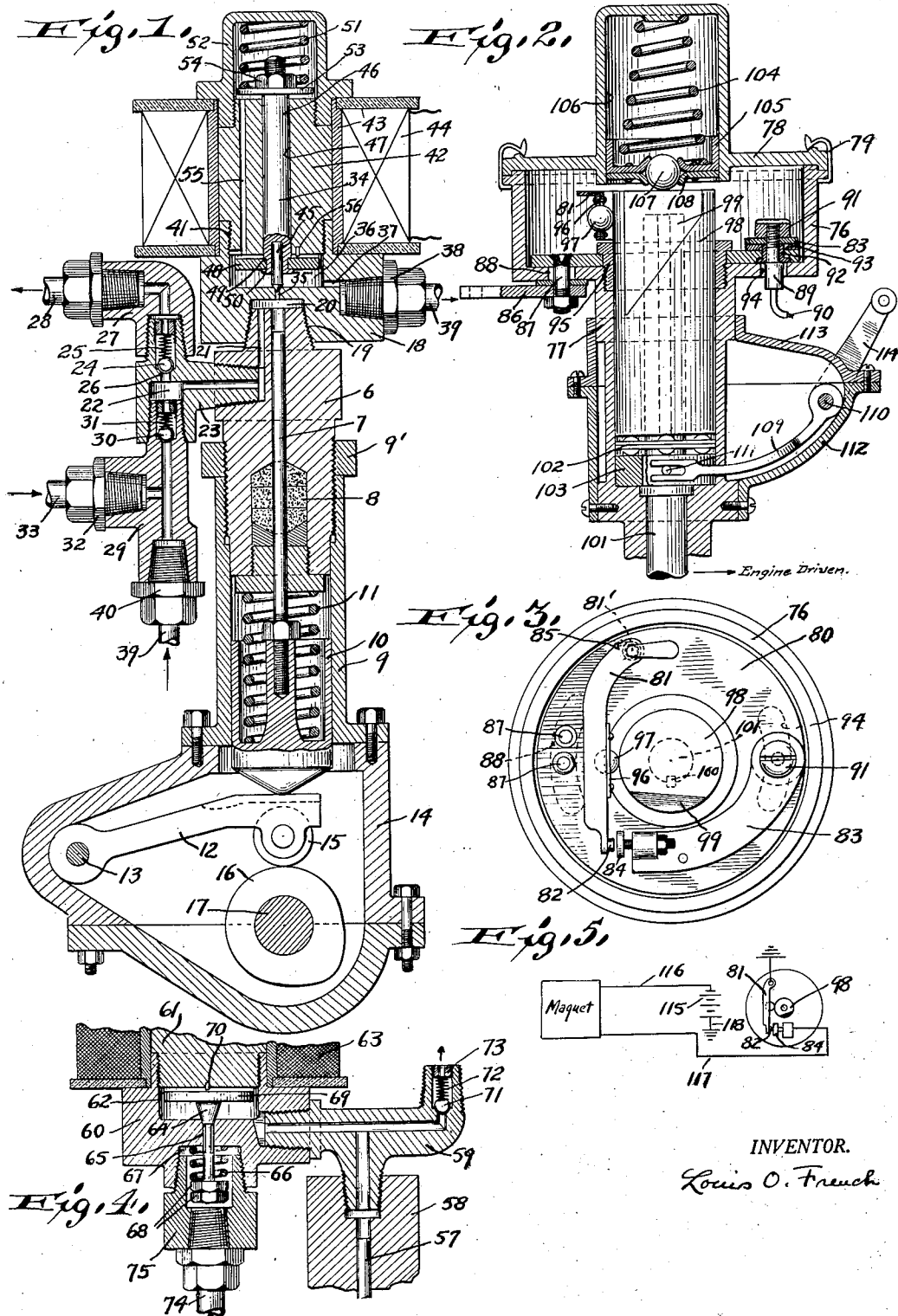


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FUEL INJECTION SYSTEM

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FUEL-INJECTION SYSTEM.

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The invention relates to fuel injection systems.

