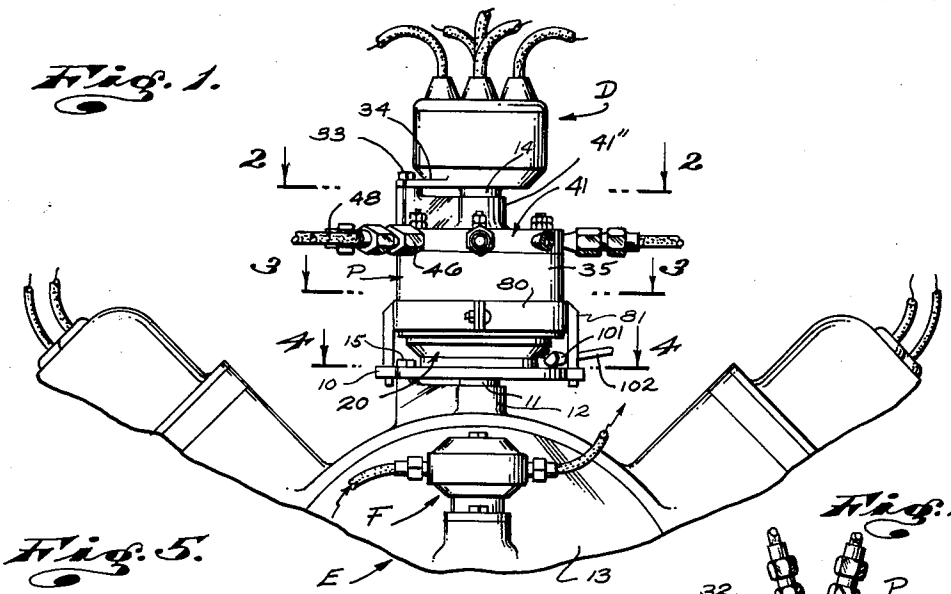


Fig. 5.

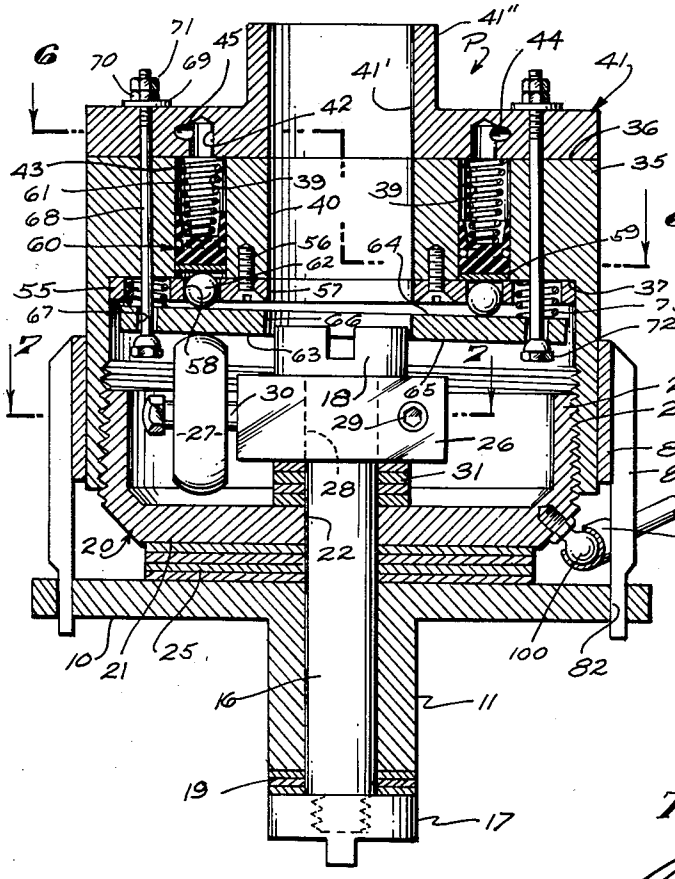


Fig. 2.

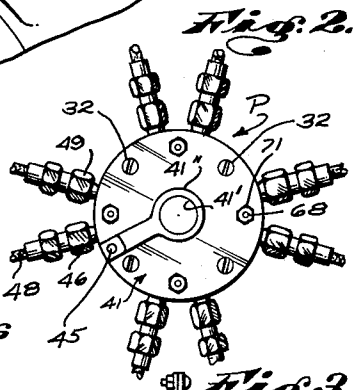


Fig. 3.

