

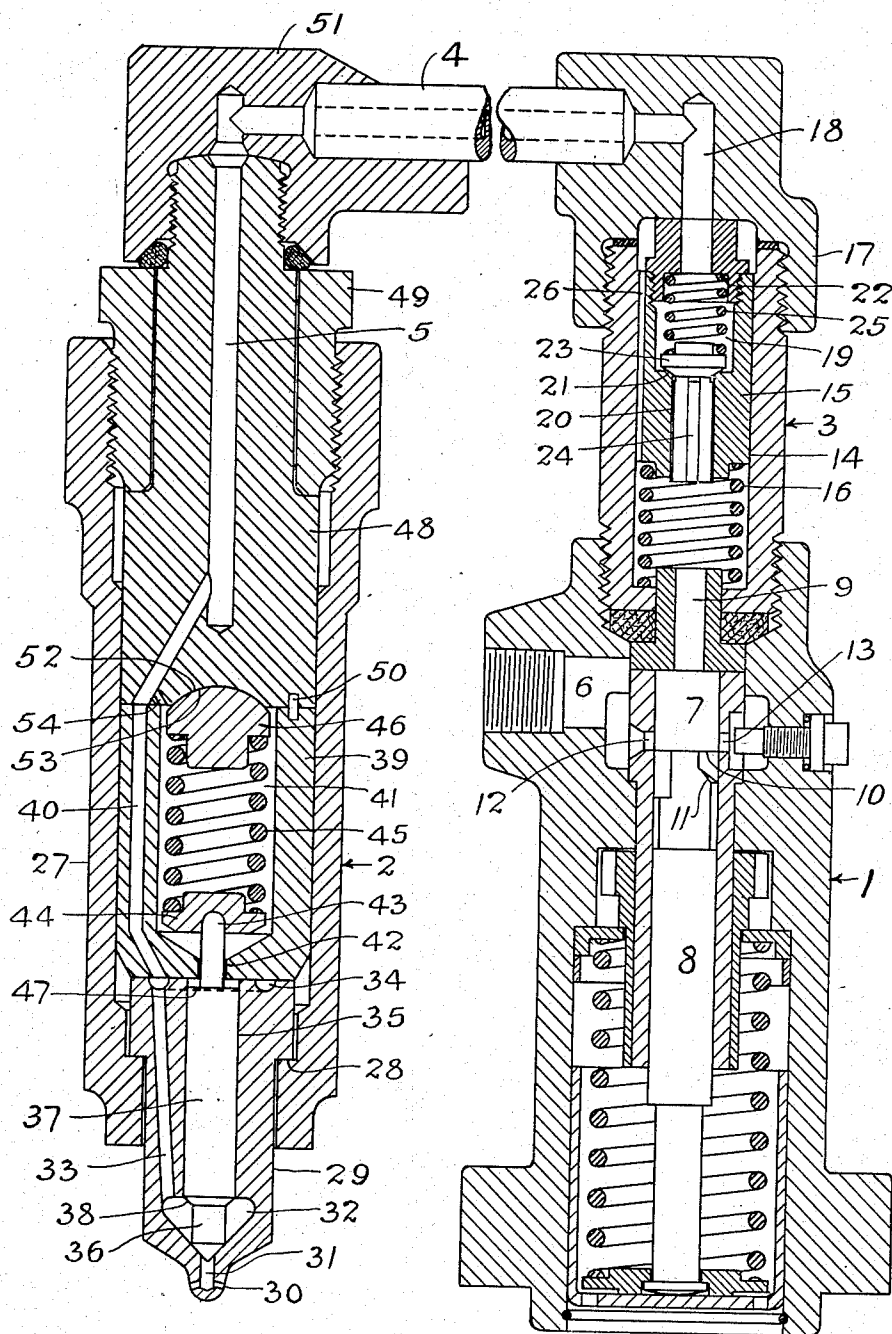
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LIQUID FUEL INJECTION APPARATUS

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LIQUID FUEL INJECTION APPARATUS

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1 Claim. (Cl. 103—41)

This invention relates to liquid fuel injection apparatus, and more particularly to a fuel injection apparatus having an injector provided with a hydraulically-loaded valve.

