May 9, 1944. A. T. BREMSER 2,348,282

FUEL INJECTION APPARATUS

Filed May 1, 1941 2 Sheets-Sheet 1

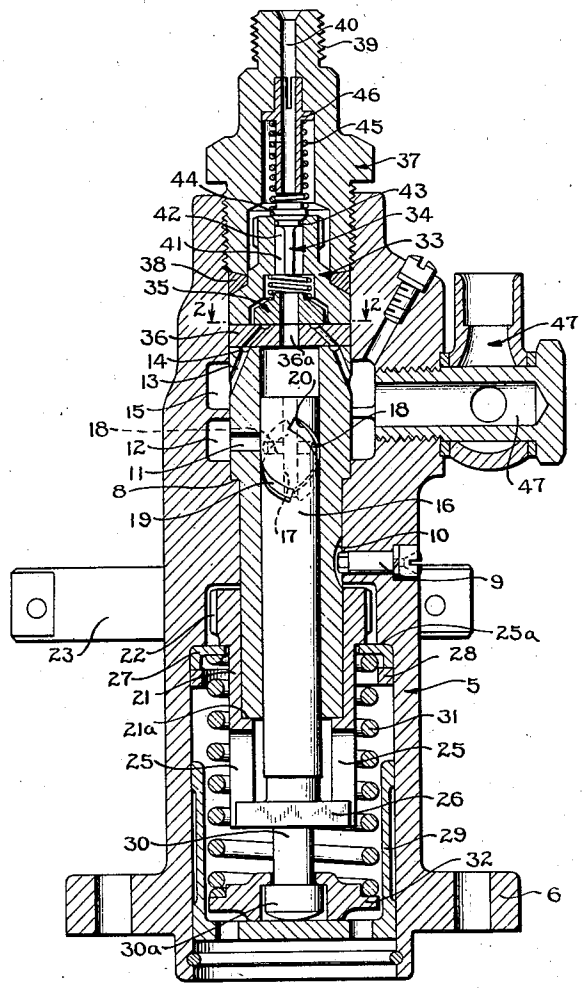

Fig 1

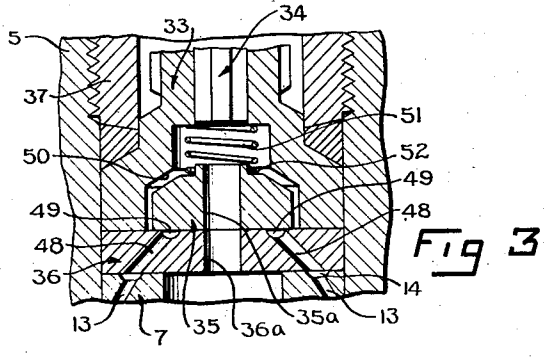

Fig 3

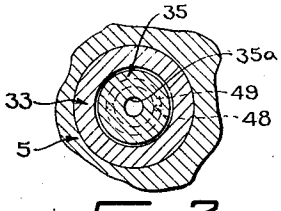

Fig 2

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FUEL INJECTION APPARATUS

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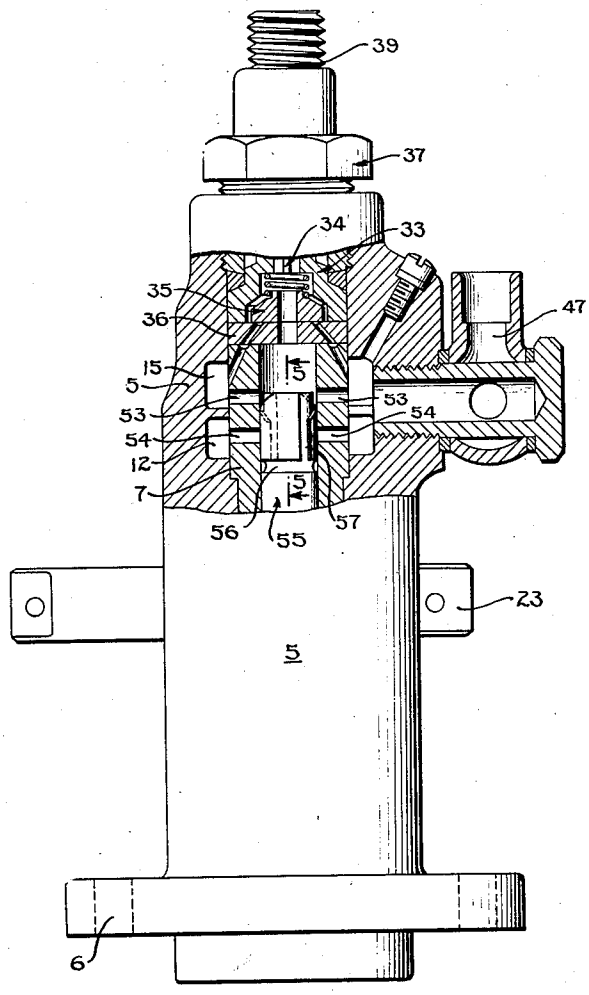

