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FLUID PUMP OR INJECTOR

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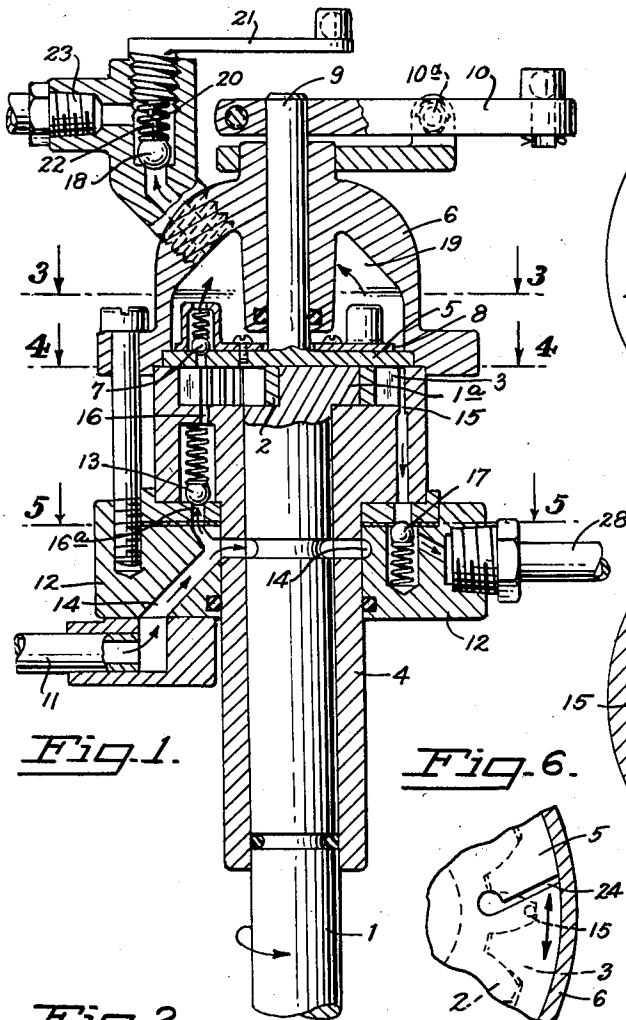


Fig. 1.

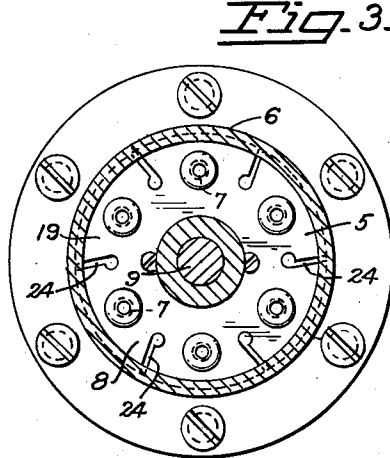


Fig. 3.

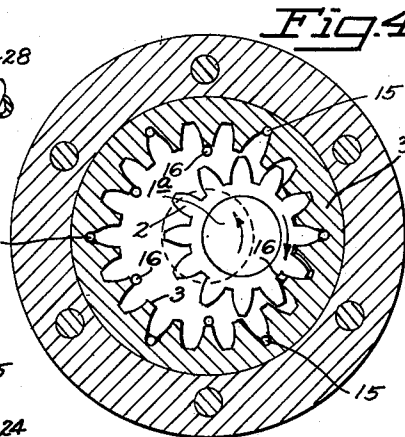


Fig. 4.

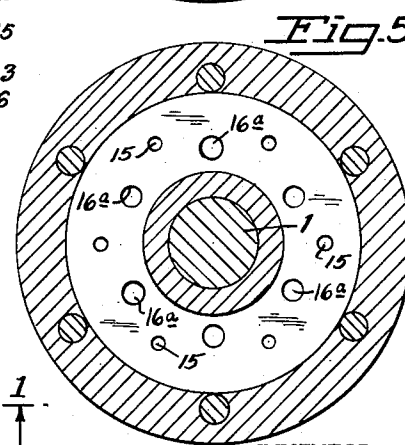


Fig. 5.

