Oct. 2, 1956 W. E. MEYER 2,764,964

FUEL INJECTION PUMP

Filed Jan. 26, 1955 2 Sheets-Sheet 1

Fig. 1.

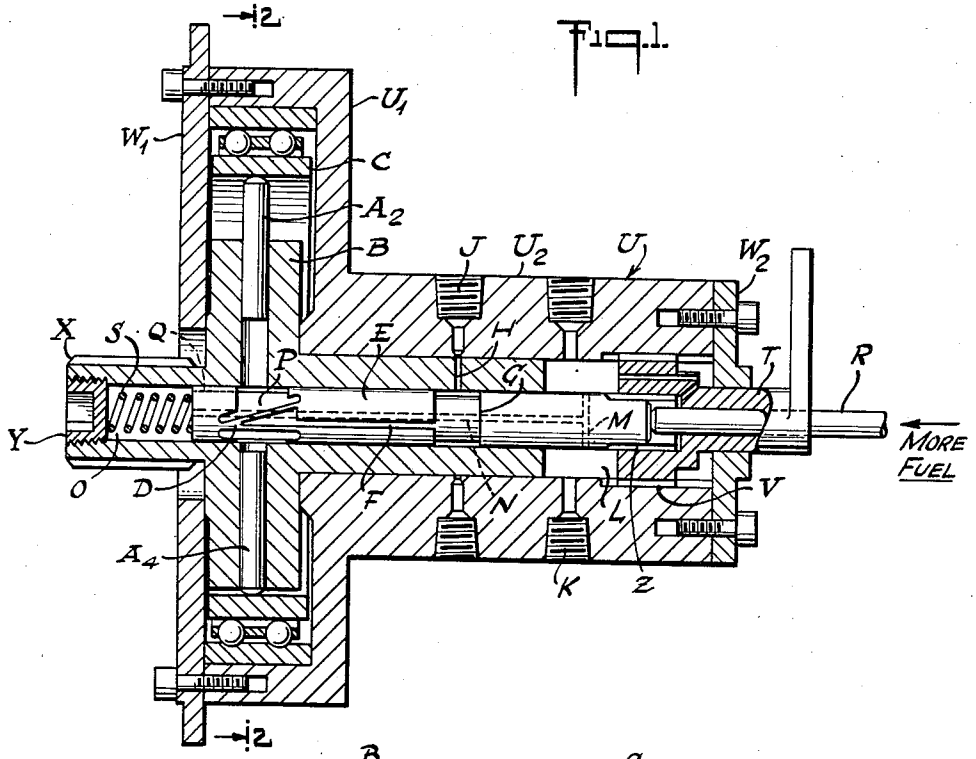
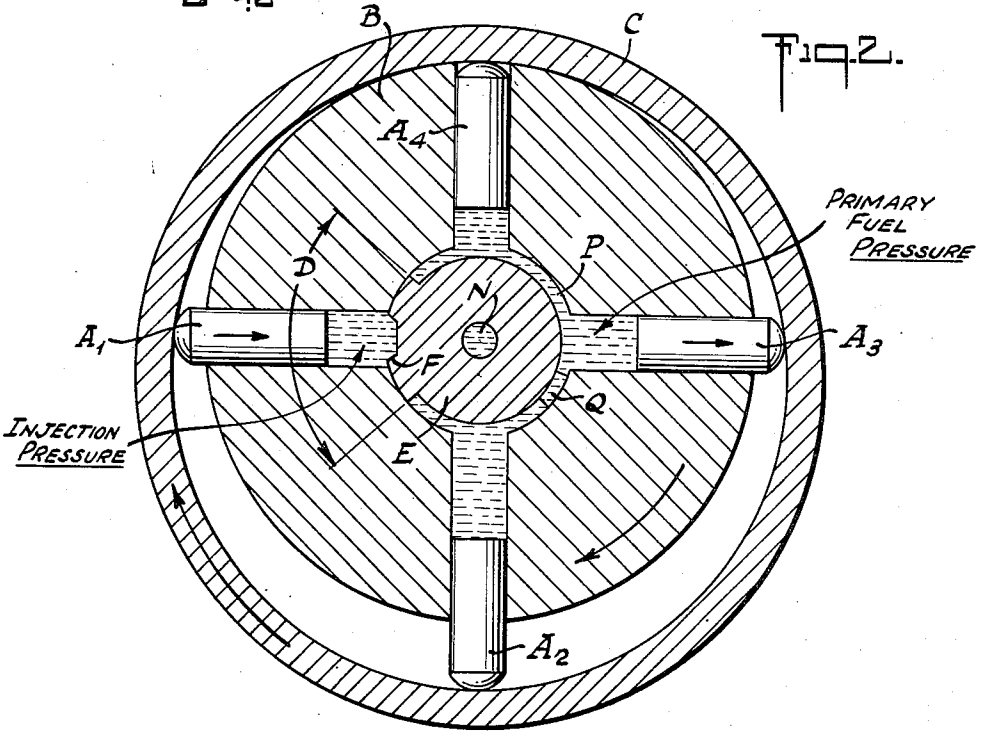


