

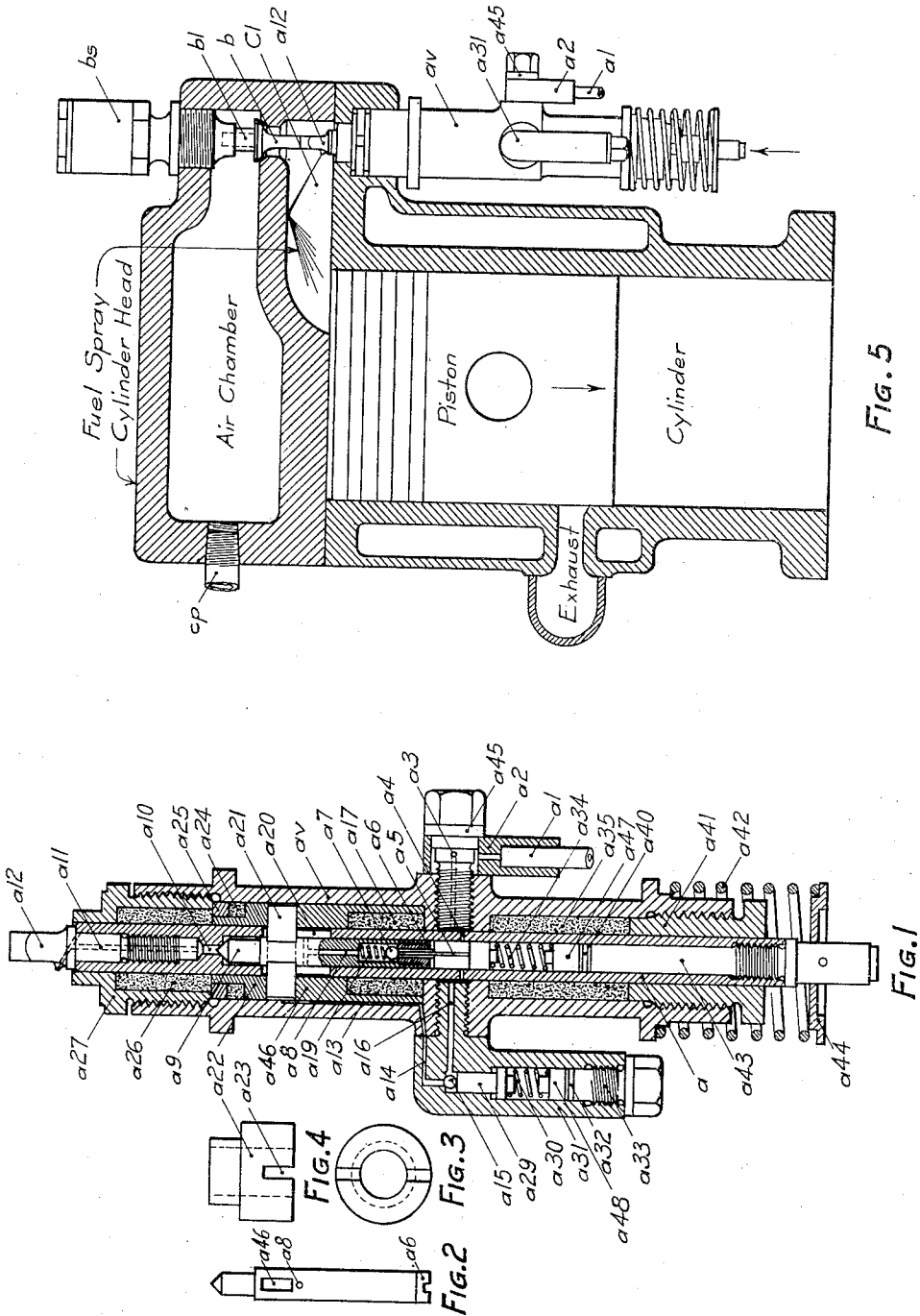
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FUEL INJECTION VALVE

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Witnesses

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FUEL-INJECTION VALVE.