Fig. 6.

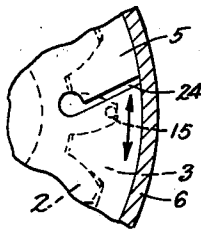
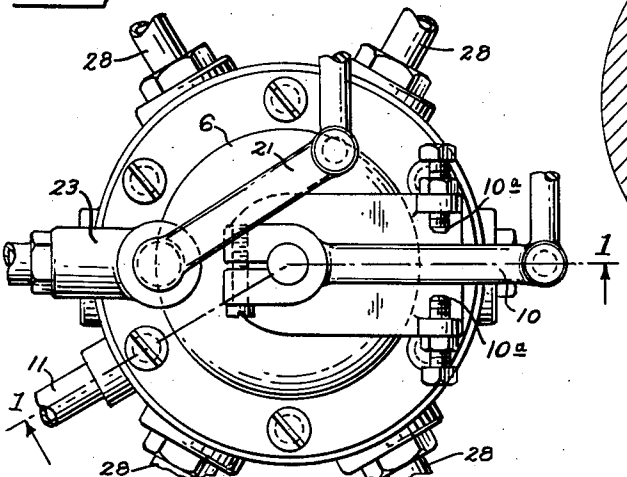


Fig. 2.



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2,912,937

FLUID PUMP OR INJECTOR

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9 Claims. (Cl. 103—120)

This invention relates to a method and apparatus for pumping fluids, liquids or gaseous. More specifically it relates to a means for obtaining controllable injection of fuel, liquid or gaseous, in an engine.

The problem of injecting a precisely timed and accurately metered quantity of liquid fuel in an engine of either spark ignition or compression ignition type, poses many difficulties which in the past have been solved primarily through the use of apparatus consisting of a large number of precision parts. While many such systems of various designs have been utilized with varying degrees of success these systems are expensive and difficult to manufacture.

The general objective of this invention (in its preferred form), which may be combined with auxiliary apparatus for automatically regulating the delivery of liquid fuel in conformance with the requirements of the engine and apparatus such as nozzles for inducting the fuel charge, is to provide improved fuel injection apparatus for an engine, and to simplify the mechanism for accomplishing this result to save cost, weight, and size of equipment required.

A prime object of this invention is to provide a fluid or liquid pump formed basically of an internal gear mounted on an offset crank pin that meshes closely with an internal stationary gear and a plate that is movable manually relative to said stationary ring gear, and into an external cavity to effect the discharge of fuel on each rotation of the rotating gear past a given ring gear tooth and when used in an engine to effect throttling.

Another object of the invention is to provide a small compact structure of symmetrical shape that can be rotated within limits to effect an advance or retarding of the timing of the injections produced.

A further objective of the present invention is to provide improved fuel injection apparatus with a minimum number of moving parts which as a consequence results in lower manufacturing costs, reduced maintenance requirements and improved reliability. The basic components of this design are adaptable to quantity production by recognized processes including gear grinding, powered metal fabrication, die casting, etc.

It is an important objective of this device to provide a variable delivery positive displacement injection pump which overcomes many of the inherent difficulties involved in injection systems of the continuous flow type, timed common rail and conventional timed positive displacement systems. With continuous flow or timed common rail systems accuracy of metering is limited by the small orifices required which are extremely sensitive to deposits, wear, corrosion, erosion, and other factors which affect their metering characteristics. These problems are solved by the use of positive displacement-type metering elements and also are solved by the present invention. With even the highest quality conventional positive displacement systems, however, the multiplicity of critical wearing surfaces which affect fuel metering, such as cams, tappets, rollers, links, racks and the like, is largely elim-

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inated by the present device as are the problems associated with wear on these parts.