Fig. 2.



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2 Sheets-Sheet 2

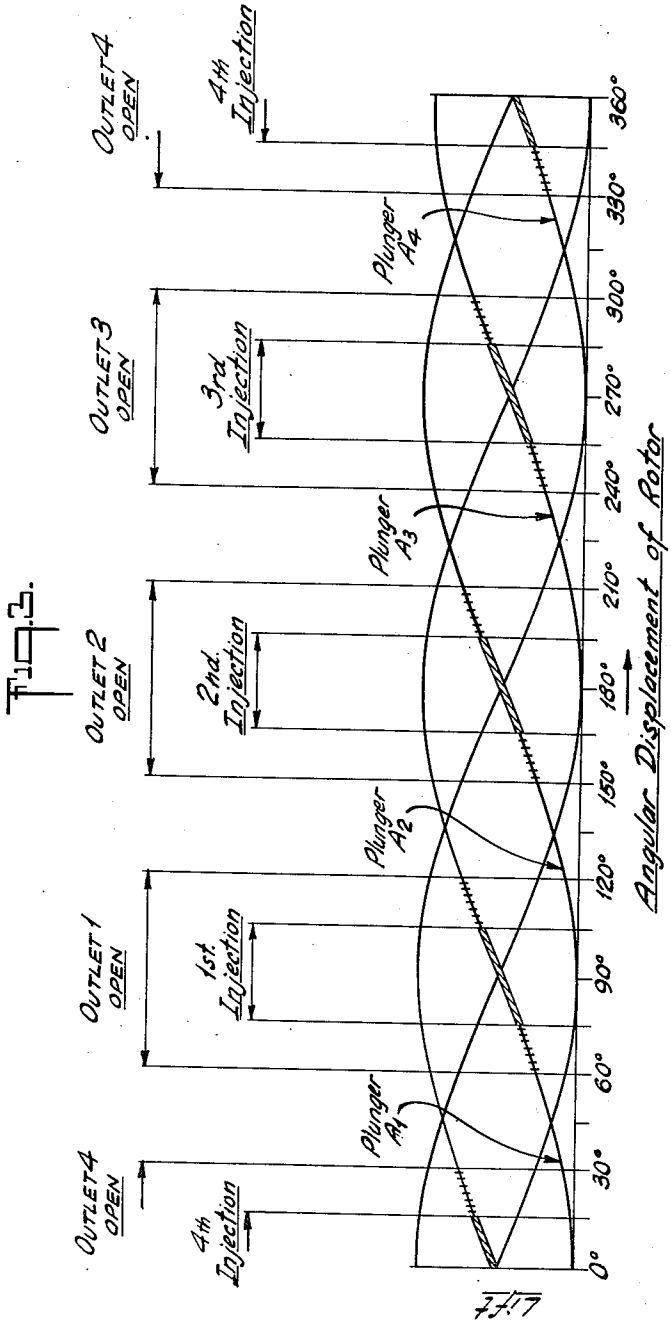


Fig. 2.

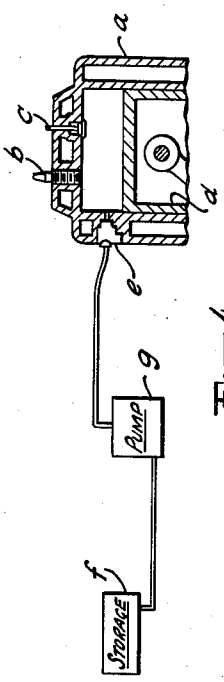


Fig. 4.