Fig 4

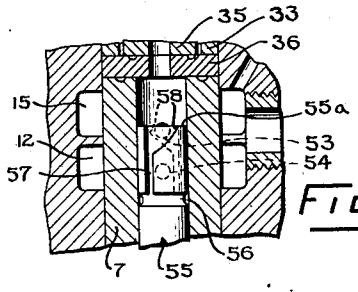

Fig 5

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FUEL INJECTION APPARATUS

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9 Claims. (Cl. 103—41)

This invention relates to pumping devices, and more particularly to fuel pumps for internal combustion engines of the solid fuel injection type.

It has been heretofore proposed to provide fuel pumps with suction valves in order to obtain more accurate metering of intake fuel than is obtained, for example, in pumps wherein the pressure plunger acts as a slide valve to control the fuel input and also as the pressure member for pumping said fuel. The provision of a separate suction valve in a pump of the latter type minimizes the wear on the plunger. In addition, the use of a suction valve permits the beginning of actual pumping to take place earlier in the cam stroke. In a pump with a suction port, a portion of the upstroke is lost while the suction port is being closed by the plunger, this lost portion being eliminated in the suction valve pump. However, these advantages, if realized, in the proposed prior devices, when combined with fuel pumps, were so offset by attendant disadvantages and additional costs in production, maintenance and replacement, as to render the valves impracticable. The valves, as proposed, have been relatively complex and delicate, requiring careful and accurate machining during production, and have been so combined with the other pump parts as to complicate the structure and assembly of the latter and as to be subjected to considerable wear during use, limiting the efficient utility thereof and requiring frequent replacement.

It is, accordingly, an object of the present invention to provide a fluid pump with a novel practicable suction valve mechanism wherein the above limitations and disadvantages of prior devices of this nature are obviated.

Another object is to provide a pump with a novel suction valve mechanism which is symmetrically and centrally disposed relative to the other moving parts of said pump.

A further object is to provide a novel valve mechanism disposed between and coaxial with the delivery valve and pressure chamber of a fuel pump for controlling fuel flow into said chamber.

Still another object is to provide a novel valve mechanism of the above type which permits direct and continuous fuel flow from the pressure chamber to the delivery valve.

A still further object is to provide a fuel pump with a novel suction valve adapted to have engagement with a plane surface for controlling the fuel flow into the pressure chamber of said pump.

Another object is to provide a novel suction valve in a fluid pump, said valve being compactly constructed, comprising a minimum number of parts and requiring no eccentrically located fluid discharge ports or passages through which the fluid is pumped from the pressure chamber.

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 drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are 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 drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a section view of one form of apparatus embodying the present invention, said section being taken along the longitudinal axis of said apparatus;

Fig. 2 is a sectional view of said apparatus taken substantially on line 2—2 of Fig. 1;

Fig. 3 is an enlarged view of a fragment of Fig. 1, showing in more detail the novel suction valve of the present invention;

Fig. 4 is a view similar to Fig. 1 of another embodiment of the invention; and

Fig. 5 is a sectional view with parts broken away taken along line 5—5 of Fig. 4.

An embodiment of the present invention is illustrated in the drawings, by way of example, in the form of a fuel injection pump assembly having a novel centrally and symmetrically located suction operated inlet valve in combination therewith. In the form shown, said pump assembly comprises a tubular casing 5 having laterally projecting lugs or ears 6 whereby the pump may be connected to an engine cylinder (not shown). 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 relative to said casing by a screw 9 which threadedly engages the casing wall and extends into an axially extending groove 10 in the cylinder wall. A by-pass or metering port 11 is provided in the wall of cylinder 7 adjacent the upper end thereof and connects the interior of said cylinder with a peripheral groove 12 provided in casing 5. A plurality of fuel inlet passages 13 are also provided in the upper end of cylinder 7, said passages extending angularly upward from the outer wall of said cylinder to the upper end thereof and connecting an annular groove 14 provided in said end with an annular channel 15 in casing 5. The functions of the above communicating passages will appear more fully hereafter.