A further important objective of the present invention is to eliminate all high speed reciprocating action inherent to injection pumps of conventional design which include cams, rollers, tappets, wobble plates, racks, etc. Only rotary motion is involved in the basic components of this system which makes it adaptable to the high engine speeds of present day engines and projected future designs. As engine speeds continue to go higher and higher in new designs the problems associated with reciprocating-type injection systems will increase. These problems are eliminated in the present invention.

With almost all other injection systems of the positive displacement type a transfer pump is required to supply fuel to the injection pump and an object of the present invention is to eliminate the necessity for a separate transfer pump. It is important to note that the transfer pump is built into the injection pump and uses the same basic components with only check valves added to control the flow. The problem of providing an auxiliary transfer pump is therefore solved.

Another objective is to provide a fuel pump system which is self-priming, this being accomplished by the built in transfer pump, a feature which solves the problem of starting the engine when no fuel is initially present in the fuel system. This must also be done in a fashion to purge the system of air or vapor trapped in various components. In conventional systems purging is a problem because of dead end cavities, voids, passageways, etc. inherent in the design. With the present system these vapor traps are eliminated by the basic design which includes a vapor eliminating dome freely communicating with the basic pumping elements. In addition, means may be also included to cut off the recirculation of fuel back to the tank in order to make the full displacement capacity of the transfer pump portion available to purge fuel lines to the individual injectors. This same cutoff feature may be used as an enrichment device for starting.

It is also the objective of the present system to provide means to match the injection rate (the rate during one injection) of the fuel to the varying requirements of the engine. This problem is solved through the use of appropriate profiles for the gear teeth, cutoff ports, etc.

Another objective of the present invention is to provide inherent damping of pressure waves or fluctuations in fuel injection lines, particularly at cutoff of the injection nozzle. These pressure waves adversely affect the operation of the nozzle and in conventional systems require the use of critically designed nozzles to obtain desirable flow characteristics and clean cutoff with no dribble. At the end of delivery, the action of this device is such that an instantaneous partial vacuum is drawn on the fuel delivery line which cavitates fuel in the line and damps pressure fluctuations. Thus, the problem of nozzle dribble due to pressure fluctuations at cutoff are also solved.

With the present invention the basic design is such that a wide range in engine sizes could be accommodated with the interchangeability of only a very few parts. This, therefore, solves the problem of providing for many different sizes.

It is another object of the present invention to provide means to equalize wear effects in the basic elements in order that metering accuracy is maintained throughout the life of the pump. This problem is solved by the use of a hunting tooth pinion gear which mates with different teeth in the ring gear in a predetermined sequence depending on the relative number of teeth on the pinion and ring gears.

A further object of this device is to provide means whereby fuel may be injected into an engine combustion chamber at high pressures, which are required for head injection systems, without high pressure differentials across the basic metering elements. The use of an external pump to pressurize the present invention to a high pressure but just lower than the nozzle opening pressure allows the basic metering elements to produce only the additional pressure required to satisfactorily operate the nozzle in a positive manner. In some cases the pressure built up by the transfer pump suction would be sufficient for the above, but an additional pressure stage may be obtained where necessary, as just described.

As the present invention may also be described as a controllable means for pumping liquids a further objective not related to its functions as a fuel injection device is to provide a variable delivery positive displacement pump. Such a pump may be used in hydraulic power transmission and control devices.

Other features of the invention will be more particularly pointed out in the accompanying claims and specifications.

I have illustrated my invention by way of example in the accompanying drawings:

Fig. 1 is a view of one form of the present invention shown in elevation, parts being broken away and parts being shown in section therein taken along the section line 1—1 of Fig. 2.

Fig. 2 is a top plan view of the apparatus shown in Fig. 1.

Fig. 3 is a horizontal sectional view taken from the plane of the section line 3—3 of Fig. 1.

Fig. 4 is a horizontal sectional view taken from the plane of the section line 4—4 of Fig. 1.