One object of the invention is to provide a fuel injection system in which the pump will be capable of ready control, will accurately deliver the very small quantities of fuel required by engines of the automotive type and operate efficiently at the high speeds used in such engines, will deliver its fuel charge at the particular time in the engine cycle and in the amount desired so as to accommodate for a wide range of speeds and loads with the proper timing of the injection of the fuel charge into the cylinder, the pump embodying a control valve for its supply side with electro-magnetically-operated means controlling the operation of said valve so that fuel may be returned to the fuel supply at any time during the expressing stroke of the pump and in the quantity desired, thereby providing a flexible control.

A further object of this invention is to provide a construction in which the power required for regulating the action of the pump is reduced to a low figure.

A further object of this invention is to provide a switch mechanism whereby the time of and duration of energization of the control magnet of a fuel-metering device may be easily effected.

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 a pump of the fuel injection system embodying the invention;

Fig. 2 is a vertical sectional view with parts broken away, of control switch mechanism for the control electromagnet of the fuel metering device. It is further to be noted that the electromagnet controls the amount of fuel metered by the pump and hence it may be called a metering control electromagnet.

Fig. 3 is a detail plan view of the interior of the switch casing shown in Fig. 2;

Fig. 4 is a detail sectional view, with parts broken away, of a pump of the fuel injection system embodying the invention;

Fig. 5 is a diagrammatic view of a circuit arrangement for the fuel injection system.

Referring to Fig. 1 of the drawings, the numeral 6 designates the pump barrel, 7 the

plunger working in a bore in said barrel, 8 the stuffing box for the plunger, 9 a guide for the tappet head 10 of the plunger, said guide having threaded engagement with the barrel and held tight by a locknut 9', 11 a spring interposed between the barrel and the head 10 to move the plunger downwardly, 12 a tappet lever engaged by the head 10 and pivotally mounted on a pin 13 within a casing 14 and carrying a roller 15 running on a cam 16 on the shaft 17 which is driven by the engine whereby the cam acts to move the plunger upwardly on its fuel-expressing stroke and the spring acts to move the plunger down on its suction stroke.

A member 18 has a threaded bore 19 receiving the threaded end of the pump barrel and cooperates therewith to form a pressure chamber 20 which also includes a passage 21 in the barrel and a passage 22 in a fitting 23 in threaded engagement with the barrel. The fitting 23 has the discharge valve 24 mounted therein and may, in addition to its own weight, be normally closed by a spring 25 and controlling the passage of fuel through a delivery port 26 to a fitting 27 connected with a pipe 28 leading to the fuel injector of the engine.

A fitting 29 in threaded engagement with the fitting 23 has the suction valve 30 mounted therein and controlling the passage of fuel from a source of supply to the passage 22 and which may, in addition to its own weight, be held closed by a spring 31, said fitting 29 having a pipe fitting 32 secured thereto and connecting a fuel supply pipe 33 with the valve-controlled passage in said fitting 29, said pipe 33 communicating with a fuel tank, not shown.

In this construction the suction and discharge valves operate in a well-known manner, and in order to control the amount of fuel delivered by the pump and the time at which delivery starts, I provide a by-pass valve 34 which is electro-magnetically operated and controls the passage of fuel through a duct 35 to a chamber 36, passage 37, pipe fitting 38 and pipe 39 which connects with pipe fitting 40 in threaded engagement with the fitting 29, whereby the fuel is returned to the supply line or side of the pump when the valve 34 is open.

The member 18 is of non-magnetic material, such as brass or bronze, has a bore 41 formed therein and threaded at its upper end

to receive the lower threaded end of the core 42 of the electro-magnet and cooperates therewith to form the fluid-tight chamber 36. A spool 43 of usual construction, including a
5 brass tube and insulating disks, carries the magnet coil 44 for energizing the core.