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My invention relates to a fuel injection valve for constant pressure, internal combustion engines and, particularly, to a type of constant pressure engine employing an air chamber into which the compressed air of the compression stroke is delivered during the latter part of the compression stroke and from which this air is again inducted into the cylinder during the early part of the power or combustion stroke.

With proper modification, this valve may also be employed in any solid injection type of oil engine in which a close approach to a constant pressure thermal cycle is desired.

Referring particularly to the type of constant pressure solid injection oil engines employing an air chamber and a non-return valve between the air chamber and the cylinder, and which engine is illustrated in Figure 5 of the drawings, it will be seen that this type of engine requires that the oil be injected at such a rate that the pressure does not tend to rise in the cylinder. If the oil is injected at a higher rate, there is nothing to prevent the flame or products of combustion from passing through the air chamber valve and into the air chamber. Although there is nothing seriously harmful for the flame to enter the air chamber, for best operating results the flame should always be directed toward the cylinder, so that the products of combustion are continually passing on out of the way of succeeding portions of oil as the piston advances and thereby insure perfect combustion. If this process is not approximately carried out, imperfect combustion results because the products of combustion of the earlier portions of oil become mixed with the pure air in the air chamber.

The air from the air chamber flows into the cylinder by induction; that is, as the piston moves out from the cylinder head, it tends to lower the pressure in the cylinder and the air from the air chamber naturally flows through the open valve into the cylinder as fast as the piston advances. Now, as the piston starts slowly and accelerates its speed as it advances, so the air entering the cylinder flows in with an accelerating velocity in exact proportion to the accelerating speed of the piston. It is clear that the fuel should be injected at the same rate as the flow of the air, which is equivalent to saying that the fuel should be in-

jected at an accelerating rate in correspondence with the piston travel.

In the practical operation of this type of engine, it is not desirable to inject as much oil as the air will consume, but to leave a considerable quantity of excess air in the products of combustion to oxidize the carbon deposits on the piston and to give the engine a higher thermal efficiency. Furthermore, there is considerable self regulation going on in the way of automatically adapting the combustion to the fuel injection rate by a raising or lowering of the pressure, which changes the density of the compressed air and, therefore, its relation to the rate of piston travel. For these reasons, it has been found that the oil does not have to be injected precisely in accordance with the rate of piston travel, but only approximately so.

In a single cylinder engine the fuel pump may be so designed as to deliver oil to the injection valve at an accelerating rate of flow and, therefore, a simple valve is all that is required. But, with a multiple cylinder engine, it is desirable to use a constant pressure pump, supplying the valves with oil at constant pressure and using a valve of such construction that the fuel will be injected at an accelerating rate.

In my invention, this is accomplished in the manner as shown by the drawings and the description which follows. It must, however, be observed that the details of construction are not essential, as there are numerous ways in which the same idea can be carried out, but the principle, as set forth in the claims taken in connection with a practical example, as shown in the drawings, is to be taken as representing the scope of the invention.

Referring to the drawings:

Figure 1 is a sectional view of the valve, showing all of its parts. The section plane passes through the axis of the valve, cutting all the parts upon a diametrical plane, except the parts a^{12} , a^{21} , a^7 , a^5 , a^{45} , a^{47} , a^{40} , a^{43} , a^{15} , a^{20} , a^{48} , a^{32} and a^{33} , which are shown in elevation, and the part a^9 , which is shown partly in elevation and partly in section.

In this figure, the by-pass, " a^{31} ," is shown diametrically opposite the inlet connection, " a^{45} ," in order to simplify the drawing, but it is more convenient to arrange it on the side of the valve body as shown in Figure 5.

Figure 2 is a separate view of the part, a^9 , taken perpendicular to its assembled view in Figure 1.

Figures 3 and 4 are two views of the part, a^{22} , also shown perpendicular to its assembled view in Figure 1.

Figure 5 is a typical illustration of the valve in position in the engine cylinder with those parts of the engine with which it co-operates. The view is taken upon a section plane passing through the cylinder and air chamber perpendicular to the crank shaft and shows the piston and valve in elevation.

No fuel pump is illustrated because any pump will answer which is capable of furnishing a nearly constant pressure oil supply.

