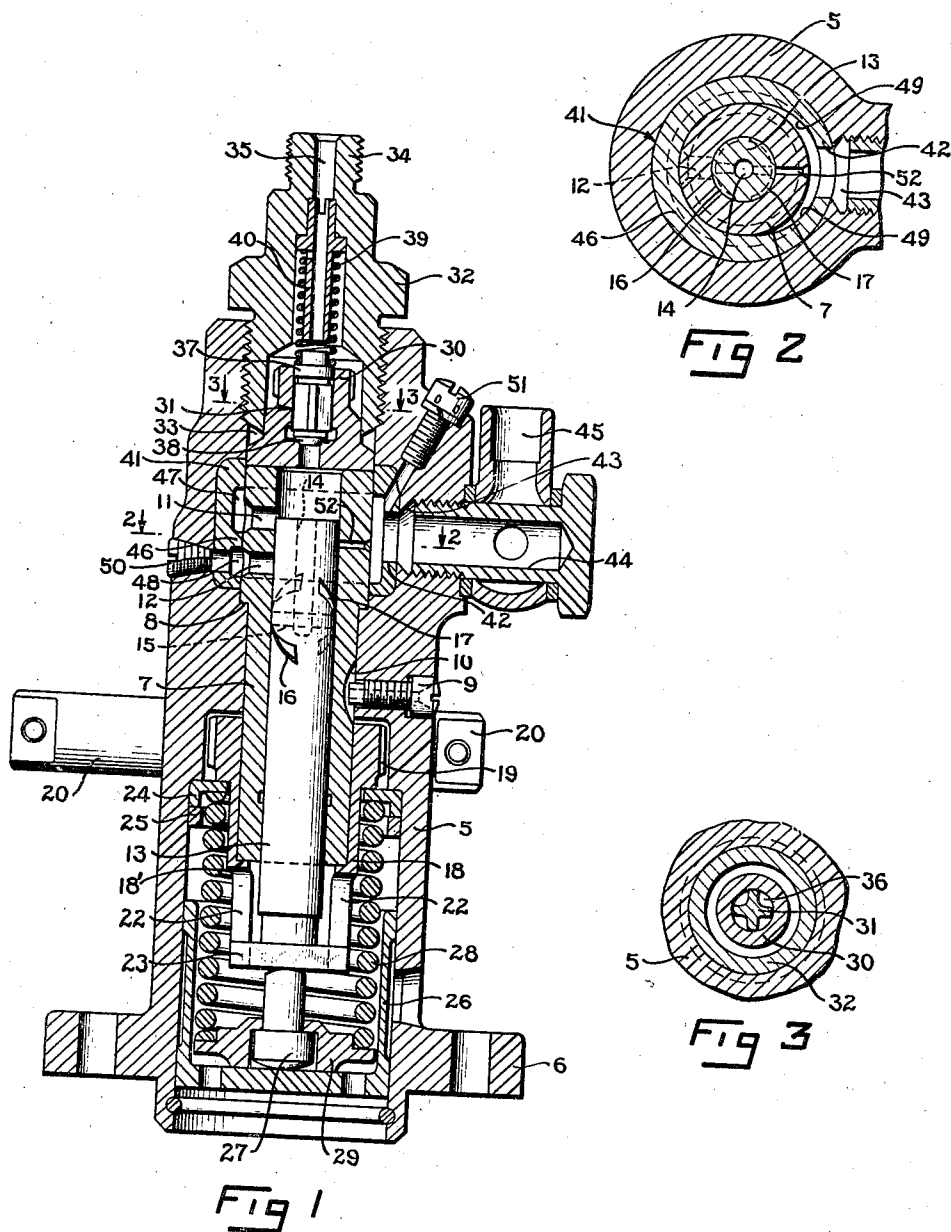


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FUEL INJECTION APPARATUS

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FUEL INJECTION APPARATUS

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This invention relates to pumping apparatus and more particularly to liquid pumping means such as fuel injection pumps for use in connection with solid fuel injection internal combustion engines.

In port-controlled fuel pumps heretofore provided for injecting solid liquid fuel into internal combustion engine cylinders, considerable difficulty has been experienced in providing an efficient seal at the intake and by-pass ports in the pump cylinder without causing undue wear of the pump piston and cylinder wall which in turn shortens the life of the pump and alters the fuel metering characteristics thereof. Furthermore, in pumps of the above character heretofore provided the personal attention of an operator is required to start the flow of fuel through the pump when a substantial quantity of air collects in the pressure chamber thereof.

