

July 13, 1948.

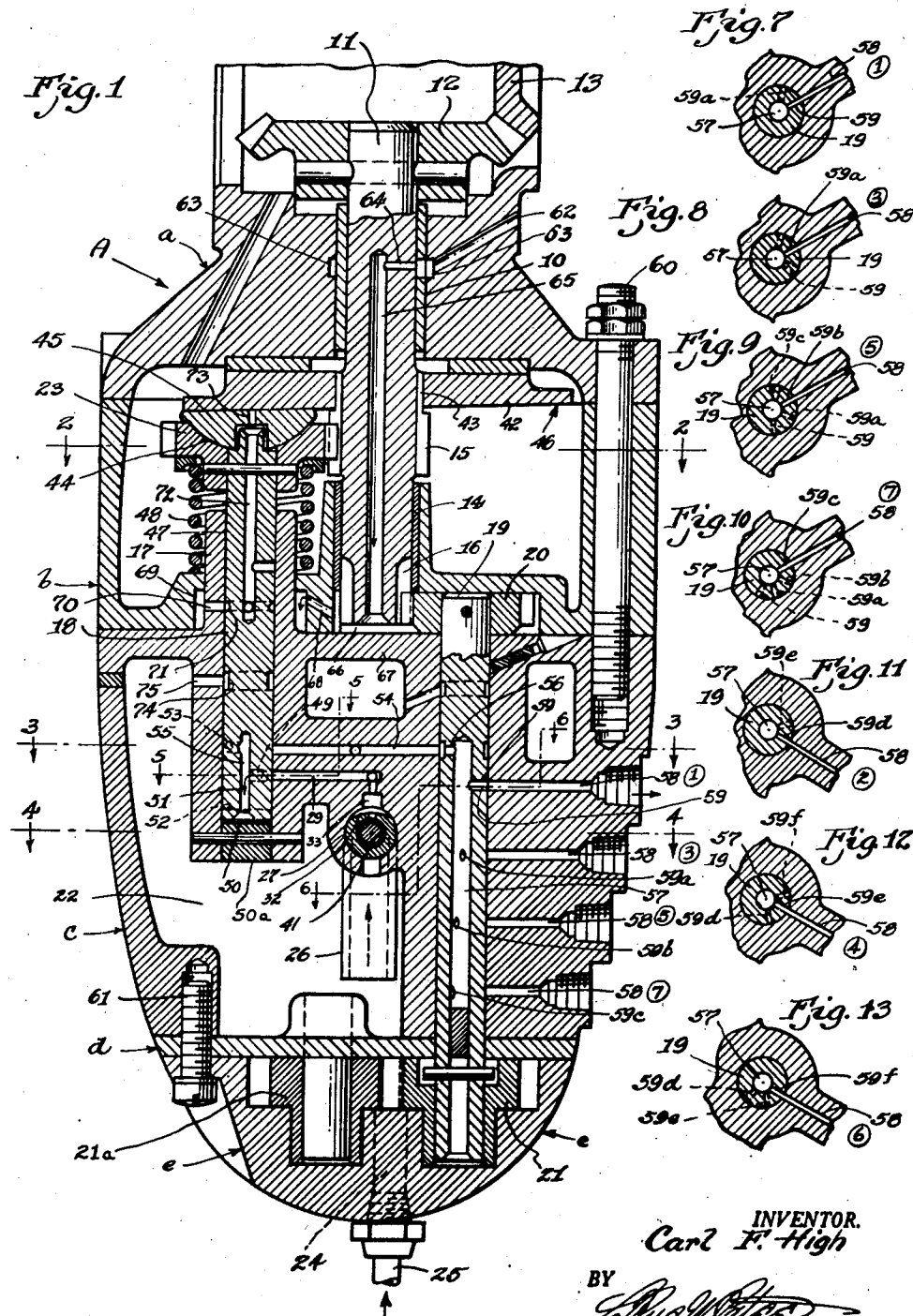
C. F. HIGH

2,445,266

FUEL PUMPING AND DISTRIBUTING DEVICE

Original Filed April 4, 1940

2 Sheets-Sheet 1



INVENTOR.
Carl F. High
BY
John W. White
Attorney.

July 13, 1948.

