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FUEL INJECTION APPARATUS

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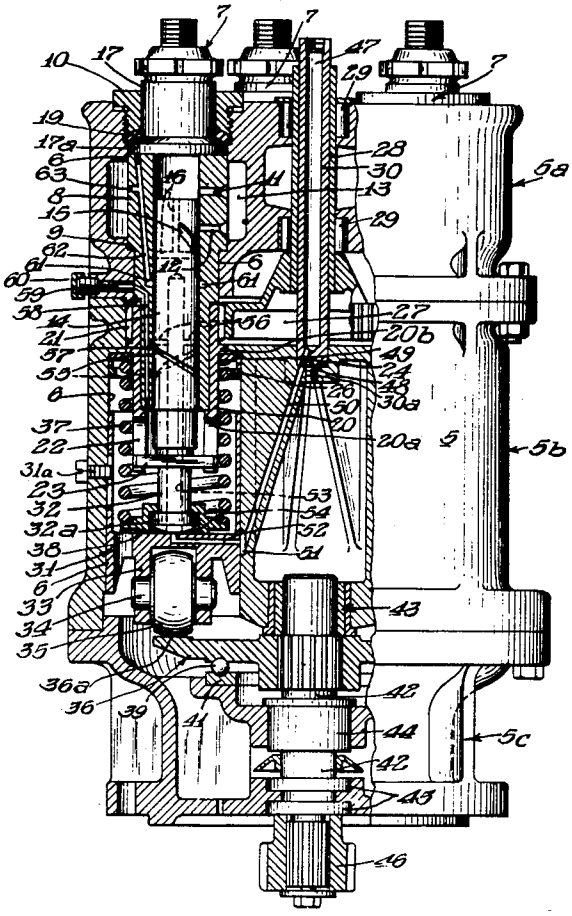


FIG. 1

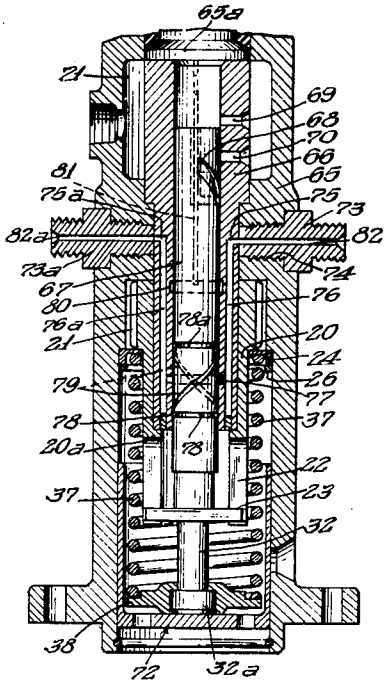


FIG. 2.

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FUEL INJECTION APPARATUS

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28 Claims. (Cl. 103—41)

This invention relates to fuel injection apparatus and more particularly to injection pumps for volatile fuels wherein means are provided for lubricating the pumping elements.

Considerable difficulty has heretofore been experienced in lubricating the plunger, for example, of a gasoline injection pump. It has been proposed to provide an annular oil supply channel in the plunger or in the cylinder therefor and to supply lubricating oil to said channel to establish a lubricating film between the plunger and cylinder walls. However, in this arrangement, the fuel when subjected to compression in the pressure chamber flowed between the piston and cylinder walls to dilute and replace the film of lubricating oil formed between said walls. Efforts have been made to prevent the deleterious effect on a lubricating film of this fuel seepage from the pressure chamber and have consisted chiefly in the provision of a second channel between the lubricant channel and the pressure chamber to serve as a fuel trap. However, high pressures were built up in the latter channel after a short period of operation and, in turn, tended to force the fuel into the film of lubricant and to otherwise affect the proper operation of the plunger. To remedy this defect the periodic connection of the fuel channel to the fuel inlet source at one position of the plunger during its stroke has been suggested but has provided only a partial solution to the problem. In the latter structures the relief or fuel channels have been located too close to the pressure end of the plunger and the pressure of the fuel trapped therein produced leakage back to the pressure chamber which, in turn, caused erosion of the plunger and cylinder greatly reducing the effective life of the pump.