Referring to Figure 1, the valve will be seen to consist of a housing, av , with four openings. The upper and lower openings are provided with packing glands, a^{27} and a^{41} . The side outlet to the right is connected to the fuel pump and the side outlet to the left embraces the by-pass device, a^{31} .

The bore of the housing is much smaller near the middle, just large enough to pass the rod. Directly above this contraction is a third set of rod packing, a^{17} , held in place by the gland, a^{40} . This arrangement divides the valve into an upper and lower chamber separated by the packing, a^{17} , and made tight at the ends by the packings, a^{26} and a^{35} .

The rod, a , passes through the three packings and is hollow, with a contraction of the bore at a^{10} .

Into the upper end is screwed the nozzle, a^{12} , and into the lower end the plug, a^{43} . The rod, a , is slotted at the sides, a^{20} , a sufficient distance so that it may freely slide up and down the full amplitude of its stroke without striking the member, a^{21} , which passes through the slots. One or more holes are drilled through the side of the rod at a^{11} to admit the oil into the interior. A plunger, a^9 , is closely fitted to the interior bore of the rod, a , and forms a valve by seating against the contraction, a^{10} .

This shuts the oil from the nozzle, a^{12} . The plunger, a^9 , is also slotted to receive the member, a^{21} , but the slot is no longer than the depth of the member, a^{21} , and is, therefore, securely held in place by it. The lower portion of the plunger, a^9 , is hollow to receive a non-return back pressure valve comprising a ball, a^7 , resting upon a seat, a^6 , which screws into the plunger, and a stiff spring, a^{19} , bearing upon the ball, a^7 . A port, a^8 , completes the communication between the lower and upper chambers.

Just below the plunger, a^9 , is a spring seat having a stem, a^5 , bearing against the lower surface of the ball, a^7 . A spring, a^{35} , is pressed upward from below by the

seat, a^7 , and the plug, a^{43} . Washers, a^{40} , are used to adjust the tension of the spring.

The member, a^{21} , is securely seated in the slot, a^{23} , Figure 4, and rests upon the upper surface of the part, a^{46} .

In order to prevent the oil from leaking out through the threads of a^{27} , the member, a^{22} , is turned down near its upper end, a ring of packing, a^{24} , placed over it and held down by a metal ring, a^{25} . It will be seen that when the gland, a^{27} , is tightened it firmly forces together the parts, a^{25} , a^{24} , a^{22} and a^{46} and securely seats the member, a^{46} , against the valve body. The oil can only pass from the lower chamber to the upper chamber through the valve, a^7 , against the tension of the spring, a^{19} , minus the tension of the spring, a^{34} .

The spring, a^{19} , bears upon the ball, a^7 , with a constant load, while the spring, a^{34} , is so adjusted as to bear very lightly upon the under side of the ball, a^7 , when the rod, a , is down, but as the rod rises the tension of the spring, a^{34} , rapidly increases so that when the rod has reached the height of its travel it bears the ball upward with about as much force as the spring, a^{19} , bears it downward. The result of this combined action is that, when the rod is down, the back pressure against the oil is a maximum; while, when the rod is up, the back pressure is nil.

The size of the plunger, a^9 , is so chosen as to give the required displacement with due regard to the quantity of oil to be injected. When the rod, a , rises, the plunger, a^9 , causes a negative displacement in the upper chamber because it is stationary while the rod, a , is movable. When the rod, a , falls, the plunger, a^9 , causes a positive displacement tending to force the oil out through the nozzle, because it cannot pass back through the valve, a^7 .

Now, the size of the plunger could be so nicely chosen as to exactly meet the requirements of the quantity of oil to be injected, but this is impractical because of leakage and other variable conditions and so it is made with an ample factor of oversize and a by-pass provided for the surplus oil.

In order to bring the oil from the upper chamber to the by-pass a port, a^{43} , is formed in the valve housing which communicates with the port, a^{14} . The by-pass communicates with the lower chamber through the port, a^{10} .

The by-pass consists of a ball, a^{15} , held to its seat against the pressure in the upper chamber by the spring seat, a^{20} , the spring, a^{30} , and the plug, a^{33} . The members, a^{32} , are washers for adjusting the tension of the spring.