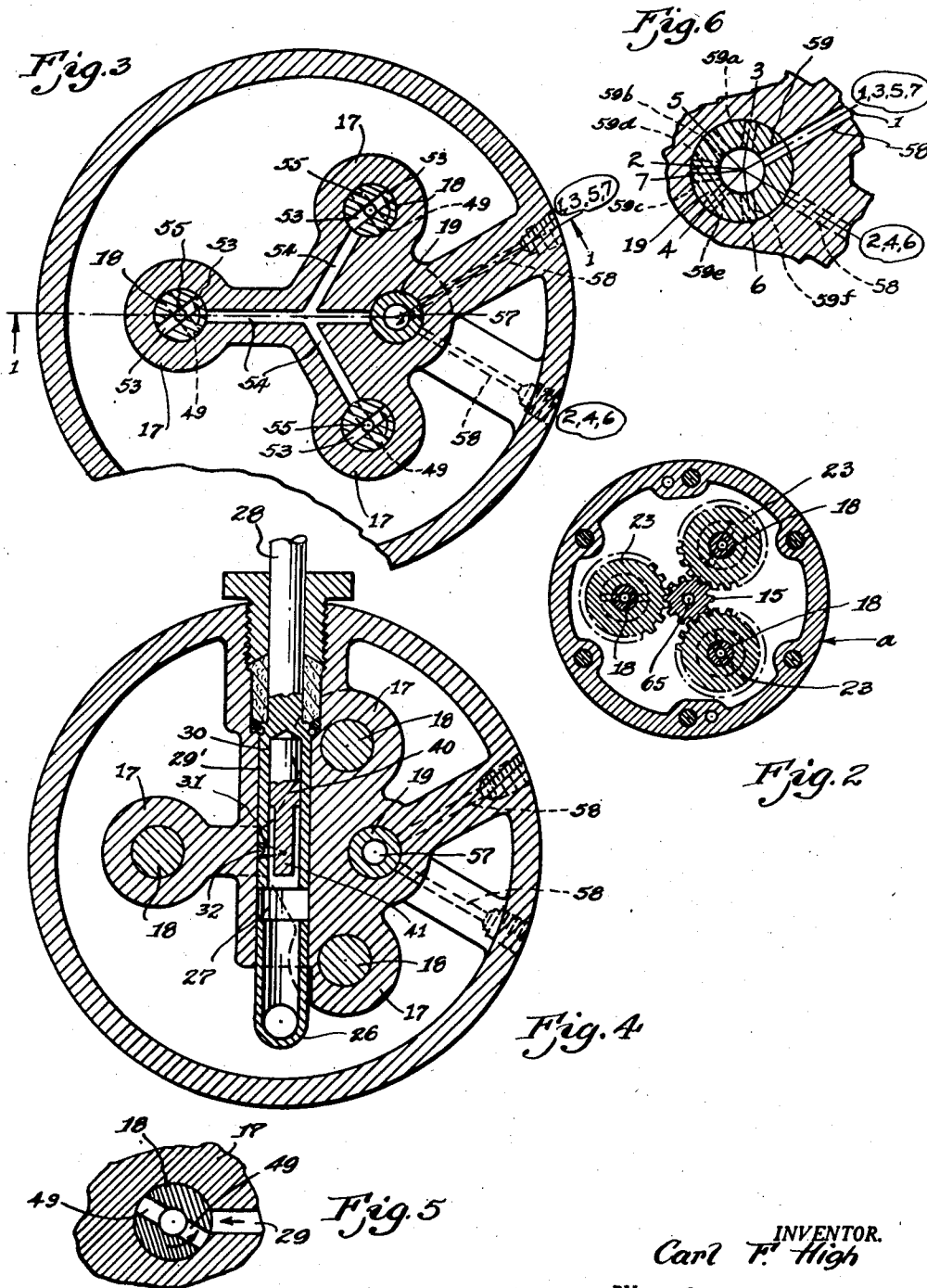
C. F. HIGH

2,445,266

FUEL PUMPING AND DISTRIBUTING DEVICE

Original Filed April 4, 1940

2 Sheets-Sheet 2



INVENTOR.
Carl F. High
BY *James W. Bates*
Attorney.

