MULTIPLE PLUNGER FUEL PUMP

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9 Claims

ABSTRACT OF THE DISCLOSURE

A multi-plunger fuel pump having the plunger units arranged in an "X" configuration about the axis of a cam shaft. The plunger units are supported in two intersecting planes with two opposed banks in each plane. Each opposed bank is arranged on opposite sides of the axis defined by the intersection of the planes and with the actuating elements of the individual units directed toward the axis. The cam shaft rotates about the axis of the intersecting planes and has cam surfaces engaging the plunger actuating elements in a progressive sequence.

Both 12 and 6 plunger unit pump versions are disclosed.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to fuel pumps having multiple plunger elements and more specifically to a fuel pump having 4 banks of plunger elements arranged in an "X" configuration about the axis of a cam shaft.

Description of the prior art

Fuel pumps of the type having a series of plunger units, each of which is connected with an individual engine cylinder, are designed for maximum compactness because of space limitations. Thus, for engines having their cylinders arranged in a "V" configuration, the fuel pump is normally located in the V-shaped area between the cylinder heads in order to reduce the total space occupied by the engine and its associated accessories and to minimize the length of the injection lines connecting the individual plunger units with their respective cylinders.

Theoretically, the most compact pump arrangement is the distributor type wherein a single plunger unit is employed to supply the fuel to a plurality of cylinders, normally by making a pumping stroke for each of the cylinders it supplies. This type of pump has some weaknesses when employed with modern high speed engines. The delivery of a precise and uniform charge of fuel to each cylinder is difficult to obtain and the relative quantity of the charges cannot be adjusted. In addition, the reliability of the engine is low because failure of the single plunger unit affects all of its associated cylinders. The life expectancy of the operating parts of the plunger unit is low because the plunger has to produce as many pumping strokes as the number of cylinders to which it is delivering fuel.

An in-line type pump avoids the deficiencies of the aforementioned distributor type pump by having a separate plunger unit for each individual cylinder. The major drawback of the in-line type pump is its excessive length. This length is generally a function of the number of pumping units and the center distance between adjacent pumping units.

To shorten the pump length, "V" arrangements and opposed bank arrangements have been disclosed in the prior art. In the "V" arrangements, the plunger units are supported in two banks arranged in a pair of intersecting planes with the plunger units in each bank arranged in a series. In the opposed bank arrangement, the individual plunger units are supported in a pair of opposed banks with two banks arranged in a common plane. Both of the aforementioned plunger unit arrangements reduce the overall height of the pump and partially reduce the length which however still remains substantial. Since the overall length is a function of the center-to-center distance between adjacent plunger units, efforts to reduce this overall length have taken the form of minimizing the center-to-center distance by providing the plunger units so that the removal of an entire pumping assembly comprising a delivery valve, plunger and barrel assembly, control components, spring and tappet and roller components as a unit from the pump housing is impossible.

For purposes of maintenance or repair, the components of the individual plunger unit must be partially disassembled in the pump housing. Thus, for example, in a conventional multi-plunger pump, replacement of a secured actuating roller forming a part of an individual plunger unit requires not only the disassembly of the pumping element associated with the roller but, in addition, of the cam shaft, the pump governor and other major components.

The preferred embodiment of the present invention overcomes the above drawbacks of conventional pump assemblies by providing a novel "X" arrangement for the plunger units which results in a greatly reduced overall length while still permitting a sufficient center-to-center distance between the plunger units to permit the removal of an individual plunger unit from the pump housing for maintenance or repair.

SUMMARY

The preferred embodiment of the present invention, which will be subsequently described in greater detail, is described with reference to a pump having 12 reciprocally actuated plunger units, each plunger unit being connected to an individual engine cylinder. The plunger units are arranged in two intersecting planes with 6 plunger units arranged in two opposed banks in each plane. Each individual plunger unit has its actuating element directed toward the intersection of the two planes which intersection defines the axis of rotation of the cam shaft. The angle between the planes is a function of the engine crank angle between the firing of successive cylinders and the ratio of the rotation of the pump cam shaft and the rotation of the engine crankshaft.