Slidably extending within cylinder 7 is a pump plunger or piston 16, which also functions as a slide valve for controlling the flow of fuel through port 11. Plunger 16 is provided with an axially extending passage 17 and a radial passage 18 which continuously connects the upper end or

pressure chamber of cylinder 7 to a helical groove 19 in the surface of piston 16, which groove cooperates with port 11 and constitutes a metering or cut-off groove. If desired, an additional helical groove 20 may be provided in the surface of piston 16 diametrically opposite groove 19, the latter having continuous communication with passage 18 and being adapted to provide a pressure balancing effect on the piston. An additional radial by-pass port (not shown) may be arranged diametrically opposite port 11 thus providing dual by-pass means in the plunger and barrel.

Means are provided for angularly adjusting piston 16 to vary the relation between metering groove 19 and cut-off or by-pass port 11 and thereby vary the effective pumping stroke of the piston. In the form shown, said means comprises a sleeve 21 loosely surrounding the lower end of cylinder 7 in an enlarged portion of casing 5. Gear teeth 22 are formed on the upper end of sleeve 21 for cooperation with a rack 23 slidably mounted in casing 5, the movement of said rack being limited by any suitable means well-known in the art. The lower end of sleeve 21 is axially slotted as at 25 for slidably receiving a cross-bar 26 rigidly connected to plunger 16. Sleeve 21 is held against axial movement relative to cylinder 7 by an internal shoulder 21*a*, which engages the lower end of said cylinder, and an external shoulder which rests on the upper surface of an inwardly extending flange formed on a ring 27. The latter is positioned against an internal shoulder 25*a* in casing 5 and is held in place by any suitable means, such as a snap-ring 28. Accordingly, by reciprocating rack 23, angular adjustment of sleeve 21 and, hence, plunger 16 may be effected without affecting the reciprocating movement of the latter.

Means are also provided for reciprocating piston 16 in cylinder 7 without subjecting the former to any lateral forces or pressures which would cause unnecessary friction and binding. Said means in the illustrated embodiment includes tappet cup 29 which is slidably positioned in the lower end of casing 5 for engagement with an enlarged head portion 30*a* of a member 30 operatively connected to or integrally formed with the lower end of piston 16. 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 29 in a manner well understood in the art. The return or downward movement of piston 16 is effected by a spring 31 interposed between the internal flange of ring 27 and a slotted washer 32 which engages the upper shoulder of head 30*a*.

The upper end or pressure chamber of cylinder 7 may be connected by any suitable means to an injection nozzle (not shown) of an internal combustion engine cylinder. The means shown for this purpose comprise an adapter element 33 which constitutes a guide and a seat for a delivery valve 34 and also forms a housing for a novel suction valve 35, to be more fully described hereinafter. The seat for said suction valve and for said adapter element is preferably formed on the upper surface of washer element 36 which, in turn, rests on the upper end of cylinder 7 and is provided with a central passage 36*a* (Fig. 3), which communicates with a central passage 35*a* in valve 35 and directly connects the interior of adapter element 33 to the upper end or pressure chamber of said cylinder. To fix said adapter element, and said washer element in fluid-tight engagement with each other and relative to said cylinder, a gland or sleeve nut 37 is preferably provided and engages internal threads in the upper end of casing 5. A suitable packing washer 38 may be interposed between the inner end of member 37 and an external flange on adapter 33 to further insure fluid tightness. The upper end of member 37 terminates in a threaded portion or nipple 39 having a delivery passage 40 therein, whereby a conduit (not shown) leading to a fuel injection nozzle of an engine cylinder may attached thereto.