UNITED STATES PATENT OFFICE

2,445,266

FUEL PUMPING AND DISTRIBUTING DEVICE

Carl F. High, Detroit, Mich., assignor to Ex-Cell-O Corporation, Detroit, Mich., a corporation of Michigan

Original application April 4, 1940, Serial No. 327,834. Divided and this application July 17, 1944, Serial No. 545,308

5 Claims. (Cl. 103—2)

1

My invention relates to liquid fuel injectors and more particularly to one embodying a fuel pump and means for timing, measuring and pumping charges of liquid fuel to a plurality of engine cylinders in relation to the order of firing thereof.

More particularly the present fuel pump is constructed and arranged to include fuel metering means on the suction side of the pump and a pump plunger or plungers operable in timed relation with the engine which drives same to pump liquid fuel and to distribute same to a plurality of fuel outlet means which may be connected by fuel conduits (not shown) to convey metered charges of fuel respectively to the several cylinders. More particularly my invention embodies a pump plunger driven with a combined reciprocating and rotating motion for controlling inlet and discharge valving functions in addition to its pumping function.

In the present embodiment of my invention, the pump plunger is operable to discharge fuel to one or more discharge passages leading to a fuel distributor which may register at predetermined periods with one of a plurality of delivery passages which may be used to direct single charges of fuel respectively toward the several engine cylinders in the order of their firing and in timed relation thereto.

Another object of my present invention is to facilitate engine operation by providing a fuel pumping, metering and distributing unit of light weight, compact design and of economical construction which makes possible the assembly of the pumping unit with an aircraft engine.

Other objects of my invention relate to various features of construction and operation embodying improved controlling and operating devices and improved means for lubricating the moving parts of the unit.

For a more detailed understanding of my invention, reference may be had to the accompanying drawings illustrating various preferred embodiments of my invention and illustrating in detail the various features and improvements as hereinafter described, and in which like parts are identified by like reference characters throughout the several views, and in which:

Fig. 1 is a fragmentary longitudinal sectional view through my fuel injector pump taken on lines 1—1 of Fig. 3 embodying a rotating and reciprocating pump plunger and a distributing device all of which are operated from a single driving element driven by the engine (not shown) which may be associated therewith, this fuel injector device being particularly constructed for

2

assembly with a seven cylinder radial four cycle engine and timed to sequentially inject a charge of fuel to each cylinder of the engine once for each two revolutions of the engine crankshaft,

Fig. 2 is a transverse sectional view on the line 2—2 of Fig. 1, reduced in scale and illustrating means for rotatively driving the plurality of pumping plungers,

Fig. 3 is a transverse sectional view taken on line 3—3 of Fig. 1, and illustrating in detail the pump unit and its relation with the fuel discharge passage in the pump housing,

Fig. 4 is a transverse sectional view on the line 4—4 of Fig. 1, illustrating in detail the fuel intake metering means incorporated with the fuel injector unit as illustrated in Fig. 1,

Fig. 5 is an enlarged fragmentary detail transverse sectional view of the pump inlet taken on the line 5—5 of Fig. 1,

Fig. 6 is a fragmentary enlarged transverse sectional view through the distributor valve taken substantially on the line 6—6 of Fig. 1, and

Figs. 7 to 13 inclusive are fragmentary cross sectional views each taken in the horizontal plane indicated by the encircled numeral on Fig. 1 which indicates the number of the engine cylinder which is supplied with fuel by the port similarly indicated in the respective views. These figures show a series of positions assumed by the distributor valve in distributing the fuel to the several points of ultimate delivery within or about the associated engine.

This application is a division of my prior application Serial No. 327,834 filed April 4, 1940, (now Patent No. 2,361,399 issued October 31, 1944) for an improvement in fuel pumping and distributing device.

Referring more particularly to the injector illustrated in the accompanying drawings, it will be noted that this construction is particularly designed for application with an engine having an odd number of cylinders and more particularly the injector proper is provided with an equal number of liquid fuel outlets. This particular construction is especially designed for assembly with a seven cylinder radial engine and is constructed particularly compact and light in weight so as to be applicable to an aircraft engine.