Fig. 5 is a horizontal sectional view taken from the plane of the section line 5—5 of Fig. 1. Figs. 3, 4 and 5 show their respective sections only, and not piping, etc., which might appear below.

Fig. 6 shows a portion of Fig. 3 enlarged.

Referring now to the above mentioned drawings wherein like numerals designate corresponding parts throughout the various views, 1 is an eccentric shaft, driven at its lower end by suitable means from the cam shaft of an internal combustion engine, or by other means where the device is used for pumping liquids rather than a fuel injection pump. Eccentric shaft 1 carries the pinion gear 2 eccentrically at its upper end 1a. Pinion gear 2, being thus driven, engages with a stationary ring gear 3 which is attached to pump body 4. Metering control plate 5 is held in close contact with pinion gear 2 and ring gear 3 by surge chamber housing 6. Thus, the pump body 4, including the ring gear as in effect a part thereof, cooperates with the surge chamber housing 6 and a retaining plate 12 to define a pump housing, which is divided by the plate 5 into a surge chamber 19 above the plate 5 and a pumping chamber below it.

Priming pump section discharge valves 7 are carried by priming pump discharge valve plate 8 which is attached by screws to metering control plate 5. Metering control shaft 9 is attached to metering control plate 5 at the lower end and to metering control lever 10 at its upper end, which is limited in its travel by stops 10a.

Intake fuel line 11 is suitably attached to retaining plate 12 and communicates with intake valve 13 through intake ports 16a, of which six are shown in Fig. 5 by way of example. Discharge ports 15, of which six are shown in Fig. 4, corresponding to a six cylinder engine, each communicate with a delivery valve 17 which delivers metered and timed fuel through tube 28 and suitable means not shown to an internal combustion engine also not shown.

Pressure regulating valve 18 regulates the pressure in surge chamber 19 and is held on its seat by pressure regulating valve spring 20. The pressure in surge chamber 19 is controlled by pressure regulating control lever 21 which

adjusts the tension on pressure regulating valve spring 20. Pressure regulating valve 18 may be held rigidly against its seat by pressure regulating valve shutoff pin 22 when pressure regulating control lever 21 is in the proper position. Excess fuel is returned to the fuel tank (not shown) through fuel return outlet fitting 23.

Operation

Again referring to the drawings described in detail above, the operation of the present invention may be described in the following manner. As the pinion gear 2 rotates within the pump housing in mesh with ring gear 3, a suction (negative pressure) is produced successively in the tooth cavities over intake ports 16 as any particular gear tooth in ring gear 3 recedes from its mating teeth in pinion gear 2. This suction draws liquid fuel into the cavity between gears 2 and 3 through intake valve 13, of which six are shown. As this action continues the pump housing becomes filled with liquid fuel and after the housing is sufficiently filled each tooth of the ring gear 2 will also exert compressive force on fuel as it goes into mesh with the mating teeth of the pinion gear 3 and discharge valve 7 will open and allow liquid fuel or otherwise, to be forcibly displaced into surge chamber 19 which in due course becomes filled with liquid fuel. After surge chamber 19 is completely filled with liquid fuel and purged of air and/or vapor, pressure regulating valve 18 will open at a controlled predetermined pressure and allow excess fuel to be discharged from the fuel return outlet fitting 23 which returns fuel to the main fuel tank (not shown). The foregoing describes the action of the self priming "transfer" pump section of the device.

Simultaneously with the action of the "transfer" pump section timed and metered fuel in being delivered from the "injection" section of the device to each individual cylinder of the engine (not shown). The action of the "injection" portion may be described in the following manner. Starting with the pump housing and surge chamber filled with liquid fuel and with control plate 5 set in a position which will seal the cavity between meshing teeth at least during part of the time that a particular pinion gear tooth is engaging with the meshing ring gear teeth, the fuel in the cavity will be compressed and forced through a particular discharge port 15, six of which are shown. This pressure will open delivery valve 17 which is connected through suitable means (tube 28) to the fuel injection nozzle, not shown, in the engine, also not shown. As the metering control lever is positioned by suitable means (not shown) responsive to engine requirements, the control plate 5 rotates and positions and spill ports 24 so that variable delivery is effected by spilling a controllable portion of fuel trapped in the gear cavity between meshing gears. The spilled fuel is retained in the surge chamber and commingles with the fuel being recirculated back to the fuel tank. Any vapor and/or air released due to turbulence therefore is purged out of the system by recirculation back to the tank which is considered very advantageous.