Accordingly, one of the objects of the present invention is to provide a fuel pump having a novel arrangement for lubricating the plunger thereof whereby the leakage of fuel into the film of lubricant established between the plunger and cylinder walls is substantially eliminated without affecting the proper operation or useful life of the pump plunger.

Another object is to provide a novel multiple unit pump adapted to deliver measured quantities of volatile fuel, such as gasoline, at high pressures for injection into the cylinders of a rotary engine.

A further object is to provide a pump of the above type with novel means for lubricating the plungers thereof and a novel delivery system for supplying oil to said lubricating means.

Still another object is to provide a novel system for lubricating the reciprocating element of a fuel injection pump so that air pockets in the lubricating oil line are eliminated.

A still further object is to provide a novel lubricating arrangement for the plunger of a fuel pump wherein circulation of the lubricating oil is obtained.

The above and further objects and novel features of the invention will more fully appear from the following detailed description when the same is read in connection with the accompanying drawing. It is to be expressly understood, however, that the drawing is for the purpose of illustration only and is not intended as a definition of the limits of the invention, reference for this latter purpose being had primarily to the appended claims.

In the drawing, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is an elevation view, partly in section, of a fuel injection pump apparatus embodying the present invention; and,

Fig. 2 is a view in section, with parts broken away, of another fuel injection pump embodying a modified system for lubricating the plunger thereof.

Referring to Fig. 1, there is shown a novel pumping apparatus adapted to deliver a volatile fuel, such as gasoline, to injection nozzles at the cylinders of an internal combustion engine, said apparatus embodying a separate pump unit for each cylinder with common actuating means and common adjusting or control means for said units. In the form illustrated, said apparatus comprises a substantially cylindrical housing 5 consisting of three vertical sections 5*a*, 5*b* and 5*c* secured to each other in end to end relation, said housing having a plurality of annularly disposed vertical bores or recesses 6 formed therein, each of which is adapted to receive a pump unit 7. Each of said pump units preferably comprises a cylinder 8 supported on an internal shoulder 9 in said bore and held in rigid engagement with said shoulder by a gland nut 10 threaded into the upper end of said bore. Cylinder 8 has axially spaced radial inlet and bypass ports 11 and 12, respectively, formed therein adjacent the upper end thereof, said ports connecting the central bore of said cylinder with an annular groove 13 surrounding said cylinder. Grooves 13 are provided in each of bores 6 by an enlargement of the diameters of the latter and

preferably communicate with each other and with a source of fuel (not shown).

Slidably mounted in the bore of cylinder 8, for reciprocation therein, is a plunger 14 adapted to serve as a slide valve for controlling the flow of fuel through port 11 and to apply pressure to the fuel admitted into the pressure chamber formed in said cylinder about the upper end of said plunger. A helical groove 15 formed in the surface of said plunger and connected by passages 16 to the pressure chamber cooperates with by-pass port 12 in the well-known manner to control the point in the plunger power stroke at which fuel delivery is cut off. An adapter 17 is mounted in the upper end of bore 6 in engagement with cylinder 8 and contains a delivery valve (not shown) of any well-known type for controlling the delivery of fuel from the pressure chamber of the pump to a fuel injection nozzle on an engine cylinder. Gland nut 10 cooperates with an external flange 17a formed at the lower end of said adapter and presses the lower end of the latter into fluid-tight engagement with the upper end of cylinder 8, a gasket 19 being preferably interposed between said nut and said flange.

In order to vary the effective pumping stroke of piston or plunger 14, novel means are provided for angularly adjusting said piston to vary the relation between metering groove 15 and cut-off or by-pass port 12, said means, in the form shown, comprising a sleeve 20 loosely surrounding the lower end of cylinder 8 in an enlarged portion of bore 6. Gear teeth 21 are formed at the upper end of sleeve 20 and at the lower end of said sleeve an axial slot 22 is formed for slidably receiving a cross bar 23 rigidly connected to plunger 14. Sleeve 20 is held against axial movement relative to cylinder 8 by an internal shoulder 20a, which engages the lower end of said cylinder and by an external shoulder 20b which rests on the upper surface of an inwardly extending flange formed on a ring 24. The latter is positioned against an internal shoulder in the wall of bore 6 and is held in place by any suitable means, such as a snap ring 26.