The fuel injector comprises a composite housing structure A including complementary housing sections or portions a, b, c, d and e. The housing portion a which is only fragmentarily shown is adapted to fasten the injector to the associated engine (not shown) and carries a bearing 10 for supporting a central driving shaft 11, to

3

which is pinned a beveled gear 12 meshing with a beveled gear 13 driven in any suitable manner from an engine driven element. The driving shaft 11 is preferably driven at a speed which bears a ratio of $2\frac{1}{3}:2$ to the engine crankshaft speed. The inner end of the driving shaft 11 is supported in a bearing 14 carried by the housing portion b and carries an intermediate pinion 15 and a second pinion 16 located adjacent the inner end thereof.

Housing portion c is formed with a plurality of pump cylinders 17 (in this instance three) closed at their innermost ends by suitably fastened closure members 50—a. In these cylinders the rotating and reciprocating pump plungers 18 are operable. The pump cylinders are parallel to and equally spaced about the central drive shaft 11. (See Figs. 3 and 4.) Said casing c also supports the rotating distributor valve 19 which valve is provided with a driving gear 20 at one end meshing with the gear 16 carried by the drive shaft 11. A gear 21 at the other end of distributor 19 coacts with gear 21—a to form a conventional gear pump for pumping liquid fuel into the receiving chamber 22 carried by housing portion c. The ratio between the gear 20 and pinion 16 is such as to drive the distributor rotor 19 one complete revolution for each two revolutions of the engine crankshaft, in other words, at one half engine crankshaft speed. The ratio between the revolutions of the gear 20 and pinion 16, therefore, is $1:2\frac{1}{2}$. The ratio of revolutions of the pinion 15 with the gear 23 pinned or otherwise secured to the pump plunger 18 is $2:1$ so that these pump plungers are rotated at a speed which is one half the speed of the driving shaft 11.

The liquid fuel is drawn into the intake duct 24 in housing portion e from the feed line 25 and is pumped into chamber 22 by the gear pump 21, 21—a. Referring particularly to Figs. 1 and 4, it will be observed that the fuel is introduced into the depending intake pipe 26 and then into the intake passage including a portion of the bore 27 in the housing structure which extends substantially transversely thereof, substantially normal to the axis of the pump shaft 11 (if extended). A liquid fuel metering valve is fitted into this bore 27 and includes a stem 28 which may be angularly adjusted manually to control the amount of fuel admitted into the intake passage 29 leading to the several fuel pump cylinders 17. This valve is constructed to provide a sleeve-like cylindrical extension 29' (see Fig. 4), which has an internal bore 30 and a transverse port 31 which communicates with a segmental crescent shaped groove or slot 32 of varying cross section peripherally surrounding a portion of the extension 29' and connecting with the transverse port 31. The fuel which is introduced into chamber 27 enters the bore 30 thence flowing through the port 31, crescent groove 32, and into the pocket 33 and thence to passage 29. A plug 40 is fitted within the bore 30 of the valve and carries an extension 41 of reduced diameter which extends across the port 31 and serves to reduce the volume of the intake passage 30 to reduce the effect of liquid fuel surge to facilitate the normal flow of liquid fuel through the port 31.

The position of the pump plunger 18 in Fig. 1 is at the beginning of intake, as also seen in Fig. 5. This plunger is reciprocated by means of a swash plate cam 42 which has an internally splined central aperture 43 driven by an externally splined portion of the pinion 15. The gears 23 are provided with a concave spherical recessed

4

portion 44 in which is seated the convex cam follower 45 having a flat face engaging the cam surface 46 of the cam 42. As this cam is rotated the plunger is forced inwardly of the pump cylinder 47 against the resistance of spring 48, this spring 48 exerting a force outwardly so as to maintain the cam follower 45 constantly in contact with the cam surface 46. In the position illustrated in Fig. 1 and Fig. 5, it will be noted that the intake passage 49 of the pump plunger is moving into registration with the passage 29 as the pump plunger is beginning its outward movement. The liquid fuel is thus introduced into the pump chamber 50 as indicated by arrow 51, said fuel filling the chamber 50 which, in its opposite terminal position, will have a length as indicated at 52. The intake cycle will take place during substantially 90 degrees of angular travel of the plunger 18, and, as the intake closes, the outlet passage 53, which is included in a section substantially similar to Fig. 5 but with outlet passage 53 angularly displaced substantially 90 degrees from passage 29, is brought into registration with the outlet passage 54 in the housing portion c. At this time the plunger 18 is at the upper end of its stroke and is beginning the pumping stroke, said plunger now beginning to displace the fuel and force same through the internal passage 55 in said pump plunger through said discharge passage 53 into passage 54 and thence through the inlet port or intake 56 in the distributor valve 19 and into the internally drilled hole or passage 57, from which passage the liquid fuel is caused to flow sequentially through the several outlet ports or passages 59 to 59—f inclusive identified by encircled numerals opposite the said outlets in the drawings and described in detail in Figs. 7 to 13. It will be observed that in the position shown in Fig. 1, the passage outlet 59 which is connected with cylinder 1, is in registration with the uppermost port 59 in the distributor valve body (see also Fig. 7). The timing of the distributor valve and the pump plunger is such that the various ports 59 to 59—f inclusive are held in registration with the various outlet passages 53 concurrently with the registration of pump outlet passages 53 with passages 54 and thus a column of fuel is successively moved through the said passage to the various discharge passages 58. In Figs. 7 to 13 inclusive I have illustrated diagrammatically how these discharge passages 59, which lead to the various engine cylinders, are successively brought into registration with the discharge ports 59, 59—a, 59—b, 59—c, 59—d, 59—e and 59—f of the distributor valve 19.

