March 19, 1929. L. O. FRENCH 1,705,665

FUEL INJECTION SYSTEM

Filed Dec. 31, 1925

Fig. 1.

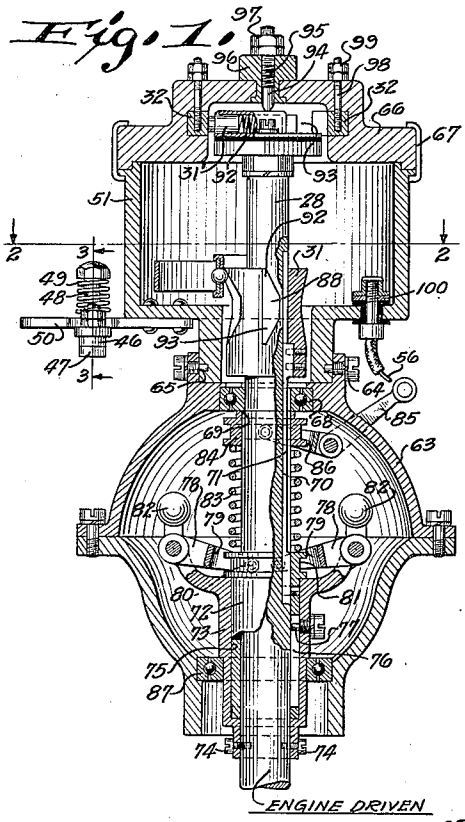


Fig. 2.

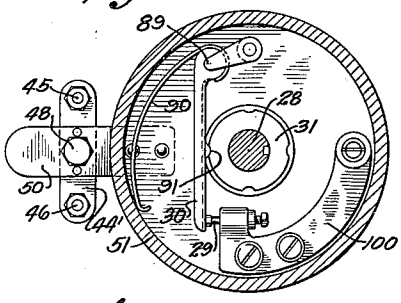


Fig. 4.

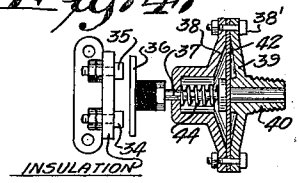


Fig. 3.

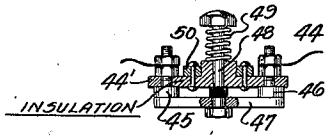
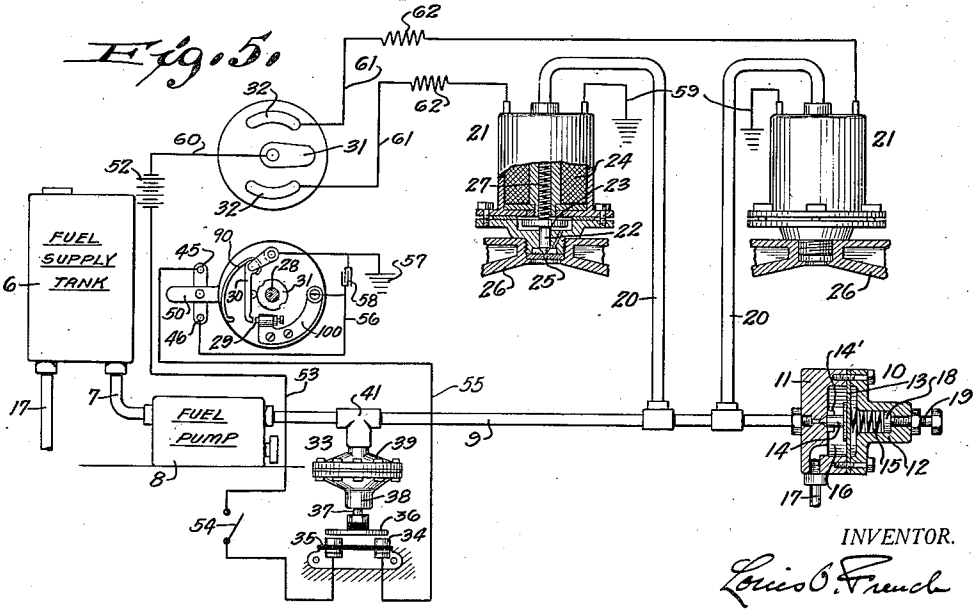


Fig. 5.



INVENTOR.

Louis O. French

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UNITED STATES PATENT OFFICE.

LOUIS O. FRENCH, OF MILWAUKEE, WISCONSIN.

FUEL-INJECTION SYSTEM.

Application filed December 31, 1925. Serial No. 78,641.

The invention relates to fuel injection systems.

In electrically-controlled fuel injection systems, where the fuel is maintained in a supply pipe and released to the engine cylinder or cylinders by an electromagnetically-operated valve or valves which is or are controlled by switch mechanism driven by the engine, when the engine is stopped the contacts of the switch mechanism may be engaged so that should the operator turn on the fuel control switch previous to turning over the engine one of the injector valves may be opened before the engine is started, and while the fuel is not then under pumping pressure some of the fuel may dribble into the engine cylinder if parts of the fuel supply passages to the engine cylinder are elevated. To obviate this difficulty one of the objects of this invention is to prevent the operation of the electromagnetically-operated valves until the engine is being started or turned over.

In some instances it is desirable to make the engine directly reversible, and another object of this invention is to provide a fuel injection system wherein direct reversal by preignition may be obtained through switch mechanism associated with the control circuit of the electrically-controlled fuel injection system.

A further object of the invention is to provide, in connection with a governor-controlled switch mechanism for fuel injection systems of the type above referred to, a timing cam which at starting accommodates for the relatively slow speed of the engine that may exist during this period, and prevents excessive charges of fuel being introduced into the engine cylinder during starting.