One of the objects of the present invention is to provide novel fuel injection apparatus whereby the foregoing difficulties and disadvantages are obviated.

Another object of the invention is to provide novel liquid pumping means wherein the fluid pressure acting on the side walls of the pump plunger is controlled in a novel manner.

Another object is to provide a novel port controlled fuel injection pump which is so constructed as to minimize erosion of the edges of the fuel ports and the edges of the metering grooves in the pump plunger.

Still another object is to provide novel valve means in combination with a fuel injection pump whereby the latter is prevented from becoming air-bound.

A further object is to provide novel retraction valve means in the fuel injection system of an internal combustion engine.

A still further object is to provide novel fuel pumping apparatus which is so constructed that wear is reduced to a minimum and accurate metering, which entails good sealing, is assured.

Still another object is to provide a novelty constructed pump, the efficient operating life of which will be comparatively greater than the life of similar devices heretofore provided.

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 are not intended to define 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 a side elevation, partly in section, of one form of apparatus embodying the present invention;

Fig. 2 is a sectional view of said apparatus with parts broken away, the section being taken substantially on line 2—2 of Fig. 1.

Fig. 3 is a sectional view with parts broken away, the section being taken substantially on line 3—3 of Fig. 1.

A single embodiment of the invention is illustrated in the drawing, by way of example, in the form of a fuel injection pump assembly having a novel delivery valve in combination therewith. In the form shown, said pump assembly comprises a tubular casing 5 having laterally projecting ears 6 by means of which the same may be connected to an engine or other support (not shown) in the usual manner. Mounted in casing 5 intermediate the ends thereof is a pump cylinder 7, the latter being supported on an internal shoulder 8 in the casing and held against rotary movement therein by a screw 9 which threadably engages the casing wall and extends into an axially extending groove 10 in the cylinder wall. A pair of axially spaced ports 11 and 12 are provided in the wall of cylinder 7 adjacent the upper end thereof, as viewed in the drawing, for directing the flow of fuel to and from the pump cylinder in a manner to more fully appear hereafter.

Slidably extending into the lower end of cylinder 7 is a pump plunger or piston 13 which also functions as a slide valve for controlling the flow of fuel through ports 11 and 12. For a purpose which will more fully appear from the description of the operation which follows, plunger 13 is provided with an axially extending passage 14 and a radial passage 15 which continuously connects the upper end or pressure chamber of cylinder 7 to a helical groove 16 in the surface of piston 13, which groove cooperates with port 12 and constitutes a metering or cut-off groove. If desired, a somewhat smaller helical groove 17 may be provided in the surface of piston 13 diametrically opposite groove 16, the latter having continuous communication with passage 14 and being adapted to act as a lubricating and pressure balancing groove.

Means are provided for angularly adjusting piston 13 to change the relation between metering groove 16 and cut-off or by-pass port 12 and

thereby vary the effective pumping stroke of the piston. In the form shown, said means comprise a sleeve 18 loosely surrounding the lower end of cylinder 7 in an enlarged portion of casing 5. Gear teeth 19 are formed on the upper end of sleeve 18 for cooperation with a rack 20 slidably mounted in casing 5, the movement of said rack being limited by any suitable means well-known in the art, such as a set screw extending through the wall of casing 5 into a groove in said rack. The lower end of sleeve 18 is axially slotted, as at 22, for slidably receiving a cross-bar 23 rigidly connected to plunger 13. Sleeve 18 is held against axial movement relative to cylinder 7 by an internal shoulder 18' which engages the lower end of said cylinder and an external shoulder which rests on the upper surface of an inwardly extending flange on a ring 24. The latter is positioned against an internal shoulder in casing 5 and is held in place by any suitable means, such as a snap ring 25. It will thus be seen that by reciprocating rack 20, angular adjustment of sleeve 18 and hence plunger 13 may be effected without hindering the longitudinal or pumping movement of the latter.