Fig. 6 shows the angular relationship of each of the distributor valve discharge ports 59 to 59—f inclusive with the discharge passages 58 which direct fuel respectively from the bank of discharge passages serving engine cylinders 1, 3, 5 and 7.

It will be noted that the pump plungers 18 are continuously rotating and carry a pair of oppositely extending discharge passages 53 angularly spaced 180 degrees apart and connecting with axial passage 55. The pump has two discharges for each revolution of the plunger 18 and each discharge enters the common discharge passage 54. In like manner (see Figs. 1 and 5) the pump plunger 18 has two intake passages 49 which preferably lie at right angles to passages 53. Passages 49, at substantially the middle of the plunger suction or filling stroke, come into substantially full registry with fuel supply port 29 both longi-

5

tudinally and angularly twice each plunger revolution, or once each plunger stroke. The construction of the three pump plungers shown in detail in Fig. 3 is such that for every $\frac{1}{4}$ rotation of the distributor valve, one of the pump plunger discharge passages 53 are brought into registration with the passage 54 and a volume of liquid fuel, as predetermined by the positioning of the metering valve 28, is moved through the system and discharged into an engine cylinder. This is accomplished in part by properly proportioning the gears which drive the distributor valve 19 and the pump plungers 18 and in part by other factors.

It will be noted that the parts *a*, *b*, *c*, *d* and *e* of the pump housing are secured together by suitable bolts, the bolts 60 securing parts *a*, *b* and *c* together while the bolts 61 secure the parts *d* and *e* to portion *c*.

The various moving parts of the above described mechanism are lubricated as will hereinafter be described. The lubricating oil is introduced into the passage 62 in housing portion *a* and thence fed into the circular groove 63 then through the transverse passage or duct 64 into the central or axial drilled passage or hole 65 in the driving shaft 11. The lubricating oil enters the chamber 66 formed by spacing the inner end of shaft 11 from the wall 67 of the housing and is then fed through the passage 68 into the annular chamber 69 about the pump cylinder 17, and through the transverse duct 70 into an annular groove 71 on the pump plunger. Some of this lubricating oil is thus allowed to spread in a film on the surface of the pump cylinder to lubricate same and some is fed outwardly of the pump plunger through the central axial passage 72 to the upper end thereof and through the passage 73 to lubricate the cam surface 46. The pump plunger is provided with an annular groove 74 intermediate the groove 71 and the fuel outlet passages 53. The cylindrical portion of the pump plunger cylinder intermediate port 70 and port 75, which latter port communicates with the annular groove 74 has a very close fit with the plunger in order to minimize leakage of the lubricating oil into the annular groove 74. I preferably provide a system in which the oil pressure forcing the lubricating oil to the various elements to be lubricated is greater than the fuel pressure and, therefore, if there is any leakage resulting in intermingling of the fuel and lubricating oil, the lubricating oil leaks into the fuel instead of the fuel leaking into the lubricating oil. The drain passage 75 obviously drains any leakage of fuel and oil along the surface of the pump plunger back into the intake chamber 22, and any minute portion of the lubricating oil which may find its way into the chamber 22 is readily carried along with the fuel and burned in the engine.