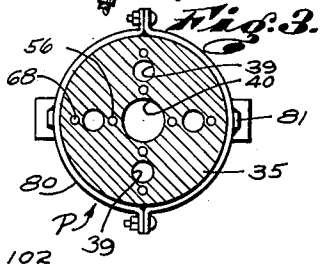
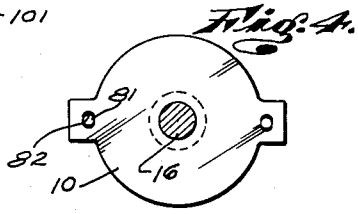


Fig. 4.



INVENTOR.

Thomas V. Arbanas

BY

George A. Tramontozzi

April 21, 1964 T. V. ARBANAS 3,129,702

VARIABLE DELIVERY PUMP

Filed June 26, 1962 2 Sheets-Sheet 2

Fig. 6.

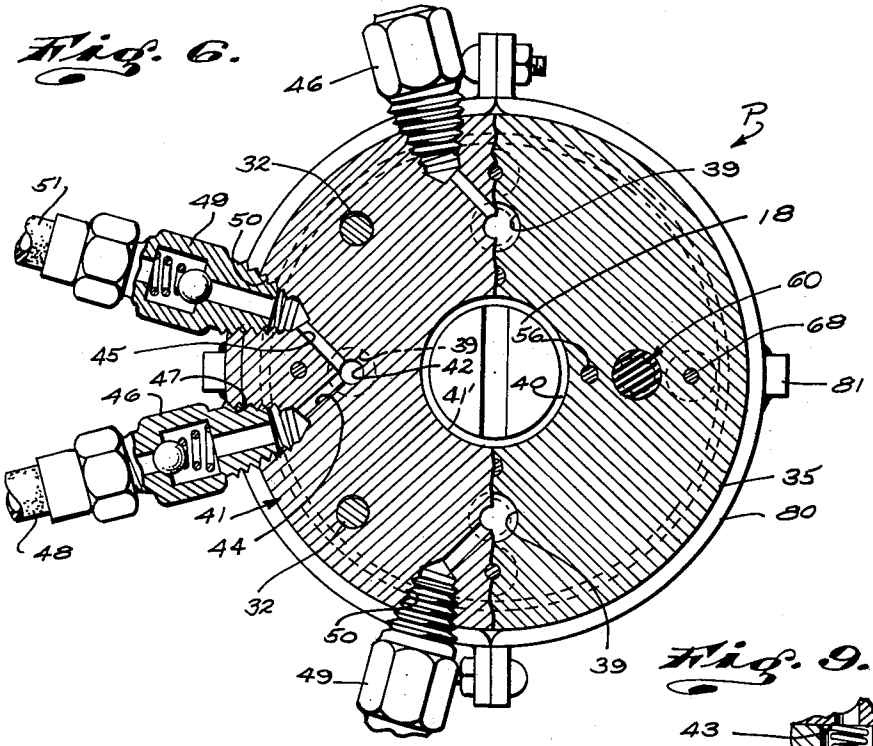


Fig. 9.

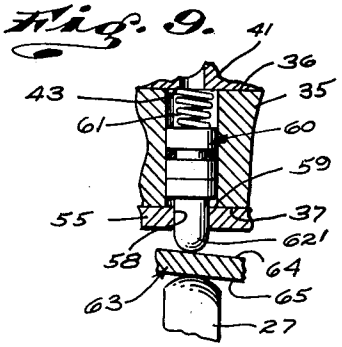


Fig. 7.

