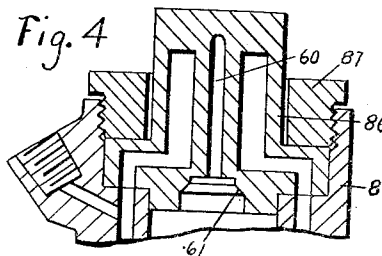
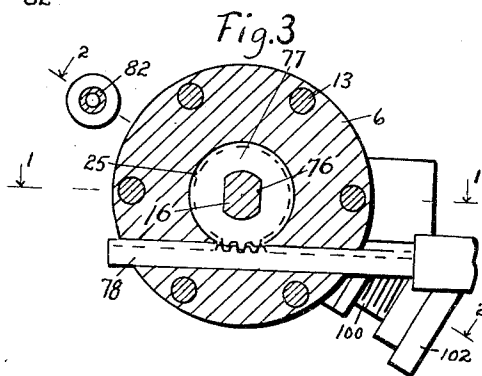
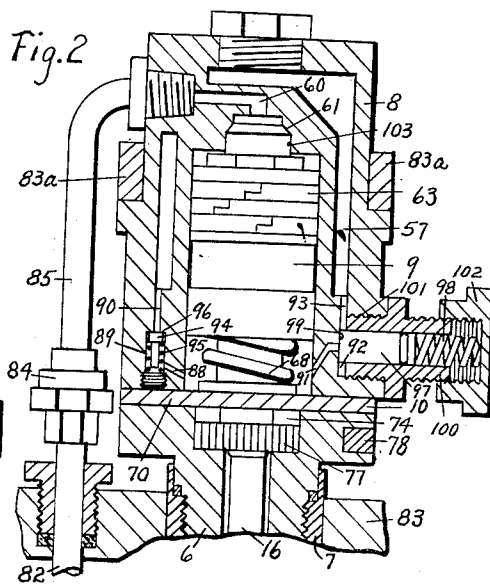
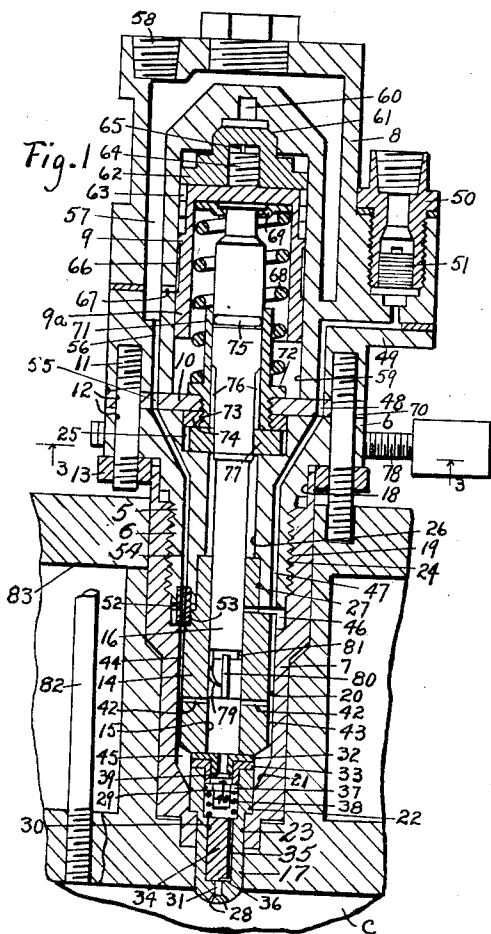


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FUEL INJECTION APPARATUS

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FUEL INJECTION APPARATUS

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1

The invention relates to fuel injection apparatus and more particularly to compression pressure operated fuel injection apparatus.

The main object of the invention is to provide a unit injector or combined high pressure fuel pump and sprayer of simple construction of the type in which the fuel pump plunger is directly operated by a compression pressure operated actuating piston mounted in a cylinder on the top of the injector housing.

A further object of the invention is to provide a unit injector of the type above described formed to provide cooling spaces for the pump body and the cylinder of the operating piston in which the fuel is successively passed through said spaces and in which the actuating piston and its cylinder forms a pump connected by a check valve and a relief valve with the cooling space of its cylinder and acting as a coolant pump for internal cooling of the actuating piston and also as a control for the movement of said piston.