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FUEL INJECTION PUMP

Wolfgang E. Meyer, State College, Pa., assignor to The Texas Company, New York, N. Y., a corporation of Delaware

Application January 26, 1955, Serial No. 484,201

16 Claims. (Cl. 123—139)

This invention relates generally to a fuel injection pump for use in an internal combustion engine and particularly to a multi-plunger type of injection pump wherein a single delivery valve provides fuel to a plurality of outlets.

In my previous application, Serial No. 338,043, filed February 20, 1953, there is disclosed a fuel injection pump in which a single reciprocating and rotating plunger provides fuel to a plurality of engine cylinders, and from which the conventional delivery valve has been eliminated without vacuum formation in the fuel discharge path. The disclosed structure therein has the plunger itself serving in effect as a delivery valve, and, upon completion of fuel delivery, permits the high pressure fuel discharge lines to be relieved to sump pressure and to be maintained at that pressure during the suction stroke, thereby preventing vaporization of the fuel.

The elimination of the delivery valve reduces the high pressure fuel volume considerably, thereby reducing the increase of the injection duration with speed and improving the uniformity of the fuel delivery from the individual nozzles. This prototype pump is highly effective for 4-cylinder engine operation, for which it was designed, but construction difficulties arise when used with 6-cylinder engines, especially for high speed operation if delivery durations of 60° crankshaft angle are to be provided. On a single plunger pump, this would leave only 60° before delivery ending for one nozzle to delivery beginning for the next nozzle. Since it is virtually impossible to design for a 60° duration with much less than 80° for the entire pumping stroke, only 40° remain for the return stroke, leading to a difficult cam design and the need for extremely heavy return springs. The pump disclosed herein is an advance over the prototype pump while incorporating the advantages thereof and making it suitable for 8-cylinder engine operation.

It is an object of my invention to provide an improved fuel injection pump for use with a high speed, multi-cylinder internal combustion engine.

Another object of invention is to provide an improved simple and inexpensive fuel injection pump which is well suited for multi-cylinder internal combustion engines operating at relatively high speeds.

It is a further object of invention to provide an improved fuel injection pump of compact overall design and inexpensive manufacture for providing fuel under pressure to more than one engine cylinder.

A still further object of invention is to provide an improved fuel injection pump of the aforesaid type in which the conventional fuel pressure-actuated delivery valve is eliminated.

A still further object of invention is to provide a fuel injection pump for a multi-cylinder internal combustion engine having a single distributing member controlling the fuel flow from individual pumping chambers.

Still another object of invention is to provide a fuel injection pump of improved design for use with a multi-cylinder, high-speed internal combustion engine in which

vacuum formation leading to fuel vaporization in the fuel discharge path is prevented.

Another object is to provide an improved fuel injection pump for the aforesaid use in which the period of injection may be varied independently of the pumping stroke and the beginning of injection.

And another object is to provide the aforesaid apparatus in which there is a relatively long time for filling each pumping chamber.

These and other objects and advantages of the invention will be apparent from the following description of the accompanying drawings in which:

Fig. 1 is a longitudinal section view of a pump constructed in accordance with my invention for use in a four cylinder engine showing the start of the pumping process in the topmost plunger;

Fig. 2 is a partial sectional view taken on line 2—2 of Fig. 1, looking in the direction of the arrows, but with the indicated pumping process 180° out of phase of Fig. 1;

Fig. 3 shows the lift curves of the individual pumping plungers for the construction disclosed in Fig. 1; and

Fig. 4 is a diagrammatic illustration of an engine cylinder with a fuel system utilizing the disclosed invention.

My improved structure provides pressurized fuel to a plurality of cylinders by means of a corresponding number of individual pumping plungers under control of a single metering member.

Referring to Figs. 1 and 2 of the drawings, the pump disclosed comprises four plungers or pistons for pumping indicated as A_1, A_2, A_3, and A_4, arranged in radial bores in the flange or disc portion of rotor *b*. The outer, rounded ends of the plungers are in contact with the inner race of a suitable anti-friction bearing C, mounted eccentrically with respect to the rotor B, so that upon rotation of the latter, the plungers will reciprocate within these radial bores in the rotor. Their contact with the inner bearing race will be maintained by hydraulic and centrifugal forces. Although an anti-friction bearing inner race is disclosed as the surface in contact with the plunger ends, other combinations of elements are not excluded so long as an eccentric relationship with respect to the axis of rotation of the rotor is maintained at the line of contact.