The spill ports 24 are in communication with the outlet ports 15 of the pump only up until the time when the tooth of the pinion 2 engages the wall of the cavity of the ring gear 3. Then the spill ports are separated from the outlet ports 15, and, during the remainder of a very short stroke, the gears 2 and 3 send fuel into the outlet ports 15.

The plate 5 is rotated only in order to vary the cut-off point for the spill ports 24. This movement varies the proportion of fuel pumped into the fuel-injection outlets 15 relative to the proportion pumped up (at an earlier portion in the cycle) through the spill ports 24. That is the only purpose of moving the plate 5, and that movement is made to accord with the fuel consumption of

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the engine, that is, whether the engine is idling, accelerating, decelerating, or whatever.

It is understood of course that different numbers of valve ports and delivery ports may be used to accommodate engines with various number of cylinders and that multiple or single tooth cavities may be used as the variable displacement volumes for either the transfer pump portion or the injection pump portion.

During startup or for purging the pressure regulating control lever 21 may be positioned so as to shut off the recirculation of fuel back to the tank. In this case the entire pumping capacity of the transfer pump portion of the device will discharge continuously through the six delivery valves 17 and subsequently to the six cylinders of the engine. As the startup fuel requirement of the engine is relatively large, the greater throughput from the transfer pump section may be used to advantage as an enriching (priming or choking) device and may be controlled by automatic means responsive to engine parameters which dictate the correct startup fuel requirement.

If flexible lines are used between this injection pump and the injection nozzles, a slight rotation of the pump body relative to its mounting will result in an advance of injection if rotated one way and a retarding if rotated in the other direction. As the fuel injection lines are very small, if grouped together such a slight rotation of the pump as is needed might be accomplished without using flexible non-metallic lines.

1. A fuel injection device combining the functions of both a transfer pump and a fuel injection pump in a single structure and including in combination: a hollow pump housing having a fuel inlet means, fuel injection outlet means, and an excess-fuel-return outlet; a plate mounted in said housing and dividing its interior into a pump chamber below said plate and in communication with said fuel inlet means and said fuel-injection outlet means, and a surge chamber above said plate and in communication with said excess-fuel-return outlet, said plate having intake means and spill ports therethrough; a ring gear mounted to said housing and defining the outer periphery of said pump chamber, with an upper surface in contact with said plate, said ring gear having teeth with crests alternating with tooth cavities, said intake means in said plate opening adjacent and just radially inside some of said tooth crests, said housing inlet means including inlet ports located just radially inwardly from and closely adjacent the crests of some teeth of said ring gear in vertical alignment with said intake ports, said housing fuel-injection outlet means including discharge ports in some of said teeth cavities between said inlet ports, said spill ports opening into the same cavities but being spaced apart a short horizontal distance from said outlet means; a rotatable shaft in said housing below said plate; and a pinion gear mounted eccentrically on the upper end of said shaft in said pump chamber in mesh with said stationary gear, with an upper surface in contact with said plate and a lower surface in contact with said housing, whereby as said pinion gear moves around in said ring gear it sucks fuel in through each inlet port into said pump chamber where moving out of mesh and simultaneously expels fuel through said intake means into said surge chamber where moving into mesh, once said fuel chamber contains some fuel successively, and expels fuel through said spill ports and said outlet ports where moving into mesh.

2. The device of claim 1 having means for rotating said plate relatively to said stationary ring gear for varying the porting area of said spill ports by closing portions thereof against said stationary ring gear, so as to vary the relative proportions of fuel expelled through said spill and outlet ports.