Means are also provided for reciprocating piston 13 in cylinder 7 without subjecting the former to any lateral force or pressure which would cause unnecessary friction and binding. Said means in the illustrated embodiment include a tappet cup 26 slidably positioned in the lower end of casing 5 for engagement with an enlarged head portion 27 at the lower end of piston 13. The latter may be moved upwardly by a rotating cam or other suitable means (not shown) which is adapted to engage the closed end of tappet cup 26 in a manner well understood in the art. The return or downward movement of piston 13 is effected by a spring 28 interposed between the internal flange of ring 24 and a slotted washer 29 which engages the upper shoulder of head 27.

The upper end or pressure chamber of cylinder 7 may be connected by any suitable means to an injection nozzle (not shown) at an internal combustion engine cylinder. The means shown for this purpose comprise an adapter element 30 which constitutes a guide and seat for a novel delivery valve 31. Adapter 30 rests upon the upper end of cylinder 7 and is held in fluid tight engagement therewith by a nipple or a sleeve nut 32 which engages internal threads in the upper end of casing 5. Adapter 30 thus completes the pressure chamber of the pump and, in effect, forms a part of the pump cylinder. A suitable packing washer 33 may be interposed between the inner end of member 32 and an external flange on adapter 30 to further insure fluid tightness. The upper end of member 32 terminates in a threaded portion 34 having a delivery passage 35 therein whereby a delivery conduit (not shown) leading to a fuel injection nozzle of an engine cylinder may be attached.

Adapter 30 has a differential cylindrical passage therein through which the flow of fuel from cylinder 7 into member 32 and delivery conduit 35 is controlled by the novel delivery valve 31 which functions in a novel manner to prevent the pump from becoming airbound and to relieve the pressure in the delivery passages between the pump and injection nozzle during the suction stroke of piston 13. As shown, the central portion of valve 31 which is provided with axial flutes or grooves 36 (Fig. 3) serves to guide the valve in the central passage in adapter 30 and yet permits the flow of fuel through the

latter when the valve is in fully open position. Adjacent the upper end of valve 31 is a piston portion 37 of limited extent which is adapted to slidably fit into said adapter passage and at its lower end said valve is provided with a tapered head portion 38 adapted to engage a valve seat formed in the adapter adjacent the pressure chamber of pump 7, 13. Valve 31 is yieldingly held on said seat by a coil spring 39 that engages piston portion 37 and is centered within member 32 by a tubular member 40. The latter has continuous communication with the interior of member 32 and with passage 35 and, in addition, may function as a stop for limiting the opening movement of valve 31.

In order to minimize erosion and the effects thereof and to insure smooth and consistent suction by pump 7, 13, means are provided in casing 5 for directing the flow of fuel to and from cylinder 7 through ports 11 and 12. Preferably said means are constituted by an insert or lining 41 of stainless steel or other hard material, cast or otherwise fixed, in a peripheral groove or recess formed in casing 5. Lining 41 and said casing are provided with registering openings 42 and 43, respectively, which communicate with a source of liquid fuel (not shown) through conduits 44 and 45, said openings being circumferentially spaced from and preferably diametrically opposite ports 11 and 12.

Lining 41 is channel-shaped in radial cross-section to provide a fuel passage around cylinder 7 and is provided with a radially extending internal rib 46 which engages the outer wall of cylinder 7 between ports 11 and 12 to thereby form a pair of grooves 47 and 48 in said lining, both of which grooves are in communication with fuel supply opening 42, 43. In the embodiment shown rib 46 engages the wall of cylinder 7 throughout substantially half the circumference thereof and then tapers off, as at 49 (Fig. 2), toward opening 42, 43.

To further insure against erosion adjacent cut-off port 12, a hardened steel screw 50 may be threaded into casing 5 with the pilot tip thereof extending through insert 41 radially outward from said cut-off port. Screw or plug 50 may also be used as a vent plug when the pump is mounted in a horizontal position. A vent plug 51 is provided for this latter purpose when the pump is mounted in an upright position. Screw 50 may also be replaced by a pipe fitting and this fitting connected to an outside conduit so that the fuel which is by-passed through port 12 may be returned to the fuel supply tank without first entering the supply line attached to fitting 45. In the latter case, internal rib 46 may completely surround cylinder 7 so that grooves 47 and 48 may communicate with each other only by way of ports 11 and 12, passage 14, 15 and groove 16.