At the inner end of the plungers, compression will occur whenever the control land D of the non-rotating metering member or valve E obstructs the inner end of one of the radial bores in the rotor flange. The fuel compressed between the individual plunger and the control land will be discharged through a longitudinal groove or channel F on the face of the metering member or valve E which terminates in an annular groove G, from which the fuel is directed to one of the high pressure fuel outlet ports or passageways J through a radial distributing hole H in the shaft extension of rotor B. The number of cylinders to which fuel is to be provided determines the number and position of the fuel outlets.

Delivery duration is varied by movement of the metering member or valve longitudinally, which movement varies the period during which the compression space of any one plunger is isolated from the low pressure fuel in the system. This fuel is supplied at one end of the metering member or valve E through the inlet ports or passageways K to the space L, and radial duct M and longitudinal duct N in the metering member or valve, to the space O at the other end of the metering member or valve. From space O, the fuel flows through groove or channel Q on the face of the metering member or valve to the recessed portion P of the control or metering section of the valve.

The metering member or valve E is positioned longitudinally by rod R which extends to the outside of the pump casing or housing U, so that the duration of injection may be varied from outside the pump housing. This

housing has a T-shaped cross section formed by an eccentric shaped end chamber at U_1 for enclosing the pumping section of the rotor B and a shaft extension, U_2, with its center bore and the fuel inlet and outlet passageways (K and J) opening thereon, for receiving the shaft portion of the rotor. Alternatively, the end chamber U_1 could be made concentric with the center bore of the shaft extension U_2 but this would require that the anti-friction bearing C be mounted eccentrically with respect to the shaft extension bore in order to effectuate the reciprocation of the pumping plungers upon rotation of the rotor, the bearing being disclosed now as mounted concentric with the end chamber. Provisions are made for keeping the metering member or valve E in contact with rod R by spring S in space O, and the metering member or valve E from rotating by means of element T, through the spline connection at Z, with V indicating mating threads between element T and housing U. Thus, the metering element or valve E may be moved longitudinally by means of rod R and rotated by means of the lever forming part of element T.

Cover plates, W_1 and W_2, at the ends of the pump housing complete the assembly, and for driving the rotor, there is a spline drive end on hub X. Although the housing has been indicated as made of one piece, it can be composed of several sections.

In Fig. 2, the partial section through the flange of rotor B is shown in the plane of the pumping plungers. The plunger A_1 is in the middle of its pumping stroke, at which time the metering land D on valve E obstructs the inner end of the bore in which the plunger A_1 operates, so that fuel is being discharged through groove F located within the land. The spaces below the three other plungers are at this time in connection with the low pressure fuel system through the recess P of the metering member or valve E. If the pump delivery were to be varied, the metering member or valve E would be shifted longitudinally so that a longer or shorter segment of the land would be covering the inner end of the bore, as for plunger A_1. Also, so long as the lever of element T is not moved, the valve E is prevented from rotating. However, when its angular relationship to the inner race of the eccentrically mounted bearing C is changed by movement of the lever, the timing of injection is changed, which can be done without changing its duration. As the rotor turns, successive plungers will deliver fuel when the inner ends of their respective bores are closed off by the land D on the valve E.

Fig. 3 shows the lift curves of the individual plungers for use in a 4-stroke 4-cylinder engine having respective injection durations of 60° of crankshaft angle. The metering valve is positioned with respect to the eccentric contact surface which controls the plunger motions so that fuel delivery takes place in the middle portion of the plunger lift, viz., 75–105° as in the case of plunger A_1, resulting in practically constant plunger velocity during the delivery stroke. To insure that the injections are spaced exactly 90° apart, it is necessary only for the plunger bores to be dimensioned and located accurately.

Thus it can be seen that a plurality of plungers discharge fuel through the same groove in the metering member or valve, the rotor shaft providing for connection of the proper fuel outlet to its associated pumping plunger. The radial hole H in the rotor shaft, which provides this function should be so proportioned with respect to the fuel outlets J that the connection between the plunger and the nozzle remains open for a period slightly exceeding the period during which the metering member or valve closes off the plunger bore.

Referring to Fig. 4, there is disclosed in combination, an engine cylinder shown at *a*, provided with a spark plug *b*, an exhaust valve *c*, and an intake valve, not shown. A piston *d*, having the usual connecting rod, is shown in the cylinder. An injector *e*, is set in the wall of the cylinder. Fluid fuel for the operation of the engine is fed at a selected pressure to the injector from a storage tank *f*, by means of a pump represented generally at *g*, and in detail in Fig. 1.