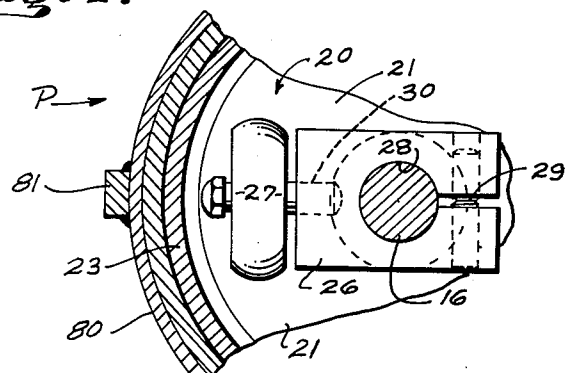
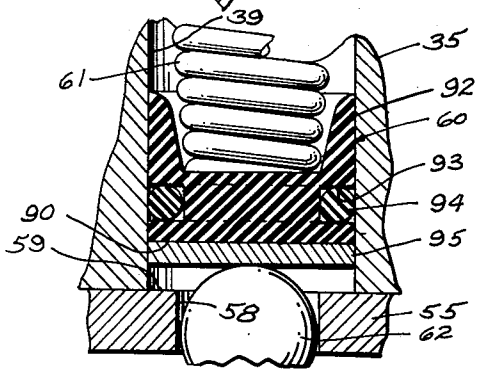


Fig. 8.



INVENTOR.
Thomas V. Arbanas
BY
George C. Maxwell

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3,129,702

VARIABLE DELIVERY PUMP

Thomas V. Arbanas, Cheyenne, Wyo.
(% Marion Arbanas, Rte. 1, Mattawan, Mich.)

Filed June 26, 1962, Ser. No. 205,417
9 Claims. (Cl. 123—139)

This invention has to do with a novel variable delivery pump and is more particularly concerned with a pump for the direct injection of fuel into a reciprocating internal combustion engine.

Many attempts have been made to provide a suitable variable displacement pump for use in connection with fuel injection systems; however, each has failed or has proven to be commercially impractical due to its complex nature, the necessity for constant adjustment and the like and/or due to fuel leaks, and the like.

Still another disadvantage in such a pump has been the necessity of providing special drive means therefor and means for timing the pumps with the engines with which they are related.

An object of the present invention is to provide a variable delivery or displacement fuel pump for fuel injection systems for automotive type internal combustion engines which is extremely small, neat and compact, a pump which involves few parts, each of which is easy and economical to manufacture and a pump which is easy to assemble, install and to maintain.

It is an object of the present invention to provide a pump of the character referred to which is such that it can be mounted in tandem with and driven with the distributor or magneto of a conventional automobile engine.

Still another object of my invention is to provide a variable displacement pump of the character referred to which maintains a constant head pressure throughout its delivery range and which is such that it can be conveniently manually controlled or controlled by any suitable servo means responsive to any desired variables, such as altitude, humidity, temperature and the like.

An object of my invention is to provide a pump of the character referred to having a separate, valve-controlled cylinder and piston for each cylinder of the engine with which it is related and a pump wherein the several pistons are driven by a single swash plate, which plate is driven by a roller on a rotary arm driven from the distributor drive means of the engine.

A further object of ths invention is to provide a swash plate type variable displacement pump of the character referred to wherein the rotary arm and roller thereon is fixed axially, where the cylinders and pistons are arranged in a non-rotating axially shiftable block and where the swash plate is carried by the block for free floating movement within axial limits, relative to the block.

The various objects and features of my invention will be fully understood from the following detailed description of a typical preferred form and application of my invention throughout which description reference is made to the accompanying drawings, in which:

FIG. 1 is an end elevational view of a portion of an internal combustion engine showing the pump provided by the present invention related thereto;

FIG. 2 is a top plan view of my new pump, taken as indicated by line 2—2 on FIG. 1;

FIG. 3 is a sectional view taken as indicated by line 3—3 on FIG. 1;

FIG. 4 is a sectional view taken as indicated by line 4—4 on FIG. 1;

FIG. 5 is an enlarged detailed, longitudinal sectional view of my new pump construction;

FIG. 6 is a transverse sectional view taken as indicated by line 6—6 on FIG. 5;

FIG. 7 is a sectional taken as indicated by line 7—7 on FIG. 5;

FIG. 8 is an enlarged detail view of a piston as provided by the present invention; and

FIG. 9 is a view of a modified form of piston and tappet.

The pump P provided by the present invention is adapted to be applied to an automotive type internal combustion engine E, to deliver varying, predetermined volumes of fuel to each of the several cylinders of the said engine upon each intake stroke of the pistons in said cylinders.