The plunger units of adjacent banks are preferably staggered. This staggered arrangement permits the axial distance between adjacent plunger units to be determined by the tappet diameter while at the same time providing sufficient space for the plunger units to be individually removable from the pump housing.

The reduced length of the preferred 12 plunger pump makes it possible to employ a cam shaft supported by only two bearings. This is a distinct advantage over conventional pumps having a long shaft requiring a center bearing and is reflected in manufacturing cost reductions and longer disassembly. In addition, the cam shaft of the preferred pump requires only 3 cam lobes. This is only half the number of lobes required in a conventional "V" or opposed plunger unit arrangement and results in additional cost reductions over conventional arrangements.

Another embodiment of the present invention contemplates a pump having 6 plunger units in a "V" configuration and also actuated by a 3 lobe cam shaft. In the 6 plunger unit version, the plunger units are arranged in 2 sets of opposed banks. The opposed banks of one set each have 2 plunger units and the banks of the other set each have a single plunger unit.

It is therefore an object of the present invention to provide an improved arrangement for the plunger units.
in a multi-plunger fuel pump wherein the plunger units are arranged in two intersecting planes, with two opposed banks of plunger units in each plane and each pair of opposed banks arranged on opposite sides of the axis of intersection of the planes.

It is another object of the present invention to reduce the overall length of a multi-plunger fuel pump wherein the plungers are actuated by a common cam shaft by arranging the plunger units in an "X" configuration about the axis of rotation of the cam shaft.

It is a further object of the present invention to reduce the overall length of the cam shaft actuating the plunger units of a multi-plunger fuel pump by arranging the plunger units in at least 4 banks, each bank having its actuating element directed toward the axis of rotation of the cam shaft.

It is another object of the present invention to provide a plunger arrangement for a multiple plunger fuel pump comprising a first group of plunger units arranged in a first plane in a pair of opposed banks; a second group of plunger units arranged in a second plane in a pair of opposed banks; and the first and second groups of plunger units so that the first and second plane intersect to define an axis with the individual banks of the first and second groups arranged on opposite sides of the axis of intersection.

Still another object of the present invention is to provide a plunger arrangement for a multi-plunger fuel pump comprising means defining a first axis; a pair of opposed plunger units arranged in a second axis which is transverse to the first axis and intersects the first axis intermediate the pair of opposed plunger units; a second pair of opposed plunger units arranged in a third axis which is transverse to the first axis and intersects the first axis intermediate the second pair of opposed plunger units, and the individual plunger units of the first and second pair of opposed plunger units having actuating elements laterally movable with respect to the first axis.

Still further objects and advantages of the present invention will readily occur to one skilled in the art to which the invention pertains upon reference to the following detailed description.

**DESCRIPTION OF THE DRAWINGS**

The description refers to the accompanying drawings in which like reference characters refer to like parts throughout the views and in which:

FIG. 1 is an end view of a 12 unit fuel pump for supplying fuel to a 12-cylinder engine and illustrating the preferred embodiment of the invention;

FIG. 2 is a longitudinal sectional view through the pump of FIG. 1 with parts removed for purposes of clarity and the engine cylinders indicated schematically;

FIG. 3 is a transverse, sectional view taken along lines 3—3 of FIG. 2 with parts shown schematically for purposes of description;

FIG. 4 is a diagrammatic representation of the arrangement of the plunger units of the 12-unit fuel pump and their respective banks;

FIG. 5 is a longitudinal sectional view through a 6-unit pump illustrating another embodiment of the invention;

FIG. 6 is a diagrammatic illustration of the plunger arrangement of the fuel pump illustrated in FIG. 5; and

FIG. 7 is a diagrammatic representation of the camshaft of the 6 plunger unit version.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

As can be seen in FIG. 1, the preferred pump 10 includes a housing 12 mounted by a flange (not shown) to an engine indicated at 16 and supported by a bracket 14. The housing 12 supports four groups of plunger units generally indicated at 18, 20, 22 and 24. The banks 18 and 24 are opposed to one another in a first plane and the banks 20 and 22 are opposed to one another in a second plane, the two planes intersecting to define the axis of rotation of a cam shaft 26 which is best seen in FIG. 2. Each plunger unit is individually removable from the housing 12 for purposes of repair or maintenance by removing a cap 30 which is retained by threaded fasteners 32 to the housing 12.