Although my improved pump requires as many plungers as there are engine cylinders, these plungers are of extremely simple design. They do not require control edges, and neither their lengths nor their fits in the radial bores are as critical as in conventional pumps, because of the longitudinal sealing length available. In an engine with an even number of cylinders, two opposite plunger bores lie on the same axis so that for machining, a through-hole is available. Similarly, the center bore of the rotor in which the metering valve operates is also designed as a through-hole, even though one end of this bore is closed off by a plug Y as a seal against low pressure fuel.

No cam is required since the eccentrically positioned circular bearing race produces the plunger reciprocation, and the delivery rates of fuel can be fully controlled by a choice of plunger diameter and total lift. The number of plungers used does not impose any restrictions on the duration of injection that can be employed. Although there is a limit to the number of plungers, it is not difficult to arrange two rows of them in the rotor and to equip the metering member or valve with two control lands. Thus, with two eccentrically mounted ball bearings used with their centers on opposite sides of the pump shaft center, complete balance of mechanical and hydraulic forces acting on the metering member or valve is obtained. In the case of a double row of plungers, ducts instead of grooves would have to be used to connect the two metering sections with two annular grooves on the valve co-operating with two radial distributing holes in the rotor shaft.

Proper high speed operation is insured by long filling periods, as reference to the lift curves in Fig. 3 will bear out. It is to be noted that the fuel volume within the rotor remains substantially constant at all times, for at zero delivery, fuel is being transferred between plunger bores by way of recess P as the plungers reciprocate within the rotor flange. As the recess P is designed for maximum flow capacity, all compression spaces will remain completely filled with fuel at all times. With the metering member or valve E adjusted for delivery, the amount of fuel discharged at high pressure through the groove F is replaced by an equal amount flowing into recess P through the groove Q.

If the filling process is incomplete as under some conditions of extremely high speed, the fact that delivery begins 75 or more degrees after the outermost plunger position provides sufficient time for reabsorption of precipitated air and vapor, which is another advantage of the improved type of pump over that disclosed in my previous application, cited above, wherein delivery beginning takes place very early in the pumping stroke, following a very brief filling period.

Obviously many modifications and variations of the invention as set forth above may be made without departing from the spirit and scope thereof, and therefore, only such limitations should be imposed as are indicated in the appended claims.

I claim:

1. A fuel pump for an internal combustion engine comprising a bored housing having fuel inlet and outlet passageways leading therefrom, a hollow rotatable member in said housing having a pumping section, a metering member located in said rotatable member for establishing communication between said fuel inlet and outlet passageways in said housing, and means for adjusting the longitudinal and radial positions of said metering member in said rotatable member.

2. In a fuel pump for an internal combustion engine, the combination comprising a housing having an end chamber section and a shaft section with a cylindrical bore and with a plurality of fuel inlet and outlet passageways leading therefrom, a hollow rotor member in said

housing having a pumping section located in said end chamber section, a drive hub section and a shaft bearing section located in said shaft section, said latter two sections being on either side of said pumping section, a metering member positioned in said rotor member having means for establishing communication between said plurality of fuel inlet and outlet passageways in said housing through said pumping section, means for adjusting the longitudinal position of said metering member in said rotor member, and means for adjusting the radial position of said metering member in said rotor member, said pumping section including piston means for reciprocation in a radial bore in a flange in said rotor member, said end chamber mounting a contact surface in eccentric relation with said rotor member against which said piston means bear.

3. A fuel pump for delivering a predetermined quantity of fuel to an internal combustion engine having a plurality of cylinders comprising a housing with fuel inlet and outlet passages, a rotatable member with a center bore located within said housing having a flange portion thereon comprising a pumping section, said pumping secing including pumping plungers located in radial bores in said flange, said housing having an eccentrically spaced chamber for receiving said flange portion, a non-rotating metering member, adapted to be spaced in radial and longitudinal relationship with respect to said rotatable member for controlling the timing of and said predetermined quantity of fuel, located in said bore of said rotatable member and including grooves connecting said inlet and outlet passages, said chamber including a bearing surface mounted in eccentric relationship to said rotatable member against which said pumping plungers within said radial bores in said flange portion contact so that as said rotatable member completes one revolution, a complete pumping cycle transpires, and means for radially and longitudinally adjusting the position of said metering member in said rotatable member.