The pump P includes, first, a flat horizontally-disposed substantially disc-shaped base plate **10** having a central depending tubular mounting stem **11**, which stem is slidably engaged in a tubular boss **12** projecting from the block **13** of the engine E, which boss **12** is in axial alignment with a distributor driveshaft (not shown) within the engine and is normally adapted to receive the mounting stem **14** of a conventional distributor D. The base plate **10** is held in fixed position on the boss **12** by a suitable lock fastener **15**.

A drive shaft **16** is rotatably engaged in the stem **11** to project above the plate and below the lower end of the stem and is provided at its lower end with a keyed coupling **17** to oppose and engage the end of the distributor drive shaft (not shown) which, in accordance with common practice, is provided with a keyway.

The upper end of the shaft **16** is provided with an enlarged upper head **18** having an upwardly-disposed keyway therein, which head is adapted to oppose and engage the end of the keyed shaft in the distributor D, as will hereinafter be described.

A suitable thrust bearing **19** is arranged between the coupling **17** and the lower end of the stem **11**.

Slidably engaged about the shaft **16**, above the plate and spaced below the upper head **18** is an upwardly-opening screw cup **20**. The screw cup **20** has a flat bottom **21** with a central shaft-receiving opening **22**, and an upwardly-projecting annular sidewall **23**. The sidewall **23** is externally threaded as at **24**.

A suitable thrust bearing **25** is provided between the bottom **21** of the screw cup and the plate **10**.

Mounted on the shaft **16** below the upper head **18** thereof is an elongate, horizontally-disposed rotary arm **26** having a swash plate-engaging roller or follower **27** at one end thereof.

The arm **26** has an opening **28** through which the shaft **16** extends. The arm is split longitudinally from the opening **28** therein to its end, remote from the roller, and is provided with a lock fastener **29** which fastener serves to hold the arm in tight clamped engagement on the shaft **16**.

The roller **27** is a simple anti-friction roller mounted at the first mentioned end of the arm **26**, on a horizontal axis, by means of a suitable axle member **30**.

A suitable thrust bearing **31** is provided between the arm **26** and the bottom **21** of the cup.

The thrust bearings **19**, **25** and **31** are shown as simple stacks of thrust washers. In practice, ball-type thrust bearings could be employed without departing from the spirit of this invention.

It will be apparent from the above and from a study of the drawings, that the rotary arm and roller thereon are within the confines of the screw cup and are free to rotate therein.

The pump P that I provide next includes a cylindrical cylinder block **35** having a flat top **36**, a flat bottom **37** and an annular, internally-threaded depending extension or sleeve **28**, which sleeve is threadedly engaged about the exterior of the sidewall **23** of the screw cup **20**.

The block 35 is provided with a plurality of circumferentially spaced axially disposed, straight through cylinder bores 39. The cylinder bores 39 are spaced radially from the central axis of the construction with their axes intersecting the loci of travel of the central vertical plane of the roller 27, as clearly illustrated in FIG. 5 of the drawings.

The block 35 is provided with a central opening 40 to freely receive or accommodate the stem 14 of the distributor D related to the pump P.

A flat disc-shaped manifold head 41 is fixed to the top 36 of the block by means of a plurality of screw fasteners 32. The head 41 is also provided with a central opening 41' and an upwardly-projecting annular boss 41'' to slidably receive the stem 14 of the distributor D. A lock bolt 33 is carried by a radially projecting anchor arm 34 on the distributor and engages in a radial projection on the boss to fix the distributor in position relative to the pump.

With the construction thus far described, it will be apparent that the pump P is mounted on the engine by the distributor mounting means thereof, is driven by the distributor drive means thereof and that the distributor D is mounted on the pump and is also driven by the distributor drive means of the engine through the driveshaft 16 of the pump.

It is understood that the particular manner in which the pump is fixed to the engine and the manner in which the distributor is fixed to the pump can be varied widely in practice and so as to conform to any one of the several means that are commonly used.

In the case illustrated, I have shown the block provided with four cylinder bores. As a result, the particular pump illustrated is adapted for use in connection with a four cylinder internal combustion engine.

The head 41 is provided with four downwardly-opening, dead end bores or chambers 42, in axial alignment with the cylinder bores 39 in the block. The chambers 42 are of less diametric extent than the bores 39 and cooperate therewith to establish annular downwardly-disposed spring seats 43 at the upper ends of the bores. A circumferential seal is provided at each bore, seated either in head or block to prevent escape of fluid at mating surface of head to block.