3. A fuel injection device combining the functions of both a transfer pump and a fuel injection pump in a single structure and including in combination: a hollow

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pump housing having a fuel inlet means, fuel-injection outlet means, and an excess-fuel-return outlet; a plate mounted in said housing and dividing its interior into a pump chamber below said plate and in communication with said fuel inlet means and said fuel-injection outlet means, and a surge chamber above said plate and in communication with said excess-fuel-return outlet, said plate having intake ports and spill ports therethrough, said ports being arranged in a circle and alternating spill and intake ports; a stationary ring gear mounted to said housing and in said pump chamber, with an upper surface in contact with said plate, said ring gear having teeth alternating crests with tooth cavities, said intake ports lying just above and radially inwardly from the crests of some teeth and spaced no closer than every third crest, said housing inlet means including inlet ports opening into said pump housing just below said intake ports, said fuel-injection-outlet means including discharge ports in tooth cavities spaced apart by at least three teeth, located between said inlet ports and the same cavities into which said spill ports open, said spill ports being spaced horizontally from said discharge ports; a rotatable shaft in said housing below said plate; a pinion gear mounted eccentrically on the upper end of said shaft in said pump chamber in mesh with said stationary gear, with an upper surface in contact with said plate and a lower surface in contact with said housing, whereby as said pinion gear moves around in said ring gear it sucks fuel in through each inlet port into said pump chamber while moving into mesh and simultaneously expels fuel through said intake ports into said surge chamber, while moving out of mesh, once said fuel chamber contains some fuel, and expels fuel through said outlet ports and said spill ports; a check valve for each said inlet port in said inlet means; a check valve for each said intake port; a check valve for each said outlet port in said fuel-injection outlet means; and a check valve for said excess-fuel-outlet.

4. The device of claim 3 having means for rotating said plate relatively to said stationary gear for varying the amount of porting afforded by said spill ports from their cavities by closing portions of said spill ports against said stationary ring gear.

5. A fuel injection device combining the functions of both a transfer pump and a fuel injection pump in a single structure and including in combination: a hollow pump housing having a fuel inlet means, fuel-injection outlet means, and an excess-fuel-return outlet; a plate mounted rotatably in said housing and dividing its interior into a pump chamber below said plate and in communication with said fuel inlet means and said fuel-injection outlet means, and a surge chamber above said plate and in communication with said excess-fuel-return outlet, said plate having intake ports and spill ports therethrough, said ports being arranged in a circle and alternating spill and intake ports but at different radial distances from the center; a stationary ring gear mounted to said housing and in said pump chamber, with an upper surface in contact with said plate, said ring gear having teeth alternating crests with tooth cavities, said intake ports in said plate lying just above and opening into said pump chamber at the crest of every third tooth, said housing inlet means including inlet ports opening into said pump housing at the crest of every third tooth in vertical alignment with said intake ports, said housing fuel-injection-outlet means including discharge ports located in the bottom of the every third cavity midway between the crests where said intake ports open said spill ports opening into the same cavity but at a different location therein; a rotatable shaft in said housing below said plate; a pinion gear mounted eccentrically on the upper end of said shaft in said pump chamber in mesh with said ring gear, said pinion gear having fewer teeth than and in hunting relation with said ring gear, with an upper surface in contact with said plate

and a lower surface in contact with said housing, whereby as said pinion gear moves around in said ring gear it sucks fuel in through each inlet port into said pump chamber adjacent some crests and simultaneously expels fuel through said intake ports into said surge chamber adjacent other crests, once said fuel chamber contains some fuel, and expels fuel through said outlet ports and said spill ports; a check valve for each said inlet port in said inlet means yielding to and opening under suction on its inlet port; a check valve for each intake port yielding to and opening under pressure; a check valve for each said outlet port in said fuel-injection outlet means yielding to pressure in said outlet port; a check valve for said excess-fuel-outlet yielding to pressure in said surge chamber; and means for rotating said plate relatively to said stationary gear for varying the porting areas of said spill ports into their cavities by closing portions thereof against said stationary ring gear and thereby varying the relative proportions of fuel expelled through the spill ports and outlet ports.