It has been found advisable, in the case of high speed, high power modern oil (Diesel) engines, to employ a fuel injection apparatus in which the valve of the injector is closed, not only by the usual valve spring, but also by some auxiliary closing means which augments the closing force of the valve spring and insures a quick closing of the valve, effecting a sharp cut-off of the fuel then being injected at a high pressure. This sharp cut-off prevents dribbling of fuel into the cylinder at the end of injection, which dribbling would result in poor atomization of the fuel in the cylinder, and poor combustion, accompanied by poor economy and operation of the engine.

It has been proposed to employ hydraulic means to provide the force augmenting the force of the usual valve spring, and various attempts have been made previously to provide a satisfactory hydraulic feature. The present invention is directed to hydraulically augmenting the usual valve-closing spring in a simple, economical manner necessitating only a slight change in the usual fuel injector.

An object of the present invention is to provide a fuel injection apparatus having an injector provided with a valve closable by the combined forces of a spring and a hydraulic feature.

Other and further objects of this invention will appear from the following description, the accompanying drawing and the appended claim.

Referring to the drawing forming a part of this application, the figure shown therein is of a fuel injection apparatus for one cylinder of an oil (Diesel) engine, shown in vertical central section, parts being shown in full and parts being broken away.

The fuel injection apparatus includes a fuel pump 1, a fuel injector 2, and a constant residual pipe-line pressure device 3 connected to the delivery end of the pump 1. A pipe-line 4 connects the device 3 with a fuel passage 5 of the injector 2.

The pump 1 is of conventional design, and includes a fuel inlet 6 opening into a cylinder 7, a plunger 8 disposed in the cylinder, and a fuel delivery port 9. Control edges 10 and 11 on the plunger are adapted to control ports 12 and 13 of fuel inlet 6 in the usual manner as will later more fully appear.

The device 3 includes a cylinder 14 connected

at one end to the pump and in communication with port 9, and a slidable piston 15 disposed in the cylinder 14. A spring 16 engages the piston 15 and the opposed lower end of the cylinder 14 for forcing the piston 15 away from the pump. A fitting 17 is secured to the other end of the cylinder 14. It is provided with a passage 18 adapted to be controlled by piston 15, as will presently appear.

Piston 15 is made in two pieces, as is clearly shown in the drawing, this being for convenience in manufacture. It has a central bore for the passage of fuel, the bore being enlarged intermediate its ends to provide a chamber 19, the reduced portion below the chamber 19 forming a guide 20 for a valve stem, as will presently appear, a valve seat 21 being formed on the shoulder between the guide 20 and chamber 19. The shoulder between the chamber 19 and the upper reduced portion of the bore provides a valve spring seat 22.

A valve 23 is disposed in chamber 19, normally seated on valve seat 21. It includes a fluted stem 24 disposed in guide 20. A spring 25, compressed between valve 23 and seat 22, normally holds valve 23 in closed position.

Spring 16 normally holds piston 15 in full upward position so that the upper end of the piston acts as a valve closing the upper end of cylinder 14 from passage 18, the upper end of the piston engaging the adjacent face of the fitting 17. Thus the portion of this face surrounding passage 18 provides a valve seat for the piston upper end. An external longitudinal groove 26 is formed in the piston, for by-passing the piston and connecting passage 18 with port 9. This by-passing will be later more fully referred to.

The fuel injector includes a casing 27 open at both ends and provided adjacent its lower end with a shoulder 28. A nozzle 29 is carried by the casing and seats against the shoulder 28 and projects through the open lower end of the casing. The nozzle includes the usual injection jets 30, injection port 31, injection fuel chamber 32, passage 33 leading thereto, groove 34 in its upper face in communication with passage 33, cylinder 35, valve 36 controlling port 31, and plunger 37, formed integral with valve 36 and being slidably disposed in the cylinder 35. Plunger 37 has a shoulder 38 providing a working pressure face disposed in chamber 32.

A spring housing member 39 is disposed in the casing above and seating on the nozzle 29. It has a passage 40 in communication with groove 34, a large loading fuel and spring chamber 41,

and a small passage 42 connecting chamber 41 with cylinder 35. A stem 43 forming an integral part of plunger 37 extends upwardly through passage 42 and supports a spring seat 44 disposed in chamber 41. A spring 45 is disposed between seat 44 and a seat 46, later to be referred to. Stem 43 is of smaller diameter than passage 42, the part of plunger 37 in cylinder 35 providing a shoulder 47 therewith. Shoulder 47 provides part of an upper working pressure face for the plunger 37, the remainder being provided by the seat 44 supported on the stem 43.