The cam shaft 26 is supported for rotation in the housing 12 by a pair of spaced apart roller bearing units 33 and 34. The end 36 of the cam shaft 26 is adapted to receive a pair of governor flyweights (not shown). The opposite end 38 of the cam shaft 26 carries a drive gear 40 which is connected by a timing chain (not shown) to the crankshaft of engine 16 to rotate the cam shaft 26 at a rate accommodating the firing of the engine cylinders.

The cam shaft 26 has three cam sections 42, 44 and 46 axially spaced between the bearings 33 and 34. For purposes of description, the cylinders of engine 16 are arranged in two banks, a left bank 48 and a right bank 50. Each of the banks 48 and 50 comprise 6 cylinders. The pump 10 has an individual plunger unit for supplying fuel to each of the cylinders. Thus the banks of plunger units 18 and 20 are connected with the left bank 48 of engine cylinders while the banks of plunger units 22 and 24 are connected with the right bank 50 of engine cylinders. The plunger units are arranged such that the first cam section 42 actuates the plunger units connected with cylinders 1 and 6 of the left bank and cylinders 3 and 5 of the right bank of the engine. The second cam section 44 actuates the plunger units connected with cylinders 2 and 4 of the left bank and cylinders 1 and 6 of the right bank; and cam section 46 actuates plunger units supplying cylinders 3 and 5 of the left bank and 2 and 4 of the right bank of the engine.

Referring to FIG. 4, the bank of the plunger units 18 is connected with cylinders 1, 2 and 3 of the left bank; the bank of plunger units 20 is connected with cylinders 4, 5 and 6 of the left bank; the bank of plunger units 22 is connected with cylinders 4, 5 and 6 of the right bank; and the bank of plunger units 24 is connected to cylinders 1, 2 and 3 of the right bank. FIG. 4 also illustrates how the banks of plunger units 18 and 24 are arranged in a common plane 54 and on opposite sides of the axis of rotation of the cam shaft 26. The banks of plunger units 20 and 22 are also arranged in a common plane 52 on opposite sides of the axis of rotation of the cam shaft 26. It can also be seen that the axis of rotation of the cam shaft 26 is defined by the intersection of the planes 52 and 54.

The angle between the planes 52 and 54 is a function of the engine crank angle between the firing of any two consecutive cylinders of the engine 16 and the rate of rotation of the engine crankshaft. Considering engine 16 as a four-stroke engine, with the cylinders progressing through a firing cycle within a 720 degree angle, the engine crank angle between the firing of successive cylinders is therefore computed as 720/12=60 degrees. Since the cam shaft 26 is rotating at one-half the rate of the engine crankshaft, the angle between the planes 52 and 54 is therefore one-half the angle rotated by the engine crankshaft or 30 degrees.

Preferably, the plunger units of bank 18 are staggered with respect to the plunger units of the neighboring bank 20. Thus, for example, the cam section 42 actuates plunger units supplying cylinders 1 and 6 of the engine's left bank; with the forward part of the cam 42 actuating cylinder 1 and the rearward part of the cam 42 actuating cylinder 6. Referring to FIG. 4, it can be seen that the
plunger units associated with cylinders 1 and 6 are in banks of plunger units 18 and 20 respectively. Similarly, the individual units of banks 22 and 24 are staggered with respect to one another to shorten the overall length of the pump and still provide sufficient room between adjacent plunger units to permit easy removal of an individual plunger unit from the housing 12.

The cam sections 42, 44 and 46 have actuating cam lobes 56, 58 and 60 respectively. These cam lobes are arranged on their respective cam sections at an equiangular relationship with one another of 120 degrees.