The head 41 is further provided with substantially radially-outwardly extending inlet and outlet ports or ducts 44 and 45, communicating with each chamber 42 and with the exterior of the head, about the outer periphery thereof.

The several inlet ducts 44 are provided with check valves 46 to allow for flow of fuel into the chambers and cylinder bores only. The check valves are conventional check valve fittings occurring at the exterior of the head and are threadedly engaged in socket openings 47 in the head at the outer ends of the ducts 44.

The check valves 46 are connected with suitable supply ducts or hoses 48, supplied with fuel, under constant pressure, from a fuel pump F on the engine E, or an external electrically driven pump.

The several outlet ports or ducts are provided with check valves 49 to allow for flow of fuel out of the chambers and cylinder bores only. The valves 49 are conventional check valve fittings occurring at the exterior of the head and are threadedly engaged in socket openings 50 in the head at the outer ends of the ducts 45.

The check valves 49 are connected with delivery ducts 51 extending to the several related cylinders of the engine E. In practice, suitable nozzles are or may be provided at the engine cylinders, with which the ducts 51 connect.

In practice, the check valves 46 and 49 could be arranged within the head, instead of being in the nature of separate fittings, without departing from the spirit of this invention.

The construction that I provide further includes a disc-shaped keeper plate 55, fixed to the bottom 37 of the block by means of suitable screw fasteners 56.

The plate 55 is provided with a central opening 57 to accommodate the stem 14 of the distributor D and is provided with four circumferentially-spaced guide openings 58, in axial alignment with the bores 39. The openings 58 are less in diameter than the cylinder bores and establish annular, upwardly-disposed stop shoulders 59, at the bottoms of the bores.

Arranged within each cylinder bore 39 is a piston 60 and a return spring 61. The spring 61 normally yieldingly urges the piston downwardly in the bore and into stopped engagement on the shoulder 59.

Arranged in each guide opening 58 is a tappet 62, which tappet engages the lower or bottom end of the piston related thereto and projects below the plate to engage a swash plate 63, as will hereinafter be described.

In the form of the invention illustrated in FIG. 5 of the drawings, the tappets 62 are simple ball bearings.

The swash plate 63 is a simple disc-shaped plate arranged within the pump construction to occur between the roller 27 on the rotary arm and the tappets 62. The plate 63 is shown as having at flat top 64 which engages the tappets, a flat bottom 65 which is engaged by the roller, a central opening 66 to freely accommodate the stem 14 of the distributor D, and a plurality of circumferentially-spaced openings 67 about its outer peripheral portion to freely receive vertically adjustable hanger rods 68.

The hanger rods 68 are elongate, vertically-disposed members extending through the plates 63 and 55, block 35 and head 41.

The upper ends of the rods 68 are threaded and carry suitable washers, nuts and lock nuts 69, 70 and 71, to engage and act against the head 41 and which allow for vertical shifting and/or adjustment of the rods relative to the remainder of the construction.

The lower ends of the rods 68 are provided with enlarged heads 72, which heads engage the bottom 65 of the plate 63 and limit its downward movement.

Engaged about each rod 68, between the plate 63 and the bottom 37 of the block 35 is a compression spring 73, which spring normally yieldingly urges the plate 63 downwardly into seated or stopped engagement on the head 72 of the rods 68.

The plate 55 is provided with openings through which the rods 68 extend and which freely receive and retain the springs 73 in axial alignment with the rods.

With the construction set forth above and illustrated in the drawings, it will be apparent that the pistons 60 normally occur in the bottoms of the cylinder bores 39 by virtue of the action of the springs 61 and by the action of the fluid pressure acting upon them, that the tappets 62 normally engage the bottom of the pistons and are engaged by the swash plate 63. It will be further apparent that when the cup 20 is rotated to force the block and plate downward, and the bottom surface 65 of the plate 63 to occur below the top or uppermost extremities of the roller 27, the tappet 62 and piston 60 nearest the roller is urged upward in the bore 39 effecting a discharge of fuel therefrom. As the roller continues in its path the plate 63 describes a wobble motion, more or less, depending upon the volume output per piston stroke selected by positioning cup 20.