The valve 34 is preferably in the form of a needle valve having a renewable hardened steel tip 45, seated on the seat at the upper
10 end of the duct 35, a non-magnetic metal stem 46 slidably mounted in a bore 47 and having the tip 45 mounted in its lower end which also carries a disk 48 of magnetic material disposed in close proximity to the
15 lower end of the core. The disk 48 is preferably secured to the stem by forming an annular shoulder 49 thereon against which the disk abuts and upsetting a portion 50 of the stem against the lower side of the
20 disk. The valve is normally held closed against delivery pressure by a non-magnetic metal spring 51 interposed between a cap 52, having a fluid-tight connection with the upper end of the core, and a non-magnetic
25 disk 53 clamped to the threaded upper end of the stem 46 by a nut 54 of non-magnetic material. To equalize the pressure in the chamber formed by the cap and the core and in the chamber 36, a passage is provided
30 in the core as shown and to prevent any liability of so-called "freezing" a small brass pin 56 is mounted in the lower face of the core to project a very slight distance to prevent direct contact between the core and the
35 disk 48.

In the construction shown in Fig. 4 the suction valve is operated upon by the magnet and in this construction I have shown the
40 pump plunger 57 working in a barrel 58 having a chamber formed in part by said barrel, a brass fitting 59, and a valve housing 60 of brass or other non-magnetic material. The operating parts for the plunger may be the same as those previously described. As before, the core 61 of the electro-magnet has a threaded and fluid-tight
45 connection at its lower end with a bore 62 in said housing 60, and a coil 63 with its spool is mounted on the core 61. A conically seating suction valve 64 controls passage of fuel through the duct 65 to the pump and may, in addition to its own weight, be normally held closed by a spring 66 interposed between the end of a bore 67 in the
50 housing 60 and nuts 68 on the stem of the valve, and has integrally formed therewith or secured thereto a disk 69 of magnetic material arranged in close proximity to the lower face of the core 61 of the electromagnet. A brass
60 pin 70 mounted in the end of said core may be used to just prevent direct contact between said disk and magnet to prevent any possibility of freezing.

The pipe fitting 59 has threaded engagement with the housing 60 and with the pump

barrel with passages establishing communication therebetween, and has a discharge valve 71 seated on its delivery end and held thereagainst by a spring 72 interposed between said valve and a sleeve nut 73. Fuel,
70 from a suitable source of supply, is conducted by a supply pipe 74 to a plug fitting 75 in threaded engagement with the lower end of the bore 67.

The control switch mechanism is shown in
75 Figs. 2 and 3. It includes a casing 76 having a bearing extension 77, a cover 78 for the casing detachably secured thereto in any suitable manner, as by spring clips 79, a rotary switch-carrier plate 80, a pivoted switch arm
80 81, pivoted at 81' and provided with contact 82, mounted on said plate and a fixed member 83 secured to but insulated from the plate and carrying a fixed contact 84, a
85 spring 85 for normally moving the arm 81 to bring contact 82 into contact with contact 84, an arm 86 outside the casing and connected to the plate 80 by screw bolts 87 having their heads upset against the plate and working
90 in an arcuate slot 88 in said casing whereby the plate, with the switch members, may be turned within the casing. The terminal end 89 of a conductor 90 is secured to the member 83 and is clamped to the
95 plate 80 by a nut 91 and a bushing 92 of insulating material and a washer 93 of insulating material, the end 89 extending down through an arcuate slot 94 in the casing so as to permit rotation of said plate, as above described. The plate 80 is centered in the
100 casing by a flanged sleeve 95 in threaded engagement with the casing and about which said plate turns. In the construction shown the switch arm 81 is grounded through the
105 casing.

The switch arm 81 is preferably of sheet metal having a medial angular section which is apertured to cooperate with an apertured
plate 96 riveted thereto to retain a hardened steel ball 97, such as a ball bearing, on the
110 arm, either in a fixed or rotatable relation, and which ball rides on a cam 98.