A preferred firing order for the 12-unit pump 10 is as follows:

<table>
<thead>
<tr>
<th>Firing Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder....</td>
</tr>
<tr>
<td>Crankshaft, degrees....</td>
</tr>
<tr>
<td>Pump Camshaft, degrees....</td>
</tr>
<tr>
<td>Cam section....</td>
</tr>
</tbody>
</table>

Now referring to FIG. 3, a typical plunger unit 62 is illustrated and forms a part of the bank of plunger units 18. The plunger unit 62 is connected to the first cylinder of the left bank of the engine and is arranged in the plane 54 opposite a plunger unit 64 connected to the third cylinder of the right bank of the engine. The plunger units 62 and 64 are opposed to one another on opposite sides of the cam shaft 26 and are actuated by the cam lobe 56. Plunger unit 62 is briefly described for the purpose of illustrating a typical injector type plunger unit having a reciprocally arranged actuating element.

The plunger unit 62 comprises a roller 66 supported for movement toward and away from the cam shaft by a tappet assembly 68 which is biased toward the cam shaft by a coil spring 72. A plunger 74 is arranged for reciprocation in a bore 80 within a body 76. A delivery valve unit 78 is arranged at the upper end of the bore 80 to close a pressure chamber 82. The delivery valve unit 78 includes a spring loaded delivery valve 84 regulating communication between the pressure chamber 82 and a fuel delivery line 86. A fuel passage 88 transfers fuel from the supply chamber 89 to the pressure chamber 82 on the return stroke of the plunger 74 toward cam shaft 26.

Rotation of the cam shaft 26 causes the cam lobe 56 to reciprocate plunger 74. The plunger 74 moves away from the cam shaft 26 in a compression stroke, passage 88 is closed and the fuel trapped in the pressure chamber 82 is compressed until the delivery valve 84 is unseated and fuel is delivered to the injection nozzle of the first cylinder of the left bank of the engine. The plunger 74 is biased away from the delivery valve 84 by the spring 72 in a return stroke as the roller 66 follows the trailing edge of the cam lobe 56. The cam shaft 56 continues its rotation to actuate the other plunger units.

FIGS. 5 and 6 illustrate a pump 90 having 6 plunger units arranged to supply a 6 cylinder engine. This embodiment of the invention comprises a pump housing 92 and a pair of axially spaced apart bearings 94 and 96 supporting a cam shaft 98. The forward end 100 of the cam shaft 98 is adapted for attachment to a governor flyweight (not shown) and the rearward end 102 is machined to receive a drive gear or coupling (not shown). The cam shaft 98 has three axially spaced cam sections 104, 106 and 108, each of which has a lobe for engaging a pair of opposed plunger units. As shown diagrammatically in FIG. 6, the plunger units are arranged in a pair of banks including a left bank 110 comprising plunger units 112, 114 and 116, and a right bank 118 comprising plunger units 120, 122, and 124. Each individual plunger unit of the banks 110 and 118 is of the same basic construction as the plunger unit 62 illustrated in FIG. 3 and described earlier.

With reference to FIG. 7, the plunger units are arranged in two planes 126 and 128 intersecting along a line corresponding to the axis of rotation of the cam shaft 98.

The plunger units of pump 90 are arranged in opposed pairs in two planes with opposed plunger units 112 and 120 and opposed plunger units 116 and 124 supported in plane 128 and the intermediate pair of opposed plunger units 114 and 122 supported in plane 126. As best seen in FIG. 7, plane 126 intersects plane 128 with an included angle of 30°.

The angle between the actuating lobes of cam sections 104 and 106 is 150°, the angle between the actuating lobes of cam sections 106 and 108 is 90°, and the angle between the actuating lobes of cam sections 108 and 104 is 120°.

The unsymmetrical arrangement of the cam lobes accommodates various considerations including the cylinder firing order and interchangeability of components between the 6 and 12 plunger unit pumps. Thus, by maintaining the 30° angle arrangement between the plunger unit supporting planes, the pump flange, the governor (not shown) which is attached to the flange, the control racks (not shown) and other component parts are interchangeable. Since the angle rotated by the engine crankshaft between any two successively fixed cylinders is 120° and the angle between the plunger units is 150° and 30°, the lobe of cam 106 is at an angle 30° offset with the cam 104 and 108 in order to provide a proper firing sequence.