It is further apparent that any discrepancy in face runout of lower surface of block to the path of roller can be minimized by suitable adjustment of hanger rods 68, and during the active lifetime of pump the tappets may wear or seat unevenly, in which case a suitable adjustment of the hanger rods can restore the original condition, i.e., each piston pumping identical volume.

It will be apparent that by shifting the block and the swash plate 63 carried thereby, vertically relative to the rotary arm and roller, the stroke effected by the action of the roller, through the swash plate and to the pistons is reduced, thereby reducing the volume of fluid being pumped.

In practice, the block and swash plate can be elevated to an extent where the roller **27** does not engage the tappets at all and no pumping action is obtained.

The block **35** is provided with means connected or engageable with the base plate **10**, to allow for free vertical shifting of the block relative to the base plate, screw cap and rotary arm, but to prevent relative rotation between the said base plate and the block.

In the case illustrated, the above mentioned means includes a clamp band **80** engaged about the block and having a pair of circumferentially-spaced index pins **81** depending therefrom and slidably engaged in suitable openings **82** provided in the base plate.

With the above relationship of parts, it will be apparent that apart from the shaft **16**, arm **26** and roller **27**, the screw cup **20** is the only part of the construction that is free to rotate.

It will be further apparent that by rotating the screw cup **20**, the block assembly is effectively raised and lowered in such a manner as to effectively change or vary the displacement of the pump.

Still further, it will be apparent that the displacement of the several cylinder and piston units of the pump are varied uniformly, as the block in which they are arranged is shifted bodily relative to the rotary arm and roller.

The screw cup **20** is provided with a ball-end stud **100**, at its lower end, which stud is engaged by a socket cup **101** on the end of an actuating rod **102**, extending to a suitable control means (not shown). The control means serves to shift the rod **102** axially and as a result to rotate the cup and shift the block assembly.

In practice, the rod can be manually actuated as by a conventional foot pedal set up or can, if desired, be driven by a suitable servo mechanism, which mechanism can be responsive to any desired secondary control means.

The pistons **60** that I provide are simple cylindrical bodies of plastic material having flat bottoms **90**, flat tops **91**, upwardly-projecting fluid pressure actuated, expansible, annular sealing skirts **92** and an annular radially-outwardly opening O-ring groove **93**, in which an O-ring seal **94** is engaged. The pistons **60** are further provided with a wear-receiving washer or disc at their bottom ends to occur between the pistons and the tappets **62**.

The return springs **61** are simple compression springs and have their upper ends seated against the shoulders **43**, at the upper ends of the cylinder bores and their lower ends seated on the tops **91** of the pistons, radially-inwardly of the skirts.

The O-ring grooves **93** in the pistons are arranged in the upper portions thereof so that they remove substantial stock where the skirts **92** join the bodies of the pistons and thereby establish thin, flexible ties between the piston bodies and the skirts, which allow free relative flexing and resulting sealing of the skirts in the cylinder bores.

In the form of the invention shown in FIG. 9 of the drawings, I have shown a modified tappet and piston construction. In this embodiment of the invention, the tappet **62'** is in the nature of a short rod, having a round bottom end to engage the swash plate and having its upper end joined integrally with the washer **95**. The upper washer portion **95** is preferably fused or bonded to the bottom of the piston per se, to establish a unitary assembly therewith.

Having described only a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any modifications or variations that may appear to those skilled in the art and fall within the scope of the following claims.

Having described my invention, I claim:

1. A variable displacement pump including

(1) a stationary base plate,

(2) a driven shaft rotatably carried by the base plate,

(3) a rotary arm carried by the shaft,

(4) a roller on the arm,

(5) a screw element rotatably carried by the base plate,

(6) a cylinder block arranged in axial alignment with the shaft in spaced relationship from said base plate and arm and having a plurality of circumferentially spaced axially extending cylinder bores,

(7) a part on the block engaged with said rotatable screw member on the base plate,

(8) indexing means carried by the block and engaging the plate to prevent relative rotation between the plate and the block and for free axial shifting therebetween,

(9) a piston in each cylinder bore,

(10) spring means normally yieldingly urging the pistons toward the base plate,

(11) a keeper on the block closing the ends of the bores adjacent the base plate,

(12) tappets slidably carried by the keeper to engage the pistons and projecting axially from the keeper toward the base plate and arm,

(13) a swash plate arranged between the tappets and the base base plate and rotary arm and engaged by the tappets and roller on the arm,

(14) hanger means carried by the block and supporting the swash plate for limited universal movement,

(15) a head on the block closing the other ends of the cylinder bores and having inlet and outlet ducts communicating with said bores,

(16) check valves at said ducts restricting reverse flow therethrough,

(17) and actuating means connected with said screw element to rotate said element relative to the base plate and block and effect axial shifting of the block relative to the base plate and to thereby vary the stroke of the pistons and the volumetric delivery of the pump.