A further object of the invention is to provide a unit injector and a compression pressure operated actuator therefor including an actuating piston and its cylinder in which fuel from a supply pipe is used to supply the injector, cool both the injector housing and said cylinder, and serve as a coolant for the interior of the operating piston, as a cushioning medium for taking the shocks incident to stopping the movement of said piston, as a control fluid for the timing of the beginning of injection, and as a lubricant for the actuating piston, the fuel being continuously circulated through the injector housing and the actuator cylinder.

The invention further consists in the several features hereinafter set forth and more particularly defined by claims at the conclusion hereof.

In the drawings:

Fig. 1 is a vertical sectional view through fuel injection apparatus embodying the invention taken on the line 1-1 of Fig. 3, parts being broken away;

Fig. 2 is a vertical sectional view taken on the line 2-2 of Fig. 3;

Fig. 3 is a horizontal sectional view taken on the line 3-3 of Fig. 1;

Fig. 4 is a detailed sectional view showing certain modifications.

Referring to the drawings, the numeral 5 designates generally the injector housing or casing here shown as formed of an upper part 6, and a lower part 7, 8 the cylinder of the compression pressure operated actuator; 9 the actuating or

2

operating piston working in the cylinder 8, and 10 a partition between the housing 5 and the cylinder 8. The partition 10 has flat faced fluid-tight abutting engagement with the base of the cylinder 8 on one side and the top of the housing 5 on its other side, these parts being tightly clamped together as a unit by studs 11 anchored in the base of the cylinder 8 and extending through aligned circumferentially spaced holes 12 in the partition and part 6 of the housing and provided with clamping nuts 13. The piston 9 has a checking piston portion 9a.

The injector may take various forms but will include a pump barrel 14 having a bore 15, a high pressure fuel pump plunger 16 working in said bore, and a sprayer including discharge valving and a nozzle 17.

The lower part 7 of the injector housing is shown as a sleeve member having concentric differential bores 18, 19, 20, 21, 22, and 23. The bore 19 is threaded to engage the threaded lower end 24 of the part 6. The part 6 has concentric centrally disposed differential bores 25, 26, and 27.

The nozzle 17 extends through the cylindrical bores 23 and 22 into the conical bore 21 and seats on the shoulder formed between the bores 23 and 22 and is provided with spray orifices 28.

Any suitable form of discharge valving may be used between the fuel pump and the spray nozzle, and as an example I have shown the nozzle member 17 as provided with concentric bores 29, 30, and 31. A valve seat member 32 in the form of a flanged sleeve has its tubular seat portion mounted in the bore 29 with its flange abutting the top of member 17 and another valve seat member 33 in the form of a flanged sleeve has its tubular seat portion mounted in the seat portion of the member 32 and its flange abutting the top of the flange of said member 32. A cylindrical plug 34 is mounted in the bore 30 and has flats 35 forming fuel passages connected with grooves 36 (one shown) at its lower end which communicate with the upper end of the bore 31 whose lower end connects with the spray orifices 28. A check valve 37 is mounted in the bore 29 and is normally urged against the seat of the member 32 by a compression spring 38, the head of said valve having flats or recesses to provide fuel clearance. A flat faced disk check valve 39 is mounted in the bore of sleeve 32 and may seat on the seat member 33, in case of blow back, has fuel clearance flats or grooves and is retained above the valve 37 by a projection 40 on said valve.

The lower end of the pump barrel 14 seats on the top of seat member 33, and its upper end of reduced diameter fits in the bore 27 and seats against the shoulder formed between the bores 26 and 27. The barrel 14 has inlet and relief ports 42 controlled by the plunger 16 and connected with fuel grooves 43 and 44. The lower end of the barrel is spaced from bore 21 to form a coolant space 45 surrounding the discharge valving. A portion of the upper end of the barrel 14 is spaced from the lower end of the part 5 to form a coolant space 46.