Delivery valve adapter 33 has a cylindrical passage therein through which the flow of fuel from cylinder 7 into member 37 and delivery conduit 40 is controlled by the delivery valve 34. The lower portion 41 of the latter engages the walls of the passage in said adapter and serves to guide the valve, said portion being provided with axial flutes or grooves 42 which permit the flow of fuel to an annular groove 43 located adjacent the upper end of said valve. The upper, enlarged portion 44 is adapted to engage a seat formed on the upper end of adapter 33 to prevent fluid flow from groove 43 into member 37. Valve 34 is normally held in fluid-tight engagement with adapter 33 by a spring 45 which engages the upper end 44 thereof and is centered within member 37 by means of a tubular member 46 which may also function as a stop for limiting the opening movement of valve 34.

The fuel inlet or supply line comprises inlet passage 47 which connects a source of fuel (not shown) to channels 12 and 15 and, hence, passages 13 thereby filling groove 14. The latter is connected by a plurality of passages 48 (Fig. 3) extending inwardly and upwardly through washer element 36 and communicating with an annular groove 49 in the upper face of said element. It will, of course, be understood that washer 36 may be eliminated, if desired.

Valve 35 controls the fuel flow from groove 49, the same being normally yieldably seated on the face of washer element 36 in order to prevent fuel flow from said groove. A chamber 50 is provided in adapter 33 to receive valve 35 and a spring 51 interposed between the upper wall of said chamber and said valve to normally hold the latter in engagement with washer 36. Valve 35 is preferably coaxial with said adapter and plunger 16 and comprises, as shown, a lower portion that is cylindrical, an upper portion that is frusto-conical and a shoulder 52 for supporting the lower end of spring 51. Chamber 50 is preferably similarly shaped, but is somewhat larger than valve 35 to permit movement of said valve relative to adapter 33 and to receive spring 51.

In operation, valve 35 controls the flow of fuel into the pressure chamber of cylinder 7 and, in turn, is controlled by the movement of plunger 16. Groove 14 is continuously filled with fuel from the fuel source and when plunger 16 is on its down stroke, the suction created in cylinder 7 permits the fuel pressure from the source to lift valve 35 against the resistance of spring 51 and produce a fuel flow into the pressure chamber of the pump. It is to be noted that prior to the creation of sufficient suction to actuate valve 35, delivery valve 34 is seated in fluid-tight engagement with adapter 33. When the pressure stroke begins, valve 35 shuts off any fuel flow into the pressure chamber and, as the pressure stroke continues, delivery valve 34 opens to allow

fuel to be pumped through passage 40 to the fuel injection nozzle in the well-known manner.

The adapter element 33 and suction valve 35, as well as washer 36, are readily assembled and need not be specially aligned as the angular position of washer 36 relative to the end of cylinder 7 and of valve 35 relative to the washer does not affect the fuel flow into the pressure chamber. It is to be noted that chamber 50 constitutes a coaxial continuation of the pressure chamber in cylinder 7 and that valves 34 and 35 are concentric with each other and with the line of flow of fuel under pressure, thereby producing an extremely compact and sturdy structure. Valve 35 is also centrally and symmetrically located relative to the fuel passages 48 and groove 49 and, accordingly, is not subjected to any unbalancing forces during operation.

Another embodiment of the invention is illustrated in Figs. 4 and 5 and comprises a novel plunger cooperable with the suction valve to control fuel inlet and thereby produce more efficient fuel flow for the various engine speeds. A substantial number of the parts of this second embodiment are similar to those shown in Figs. 1 to 3 and accordingly like numerals are utilized to designate like parts of the two structures. As shown, cylinder 7 is provided with a pair of radial diametrically opposed inlet ports 53 and with a pair of diametrically opposed by-pass ports 54 located further from the cylinder end than said inlet ports, said by-pass ports communicating with annular channel 12 and said inlet ports communicating with annular inlet passage 15. A novel plunger 55 is mounted for reciprocating movement in cylinder 7 and has an annular by-pass groove 56 formed therein. Groove 56 cooperates with ports 54 to by-pass fuel from the pressure chamber, being adapted to overlap said ports during the pumping stroke of the plunger for this purpose. It is to be noted that by providing an annular horizontal by-pass groove as shown, angular adjustment of the plunger has no effect on the point at which by-pass begins during the power or pumping stroke. A pair of axially extending peripheral passages, 57 are provided in the wall of plunger 55 to connect groove 56 with the pressure chamber.