The cam 98 is in the form of a cylindrical member having a flattened tapered face portion 99, and is rotated in the extension 77
115 by a keyed connection 100 with a splined shaft 101 driven by the engine, said keyed connection being of the longitudinally slidable type so that different portions of the face 99 may be brought into operative position relative to the part 97. At its lower
120 end this cam 98 turns on a roller-thrust bearing 102 interposed between it and a slidable collar 103 which may be moved either manually or by a governor to shift the cam
125 98 upwardly against the opposition of a spring 104 interposed between the cover 78 and a plunger 105 slidably mounted in the bore 106 in said cover and having a thrust-ball-bearing 107 engaging the upper end of
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said cam 98 and held between the lower end of the plunger and a plate 108 riveted thereto. I have shown as a means for moving the cam 98 along its drive shaft a forked lever 109 secured to a shaft 110 and having its bifurcated ends engaging pins 111 on the collar 103, which pins project through slots, not shown, in the extension 77. The shaft 110 is pivotally mounted in a two-part casing 112, 113 and has an exterior portion projecting therefrom carrying a manually or governor controlled operating arm or lever 114.

In Fig. 5 I have shown the circuit connections of this switch mechanism with the valve-operating magnet either for the valve 34 or the valve 64 and generally designated as magnet. One side of the battery 115 is connected by a conductor 116 with one end of the magnet coil and the other end of said coil is connected by a conductor 117 to the fixed contact 84. The other side of the battery is connected by a conductor 118 to ground and the switch member 81 is grounded through its casing. With this construction when the ball 97 moves on the round part of the cam 98 the switch contacts will be separated and when the flattened face of the cam moves past said ball the switch arm 81 under the action of its spring will move inwardly toward the shaft 101 and cause contact 82 to engage contact 84 and establish current flow through the magnet coil 44 or 63, the current flowing from battery 115, conductor 116, magnet coil 44 or 63, conductor 117, contacts 84 and 82 to ground through switch arm 81 and then through ground to the other side of the battery. In Fig. 1 when current flow is established through the coil 44 the magnetized core 42 will attract the disk 48 and move the needle tip 45 upwardly allowing fuel to pass through duct 35 to the supply line. In Fig. 4 when current flow is established through the coil 63 the magnetized core 61 will attract the disk 69 and move valve 64 upwardly off its seat allowing fuel to pass through duct 65 to the supply line. Now the flattened surface 99 gradually decreases in a downward direction with the result that as the cam 98 is shifted upwardly the contacts 82 and 84 will be engaged for a less period of time so that by changing the position of the cam 98 relative to the switch member 81 the coil of the magnet controlling either the valve 34 or 64 will be energized for varying periods of time so that either of said valves will be held open for varying periods of time, and as the operation of the cam 98 is synchronized with the operation of the plunger 7 so as to cause a lift of either of said valves during the expressing stroke of the pump more or less fuel will be returned to the supply pipe and hence a less or greater amount of fuel may be delivered to the in-

jector from which it passes into the engine cylinder. The cam 98 may be rotated in either direction, and it will be noted that the drawing shows one side of the flattened surface as a straight line. This arrangement was provided especially for rotation of the cam 98 in a clockwise direction when viewed from Fig. 3, so that the straight side of the flattened portion would move past the ball 97 first, whereby the time of initiating the injection would, for any given angular adjustment of the case, be the same even though varying amounts of fuel were being introduced through the longitudinal adjustment of the cam 98.

Furthermore, since the switch members 81, 83 are angularly adjustable relative to the cam 98, by the shifting of the handle 86, either manually or under action of the engine governor, the time of initiating energization of the magnet will be varied and hence the time of starting the delivery of fuel to the injector may be varied. The result is that through the electro-magnetic control herein provided varying the amounts of fuel may be delivered by the pump during the desired period in the engine's cycle to accommodate different changes in speed and load.

The spring load on the needle valve 34 need only be slightly in excess of the predetermined delivery pressure, with the result that the electrical energy to operate said valve will be small in amount and the total spring load need not be great since the duct 35 is relatively small. With the suction valve 64 the power required to operate, if opened during the delivery stroke, will be greater than that required by the by-pass valve 34, but this construction has the advantage of employing a less number of parts and in some instances where delivery pressure is low the force required to lift the valve 64 will not be great. Furthermore, where small quantities of fuel are being handled the total energy required to operate the valves will be of a relatively small amount.

In engines of the automotive type the disks 48 or 64 may be spaced within a sixty-fourth to a hundredth of an inch from the attracting face of the magnet so that an efficient magnetic attractive force may be obtained and so that the valves with their slight travel will operate efficiently at the high speeds occurring in engines of this type.