The part 6 has an inlet conduit 47 which at its upper end communicates with a passage 48 in the partition 10 that connects with an inlet passage 49 in the base of the cylinder 8 which connects with a passage including an inlet fitting 50 and a strainer 51. The conduit 47 leads to the coolant space 46 which is connected with the space 45 by the groove 43 in the barrel. The groove 44 in the barrel is connected at one end with the space 45 and at its other end communicates with a short pipe 52 anchored in the part 6 and extending into a notch 53 in the barrel to key the barrel to the body or casing 6. The pipe 52 forms the inner end of a fuel return conduit 54 which connects with aligned passages 55 and 56 in the partition 10 and cylinder 8, respectively, the passage 56 discharging into a coolant or jacket space 57 which has an outlet 58 at its upper end.

The cylinder 8 has a centrally disposed bore 59 in which the operating piston 9 works. A passage 60 connects with the central portion of the top of the bore and has a valve seat portion 61 against which the valved head end 62 of the piston 9 seats. The piston rings 63 are mounted in a groove in the piston, one side of which is formed by the head end 62 which has threaded connection with a centrally disposed threaded stud 64 projecting from the main body of the piston, a lock washer 65 being mounted between the two piston parts. The piston 9 also has a very shallow groove 66 formed therein adapted to communicate with a port 67 communicating with the jacket space 57, so that if any gases leak by the rings 63, they will find their way out into the jacket 57 and be carried away through the fuel return which may include a suitable separator. Also this groove will act as a lubricant groove to receive fuel from the space 57 to lubricate the rings 63, this groove preferably being not more than one-thousandth of an inch in depth.

The piston 9 is returned and normally held in its outer or upper position by a spring 68 interposed between the partition 10 and a washer 69 abutting the inner side of said piston, said washer being split to receive the upper flanged end of the plunger 16.

The partition 10 may be a one piece member having a flat disk portion 70 and a centrally disposed tubular portion 71, but to facilitate grinding and finishing operations the portions 70 and 71 are preferably made as separate pieces, the portion 70 being a plain flat disk and the tube 71 being provided with an annular shoulder 72 and a threaded end 73 to receive a clamping nut 74 by which the disk is clamped between it and said shoulder.

The stem of the plunger is mounted with a close sliding fit in the bore of the tube 71 and may be provided with an O-ring 75 to further prevent leakage from the interior of the cylinder 8. The stem has flats 76 slidably engaging the flat sides of a centrally disposed opening in a

pinion 77 which is mounted in the bore 25 in the top of the part 6 in which the nut 74 is also mounted. The pinion meshes with a rack 78 that works in a guide slot in the part 5.

Metering of the fuel is accomplished by rotating or angularly shifting the position of the plunger 16. As herein shown, the plunger 16 itself is a metering member cooperating with the ports 42, said plunger being recessed and grooved to provide a control edge 79 and a passage 80 communicating with an annular recess 81 whereby as the plunger 16 is moved relative to the ports 42, the pump chamber formed in the barrel 14 will first be cut off from said ports and sooner or later, depending upon the angular adjustment of said plunger, will be connected with one of the ports 42 when the control edge 79 passes said port. This form of metering is of the known constant stroke, by-pass controlled type. Instead of the plunger 16 being scrolled, this plunger may be a plain round rod and metering be effected by providing a scroll on the skirt of the piston 9 cooperating with a relief port in the cylinder 8 as shown, for example, in my copending application Serial No. 592,675, filed May 8, 1945, Patent No. 2,516,690, July 25, 1950, in which case the connection between the plunger 16 and the piston 9, for example an Oldham coupling, would permit angular adjustment of the piston 9 by a similar adjustment of the plunger 16.

The structure above described has been designed especially for using the compressed gases of the engine cylinder, in which the injector is mounted, as an operating fluid for the piston 9, these gases being free to move in a conduit connecting the combustion chamber C of the engine with the passage 60. This conduit may include a pipe section 82 extending through the cylinder head 83 of the engine and connected by a union coupling 84 with a pipe section 85 connected with the passage 60.

As shown in Figs. 1 and 2, the cylinder 8 has an integral head, but it may be formed with a separate head 86 clamped in fluid-tight relation with the main body of the cylinder, by a sleeve nut 87, as shown in Fig. 4, if desired. The injector may be held in the cylinder head by any suitable clamping means as, for example, a work holding clamp whose forks 83a are shown in Fig. 2.