Novel means are provided in the pump comprehended by the present invention to insure a tight seal at ports 11 and 12 during the effective pumping stroke of plunger 13 and thus prevent leakage and erosion of the sharp edges of said ports and metering groove 16 without breaking the lubricating film between the plunger and cylinder walls on the side of said ports. Said novel means comprise one or more small pressure relief ports 52, one such port being shown diametrically opposite and in a plane between ports 11 and 12.

In pumps of the character described above, a slight clearance is provided between plunger 13 and the walls of cylinder 7 so that a lubricating

film may be maintained around the plunger to minimize wear and prevent seizing. During the effective pumping stroke of the plunger this lubricating film is naturally under high pressure due to the high pressure in the pressure chamber of the pump and if relief port 52 is not provided, a momentary leakage from ports 11 and 12 occurs and reduces the film pressure on the left side of plunger 13, as viewed in the drawing, thereby permitting the undiminished film pressure on the right side to press the plunger firmly against the ported side. This insures a good seal at said ports but if the fuel contains even a slight amount of grit or dirt, as most fuels do, considerable wear of the plunger and cylinder wall occurs adjacent the parts due to the absence of a lubricating film in this region. Too much wear and lack of lubrication may cause seizing and cutting. By providing relief port 52 which opens into the supply passage 44 or other low pressure chamber the fuel film pressure on the right side of plunger 13 may be controlled and reduced so that sufficient pressure is exerted thereby in the direction of ports 11 and 12 to insure a good seal at said ports without breaking the lubricating film on that side of the plunger. Some leakage through port 52 will occur but this leakage is constant and does not affect the metering accuracy of the pump.

In the operation of the above-described assembly, plunger 13 is reciprocated with a constant stroke by suitable cam means and spring 28 in a manner well understood in the art and heretofore briefly described. On the upward movement of the plunger, as soon as the latter completely covers intake port 11, pressure is built up in the upper end of cylinder 7 which is sufficient to lift valve 31 off its seat and continue the movement thereof until piston portion 37 moves out of the passage in adapter 30. Continued upward movement of the pump plunger forces fuel past the head 38 of valve 31, along flutes or grooves 36 in the walls of the valve and, thence, through member 32 and passage 35 to the injection nozzle. During this pumping stroke the pressure of the fuel film around plunger 13 is so distributed by reason of relief ports 52 that a good seal is obtained at ports 11 and 12 without breaking said film on the side of said ports. When the desired quantity of fuel has been injected into the engine cylinder, as determined by the angular seating of piston 13, metering groove 16 overlaps cut-off port 12, thereby permitting a free discharge of fuel and relieving the pressure in the pump, whereupon delivery valve 31 is closed by spring 39 and the fuel pressure acting on the upper end thereof.

After the lower edge of piston portion 37 of valve 31 enters adapter 30 continued downward or closing movement of the valve to seated position increases the available space for fuel between the upper end of the valve and the injection nozzle without increasing the volume of fuel in the delivery passages. Accordingly, the pressure of the fuel remaining in the delivery passages is reduced by the retraction of valve 31 and obviates any dribbling of fuel at the nozzle.

It will also be seen that retraction valve 31 is novelly constructed to insure operation of pump 7, 13 under circumstances which would cause pumps having retraction valves of the type heretofore known to become air-bound. If, for example, a quantity of air accumulates in the pressure chamber of cylinder 7 it will be compressed on the upward stroke of piston 13 and lift valve 31 off its seat. Even though the lift of the valve

may be insufficient to move piston portion 37 out of adapter 30 a quantity of the compressed air will be trapped in the cut away portions or flutes 36 when metering groove 16 registers with port 12 and permits valve 31 to snap back on its seat. Thus, on the next downward or suction stroke of plunger 13 some fuel is drawn into the pump pressure chamber to replace the air trapped by the delivery valve. This process continues until the air is sufficiently compressed to fully open valve 31, i. e., to move piston 37 out of adapter 30, and permit the air to discharge through the delivery passages into the engine cylinder. The necessity for manually venting the pump is thus obviated.