To effect a simultaneous angular adjustment of the sleeves 20 of each of pump units 7 so as to provide for a like variance in the effective stroke of the plunger of each unit, a central main control gear 27 meshes with the gear teeth 21 of each of the sleeves. Gear 27, as shown, is contained in a central chamber formed between sections 5a and 5b of housing 5, and is mounted on the lower end of a hollow control shaft 28 which is journalled in a pair of axially spaced bearings 29 carried by section 5a. A stationary spindle or shaft 30, to be more fully described hereinafter, extends through shaft 28 and has the lower end thereof threadedly secured to the upper end of housing section 5b by means of a threaded extension 30a of reduced diameter. Rotary movement imparted to shaft 28 by suitable control means (not shown) is effective to rotate gear 27 and hence each of sleeves 20, thereby simultaneously controlling the angular position of each of plungers 14.

Novel means are provided for reciprocating plunger 14 and, in the form illustrated, said means include a tappet cup 31 which is slidably positioned in bore 6 for engagement with an enlarged head portion 32a of a member 32 formed as an extension of said plunger. Said cup is held against rotation by a set screw 31a that extends into a slot in the cup. A pair of spaced parallel ears or lugs 33 are formed with cup 31 and extend downwardly therefrom to serve as journals for a shaft 34 on which is mounted a roller cam follower 35. The latter engages and is adapted to be moved upwardly by a cam 36, thereby imparting upward movement to plunger 14. The return or downward movement of said plunger is effected by a spring 37 interposed between ring 24 and a washer 38 which engages the upper shoulder of head portion 32a. Cam 36 is of the disc or plate type having an annular peripheral ridge 36a formed in the upper face thereof which is suitably shaped to constitute the cam control surface and said cam is centrally mounted in the upper end of housing section 5c so as to have said surface in engagement with followers 35 of all the pump units 7. Accordingly, rotation of the cam successively actuates all the plungers of the pump apparatus.

In the illustrated embodiment, cam 36 is supported for free rotary movement on a plurality of suitable bearing elements 39 shown as balls but which may be tapered rollers, the lower face of said cam constituting the upper race for said elements. The lower race of the bearing thus formed preferably consists of a flat annular member 41 mounted in the upper end of housing section 5c. To impart rotary movement to cam 36 a drive shaft 42 is keyed or otherwise connected intermediate the ends thereof to said cam and has its upper end journalled in bearing 43 in the lower end of housing section 5b. The portion of said shaft below the cam extends through housing section 5c, the same being journalled therein and fixed against axial movement by bearing means 44 which may also include suitable fluid seals 45. Mounted on the lower end of said shaft, which end projects from housing 5, is a drive gear 46 which is splined to said shaft, the teeth on said gear and on the spline arrangement being unequal in number to permit of a fine adjustment in the timing of the cam rotation. Gear 46 is adapted to be driven by suitable drive means from the main drive shaft of the engine which is fed by the pump unit.

In a fuel injection pump unit for a volatile fuel, such as gasoline, it is highly desirable to lubricate the surfaces of engagement between the pump plunger and the cylinder for example, with lubricating oil. Accordingly, there is provided in the above described pump apparatus, a novel arrangement for conducting lubricating oil to the plunger and for insuring the distribution thereof as a substantially undiluted film between the lower end of the plunger and the cylinder walls. To this end, spindle 30 has an axial passage 47 therein to serve as a lubricating oil inlet and is internally threaded at its upper end to receive a suitable conduit (not shown) for delivering oil to said passage, such as from the lubricating oil system of the engine. An annular groove 48 is provided in the surface of the shoulder formed in said spindle adjoining threaded extension 30a, and communicates with inlet passage 47 by means of one or more ducts 49. Similar lubricating systems are provided for each of pump units 7 and each of said systems preferably comprises a passage 50 which opens at its upper end into groove 48 and connects at its lower end with an axially extending slot 51 provided in the surface of bore 6 opposite the outer end of a passage 52 in tappet cup 31. Slot 51 is of sufficient length to remain connected with passage 52 throughout a substantial part of the