2. A variable displacement multiple delivery pump including,

(1) a flat horizontally disposed base plate,

(2) a vertically disposed drive shaft rotatably carried by the base plate,

(3) a rotary arm on the shaft above the base plate,

(4) a swash plate-engaging roller on the arm,

(5) a screw element rotatably carried by and projecting upwardly from the base plate,

(6) an elongate cylinder block with upper and lower ends and a plurality of circumferentially spaced straight through axially extending cyinder bore spaced above the base plate and the arm,

(7) a part on the block engaged with said rotatable screw member on the base plate,

(8) indexing means carried by the block and engaging the plate to prevent relative rotation between the plate and the block and for free axial shifting therebetween,

(9) a piston in each cylinder bore,

(10) spring means normally yieldingly urging the pistons toward the base plate,

(11) a keeper at the lower end of the block and closing the bores,

(12) tappets slidably carried by the keeper to engage the pistons and projecting axially from the keeper toward the base plate and arm,

(13) a swash plate arranged between the tappets and the base plate and rotary arm and engaged by the tappets and roller on the arm,

(14) hanger means carried by the block and supporting the swash plate for limited universal movement,

(15) a head on the upper end of the block closing the upper ends of the cylinder bore and having inlet and outlet ducts communicating with the bores,

(16) check valves at said ducts restricting reverse flow therethrough,

(17) and actuating means connected with said screw

element to rotate said element relative to the base plate and block and effect axial shifting of the block relative to the base plate and to thereby vary the stroke of the pistons and the volumetric delivery of the pump.

3. A variable displacement multiple delivery pump including,

(1) a stationary base assembly including,

(*a*) a flat horizontally disposed base plate,

(*b*) a vertically disposed drive shaft rotatably carried by the base plate,

(*c*) a rotary arm on the shaft above the base plate,

(*d*) a swash plate-engaging roller on the arm,

(2) a non-rotatable axially shiftable head assembly including,

(*a*) an elongate cylinder block with upper and lower ends and a plurality of circumferentially spaced straight through axially extending cylinder bores spaced above the base plate and the arm,

(*b*) a part on the block engaged with said rotatable screw member on the base plate,

(*c*) spring means normally yieldingly urging the pistons toward the base plate,

(*d*) a keeper at the lower end of the block and closing the bores,

(*e*) tappets slidably carried by the keeper to engage the pistons and projecting axially from the keeper toward the base plate and arm,

(*f*) a swash plate arranged below the block and engaging the tappets and engageable by the roller,

(*g*) hanger means carried by the block and supporting the swash plate for limited universal movement,

(*h*) a head on the upper end of the block closing the upper ends of the cylinder bore and having inlet and outlet ducts communicating with the bores,

(*i*) check valves at said ducts restricting reverse flow therethrough,

(3) means operatively connecting the upper and lower assemblies including,

(*a*) a screw element rotatably carried by and projecting upwardly from the base plate,

(*b*) indexing means carried by the block and engaging the plate to prevent relative rotation between the plate and the block and for free axial shifting therebetween,

(*c*) and a piston in each cylinder bore,

(4) and operating means adapted to rotate the screw element on the base assembly relative to the base plate and the block assembly and to thereby vary the axial placement of the swash plate relative to the roller and effect a change in the volumetric displacement of each cylinder and piston.