The instant that metering groove 16 moves into overlapping relation with port 12 on the pressure stroke of plunger 13 the fuel in the upper end of cylinder 7, passages 14, 15 and grooves 16 and 17 is under tremendous pressure. Accordingly, fuel is discharged through the small initial opening of port 12 at an extremely high velocity and strikes the walls of casing 5, 41. This sudden rush of fuel through the initially small opening tends to result in erosion of the pump casing and a breaking up or atomization of the fuel, as well as a setting up of fuel turbulence. The provision of the hard metallic insert 41 and hardened steel plug 50 substantially reduces erosion caused by the discharge of the high pressure fuel through cut-off port 12 and permits the use of light alloys, such as aluminum alloys, for pump casing 5 and the provision of rib or partition 46 in said insert prevents the turbulence of the discharged fuel or the atomization thereof from materially affecting the intake of fuel through port 11. Accordingly, after plunger 13 reaches the top of its stroke and is moved downwardly by spring 28, metering groove 16 is moved out of registry with port 12 so that further movement of the plunger creates a vacuum in cylinder 7. When the plunger uncovers intake port 11 the comparatively undisturbed solid fuel adjacent said port in groove 47 is drawn into cylinder 7 completely filling the space therein so that the pumping of a predetermined charge to the engine cylinder during the next upstroke of the pump piston is insured.

To vary the effective pumping stroke, and, hence, the quantity of fuel pumped into the engine cylinder during each pressure stroke of plunger 13, rack 20 is moved to the right or left, as viewed in the drawing, to thereby angularly adjust sleeve 18 and hence plunger 13. It will be clear that angular movement of the latter changes the point in the upward stroke of the plunger at which helical groove 16 begins to overlap cut-off port 12 and accordingly varies the effective pumping stroke of the plunger. For idling, piston 13 is turned sufficiently in a counter-clockwise direction, as viewed from the top, so that groove 16 will register with port 12 during substantially the full upward movement of the plunger.

There is thus provided novel fuel pumping apparatus of the port-controlled type which is simple both in construction and operation and which is so constructed as to operate efficiently with minimum wear over a long period of time and which is adapted to maintain accurate metering over long periods of use. The novel pump construction provided includes means whereby a lubricating film is maintained at all times completely around the pump plunger while insuring at the same time good sealing at the inlet and by-

pass ports controlled by the plunger. Additionally, a novel retraction or delivery valve is provided in combination with the pump whereby the latter will not become air-bound.