plunger stroke. The latter passage, as shown, extends radially to the center of cup 31 and opens upwardly to connect with a central axial passage 53 provided in member 32 and plunger 14. Head portion 32a is preferably convexly curved at its lower end for contact with cup 31 so that a yieldable annular gasket or grommet 54 can be interposed between said end and said cup without eliminating metal-to-metal contact between the latter elements. A pair of diametrically opposed helical lubricating grooves 55 are provided in the surface of plunger 14 and said grooves are connected preferably at their upper ends to passage 53 by radial ducts 56 whereby said grooves are maintained full of lubricating oil substantially at the pressure of the lubricating oil source.

In order to eliminate any air pockets which might form in the lubricating oil supply passages and the attendant deleterious effects of such a condition, a bleed hole 57, relatively small in diameter, is provided in cylinder 8 and connects with one of grooves 55 during the plunger stroke. Hole 57 communicates with an axial passage 58 in said cylinder, said passage opening at the upper end thereof into the passage in a suitable connection or fitting 59 in housing 5a. A cap 60 is threadedly secured to said fitting to normally close said passage but may be removed to open bleed hole 57 to the atmosphere to thereby permit the escape of any air trapped in the lubricating oil passages and insure proper and complete distribution of the lubricant between the cylinder and plunger. It is to be understood that fitting 59 may be connected to a conduit leading back to the oil supply line whereby a circulation of the lubricant can be obtained.

To prevent the dilution and replacement of the oil film by the volatile fuel which tends to seep downwardly between the plunger and cylinder walls from the pressure chamber of the pump, an annular relief groove 61 is provided in the cylinder wall between the uppermost position of ducts 56 and the lowest position of metering groove 15 assumed during the plunger travel. It is preferable that said relief groove be located a distance greater than the diameter of the plunger below the lower end of helical groove 15 when plunger 14 is about to begin effective pumping. To prevent the building up of excessive pressures in groove 61 the latter is connected by suitable drilled axial and radial passages 62 and 63, respectively, to the fuel inlet or supply groove 13.

In operation, rotation of cam 36 causes reciprocation of each of plungers 14 of units 7 and effects measured fuel delivery through delivery valve units 17 to the engine cylinders, the quantity of fuel delivered for each stroke being determined by the angular position of piston 14 relative to cylinder 8 and therefore being subject to the control of master or main gear 27. During reciprocation of the plunger, a film of lubricant is maintained between the surfaces of engagement of said plunger and cylinder, the lubricant being delivered to grooves 55 in said plunger through passages 47 to 53 and 56. Air traps in the lubricating oil line and the deleterious effects thereof, are readily avoided by a preliminary venting of grooves 55 in the plunger to the atmosphere through vent hole 57, passage 58 and fitting 59, and dilution and replacement of the oil film by the seepage of fuel from the pump pressure chamber is prevented by relief channel 61 which connects with the fuel supply line.

A modification of the novel lubricating system comprehended by the invention is illustrated in Fig. 2, the same being embodied in a fuel pump of the conventional type which comprises a housing 65 in the bore of which a cylinder 66 is rigidly secured, said cylinder having a plunger 67 slidably mounted therein. The latter is provided with a helical metering groove 68 and cooperates in the usual manner with inlet and by-pass ports 69 and 70, respectively, which are connected to a fuel supply groove 71 in said housing, said metering groove being in continuous communication with the pressure chamber formed by said plunger, cylinder and delivery valve adapter unit 65a. To vary the effective pumping stroke of plunger 67 means are provided for angularly adjusting said plunger relative to cylinder 66 and said means are similar to the mechanism shown in the embodiment of Fig. 1 for angularly adjusting each of plungers 14. Accordingly, like numerals are utilized to designate like parts of the structures. It is, however, preferable in the present embodiment to have a rack (not shown) instead of a gear meshing with teeth 21 for the purpose of rotating sleeve 20. The means for imparting reciprocating movement to plunger 67 are also similar to the actuating means cooperating with each of plungers 14 in Fig. 1 except that in the present embodiment a tappet cup 72 which differs from cup 31, is slidably mounted in the bore of housing 65 for engagement with head portion 32a. As shown, cup 72 is adapted to directly engage the actuating cam and accordingly is not provided with cam following brackets as is cup 31.