4. A variable displacement multiple delivery pump including an upper cylinder block assembly having a plurality of circumferentially-spaced cylinder and piston unit, valve-controlled inlet and outlet ducts communicating with each unit, an axially-shiftable tappet related to each unit to engage the piston and depending from the block, and a swash plate carried by the block for limited universal movement and engaging the lower ends of the tappets; a lower support and drive assembly, including a base plate, a drive shaft rotatably carried by the base plate and a rotary arm with a swash plate engaging roller on the shaft; index means carried by one assembly and engaging the other assembly to prevent relative rotation and permit axial shifting of said assemblies; and actuating means to shift the cylinder block assembly axially relative to the lower assembly and to shift the roller into and out of engagement with the swash plate whereby the volumetric delivery of the cylinder and piston units is controlled and varied, including a rotary screw element on the lower assembly, a part on the cylinder block assembly engaged with said screw element and drive means connected with the screw element to rotate said element relative to the lower assembly and the cylinder block assembly.

5. In combination, an internal combustion engine, a variable displacement fuel injection pump and a distributor, said engine having a fuel pump, a plurality of cylinders and pistons and a distributor-mounting and drive means, said fuel injection pump, including a lower support and drive assembly including a base plate engaged with said distributor mounting on the engine, a drive shaft rotatably carried by the base plate and engaged with said distributor drive means of the engine and having a rotary arm with a swash-plate-engaging roller thereon, an upper cylinder block assembly having a plurality of circumferentially spaced cylinder and piston units, valve control inlet ducts communicating with the cylinder and piston units and the engine fuel pump, valve control outlet ducts communicating with the cylinder and piston units and the engine cylinders, an axially-shiftable tappet related to each unit to engage the piston thereof and projecting from the assembly, a swash plate carried by the block assembly for universal movement and engaging the tappets and engageable with said roller, a distributor-mounting means, indexing means carried by one assembly and engaging the other assembly to prevent relative rotation and permit axial shifting of said assemblies, and actuating means to shift the cylinder block assembly axially relative to the lower assembly and shift the roller into and out of engagement with the swash plate whereby the volumetric delivery of the cylinder and piston units is controlled and varied, including a rotatable screw element on the lower assembly, a part on the cylinder block assembly engaged with said screw element and drive means connected with the screw element to rotate said element relative to the lower assembly and the cylinder block assembly, said distributor having a part engaged with said distributor mounting on the cylinder block assembly, a drive shaft engaged with the drive shaft of said lower assembly and distributor wires extending to the several cylinders of the engine.

6. A variable displacement multiple delivery fuel pump of the character referred to, including an elongate vertically disposed block with a plurality of circumferentially-spaced axially-extending and downwardly-opening cylinder bores, inlet and outlet ports communicating with the upper end of each cylinder, a piston arranged in each cylinder, a piston return spring in each cylinder between the top thereof and the piston therein, a tappet related to each piston and depending from the block, a swash plate arranged below the block and engaging the tappets, hanger means carried by the block and supporting the swash plate for vertical and semi-universal movement, a base plate arranged below the swash plate, an axially-extending drive shaft rotatably carried by the base plate, a rotary arm carried by the shaft and a roller on the arm and engaging the bottom side of the swash plate, indexing means between the block and the base plate to prevent relative rotation therebetween and to allow for free axial shifting therebetween, a downwardly-projecting annular skirt on the cylinder block, an upwardly-opening screw cup carried by the base plate for free rotation and against axial shifting and threadedly engaging the skirt, and operating means connected with the cup to rotate the cup relative to the base plate and the skirt and to cause the block and the swash plate to shift vertically relative to the said arm and roller.

7. A structure as set forth in claim 6, wherein said hanger means includes a plurality of elongate, circumferentially-spaced axially-adjustable hanger rods depending from the block through openings in the swash plate and provided with swash-plate-supporting heads at their lower ends, and a compression spring about each rod,

between the cylinder block and the swash plate and normally yieldingly-urging the swash plate down and into engagement with the heads and the roller.

8. A structure as set forth in claim 6, wherein the piston in each cylinder includes a cylindrical body of flexible plastic material having a flat top and a flat bottom, an annular fluid pressure actuated sealing skirt projecting upwardly from the periphery of the top and cooperating with the top to define a piston return spring seat and an annular, radially-outwardly-opening O-ring groove in the body, said groove being located in close proximity to the top of the body to relieve the body and impart flexibility to the upper peripheral portion thereof and to enhance the flexibility of the skirt.

9. A structure as set forth in claim 6, wherein the inlet

and outlet ports related to each cylinder are provided with pressure release check valves.

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