Although only a single embodiment of the invention has been illustrated and described in detail it is to be expressly understood that the same is not limited thereto. For example, plug 50 as well as balancing or lubricating groove 17 may be eliminated if desired. Various changes may also be made in the design and arrangement of parts illustrated, as will now be understood by those skilled in the art, 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 apparatus of the class described, a cylinder having axially spaced inlet and by-pass ports in only one side thereof, a plunger reciprocable in said cylinder for controlling flow through said ports, and port means in said cylinder opposite said first-named ports for relieving the fluid pressure between adjacent surfaces of said plunger and cylinder during the pressure strokes of said plunger, said port means being covered by said plunger and connected to a low pressure space outside of the cylinder.
2. In apparatus of the class described, a cylinder having axially spaced inlet and by-pass ports in only one side thereof, a reciprocable plunger having a working clearance in said cylinder for controlling flow through said ports, and at least one relatively small pressure relief port in the other side of said cylinder opposite said first-named ports for relieving the fluid pressure in the clearance space between said plunger and cylinder in the vicinity of said relief port.
3. A fuel injection pump assembly comprising a cylinder having inlet and by-pass port means in only one side thereof, a plunger reciprocable in said cylinder for controlling flow to and from the cylinder through said port means, and port means covered by said plunger and circumferentially spaced more than 90° from said first-named port means for relieving, without eliminating, the fluid pressure between said plunger and cylinder opposite said first-named port means which tends to press said plunger toward said first-named port means during a pressure stroke of the plunger.
4. A fluid pressure pump comprising a cylinder having port means in one side thereof and a reciprocable plunger having a working clearance in said cylinder for controlling the flow through said port means, said cylinder having a small bleed port in the other side thereof continuously covered by said plunger, said port being so located that during the effective pumping stroke of said plunger the fluid pressure in the clearance space between the sides of said plunger and cylinder which tends to press said plunger toward said port means is relieved in the vicinity of said port.
5. A fuel injection pump comprising a cylinder and a piston reciprocable in said cylinder and cooperating therewith to form a fluid pressure chamber, said cylinder having only one inlet port adapted to communicate with said pressure chamber for supplying fuel to the latter and an outlet port in the same side thereof as said inlet port, said piston being adapted to cover said inlet port during the pressure stroke thereof and having parts cut away for connecting said outlet port with said chamber after the piston reaches a predetermined point during the pressure stroke thereof, and said cylinder having a relatively small opening in the other side thereof opposite said ports connecting the interior of the cylinder with a low pressure space outside of the cylinder, said opening being covered at all times by said piston.
6. In a fuel pump, a cylinder having axially spaced inlet and by-pass ports in only one side thereof and a piston in said cylinder adapted to form a pressure chamber therewith, said piston having a working clearance in said cylinder for reciprocation therein to vary the volume of said pressure chamber and control flow through said ports to and from said chamber and a groove on the periphery of the piston in continuous communication with said pressure chamber and adapted to register with the by-pass port, and said cylinder having a pressure relief port in the other side thereof opposite said first-named ports connecting the clearance space between said piston and cylinder with the exterior of the cylinder, said relief port having a smaller cross-sectional area than said first-named ports.
7. A fuel injection pump comprising a cylinder and a reciprocating piston having a working clearance in said cylinder and cooperating therewith to form a fluid pressure chamber, said cylinder having only one inlet port adapted to communicate with said chamber and an outlet port in the same side thereof as said inlet port, said piston being adapted to cover said inlet port during the final portion of the pressure stroke thereof and having parts thereof cut away for connecting said outlet port with said chamber after the piston reaches a predetermined point during the pressure stroke thereof, and said cylinder having a relatively small opening in the other side thereof opposite said ports connecting the clearance space between said piston and cylinder with a low pressure space outside the cylinder, the cross-sectional area of said opening being such in comparison to the corresponding areas of said ports that a greater fluid pressure will exist in said clearance space on the side of said opening than on the side of said ports during the pressure strokes of the piston, said greater fluid pressure being adapted to hold said piston lightly against the side of the cylinder containing said ports.
8. Apparatus of the class described comprising a cylinder having an inlet port and an outlet port at one side thereof, said ports being spaced axially of the cylinder from each other, and a reciprocable plunger having a working clearance in said cylinder for controlling flow to and from the latter through said ports, said cylinder also having at least one pressure relief port in the other side thereof, said relief port having constant communication with a low pressure chamber outside of said cylinder and being so located as to cause a reduction of the pressure between the plunger and the wall of the cylinder tending to press said plunger toward said pair of ports during the effective pumping stroke of said plunger, the inner end of said relief port terminating in the inner working surface of the cylinder and being small in comparison to said first-named ports.
9. Apparatus of the class described comprising a cylinder having a pair of axially spaced ports in one side thereof and a relatively small relief port in the other side thereof, the inner end of said relief port terminating in the plane

of the inner wall of said cylinder and having an area smaller than the area of either of said pair of ports, and a plunger reciprocable in said cylinder for controlling the flow of fluid to and from the latter through said pair of ports and for covering said relief port, the latter being so located as to cause a reduction of the pressure between the plunger and the wall of the cylinder tending to press said plunger toward said pair of ports during the effective pumping stroke of the plunger.

10. In apparatus of the class described, a cylinder having a pair of axially spaced ports in one side thereof, and a plunger reciprocable in said cylinder for controlling the flow of fluid to and from the latter through said pair of ports, said cylinder also having a relatively small pressure relief port in the other side thereof, said relief port being so located as to effect a reduction in, without eliminating, the resultant pressure tending to press said plunger toward said pair of ports during the effective pumping stroke of said plunger, the inner end of said relief port terminating in the sliding surface of the cylinder engaged by said plunger and having an area smaller than the area of either of said pair of ports.

11. In apparatus of the class described, a cylinder having a pair of axially spaced ports in one side thereof, and a plunger reciprocable in said cylinder for controlling the flow of fluid to and from the latter through said pair of ports, said cylinder also having a pressure relief port in the other side thereof opposite said pair of ports, said relief port having constant communication with a low pressure space outside the cylinder and being adapted to partially relieve the fluid pressure between the plunger and cylinder in a localized area surrounding the inner end of said relief port, the area of the inner end of said port being smaller than the transverse area of either of said pair of ports.

12. In apparatus of the class described, a cylinder having port means in one side thereof, and a reciprocable plunger having a working clearance in said cylinder for controlling flow to and from the latter through said port means, said cylinder also having at least one pressure relief port in the other side thereof having constant communication with a low pressure chamber outside of said cylinder, said pressure relief port being covered by the same longitudinal portion of the plunger which covers said port means and being small in comparison to said port means, the location of said relief port being such as to cause a reduction in the pressure between the plunger and the wall of the cylinder tending to press said plunger toward said port means during the effective pumping stroke of the plunger.