In order to lubricate the surfaces of engagement between plunger 67 and cylinder 66 by establishing a film of lubricant therebetween, oil is supplied from a suitable source, such as the lubricating system of the engine, to a fitting 73 threadedly mounted in a bore 74 in housing 65. Bore 74 extends through said housing to the wall of cylinder 66, so that passage 82 in said fitting communicates with the upper radial end portion 75 of a passage in said cylinder. The axially extending portion 76 of the latter passage is drilled in the wall of cylinder 66 and has the lower end thereof plugged and communicates at a point intermediate the ends thereof with an annular groove or channel 77 formed in the surface of the bore of said cylinder. Channel 77 is adapted to communicate during the travel of plunger 67 with two axially spaced grooves 78 and 78a and with a pair of diametrically opposed helical grooves 79, said grooves being provided in the surface of said plunger and being interconnected.

To permit circulation of the lubricating oil and venting of air trapped in the above described oil passages, means are provided for connecting groove 77 to a second fitting 73a preferably similar to fitting 73 and mounted diametrically opposite the latter. Fitting 73a connects with an oil passage 75a, 76a similar to passage 75, 76 and disposed diametrically opposite the latter in cylinder 66, said passage 75a, 76a communicating with groove 77. Fitting 73a may be connected to the inlet fitting of an adjacent injection pump or directly to the engine lubricating system to permit circulation of the lubricating oil or may be provided with a suitable sealing plug which, when removed, permits venting of any air that may be trapped in the oil line.

In order to prevent dilution of the lubricating film, a relief channel 80 is provided in the sur-

face of the bore of cylinder **66** so as to be between helical metering groove **68** and the upper annular groove **78a** for all positions of plunger **67**, said relief channel being preferably located in such a manner that when said plunger begins its effective pumping stroke said channel will be separated from the lower end of said metering groove by a distance equal at least to the diameter of the plunger. A passage **81** in cylinder **66** preferably connects said relief channel to fuel supply groove **71** in the same manner that groove **61** is connected to channel **13** by passage **62** in Fig. 1.

There is thus provided novel means for lubricating the surfaces of contact of the plunger and cylinder of an injection pump unit, said means establishing and maintaining a film of lubricant between said plunger and cylinder surfaces. The novel lubricating system includes means for preventing the formation of air pockets in the lubricating line and means for preventing dilution of the lubricating film by the fuel. There is also provided a novel injection pump apparatus wherein a plurality of pump units are operatively mounted in a unitary housing and are actuated by a single control cam mounted in a novel manner. Novel means are provided in said apparatus for adjusting the angular positions of the pump plungers to vary the effective pumping stroke of the latter and for delivering oil to the lubricating systems of the pump units.

Although only two embodiments of the invention have been illustrated and described, it is to be expressly understood that the same is not limited thereto. For example, it will now be apparent, to those skilled in the art, that a circulation of oil may be achieved in the lubricating systems of the pump units of Fig. 1 by providing a return connection instead of an air vent. Moreover, relief channels for preventing oil dilution may be provided in the surface of the plunger, as well as in the cylinder wall. Various other changes may be made in the design and arrangement of parts without departing from the spirit and scope of the invention. For a definition of the limits of the invention, reference is had primarily to the appended claims.

What is claimed is:

1. In a fuel injection pump wherein a piston is slidable in a cylinder to define a pressure chamber and has a metering groove adapted to cooperate with a part in said cylinder to control the duration of effective pumping, means for establishing a film of lubricant between the plunger and cylinder surfaces, and means for preventing dilution of said film by fuel from said chamber, said last-named means comprising a relief channel in the surface of the bore of said cylinder located between said lubricating means and said metering groove and a passage in said cylinder connecting said channel to the fuel supply line.