It will be noted that the fuel pumps are nested about a common drive element, equi-angularly spaced from each other and positioned equidistant from said driving element.

It will be apparent to those skilled in the art to which my invention pertains that various modifications and changes may be made therein without departing from the spirit of my invention or from the scope of the appended claims.

I claim:

1. A fuel pump comprising, in combination, a housing, a fuel distributor rotatable in said housing and having an inlet port and an odd number of outlet ports arranged for communica-

6

tion in uniformly timed sequence successively with said inlet port once during each distributor rotation, a plurality of pumping devices, each including a rotary and reciprocatory plunger and having inlet and outlet means controlled by the rotation of said plunger for ejecting two charges of fuel during each plunger rotation and double reciprocation, the outlet means of said pumping devices being connected in common to said distributor inlet port, and means for driving said distributor and said pumping devices in timed relation to cause said pumping devices to deliver their collective charges in timed sequence and concurrently with connection of said inlet port respectively with said outlet ports.

2. A fuel pump comprising, in combination, a rotary fuel distributor having an inlet port and seven outlet ports arranged for communication in uniformly timed sequence successively with said inlet port once during each distributor rotation, three pumping devices, each including a rotary and reciprocatory plunger and having inlet and outlet ports controlled by the rotation of said plunger for delivering two charges of fuel during each plunger rotation, the outlet ports of said pumping devices being connected in common to said first mentioned inlet port, means for continuously driving said distributor, and means for continuously rotating and reciprocating said respective pump plungers in spaced phase relation, the speed ratio of said distributor to said pump plungers being 1 to $1\frac{1}{6}$, whereby the pumping devices collectively will deliver seven charges of fuel in sequence and concurrently with connection of said first mentioned inlet port respectively with said first mentioned outlet ports.

3. A fuel pump comprising, in combination, a rotary fuel distributor having an inlet port and seven outlet ports arranged for communication in uniformly timed sequence successively with said inlet ports once during each distributor rotation, three pumping devices, each including a rotary and reciprocatory plunger and having inlet and outlet ports controlled by the rotation of said plunger for delivering two charges of fuel during each plunger rotation, the outlet ports of said pumping devices being connected in common to said first mentioned inlet port, a source of fuel under pressure and including a metering device connected in common to said inlet ports of said pumping devices, means for continuously driving said distributor, and means for continuously rotating and reciprocating said respective pump plungers in spaced phase relation, the speed ratio of said distributor to said pump plungers being 1 to $1\frac{1}{6}$, whereby the pumping devices collectively will deliver seven charges of fuel in sequence and concurrently with connection of said first mentioned inlet port respectively with said first mentioned outlet ports.

4. A fuel pump comprising, in combination, a housing, a fuel distributor rotatable in said housing and having an inlet port and an odd number of outlet ports arranged for communication in uniformly timed sequence successively with said inlet port once during each distributor rotation, a plurality of pumping devices in said housing, each pumping device having a supply inlet and a discharge outlet for ejecting fuel in a succession of uniformly timed charges, said outlets of said pumping devices being connected in common to said distributor inlet port, and means for driving said distributor and said pumping devices in timed relation and said pumping device in uniformly spaced phase relation to

7

cause said pumping devices to deliver their respective charges in rotation and concurrently with communication respectively of said outlet ports successively with said inlet port.

5. A fuel pump comprising, in combination, a housing, a fuel distributor rotatable in said housing and having an inlet port and an odd number of outlet ports arranged for communication in uniformly timed sequence successively with said inlet port once during each distributor rotation, a plurality of pumping devices, each including a bore having an inlet port and an outlet port in spaced relation along the axis, and a rotary and reciprocatory plunger having two axially-spaced mutually-perpendicular diametrical intake and discharge passages, the opposite ends of which are movable alternately into and out of communication alternately and respectively with said inlet and outlet ports of said pumping device so as to eject two charges of fuel during each plunger rotation and double recipro-

8

cation, the outlet ports of said pumping devices being connected in common to said distributor inlet port, and means for driving said distributor and said pumping devices in timed relation to cause said pumping devices to deliver their collective charges in timed sequence and concurrently with connection of said distributor inlet port respectively with said distributor outlet ports.

CARL F. HIGH.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,720,657	Chorlton	July 16, 1929
2,361,399	High	Oct. 31, 1944