4. In a fuel injection pump for an internal combustion engine in which a single member is employed for metering and distributing fuel to a plurality of engine cylinders, a hollow housing with a chamber and a cylindrical bore with inlet and outlet ports leading therefrom, a hollow rotatable member including a disc portion and a shaft portion located within said housing, a non-rotating metering member located in said rotatable member, means for longitudinally locating said metering member to vary the quantity of fluid provided to the outlet port, said metering member having distributing means interconnecting said inlet and outlet ports, said disc portion including a plurality of diametral extending chambers, and a plurality of pumping pistons located within said chambers, said disc being located within the housing chamber, and means mounted within said housing chamber in eccentric relationship to said rotatable member against which said pumping pistons contact whereby rotation of said rotatable member causes reciprocation of said pistons and pumping action occurs between said chambers through said distributing portions on said metering member to complete the communication between said inlet and outlet ports.

5. In a fuel pump as set forth in claim 4, said metering member being radially adjustable to regulate the beginning of fuel delivery to said fuel outlets.

6. In a fuel pump for an internal combustion engine having a plurality of cylinders, a hollow casing with a cylindrical bore and a housing at one end thereof wherein a contact surface is mounted eccentrically with respect to said bore, said casing including inlet and outlet passages for the provision of fuel to said cylinders, a rotatable member including spaced hub, shaft and disc portions located within said hollow casing, said disc portion including a plurality of radial chambers, a corresponding number of pumping plungers located within said radial chambers and contacting the eccentrically mounted contact surface in the end chamber, a cylindrical non-rotating metering member, positioned within said rotatable member, having internal and external communicating passages, means for longitudinally and radially adjusting said metering member within said rotatable member to control the quantity of fuel delivered to said cylinders and the beginning of fuel delivery, and means for enclosing said rotatable member within said casing.

7. A fuel pump comprising a hollow casing member having fuel inlets and outlets leading from a cylindrical bore and an end chamber eccentrically located and means for enclosing said hollow casing member, a hollow rotor located within said hollow casing member and having a disc portion comprising a pumping section located between the driving hub and shaft portions of said rotor, said disc portion having a plurality of radial chambers, pumping plungers within said chambers, a contact surface located within said end chamber mounted in eccentric relationship to said rotor, the external ends of said plungers projecting against said contact surface, a non-rotating metering member located within said rotor and adapted to be positioned longitudinally and radially, means for adjusting said metering member in longitudinal and radial relationship, said metering member having grooves on the external surface and ducts interior thereof to provide communication passageways between said fuel inlets and outlets through said pumping section.

8. A fuel pump for an internal combustion engine having a plurality of combustion chambers comprising a casing having a cylindrical bore and an end chamber having a contact surface and a plurality of open passageways communicating with said bore, a hollow rotatable member comprising hub, disc and shaft portions respectively, positioned within said casing, the hub portion being adapted to receive power for rotating said rotatable member, said disc including a plurality of pumping chambers, plungers located within each of said chambers and in contact with said surface mounted within said end chamber in eccentric relationship to said rotatable member, a perforated, non-rotating metering member located within said hollow rotatable member and adapted to be positioned in radial and longitudinal relationship with respect to said pumping chambers, channels on the exterior of said metering member defining a metering land and establishing communication between said open passageways through said pumping chambers, said pumping plungers and said metering member forming a constant volume intake and discharge system in constant communication with the fuel inlet port during movement of said rotatable member, and closure means for enclosing said rotatable member and said metering member within said casing.

9. A fuel pump for a multi-cylinder, internal combustion engine comprising a plurality of pumping plungers and a single metering member whereby each cylinder is provided fuel from one of said pumping plungers including a housing with a central bore and an end chamber whereby a T-shaped housing cross section results, said housing having radial inlets and outlets leading from said bore, said end chamber having a bearing surface mounted in eccentric relationship to said central bore, a hollow rotatable member having a drive portion, a flange portion and a shaft portion located within said housing, said latter two portions being positioned in said end chamber and central bore respectively, said shaft portion having a radial duct leading from a central bore in said rotatable member, said flange portion comprising the pumping section and including radial bores in communication with said central bore of said rotatable member, pumping plungers in each of said radial bores, the outer ends of said pumping plungers being in contact with said bearing surface, and a non-rotating metering member positioned in said central bore of said rotatable member, means for longitudinally and radially positioning said metering member, said metering member including grooves and

ducts to complete communication between said radial inlets and outlets through said pumping section.