2. In a fuel injection pump wherein a plunger and cylinder define a pressure chamber and a metering groove in said plunger controls the effective pumping stroke of the latter, means for establishing a film of lubricant between the surfaces of engagement of said plunger and cylinder, and means for preventing dilution of said film by fuel from said chamber, said last-named means comprising an annular passage provided in the surface of the bore of said cylinder between said metering groove and said lubricating means, said passage being located so that when said plunger begins effective pumping a distance equal at least to the diameter of said plunger separates said passage from said metering groove, and means for continuously connecting said passage to the fuel supply line.

3. In a fuel injection pump having a cylinder and a plunger slidably mounted therein, means for lubricating the surfaces of engagement of said cylinder and plunger comprising at least one annular channel connecting with said surfaces of engagement, and means comprising passageways in said cylinder disposed on opposite sides of said plunger for circulating lubricating oil through said channel.

4. In an injection pump having a cylinder and a plunger slidably mounted in said cylinder, means for lubricating the surfaces of engagement of said cylinder and plunger comprising surface grooves in said plunger, means constituting a passageway for delivering a lubricant to said grooves, and means for permitting venting of said grooves to the atmosphere.

5. In a fuel injection pump of the type having means comprising a pressure chamber, which means include a piston and cylinder, means for maintaining a film of lubricant between said piston and cylinder comprising a channel in the bore of said cylinder surrounding said piston, passage means connecting said channel to a source of lubricating oil, a relief groove in the bore of said cylinder disposed between said channel and the pressure chamber, and a passage continuously connecting said groove to the fuel supply line.

6. In a fuel injection pump having a cylinder and a plunger slidably mounted therein, means for lubricating the surfaces of engagement of said cylinder and plunger comprising at least one passage surrounding said plunger and communicating with said surfaces of engagement, and means comprising a pair of passageways disposed on opposite sides of said plunger for circulating oil through said passage.

7. In a fuel injection pump having a cylinder and a plunger slidably mounted in said cylinder, lubricating means comprising a pair of axially spaced annular grooves in the surface of said plunger, diametrically opposed helical grooves in said plunger connecting said annular grooves to each other, an annular channel in the bore of said cylinder connecting with at least one of said grooves during the plunger travel, means for delivering lubricant to said channel comprising an axially extending passageway in said cylinder, and means for conducting oil from said channel, said last-named means comprising an axially extending passageway in said cylinder located opposite said first-named passageway.

8. In a fuel injection pump having a housing, a cylinder in said housing, a plunger mounted for reciprocation in said cylinder and means including a sleeve member slidably mounted in said housing for engaging and actuating said plunger, means for lubricating the surfaces of engagement of said plunger and cylinder comprising at least one passage in the surface of said plunger, a central passage in said plunger connecting with said surface passage, a passage in said housing connecting with a source of lubricating oil, and a passage in said sleeve member connecting at one end with said central plunger passage and at the other end with said housing passage.

9. In a fuel injection pump having a housing, a cylinder in said housing, a plunger slidably mounted in said cylinder to define a pressure

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chamber, said plunger having a metering groove therein adapted to control the effective pumping stroke thereof, and mechanism including a sleeve member slidably mounted in said housing and engaging said plunger for actuating the latter, the combination therewith of means for establishing a film of lubricant between said cylinder and plunger, said last-named means including at least one lubricant groove in the surface of said plunger, means for delivering lubricating oil to said lubricant groove comprising a central passage in said plunger, a passage in said housing connected to a source of lubricating oil and a duct in said sleeve adapted to connect said passages to each other, means for venting said groove to the exterior of said housing, and means for preventing dilution of the film of lubricant, said last-named means comprising an annular channel in the surface of the bore of said cylinder, said channel being disposed between said lubricant groove and said metering groove, and a passageway in said cylinder connecting said channel to the fuel supply line.