6. A fuel injection device combining the functions of both a transfer pump and a fuel injection pump in a single structure and including in combination: a hollow pump housing, a plate in said housing dividing its interior into a pump chamber below said plate and a surge chamber above said plate, said plate having pressure operated, normally closed intake means and spill ports therethrough, said housing having a stationary ring gear defining an outer peripheral portion of said pump chamber and in contact with said plate, said gear having teeth with crests and cavities, said intake means opening into said pump chamber adjacent some of said crests; excess-fuel-return outlet means responsive to pressure in and leading from said surge chamber; fuel inlet means opening under partial vacuum conditions into said pump chamber adjacent the crests of some teeth of said ring gear; pressure-responsive fuel-injection outlet means including outlet ports leaving said pump chamber from some of said cavities, said spill ports opening into said pump chamber in the same cavities as said outlet ports but spaced apart therefrom; and a pinion gear mounted eccentrically in said pump chamber in mesh with said stationary ring gear and in contact with said plate, to draw in fuel from said fuel inlet means where moving out of mesh adjacent a crest having associated fuel inlet means, to force drawn-in fuel into said surge chamber through said intake means where moving into mesh adjacent a crest having associated intake means, to force fuel out into said fuel-injection outlet means where moving into mesh in a cavity having associated fuel-injection outlet means, and to send excess fuel into said surge chamber through said spill ports where initially moving into mesh in a said cavity having associated fuel-injection outlet means.

7. The device of claim 6 wherein said intake and inlet means are positioned adjacent the same crests.

8. A fuel injection device combining the functions of both a transfer pump and a fuel injection pump in a single structure and including in combination: a hollow pump housing having a stationary ring gear having teeth with crests and cavities; a plate in said housing in con-

tact with said gear and dividing the interior of said housing into a pump chamber partly defined by said gear and a surge chamber, said plate having pressure actuated intake means and spill ports therethrough, said intake means opening into said pump chamber adjacent some of said crests; excess-fuel-return outlet means responsive to pressure in and leading from said surge chamber; fuel inlet means opening under vacuum conditions into said pump chamber adjacent the crests of some teeth of said ring gear; pressure-responsive fuel-injection outlet means including outlet ports leaving said pump chamber from some of said cavities, said spill ports opening into said pump chamber in the same cavity as said outlet ports but spaced apart therefrom; and a pinion gear driven eccentrically in said pump chamber and in contact with said plate and driven within and in engagement with said ring gear, to draw in fuel from said fuel inlet means while moving out of mesh adjacent a crest having associated fuel inlet means, to force drawn-in fuel into said surge chamber through said intake means while moving into mesh adjacent a crest having associated intake means, to force fuel out through said fuel-injection outlet means while moving into mesh in a cavity having associated fuel-injection outlet means, and to send excess fuel into said surge chamber through said spill ports during an initial portion of moving into mesh in a said cavity having associated fuel-injection outlet means.

9. A pumping device combining the functions of both a transfer pump and an injection pump in a single structure and including in combination: a hollow pump housing with a stationary ring gear having teeth with crests and cavities; closure means in said housing dividing its interior into a pump chamber on the same side as said gear and a surge chamber on the other side, said closure means having intake means therethrough opening into said pump chamber adjacent some of said crests; excess return outlet means responsive to pressure in and leading from said surge chamber; inlet means opening under suction into said pump chamber adjacent some of said crests; pressure-responsive injection outlet means including outlet ports leaving said pump chamber from some of said cavities; and a pinion gear driven eccentrically in said pump chamber in mesh with said stationary ring gear, to draw in liquid from said inlet means, to force liquid into said surge chamber through said intake means, and to force liquid out into said injection outlet means.

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