The nozzle member, a^{12} , screws into the rod, a , and seats against a shoulder on the

nozzle. It has a hole, "a¹¹," drilled from below to meet the hole drilled crosswise at an angle and contracted at the outlet to form a nozzle.

5 A spring, "a¹²," seats the rod, "a," firmly upon the conical end of the plunger, "a⁹," and prevents any oil from entering the nozzle until the rod, "a," is pushed upward and uncovers the port, "a¹⁰."

10 The valve is connected to a constant pressure oil supply of high pressure through the pipe, "a¹," and connections, "a²" and "a¹⁵."

15 Figure 5 is a typical installation of the valve within the engine cylinder.

This engine has an air chamber formed within the cylinder head. The volume of this air chamber is preferably a half or a third of the piston displacement. The air chamber is closed by a non-return valve, "b," held to its seat by a light spring located in the spring case, "b^s," bearing upon the plunger, "b¹."

20 The cylinder head also has a combustion port, "c¹," milled in its lower surface, forming a passage for the air between the cylinder and the air chamber.

25 The air chamber is connected to an air bottle, not shown, through the pipe, "cp," for starting the engine. No air compressor is required for the engine normally replenishes the air bottle from the air it compresses.

30 The fuel injection valve, "av," seats into a receptacle formed in the cylinder and is held up in place by a suitable yoke, not shown, under the collar of the valve.

35 The piston clearance is reduced to a minimum and does not determine the compression pressure of the engine. The compression pressure is dependent upon the fuel pressure.

40 By means of a cam and follower, not shown, or other suitable means, the valve rod, "a," is given a variable throw in accordance with the load on the engine.

45 The above description defines the uses of the different parts. To further elucidate the invention, I will describe in detail the operation of the valve and its relation to the type of engine illustrated.

50 To start the engine, it is turned over until the crank has just passed the upper dead center. The piston is now in approximately the position shown in Figure 5, viz, just beginning its power stroke. The air chamber valve, "b," is slightly open so that air can freely enter the cylinder as soon as air is admitted to the air chamber. The instant this is done the piston is driven down with much force. The valve, "b," is held open for about one-half stroke when starting but the cut-off is reduced by hand or governor as soon as normal operation is attained. Exhaust takes place at the end

of the stroke as usual and a charge of pure air is driven in. On the upward stroke, this air is compressed until it reaches a pressure equal to the pressure in the air chamber. This occurs near the end of the 70 stroke, for the pressure in the air chamber is approximately the same as the compression pressure under which the engine normally operates. As the piston continues its motion, it forces this compressed air 75 through the valve, "b," into the air chamber. When the piston has reached the end of its stroke, most of the compressed air has been delivered into the air chamber. Just as the piston starts downward on the power 80 stroke, the cam mechanism (not shown) raises the valve rod which, in turn, lifts the valve, "b," and permits the compressed air to be inducted back into the cylinder at an accelerating rate. The valve also injects the 85 oil at an accelerating rate as follows:

Assume that the engine is operating at a compression pressure of 300 lbs. and that the fuel injection begins with a pressure of 100 lbs. higher and ends with a pressure of 90 500 lbs. higher than the compression pressure in the engine cylinder. The fuel injection should not commence at too low a head, otherwise the oil will not be divided fine enough for proper combustion. Assume that the spring, "a¹⁹," has a tension such that it requires a difference in pressure of 200 lbs. per square inch to open the valve "a⁷," and that the spring, "a³⁴," is so chosen 95 that when the rod, "a," is down its pressure against the ball, "a⁷," is nil and when the rod is near the upper end of its stroke its pressure on the ball is the same as that of the spring, "a¹⁹."