10. A fuel injection apparatus comprising a housing, a plurality of pump units mounted in said housing with the longitudinal axes thereof parallel, each of said units comprising a cylinder, a plunger slidably mounted in said cylinder, said plunger having a helical metering groove therein, and means adapted when rotated to angularly adjust said plunger to vary the effective pumping stroke thereof, and means including a single member in engagement with all of said adjusting means for simultaneously rotating the latter to angularly adjust the plungers.

11. A fuel injection apparatus comprising a housing, a plurality of circularly arranged pump units mounted in said housing with the longitudinal axes thereof parallel, each of said units comprising a cylinder, a plunger slidably mounted in said cylinder, said plunger having a helical metering groove therein for cooperation with a port in said cylinder, and a gear member connected to said plunger for angularly adjusting the position of the latter relative to the cylinder, and means including an annular control gear simultaneously meshing with all the gear members of said units for imparting angular motion to said members.

12. A fuel injection apparatus comprising a housing, a plurality of pump units mounted in said housing, common means mounted in said housing for actuating all of said pump units, common means for simultaneously controlling the period of effective pumping of said units, and means for lubricating each of said units, said means having a single inlet passage in said housing and branch passages for conducting lubricating oil to the clearance space between the pump plungers and cylinders adjacent the lower ends of the latter.

13. In apparatus of the class described, rotatable means having an annular cam surface, a plurality of pumps circularly arranged around the axis of rotation of said rotatable means, each of said pumps including a cylinder and a plunger reciprocable therein, a cam follower associated with each of said plungers, guide means for each of said followers and resilient means for continuously urging each of said plungers toward its associated cam follower and for holding said follower in continuous engagement with said cam surface, whereby upon rotation of said rotatable means said pump plungers are successively reciprocated.

14. In apparatus of the class described, rotatable means having a cam surface surrounding the axis of rotation thereof, and a plurality of pump units arranged around said axis of rotation, each of said pump units including a cylinder, a plunger reciprocable in said cylinder, a cam follower associated with said plunger, means for guiding said follower, and resilient means for continuously urging said plunger toward said follower and for holding said follower in continuous engagement with said cam surface, the latter being adapted to cause successive reciprocation of the plungers of said units during rotation of said rotatable means.

15. In apparatus of the class described, a housing, rotatable means having a cam surface surrounding the axis of rotation thereof, and a plurality of pump units in said housing having the axes thereof parallel to said axis of rotation, each of said units including a cylinder, a plunger reciprocable in said cylinder, cam follower means guided in said housing and operatively associated with said plunger and common resilient means for continuously holding said plunger in operative engagement with said follower means and for holding the latter in continuous engagement with said cam surface.

16. In apparatus of the class described, a housing, rotatable means having a cam surface surrounding the axis of rotation thereof, a plurality of pump units in said housing having the axes thereof parallel to said axis of rotation, each of said units including a cylinder, a plunger reciprocable in said cylinder, cam follower means guided in said housing and operatively associated with said plunger and common resilient means for continuously holding said plunger in operative engagement with said follower means and for holding the latter in continuous engagement with said cam surface, and means mounted in said housing for simultaneously effecting equal angular adjustments of said plungers in said cylinders.

17. In apparatus of the class described, a housing, rotatable means having a cam surface surrounding the axis of rotation thereof, a plurality of pump units in said housing having the axes thereof parallel to said axis of rotation, each of said units including a cylinder, a plunger reciprocable in said cylinder, cam follower means guided in said housing and operatively associated with said plunger and common resilient means for continuously holding said plunger in operative engagement with said follower means and for holding the latter in continuous engagement with said cam surface, and means mounted in said housing for simultaneously effecting equal angular adjustments of said plungers in said cylinders, said last named means including an annular gear rotatable about the axis of rotation of said rotatable means and a sleeve surrounding each of said cylinders and having gear teeth thereon meshing with said annular gear, each of said plungers being operatively coupled with one of said sleeves for angular movement therewith and reciprocable movement relative thereto.