In order to supply fuel as a coolant to the interior of the cylinder 8 and also make the piston 9 function as its own coolant pump, the interior of said piston connects with the jacket space 57 through valve controlled passages. One of these passages includes connecting conduits 88, 89, and 90, the other includes connecting conduits 91, 92, and 93. An inlet check valve 94 is mounted in the conduit 89 and normally urged by a spring 95 against its seat 96, said check valve on the suction effect of the return stroke of the piston 9 being opened to allow fuel to pass from the space 57 through conduits 88, 89, and 90 to the interior of the cylinder 8. An outlet valve 97 is mounted in the bore or conduit 92 and normally urged by a spring 98 against its flat seat 99 formed as a part of said conduit, said valve opening against its loading pressure of its spring 98 when the piston 9 is moved inwardly or downwardly on its fuel injection stroke to allow fuel to pass from the interior of the cylinder 8 through the conduits 91, 92, and 93 back to the space 57. Thus during each cycle of the injector fuel as a coolant

is introduced into the cylinder 8 and comes in contact with the interior of the piston 9 to act to cool the same, this fuel being taken from the supply of fuel circulating through the space 57.

Thus the valve 97 acts as a discharge valve, but it also has another function, that of acting as a valve for varying the timing of the beginning of the injection period and as such it is formed as an adjustable relief valve. As shown, the valve 97 is a cylindrical plug slidably mounted in the bore of a sleeve housing 100 having a threaded mounting in a threaded portion 101 of the bore which at its inner end forms the annular conduit 92. The extended end of the sleeve 100 is threaded to engage an adjustable threaded cap 102. The spring 98 is interposed between the outer end of the valve 97 and the cap 102 whose adjustment relative to the sleeve determines the tensioning or loading of the spring 98. With this construction when the compression pressure of the gases in the combustion chamber C reach a predetermined value, the fuel in the cylinder 8 which acts as a coolant and a checking fluid will be put under sufficient pressure to overcome the loading of the spring 98, so that fuel in this cylinder may be released and escape to the space 57. The loading of the spring 98 is preferably adjusted, so that the piston 9, which acts also as a checking piston, together with the plunger 16 begins to move when the working piston of the engine is within a few degrees of top dead center, for example, ten or five degrees or less. The positioning of the conduits 88 and 91 where they enter the bore 62 is preferably such that they will be lapped by the lower or checking piston end of the piston 9 just as it is completing its inward stroke, so that the body of the fuel left in the interior of the cylinder 8 will act as a checking or cushioning fluid to check or cushion the end of the stroke of the piston 9 under the action of the gases instead of having this piston strike a metal stop to limit its movement. The final upward movement of the piston against its valve seat 61 is also preferably checked by restricting the clearance at 103 between said seat 61 and the bore 59. The restricting of the clearance at 103 as shown in the drawings also has the effect of causing the initial injection of the fuel charge to proceed at a slower rate than when the gases operate on the whole area of the piston after the valved end 61 leaves the bore 103. This is desirable as it produces a pilot type of injection during the first part of the stroke of the plunger 16.

With the above construction fuel is continuously supplied to the injector from a suitable low pressure supply connected with the fitting 50 and circulates, first through the injector housing, and then through the jacket space 57 and to the return pipe connected with the outlet 58. As the piston in the engine cylinder or combustion chamber C nears the end of its compression stroke, the gases tapped off from this cylinder to the cylinder 8 move the piston 9 and plunger 16 downwardly to first cut off the ports 42 and then compress the fuel in the barrel 14 ahead of the plunger 16 and force this fuel past the spring pressed check valve 37 and through the nozzle 17 and its spray orifices 28 into the combustion chamber of the engine, the amount of fuel being as heretofore noted determined by the angular adjustment of the plunger 16. When the pressures in the combustion chamber C drop to a value below the loading of the spring 68, 75

this spring acts to return the piston 9 and plunger 16 to their outer or upper initial positions ready for the next cycle, it being noted that during each cycle the interior of the cylinder 8 receives a new charge of coolant, cushioning, and timing fluid as a part of the fuel being circulated through the coolant space 57.

I desire it to be understood that this invention is not to be limited to any particular form or arrangement of parts except in so far as such limitations are included in the claims.