An orificed head 48 is disposed in the casing and held therein by a threaded sleeve 49, head 48 engaging the upper face of member 39 and closing chamber 41, and being connected against rotation relative to member 39 by a dowel 50. Head 48 is threaded at its upper end and a pipe fitting 51 is secured thereto, pipe-line 4 being connected to fitting 51. Passage 5 is formed partly in fitting 51 and partly in head 48 and connects pipe-line 4 with passage 40, as is clearly shown in the drawing. Head 48 has a concave seat 52 in its lower face, in which seats the spring seat 46, seat 46 having a convex surface 53 coinciding with the seat 52.

The present invention contemplates the filling of the chamber 41 with fuel for augmenting the loading of the spring-loaded plunger 37. It is contemplated that this fuel may enter the chamber 41 by passage between the plunger 37 and the wall of cylinder 35, sufficient clearance being provided for this. However, it has been found more satisfactory to provide a small port connecting the loading fuel chamber 41 with the passage 5 or with a passage connected to the passage 5. For instance chamber 41 might be connected to passage 40 or 33, or cylinder 35 above plunger 37 might be connected to any suitable one of these passages.

In the drawing a port 54 is shown connecting chamber 41 with passage 5. This port is relatively small in diameter. During delivery periods (injection periods) of the pump, the passage 5 is full of high pressure fuel. Port 54 serves to let fuel enter chamber 41 from passage 5 during such periods, but reduces the pressure thereof by throttling, the pressure in chamber 41 thereby then being below that in passage 5 so that plunger 37 may be lifted by the pressure differential (delivery pressure). Between delivery periods the constant residual pipe-line pressure device maintains a constant pressure in the delivery passage between valves 23 and 36 lower than delivery pressure, but sufficiently high so that engine cylinder pressures developed during the compression stroke can not raise plunger 37, and port 54 permits the pressure in chamber 41 to be lowered by substantially equalizing with the residual pipe-line pressure.

The operation of the fuel injection apparatus is as follows: When the pump plunger 8 is at the end of its suction stroke, as shown in the drawing, the space above the plunger 8 is in communication with the fuel inlet 6 for supply of fuel and the chambers and passages of the injector will be full of fuel at a constant pressure due to the constant residual pipe-line pressure device. The plunger 8 will be moved upwardly by the usual cam (not shown) and until edge 10 covers ports 12 and 13, the fuel above the plunger 8 will be forced back into the fuel inlet 6. When ports 12 and 13 are covered, the plunger 8 will then force the fuel thereabove toward the injector. This delivery will continue until edge 11

uncovers port 13, at which time the fuel above the piston will "spill" back into port 13, terminating injection, all in the usual manner. The period between closing of ports 12 and 13 by edge 10 and opening of port 13 by edge 11 is known as the delivery period. This may be adjusted by rotating plunger 8 in a well-known manner, edge 11 being helical.

During the delivery period, fuel is forced into the device 3, pushing valve 23 off seat 21 and delivering fuel through passage 18, pipe-line 4 and passages 5, 40 and 33. Thus chamber 32 is filled with injection fuel at injection pressure, and this, acting on shoulder 38, lifts plunger 37, effecting injection of fuel into the engine cylinder. The injection pressure initially acts only against the area of the shoulder 38 to lift the plunger 37. At this time, plunger 37 is being forced downward by the pressure of spring 45 and by the pressure of the fuel oil in loading fuel chamber 41, which at the beginning of the delivery period is at substantially the constant residual pipe-line pressure.

Raising of the plunger 37 compresses the fuel in chamber 41 a small amount. The pressure of the fuel in chamber 41 is further raised during the delivery period due to communication, by means of port 54, between the chamber 41 and the passage 5, which is then full of fuel at high pressure.