In order to vary the point at which effective pumping of fuel begins during the plunger stroke, plunger 55 is provided with a pair of grooves each having at least one helical side 58, said grooves preferably communicating with passages 57. Piston 55 acts as the valve for ports 53 and the leading edge thereof which determines the point of closure of the inlet ports during the power stroke is constituted by helical sides or metering edges 58 and upper edge 55a of the piston. By angularly adjusting piston 55 the point of closure of the inlet ports 53 can be varied, the angular adjustment causing a different part of metering edges 58 to act as the leading edge for piston 51 in its valve action relative to said ports. It is to be understood that instead of a pair of by-pass ports and a pair of fuel inlet ports a single inlet and/or a single by-pass port could be utilized.

In operation, angular adjustment of piston 55 controls the effective pumping stroke of the pump and the quantity of fuel delivered thereby to the engine during each stroke However, instead of controlling the point of by-pass in order to accomplish this result, the by-pass point is kept constant while the point of closure of the fuel inlet is varied, thereby making possible a control of the point at which effective pumping begins. Valve 35 acts to prevent turbulence and to insure a proper fuel flow into the pressure chamber, particularly during full load engine operation when the fuel inlet ports 49 are closed almost at the beginning of the upstroke of piston 55. If desired, piston 55 may extend above ports 53 in its bottom dead center position so that at full load operation, for example, ports 53 can be kept closed by the piston during the entire piston stroke.

There is thus provided a fuel pump having a novel suction valve disposed between the delivery valve and the pump plunger whereby fuel flow from the pump to the fuel source during the power or pumping stroke of the pump plunger may be eliminated and a relatively uniform flow into the pressure chamber is attained during the suction stroke of the plunger. The valve structure is extremely simple, comprising a minimum of moving parts and adapted to be readily actuated by the differential between the pressure of the inlet fuel and the pressure in the pressure chamber of the pump. The location of the valve requires a minimum routing of the high pressure, rapidly moving fuel through tortuous passages, as compared to prior known fuel pumps of a similar type. The shapes of the valve and the chamber provided therefor, as well as the washer element which preferably cooperates therewith, are such that these parts can be readily machined by present production methods in a minimum number of operations. The assembly of the parts can be readily accomplished, requiring no special alignment operations during assembly or during operation of the novel apparatus. The interruption of the fuel flow by the suction valve is accomplished by the engagement of two relatively large plane surfaces which can be readily finished to a very great accuracy and during operation of the valve these plane surfaces are subjected to substantially no wear which would affect their seal.

There are also provided novel means for controlling the quantity of fuel delivery from the pump, said means operating to maintain the point in the pumping stroke at which pumping ceases constant while varying the point at which effective pumping begins. To accomplish this, novel plunger means are provided and said means are adapted to cooperate with inlet fuel ports in the cylinder and with the suction valve to control fuel flow into the pressure chamber. As a result of this arrangement for controlling fuel flow from the pump, more economical fuel consumption is realized in an engine connected with said pump and adapted to actuate the pump plunger. It is possible to obtain, for example, at all speeds and loads, including idling speeds, a flow of fuel into the engine cylinder until the piston in said cylinder reached a predetermined position in its travel, and to utilize the most effective portion of the upstroke of the pump piston for pumping fuel at all engine speeds and loads. By providing a suction valve to cooperate with the pump piston and the inlet port, proper quantities of fuel can be introduced into the pressure chamber at high loads and effective pumping can start almost simultaneously with the beginning of the upstroke of the pump plunger.

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 washer

element 36 might be eliminated and valve 35 caused to seat on the end of cylinder 7, in which event groove 14 would be located in the end of said cylinder so as to be overlapped by said valve in the same manner as groove 49 is in the illustrated embodiment. Various other changes may be made in the design and arrangement of parts illustrated without departing from the spirit and scope of the invention. For a definition of the limits of the invention, reference will be had primarily to the appended claims.

What is claimed is:

1. In a fluid pumping means comprising a cylinder and an adapter, the latter having a valve-controlled discharge passage and a fluid chamber connected to said passage, the combination therewith of a valve mechanism comprising a valve seat secured between said adapter and said cylinder, fluid inlet passages communicating with said chamber through said seat, and a pressure responsive movable member disposed in said adapter chamber and adapted to operatively engage said seat to control the flow of fluid from said inlet passages into said chamber, said seat and said member having central passages therethrough providing continuous communication between the interior of said cylinder and said adapter chamber.