10. A fuel pump assembly for a multi-cylinder internal combustion engine wherein each cylinder is supplied by an individual pumping element and a single metering element controls the fuel flow comprising a casing having a central bore with inlet and outlet passages leading therefrom and an end chamber, means for enclosing said casing, a hollow rotor with a central bore and a hole leading therefrom having a hub portion, a flange portion and a shaft portion positioned within said casing, said shaft portion and said flange portion being positioned within said bore and said end chamber respectively, said end chamber having an eccentric bearing surface with respect to said central bore and rotor, said flange portion having radial bores in communication with said central bore, pumping plungers located within said radial bores with their outer ends in contact with said bearing surface, a grooved and perforated metering element positioned within said rotor and establishing communication between said radial bores comprising the pumping section and said inlet and outlet passages, and means for adjusting the start and the duration of fuel injection.

11. A fuel pump assembly comprising a housing having inlet and outlet passageways, a hollow rotor positioned within said housing having a pumping section and means for establishing communication with the outlet passageway, a non-rotating metering element adapted to be longitudinally and radially positioned located within said rotor and having means for establishing communication between said inlet and outlet passageways through said pumping section, and means for longitudinally and radially adjusting the position of said metering element.

12. A fuel pump combination for a multi-cylinder engine, comprising a casing defining a chamber at one end and an extension leading therefrom, said extension having a cylindrical bore with open passageways leading therefrom, a contact surface mounted in said chamber in eccentric relationship with the axis of rotation of said cylindrical bore, a rotor with a central bore having a hub portion for a driving connection, a disc section with radial bores in communication with said central bore, and a shaft portion having an open hole leading from said central bore, a perforated non-rotating fuel metering element having grooves on its surface located within said bore and adapted to be positioned radially and longitudinally within said rotor whereby respectively the beginning and the amount of fuel injection is varied, and means for the longitudinal and radial positioning of said metering element.

13. A fuel pump for a multi-cylinder internal combustion engine comprising a housing defining a chamber and a shaft extension therefrom, said shaft extension having open passageways leading into said housing and comprising fuel inlets and outlets, a rotor with a center bore having a flange comprising the pumping section, a shaft with a hole leading from said center bore and a drive hub and positioned within said casing in open communication with the fuel inlets at one end thereof, closure means for the opposite end of said rotor, said pumping section comprising radial bores in said flange open to said center bore and pumping plungers seated in said bores, a surface in said chamber having an eccentric relationship with respect to said rotor, the outer ends of said pumping plungers being in contact with said surface, a non-rotating metering member located in the center bore of said rotor and in open communication with said fuel inlets at one end through internal ducts, grooves on the surface of said metering member in open communication with said radial bores and said fuel outlets through the shaft hole and defining a metering land therebetween, said metering member being longitudinally positioned in said rotor to define a space with said closure means, said ducts and grooves leading to and from said space, and means for the longitudinal and radial positioning of said metering member in said rotor.

14. In a fuel pump as set forth in claim 13, said last-mentioned means being separate for each type of positioning.

15. In combination with an internal combustion engine, a fuel pump therefore comprising a T-shaped casing defining a chamber and a bored shaft extension with fuel inlet and outlet passageways leading from the center bore of said extension, a rotatable member with a central bore having hub, flange, and shaft portions positioned within said casing so that the latter two portions are housed within said chamber and shaft extension respectively, said flange portion comprising a pumping section including radial bore opening on said central bore and pumping piston seated in said radial bore, means for effecting reciprocation of said piston upon rotation of said rotor, said shaft having distributing means for communicating with the fuel outlet passageway upon rotation of said rotatable member comprising a distribution hole leading from said central bore and being of such length that the fuel inlet passageway is open to the end thereof, closure means for the opposite end of said rotatable member, a grooved and perforated metering member positioned within said rotatable member having ducts open to said fuel inlet passageway and grooves defining a metering section between said pumping section and said distributing means including a metering land whereby low pressure inlet fuel is separated from high pressure outlet fuel delivered by said pumping section, and means for varying the initiation and duration of fuel injection independently of each other.

16. In the fuel pump as set forth in claim 15, said means for effecting reciprocation of said piston comprising a contact surface mounted in said chamber eccentrically to the axis of rotation through said shaft extension, and said last-mentioned means in claim 15 comprising means for the radial and longitudinal positioning of said metering member within said rotatable member whereby the relative position of said metering land with respect to said radial bore is changed.

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