What I claim as my invention is:

1. In a fuel injection apparatus having a housing and pumping means in said housing including a pump cylinder and a plunger and a coolant space in said housing connected with said pump cylinder, the combination of operating means for said plunger comprising an operating cylinder mounted above said housing, an operating piston working in said last named cylinder and operatively connected to said plunger, said operating cylinder having a coolant space, and means for continuously circulating fuel through said coolant spaces.

2. The fuel injection apparatus defined in claim 1 wherein the bore of said operating cylinder in which said operating piston works is connected to the coolant space of said operating cylinder by a check valve controlled inlet and by a valve controlled outlet, the above defined structure acting as a coolant pump to supply fuel to said cylinder to cool the interior of said operating piston.

3. The fuel injection apparatus defined in claim 1 wherein the bore of said operating cylinder in which said operating piston works is connected to the coolant space of said operating cylinder by a check valve controlled inlet and by a valve controlled outlet, said inlet and outlet being positioned in said cylinder to be lapped by said piston as it nears the end of its working stroke, the above defined structure acting as a coolant pump to supply fuel to said cylinder to act to cool the interior of said operating piston and to act as a checking fluid for the operating piston.

4. In a fuel injection apparatus having a housing and pump means in said housing including a pump cylinder provided with an inlet and a pump plunger, the combination of operating means for said plunger comprising an operating cylinder mounted above said housing, a fluid pressure operated piston working in said last named cylinder and operatively connected to said plunger, said operating cylinder having a coolant space, means for continuously circulating fuel past the inlet of said pump and through said coolant space, and means including said operating piston and operating cylinder for circulating portions of the circulating fuel within the interior of said operating piston and cylinder.

5. In a fuel injection apparatus having a housing and pump means in said housing including a pump cylinder and a pump plunger, the combination of operating means for said plunger comprising an operating cylinder, a gas pressure operated piston working in said last named cylinder and operatively connected to said plunger and provided with piston rings, said operating cylinder having a cooling jacket space and a gas relief port in said cylinder back of said rings connecting the interior of said cylinder with said jacket space, and means for circulating fuel through said jacket space.

7
6. In a fuel injection apparatus having a housing and pumping means in said housing including a pump cylinder and a plunger and a coolant chamber in said housing connected with said pump cylinder, the combination of operating means for said plunger comprising an operating cylinder mounted above said housing, a gas pressure operated piston working in said last named cylinder and operatively connected to said plunger, said operating cylinder having a coolant space, a coolant circulatory system including said coolant chamber and said coolant space and a connection with the interior of said operating cylinder, a gas relief passage also connecting the interior of said cylinder with said coolant space, and means for conducting circulating fuel through said coolant chamber and said coolant space.

7. In a unit fuel injection apparatus having a housing and pump means in said housing including a pump cylinder and a plunger, the combination of operating means for said plunger comprising an operating cylinder, a gas pressure operated piston working in said last named cylinder and operatively connected to said piston, a checking chamber in said operating cylinder inlet and outlet valve controlled passages for supplying the checking chamber of said operating cylinder with a cooling and checking fluid, and a partition mounted between said housing and said operating cylinder and forming a wall of said checking chamber and having a tubular projection extending into said operating cylinder and in which said plunger is slidably mounted.

8. In a fuel injection apparatus of the compression pressure operated type having a high pressure fuel pump having a movable element, the combination of a gas pressure operated op-

erating piston operatively connected to the movable element of said pump, a cylinder in which said piston works having a gas pressure inlet, a valve seat connected with said inlet and a reduced diameter bore adjacent said valve seat, said piston having a head forming a valve cooperating with said seat and having a reduced diameter cylindrical projection fitting said reduced diameter bore during a portion of the travel of said piston relative to said cylinder to reduce the area of pressure on the piston during its initial movement to produce a pilot charge injection effect.

9. In a unit fuel injection apparatus having a housing and pump means in said housing including a pump cylinder having an inlet and a plunger, said housing having a coolant space connected with the inlet to the pump cylinder, the combination of operating means for said plunger comprising an operating cylinder associated with said housing and having a coolant space, a gas pressure operated piston working in said last named cylinder and operatively connected to said piston, and a coolant circulatory system using fuel as a coolant including the coolant spaces in said cylinders and a connection with the interior of said operating cylinder.

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