13. A port-controlled fuel injection pump comprising a cylinder having an inlet port and an outlet port at one side thereof, said ports being spaced axially of the cylinder from each other, a reciprocable plunger having a working clearance in said cylinder for controlling flow to and from the latter through said ports, and at least one pressure relief port in the other side of said cylinder in substantially the same longitudinal portion of the latter as said first-named ports, so as to cause a reduction in the pressure between the plunger and the wall of the cylinder tending to press said plunger toward said ports during the effective pumping stroke of the plunger, said pressure relief port being small in comparison to said first-named ports and having con-

stant communication with a low pressure chamber outside of said cylinder.

14. A port-controlled fuel injection pump comprising a cylinder having a pair of axially spaced ports in one side thereof, a relatively small relief port in the other side of said cylinder having an area smaller than the area of either of said pair of ports, and a slotted plunger reciprocable in said cylinder for controlling the flow of fluid to and from the pressure chamber of the pump through said pair of ports and for covering said relief port, said relief port being so positioned as to reduce, without eliminating, the fluid pressure which occurs between the plunger and the wall of the cylinder opposite said pair of ports and tends to press said plunger toward said pair of ports during the effective pumping stroke of said plunger.

15. In a fluid pressure pump, a cylinder having axially spaced inlet and by-pass ports at only one side thereof, a plunger reciprocable in said cylinder for controlling flow through said ports, said plunger having an indented portion adapted to cooperate with said by-pass port to relieve the pressure in the pressure chamber in said pump, and at least one additional port of small size in said cylinder having communication with a low pressure space outside of the cylinder, said last-named port being in the opposite side of said cylinder from said first-named ports and covered by said plunger at all times during reciprocation of the latter, the position of said last-named port relative to said first-named ports being such as to cause a reduction in, without eliminating, the pressure tending to press said plunger toward said first-named ports during the effective pumping stroke of the plunger.

16. A fuel injection pump comprising a cylinder having port means at one side thereof, a reciprocable plunger having a working clearance in said cylinder for controlling the flow of fuel to and from said cylinder through said port means, and a single port in the other side of said cylinder, said port being so located as to be covered by said plunger during the entire effective pumping stroke thereof and being further so located and of such size as to effect a reduction in, without eliminating, the resultant pressure tending to press said plunger toward said port means during said effective pumping stroke, said port having constant communication with a low pressure chamber outside of said cylinder.

17. In a fuel pump, a cylinder having flow control port means in one side thereof and a piston in said cylinder adapted to form a pressure chamber therewith, said piston having a working clearance in said cylinder and being reciprocable therein to vary the volume of said pressure chamber and to control the flow of fuel through said port means to and from said chamber, the periphery of said piston having a recess therein in continuous communication with said pressure chamber and adapted to register with said port means to relieve the pressure in said chamber, and said cylinder having a film-pressure relief port in the other side thereof opposite said port means connecting the clearance space between said piston and cylinder with the exterior of the cylinder, said film-pressure relief port being of such size as to effect a reduction in, without eliminating, the resultant pressure tending to press said piston toward said port means during the effective pumping stroke of the piston.

18. A fuel injection pump comprising a cylinder having port means in one side thereof and

a film-pressure relief port in the other side thereof, and a slotted reciprocating plunger having a working clearance in said cylinder for controlling the flow of fuel to and from the pressure chamber of the pump through said port means and for covering said film-pressure relief port during the entire effective pumping stroke thereof, said relief port being so positioned as to effect a reduction in, without eliminating, the resultant film-pressure in the clearance space between said plunger and cylinder tending to press said plunger toward said port means during the effective pumping stroke of said plunger.

19. A port-controlled fuel injection pump com-

prising a cylinder having an inlet port and an outlet port at one side thereof, said ports being spaced axially of the cylinder from each other, a reciprocable plunger having a working clearance in said cylinder for controlling flow to and from the latter through said ports, and at least one pressure relief port in the other side of said cylinder and in the same longitudinal portion of the latter as said first-named ports, said pressure relief port being small in comparison to said first-named ports and having constant communication with a low pressure chamber outside of said cylinder.

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