100 Further assume that the spring, "a³⁰," is so adjusted that it requires a difference of pressure of 200 lbs. per square inch to open the valve, "a¹⁵." Under these conditions the oil pressure in the pipe, "a¹," and lower chamber of the valve housing would be 300 lbs. higher 110 than the compression pressure, or 600 lbs. gauge. Now, the instant the rod, "a," begins to lift it uncovers the port, "a¹⁰," and as the back pressure offered by the valve, "a⁷," is 200 lbs., the oil will issue from the 115 nozzle under a head of 100 lbs. per square inch. As the valve rod rises, the back pressure of the valve, "a⁷," grows less and becomes nil at the end of the upward stroke of the valve rod. The head at the nozzle 120 is, therefore, raised from 100 lbs. to 300 lbs. per square inch during the upward stroke of the valve rod. As the rod starts downward, the displacement of the plunger, "a⁹," comes into play, the valve, "a⁷," closes, and the 125 pressure in the upper chamber rises until it reaches a pressure 200 lbs. higher than the pressure in the lower chamber when the valve, "a¹⁵," opens and by-passes the surplus. If the size of the plunger is properly chosen, 130

the pressure rise during the downward stroke of the rod, "a," is quite gradual and the by-pass does not open until the rod is nearly down.

5 It will be seen that the head at the nozzle was gradually increased from 300 lbs. to 500 lbs. per square inch on the downward stroke of the plunger. The entire range of pressure head at the nozzle is, therefore, from 100
10 lbs. to 500 lbs. per square inch during the combustion period of the engine. Changing the tension or the degree of elasticity of the springs makes it possible to secure almost any characteristic in the rate of injection of the fuel. When once the adjustment has been made, there is no further need of readjusting these parts afterward.

The valve is so constructed as to avoid air pockets and, therefore, there is no chance
20 for an accumulation of oil in the upper chamber under a pressure that would disturb the proper working of the valve, as described.

When the engine is operating at less than
25 full load, the valve rod does not rise so high and, therefore, the back pressure of the valve "a," is not brought to zero. Nevertheless, the action of the plunger, "a," quite gracefully smoothes out this discrepancy and, as the excess of air is now
30 greater, the fuel does not have to be injected with the precision which is necessary when operating at full load.

There is another factor which I may here
35 mention that makes the combustion more gradual than the fuel injection, and that is the degree of division of the oil.

The higher the head under which the oil is injected, the finer the division and the more
40 rapid the combustion. The fuel injection ends under the highest heads and, therefore, the combustion is the most rapid at this time. This is just what is needed for economical results.

45 As usual, the engine normally fires by spontaneous ignition. In a cold engine, the oil may be fired by a spark plug, by pre-heating the head with a torch, or by raising the compression the required amount.

50 I claim:

1. A fuel injection valve, comprising a movable rod; a displacement device; a non-return back pressure valve; means of reducing the back pressure through the movement
55 of said rod and means of injecting the fuel through the displacement device.

2. A fuel injection valve, comprising a movable rod; a displacement device; a non-return back pressure valve; a spring loaded by-pass; means of gradually reducing the
60 back pressure through the outward motion of said movable rod; means of injecting fuel through the displacement device by the return motion of said movable rod and means of limiting the injection pressure by the
65 by-passing device.

3. In combination with a constant pressure fuel supply a fuel injection valve comprising two chambers; a movable rod; a displacement device; a back pressure valve;
70 a by-pass valve; means of reducing the back pressure through the movement of the said rod in one direction and means of injecting the fuel through the displacement device by the movement of the rod in the opposite direction.
75

4. A fuel injection valve having a valve rod traversing two separate chambers in the valve body; a non-return valve between the two chambers; a spring bearing on said
80 non-return valve; and a second spring bearing on said non-return valve, in opposition to said first spring, with variable intensity dependent upon the position of said valve rod.
85

5. A fuel valve having a valve rod traversing two separate chambers in the valve body; a displacement rod; a spring loaded valve; a spring, operated by said valve rod, acting in opposition to said spring loaded valve;
90 and a by-pass valve connecting said chambers.

6. The combination of a fuel injection valve with a constant pressure fuel supply comprising a valve body having two chambers;
95 a valve rod traversing said chambers; a displacement rod located within said valve rod; a spring loaded valve opening toward the nozzle; a spring acting in opposition to said spring loaded valve, operated by said valve rod; and a spring loaded by-pass connected between the two chambers and opening toward the oil supply.
100

7. A fuel injection valve comprising a housing having two separate chambers; a
105 hollow movable rod; a nozzle at one end; a valve seat below said nozzle; a stationary rod within said movable rod seating against said valve seat; and a non-return valve, between said chambers, opening toward the
110 nozzle.

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