2. In a fuel pump, a cylinder, a pump plunger mounted for reciprocable movement in said cylinder, an adapter, a disc-like member secured between said adapter and said cylinder, said member having a passage therethrough connecting the interior of said adapter to said cylinder and an annular groove in the face thereof communicating with the fuel inlet of the pump, and a pressure responsive valve adapted to seat on the grooved face of said member to control the fuel flow from said annular groove into said cylinder.

3. In a fluid pump having a reciprocable pump plunger, a pressure chamber centrally disposed in said pump relative to said plunger, said chamber having an annular groove concentric with the axis of said plunger formed in the wall thereof, said groove communicating continuously with the fluid inlet of said pump, and a pressure responsive valve disposed in said chamber, said valve being adapted to engage said groove-containing wall to control the fluid flow from said groove into said chamber.

4. In a fuel pump, a cylinder, a pump plunger reciprocably mounted therein, an adapter, a washer-like valve seat disposed between said adapter and said cylinder, said seat having passages therein communicating with the fuel input line of said pump, said adapter, valve seat and cylinder constituting a fuel pressure chamber, and a pressure responsive annular valve member centrally disposed relative to an extension of the cylinder axis and adapted to engage said valve seat to control the fuel flow from said passages.

5. In a fuel injection pump, a pressure chamber comprising a cylinder having an inlet port and a by-pass port, and a piston reciprocating in said cylinder, said piston being adapted to connect each of said ports to the pressure chamber at different points in the piston stroke, a fuel inlet passage communicating with said pressure chamber, and a valve operable in said chamber for controlling the fuel flow from said passage into the chamber.

6. In a fuel injection pump, a pressure chamber comprising a cylinder having an inlet port and a by-pass port, a piston reciprocable in said cylinder, said piston being adapted to connect each of said ports to the pressure chamber at different points in the piston stroke, the point of communication between the pressure chamber and the inlet port being determined by the angular position of said piston relative to said cylinder, and the point of communication between the pressure chamber and the by-pass port being unaffected by angular adjustment of said piston, means for angularly adjusting the piston relative to the cylinder, a fuel inlet passage communicating with said pressure chamber, and a valve for controlling the fuel flow from said passage into said chamber, said valve being operable in accordance with the pressure in said chamber.

7. In fuel injection apparatus for internal combustion engines, a cylinder having port means for directing fuel to and from a pressure chamber, a plunger reciprocable in said cylinder for varying the volume of said chamber and adapted, during the pumping stroke thereof, to cut off communication between said port means and said chamber at a point dependent upon the relative angular positions of said plunger and cylinder and to thereafter establish communication between said port means and chamber, means for angularly adjusting said plunger relative to said cylinder, means including a fuel passage for connecting said chamber to a source of fuel, and valve means in said chamber operable in accordance with pressure in the latter for controlling communication between said chamber and said passage.

8. In fuel injection apparatus for internal combustion engines, a cylinder having port means for directing fuel to and from a pressure chamber, a plunger reciprocable in said cylinder for varying the volume of said chamber and adapted, during the pumping stroke thereof, to cut off communication between said port means and said chamber at a point dependent upon the relative angular positions of said plunger and cylinder and to thereafter establish communication between said port means and chamber at a predetermined fixed point of the plunger pumping stroke, means for angularly adjusting said plunger relative to said cylinder, means including a fuel passage for connecting said chamber to a source of fuel, and valve means in said chamber operable in accordance with the pressure in the latter for controlling communication between said chamber and said passage.

9. In fuel injection apparatus, a delivery valve adapter, a cylinder having port means for conveying fuel to and from a pressure chamber formed in said cylinder and adapter, a plunger reciprocable in said cylinder for varying the volume of said chamber and adapted, during the pumping stroke thereof, to cut off communication between said port means and said chamber at a point dependent upon the relative angular positions of said plunger and cylinder and to thereafter establish communication between said port means and chamber at a predetermined fixed point of the plunger pumping stroke, means for angularly adjusting said plunger relative to said cylinder, a disc-like element secured between said adapter and said cylinder, said element having a passage therethrough connecting the interior of said adapter to said cylinder and a second passage therethrough connecting said chamber to a source, and an annular valve member operable in accordance with the pressure in said chamber for controlling flow through said second passage into said chamber.

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