At the end of the delivery period, there is a sharp drop in pressure in passage 5 and chamber 32 due to the aforementioned spill of fuel back into port 13 and the return of the delivery valve 23 to its seat 21. Plunger 37 is therefore quickly and abruptly returned to its lowermost position closing port 31. This is accomplished by the closing force of the spring 45 augmented by the closing force of the fuel compressed in chamber 41. This quick closing of port 31 abruptly terminates the injection of fuel into the engine cylinder, stopping injection while the pressure of the fuel in chamber 32 is sufficient to provide complete atomization, and thereby preventing dribbling of fuel into the engine cylinder with its accompanied poor combustion results.

As soon as the delivery valve 23 engages its seat 21, the fuel trapped between the valves 23 and 36 adjusts itself to a predetermined constant residual pipe-line pressure by exerting a moving force against piston 15, moving it downward against the pressure of spring 16, and opening passage 18 to groove 26. Thus a small amount of fuel is bypassed from passage 18 to port 9 decreasing the pressure between valves 23 and 36 sufficiently so that spring 16 can return piston 15 to its uppermost position closing passage 18 from groove 26. Thus device 3 is adapted to maintain a predetermined constant residual pipe-line pressure.

Between the delivery periods, the chamber 41 again substantially equalizes the pressure therein with the residual pipe-line pressure through the port 54.

It will be seen from the foregoing that at the beginning of the injection into the engine cylinder, the plunger 37 is moved upward to initially open port 31 against a predetermined pressure, i. e., the pressure of spring 45 augmented by the pressure (constant residual pipe-line pressure) of the fuel in chamber 41. This pressure is always the same for the beginning of each injection. However, at the end of injection, plunger 37 is forced downward by the pressure of spring 45 augmented by an increased pressure of the fuel in chamber 41, the fuel pressure then

being increased by compression due to raising of plunger 37, and also by an increase in pressure due to the flow of high pressure fuel through port 54 during the delivery period. Therefore valve 36 is opened against a relatively low pressure, and closed by a relatively high pressure. This results in a clear-cut injection period, starting by a quick opening of the valve, preventing initial dribbling, and ending by an abrupt closing of the valve, preventing dribbling at the end of injection.

The afordescribed operation of the apparatus applies also to the injector not provided with the port 54, wherein the space between the plunger 37 and cylinder 35 permits passage of loading fuel to chamber 41 and equalization of pressures, between delivery periods, of the fuel in chambers 32 and 41. The space between the plunger 37 and cylinder 35 performs the functions of the port 54.

While there has been hereinbefore described an approved embodiment of this invention, it will be understood that many and various changes and modifications in form, arrangement of parts and details of construction thereof may be made without departing from the spirit of the invention and that all such changes and modifications as fall within the scope of the appended claim are contemplated as a part of this invention.

The invention claimed and desired to be secured by Letters Patent is:

A liquid fuel injection apparatus comprising a fuel injection pump of the unloading type having a pumping element for delivering pressure fuel for injection; a fuel injector having a casing provided at one end with a valve seat, an injector valve for said seat housed in said casing for reciprocating axial movement and having a working pressure face between its ends for raising said

valve by fuel pressure and another working pressure face at the end thereof remote from said valve seat, means forming a continually fuel-full chamber open at one end to said valve remote end face, a spring in said chamber loading said valve for closing said valve, said valve remote end being imperforate for completely closing said chamber at its said end preventing fuel pressure drop in said chamber due to passage of fuel from said chamber past said valve; a fuel delivery passage having a portion extending through said injector casing to said valve seat, another portion extending through said pump to said pumping element, and a portion connecting said two first mentioned portions; and a constant residual fuel pressure device forming part of said passage and disposed between said valve seat and said pumping element, including a check valve in said passage openable away from said pumping element, said check valve being open during said pump pressure stroke, and means for reducing the fuel pressure to a predetermined constant residual pressure in said passage between said injector valve seat and said check valve when said injector valve is closed, the passage between said injector valve seat and said check valve being continually full of fuel under pressure, said injector valve being raised on said pressure stroke of said pump for fuel injection simultaneously with said stroke, said injector valve automatically closing at unloading of said pump, said casing having a throttle aperture connecting said passage between said valve seat and said device with said chamber for obtaining equalization of pressures therebetween, said chamber pressures facilitating injector valve opening when at said constant residual pressure and enhancing said injector valve closing when at injection pressure.

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