18. In a port controlled fuel injection pump, a cylinder having port means in the wall thereof, a plunger reciprocable in said cylinder for controlling flow through said port means, means connecting a source of fuel to said port means, an annularly extending groove in the internal wall of said cylinder below said port means, said groove being continuously covered by said

plunger, means for connecting said groove with said first named connecting means, and means for supplying a lubricating medium to the clearance space between said plunger and cylinder below said groove.

19. In a fuel injection pump, a cylinder, a plunger reciprocable in said cylinder, means connecting the pressure chamber of the pump to a source of fuel, means connecting said first named connecting means to the clearance space between the sidewalls of the plunger and cylinder at a point which is continuously covered by said plunger during reciprocation thereof, and means for supplying a lubricating medium to said clearance space below said point.

20. In a fuel injection pump, a cylinder, a plunger slidably mounted in said cylinder for reciprocation therein, and means for lubricating the engaging surfaces of said cylinder and plunger, said means comprising at least one groove in the surface of said plunger and means including a passageway for conducting a lubricating medium to said groove from a source other than the pressure chamber of the pump.

21. In a fuel injection pump, a cylinder, a plunger slidably mounted in said cylinder for reciprocation therein, means for lubricating the engaging surfaces of said cylinder and plunger, said means comprising at least one groove in the surface of said plunger and means including a passageway for conducting a lubricating medium to said groove from a source other than the pressure chamber of the pump, and normally closed means for venting said groove to a region of low pressure.

22. In a fuel injection pump, a cylinder, a piston reciprocable therein, means for venting the clearance space between said cylinder and piston adjacent one end of the latter to a region of low pressure, and means for supplying a lubricating medium to and distributing the same in said clearance space adjacent the other end of the piston.

23. In a fuel injection pump, a cylinder, a piston reciprocable therein, means for venting the clearance space between said cylinder and piston adjacent one end of the latter to a region of low pressure, and means for supplying a lubricating medium to and distributing the same in said clearance space adjacent the other end of the piston, said last named means including a port in the wall of said cylinder and at least one groove in the surface of said piston adapted to communicate with said port during at least a part of the stroke of the piston.

24. In a fuel injection pump, a cylinder, a piston reciprocable therein, means for venting the clearance space between said cylinder and piston adjacent one end of the latter to a region of low pressure, and means for supplying a lubricating medium to and distributing the same in said clearance space adjacent the other end of the piston, said last named means including supply and discharge port means in the wall of said cylinder and groove means in said plunger adapted to communicate with said port means during at least a part of the stroke of the piston.

25. In a fuel injection pump, a cylinder, a piston reciprocable therein, means for venting the clearance space between the side wall of said piston and the inner surface of said cylinder adjacent one end of the piston, and means for conducting lubricating oil to and distributing the same in said clearance space adjacent the other end of the piston, said last named means including groove means in the surface of said piston and means including a passage for conducting the lubricating medium to said groove means, said venting means including a groove positioned in the wall of the cylinder so that said groove means does not communicate therewith during reciprocation of the piston, said groove being connected to a region of low pressure.

26. In a fuel injection pump, a cylinder, a piston reciprocable therein, a pair of axially spaced annular grooves in the inner wall of said cylinder, the first of said grooves nearest the pressure chamber of the pump being adapted to communicate only with the clearance space between the piston and cylinder and a region of low pressure outside said cylinder, such as the fuel supply line for said pump, and means for conducting a lubricating medium to the other of said grooves, said piston having at least one groove on the surface thereof adapted to communicate with said other groove during reciprocation thereof.

27. In a fuel injection pump, a cylinder, a piston reciprocable therein, and means for lubricating the engaging surfaces of said piston and cylinder, said means comprising at least one groove on the surface of said piston within said cylinder and means including an axially extending passage in said piston for conducting a lubricating medium to said groove.

28. In a fuel injection pump, a cylinder, a piston slidably mounted in said cylinder for reciprocation therein, a cam follower operatively associated with said piston, and means for lubricating the engaging surfaces of said cylinder and piston comprising connecting passages in said cam follower and said plunger.

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