A preferred firing sequence is as follows:

| Cylinder.... | 1L | 6L | 1R | 6R | 2L | 7R | 3L | 8R | 4L | 9R | 5L | 10R |
| Crankshaft, percent.... | 0 | 120 | 240 | 360 | 480 | 600 | 720 | 0 | 0 | 0 | 0 | 0 |
| Pump Camshaft, percent.... | 0 | 120 | 240 | 360 | 480 | 600 | 720 | 0 | 0 | 0 | 0 | 0 |
| Cam Section.... | 104 | 106 | 108 | 104 | 106 | 108 | 104 | 106 | 108 | 104 | 106 | 108 |

As best seen in FIGURE 6 the successive plunger units in each of the banks 110 and 118 are staggered so that the plunger units can be arranged in the housing 92 with adequate space to permit removal of the entire plunger assembly.

It can be seen that I have described in detail an improved multi-plunger fuel pump wherein the plunger units are arranged in an "X" configuration thereby reducing the overall length of the pump assembly. This reduction in overall length provides not only a more compact pumping unit, but in addition permits the employment of a single camshaft in both 12 plunger unit and 6 plunger unit assemblies which requires only 2 supporting bearings.

Thus, the center cam shaft bearing usually required in conventional fuel pumps is eliminated.

Although I have described but two embodiments of my invention, it is to be understood that various changes and revisions can be made therein without departing from the spirit of the invention.

What is claimed is:

1. A fuel pump for an engine having a plurality of cylinders, said fuel pump comprising:
   (a) a housing and a shaft rotatably supported in said housing,
   (b) a plurality of plunger units carried in said housing each disposed perpendicular to the axis of said shaft,
   (c) each of said plunger units being adapted to be connected to one of said cylinders so that the number of said plunger units is equal to the number of cylinders in the engine,
   (d) said plunger units being arranged in pairs along the axis of said shaft with the plunger units in each of the pairs disposed coaxially and on opposite sides
7 of said shaft with each pair of plunger units axially spaced from each other pair of plunger units so that no more than a single pair of plunger units is disposed at an axial position along said shaft, and
\( e \) said plunger units being arranged with their axes disposed in one of a pair of planes intersecting the axis of said shaft with a first pair of said plunger units disposed in the same plane as a second pair of said plunger units separated axially from said first pair of plunger units by a third pair of plunger units, and said third pair of plunger units being disposed in the second of the pair of planes and angularly offset with respect to said first and second pairs of plunger units.

2. The invention as defined in claim 1, wherein there are at least six of said plunger units and said cam shaft is provided with three individual cam surfaces, one of said surfaces actuating at least two of said plunger units.

3. The invention as defined in claim 2, wherein one of said cam surfaces is disposed at an angle of 150° with respect to a second of said cam surfaces and at an angle of 90° with respect to the third of said cam surfaces.

4. The invention as defined in claim 2, wherein said cam surfaces are axially spaced and have a similar transverse cross section; said cross sections being annularly arranged about said axis in a regular angular arrangement.

5. The invention as defined in claim 1, wherein said planes intersect at a predetermined angle, said angle being a function of the engine crank angle between the firing of two consecutive engine cylinders supplied by the plunger units of said fuel pump.

6. The invention as defined in claim 1, wherein said plunger units number 12 and said planes intersect with an included angle of 30°.

7. The invention as defined in claim 6, including said plunger units having actuating elements reciprocally movable toward and away from said shaft, said shaft having three individual cam surfaces arranged thereon to progressively engage the actuating elements of said plunger units in a predetermined sequence, said individual cam surfaces having a regular angular arrangement of 120° with respect to said shaft axis.

8. The invention as defined in claim 1, wherein said planes intersect with an included angle of 30°.

9. The fuel pump as defined in claim 1 and including a fourth pair of plunger units disposed in the same plane as said third pair of plunger units and axially separated from said third pair of plunger units by said second pair of plunger units.

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WILLIAM L. FREEH, Primary Examiner

U.S. Cl. X.R.

123—139
CERTIFICATE OF CORRECTION


Inventor(s) G. D. Wolff

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, on the chart, "percent" should be --degrees-- in each instance.

SIGNED AND SEALED

JUL 7 1970

(SEAL)

Attest:

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