It will also be noted that either the suction valve itself or the by-pass valve constitutes a control valve to control the passage of fuel to the supply line, that in each instance the magnet acts directly upon the valve member and that the valves are within the fuel passages or chambers so that no packing is necessary.

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 specified in the claims or necessitated by the prior art.

What I claim as my invention is:

1. In a fuel injection system, the combination with a pump having a valve controlling passage of fuel to its fuel supply, of an electromagnet for controlling the operation of said valve, means for energizing said magnet, and engine-operated circuit control mechanism including means adjustable to vary the time said energizing means is rendered operative, and means adjustable to vary the duration of operation of said energizing means whereby to vary the operation of said valve and hence cause the pump to deliver variable quantities of fuel at the desired time during its working stroke.

2. In a fuel injection system, the combination with a pump having a valve controlling passage of fuel to its fuel supply, of an electromagnet so located as to act directly on said valve for controlling its operation, means for energizing said magnet, and engine-operated circuit control mechanism including means adjustable to vary the time said energizing means is rendered operative, and means adjustable to vary the duration of operation of said energizing means, whereby to vary the operation of said valve and hence cause the pump to deliver variable quantities of fuel at the desired time during its working stroke.

3. In a fuel injection system, the combination with a pump having suction and discharge valves, of a by-pass valve of the needle type controlling the passage of fuel to the supply side of the pump, an electromagnet for controlling the operation of said valve, a control circuit for said electromagnet, and adjustable engine-operated circuit control means for controlling the duration of the operation of said magnet independently of its time of operation.

4. In a fuel injection system, the combination with a pump having suction and discharge valves, of a by-pass valve of the needle type, an electromagnet so located as to act directly upon said valve, and engine-operated circuit control means controlling the energization of the coil of said magnet and adjustable to vary the time of and duration of energization of said magnet to vary the time of and duration of flow of fuel past said by-pass valve to the fuel supply.

5. In a fuel injection system, the combination with a pump having a valve controlling passage of fuel to its fuel supply, of an electromagnet for controlling the operation of said valve, means for energizing the coil of said magnet including a source of current, and means controlling the flow of current through the coil comprising a switch, an en-

gine-driven cam for operating said switch, said cam being lengthwise adjustable relative to the switch to vary the circuit-closing period thereof whereby to vary the duration of energization of said magnet and hence vary the operation of said valve.

6. In a fuel supply system for internal combustion engines, circuit control mechanism for a metering control electromagnet of said system comprising a switch having a fixed contact and a movable contact, an engine-driven shaft, a cam driven by said shaft and lengthwise adjustable thereon and cooperating with said movable contact to move it relative to said fixed contact for varying periods of time whereby to vary the period of energization of said electromagnet, and means for bodily shifting said fixed and movable contacts relative to said cam to vary the time of action of said cam and hence the time at which said electromagnet is energized.

7. In a fuel supply system for internal combustion engines, circuit control mechanism for a metering control electromagnet of said system comprising a switch having a fixed contact and a movable contact, an engine-driven shaft, a cam driven by said shaft and lengthwise adjustable thereon, said cam having a cylindrical portion and a tapered relief portion cooperating with said movable contact to move it relative to said fixed contact for varying periods of time to vary the duration of energization of said electromagnet, and a support for both contacts angularly adjustable relative to said cam to vary its time of action on said movable contact.

8. In a fuel injection system, the combination with a fuel pump having a by-pass valve controlling passage of fuel to its supply side, of an electromagnet for controlling said valve, a control circuit for said electromagnet, circuit control means, and an engine-controlled cam for periodically actuating said control means and shiftable relative to said control means to vary its duration of operation and hence vary the duration of operation of said electromagnet and consequently vary the operation of said valve.

9. In a fuel injection system, the combination with a fuel pump having a suction inlet valve, of a spring-closed needle by-pass valve associated with said pump, an electromagnet for controlling the operation of said by-pass valve, a control circuit for said electromagnet, and engine-operated circuit control means in said circuit for controlling the operation of said valve.

In testimony whereof, I affix my signature.

LOUIS O. FRENCH.