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 control switch mechanism embodying the invention, parts being broken away;

Fig. 2 is a detail sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a detail sectional view on the line 3—3 of Fig. 1;

Fig. 4 is a detail sectional view of switch mechanism used in the system;

Fig. 5 is a diagrammatic view of a fuel injection system embodying the invention, parts being broken away and parts being shown in section.

Referring to Fig. 5, the fuel injection system includes a fuel supply tank 6 connected by a pipe 7 with a fuel pump 8, of any suitable construction, which is generally driven by the engine and is of a type to insure a relatively constant supply of fuel to a pressure pipe 9 in which the fuel is maintained, while the pump is operating, at substantially constant pressure by means of a pressure valve mechanism of any suitable construction. As shown, pressure valve mechanism 10 includes a casing made up of parts 11 and 12 with a diaphragm 13 secured between them, a valve 14 working in a slotted guide tube 14′ and being normally urged by a spring 15 acting on the diaphragm to close off communication between the pressure pipe 9 and the chamber 16 which communicates with a pipe 17 that returns the excess fuel to the tank 6, the tension of the spring 15 being adjustable by means of a slide-block 18 associated with a bolt 19 in threaded engagement with the part 12 of the casing. From the pipe 9 branch pipes 20 respectively lead to the electromagnetically-operated fuel injector valves 21 which include a control valve 22 having an armature 23 associated with an electromagnet 24 and controlling passage of fuel from its supply pipe 20 through the valve casing and the fuel nozzle 25 into the cylinder of the engine in the head 26 of which the injector valve is mounted, a spring 27 normally tending to close the valve which is opened by the electromagnet at the desired time and for the desired period. As any suitable construction of electromagnetic valve may be used in the system, further description thereof is deemed unnecessary.

The switch mechanism for controlling the operation of the electromagnetic valves is shown in Figs. 1 and 2, and includes a shaft 28 driven by the engine, a switch including a fixed contact 29 and a movable contact 30, a timing cam 31 mounted on the shaft 28 and cooperating with the contact 30 to open and close the control circuit, and in the case of a multi-cylinder engine distributor mechanism including a brush 31′ mounted on the shaft 28 and cooperating with contacts 32

respectively associated with the engine cylinders.

The means for preventing the operation of the injection valves until the engine is turned over for starting comprises a fluid-pressure-operated switch 33 in the control circuit, shown in detail in Fig. 4, and including a pair of contacts 34 and 35 suitably supported and insulated from each other and adapted to be connected by a bridging contact 36 carried by a plunger 37 slidably mounted in section 38 of a two-part casing 39 having a pipe-thread connection 40 with a T-fitting 41 in the pipe 9, the parts 38 and 39 being connected together and to a diaphragm 42 by bolts 38′, to prevent possible leakage, the plunger 37 being normally urged to "open circuit" position by a spring 44 interposed between it and the section 38. Thus when fuel pressure builds up in the pipe 9 the diaphragm 42 is flexed outwardly thereby and hence the plunger 37 is moved outwardly, and thus the contact 36 is moved into engagement with the contacts 34 and 35 to close the control circuit.

The switch mechanism 44, for use in reversing the engine, includes a pair of contacts 45 and 46 suitably insulated from each other and supported upon a block 44′ of insulating material and adapted to be connected by a bridging contact 47 carried by a manually-operated plunger 48 which is normally moved to "closed" position by a spring 49. This switch is associated with the control switch mechanism so that it is operable simultaneously with the shifting of the contact 30 angularly relative to the cam and is here shown as mounted on the lever 50 secured to the angularly adjustable casing 51 of the control switch, though it will be understood that it may be associated with linkage for operating said lever 50 from a distant point.

The circuit connections for the various units of the system are shown in Fig. 5, wherein the numeral 52 designates a battery and 53 a conductor connecting one side of the battery with the contact 35 and including a manual cut-out switch 54. A conductor 55 connects the contact 34 with the contact 45 and a conductor 56 connects the contact 46 with the fixed contact 29. The contact 30 is grounded at 57 and a condenser 58 is connected across the contacts 29 and 30 to reduce arcing. One terminal of the coil of each electromagnet has a ground connection 59. The other side of the battery 52 is connected by a conductor 60 to the brush 31 and each of the contacts 32 is connected to the other terminal of the coil of each electromagnet by a conductor 61 which may include a resistance 62 to reduce the time constant of the magnet circuit.

If the switch 54 is closed by the operator and the contact 30 is in "closed" position before the engine is started and the switch mechanism 33 not used, it is apparent that if one of the electromagnets is then receiving current through the distributor contact 32, with the result that its control valve is open, that some fuel may dribble into the engine cylinder. However, with the switch mechanism 33 included, the control circuit to the electromagnets cannot be completed until the engine has been turned over to such an extent that the pump 8, driven thereby, has established a pressure head of fuel in the pipe 9 which then acts upon the diaphragm 42 to move the plunger 37 and the bridging contact 36 so as to close the circuit through the contacts 35 and 34. Thus, when the switches 54 and 33 are closed and the contacts 47 is in contact with the contacts 45 and 46, current will flow from one side of the battery 52 through conductor 53, contacts 35, 36 and 34, conductor 55, contacts 45, 47 and 46′, conductor 56, contacts 29 and 30 (assuming the cam 31 has permitted the contact 30 to move to closed position) to ground 57. At this time the brush 31 is engaged with one of the contacts 32 so that from ground 57 the current passes to ground 59 of one of the coils 24, through said coil and conductor 61, contact 32, brush 31 and conductor 60 to the other side of the battery, thereby energizing this coil 24 and causing it to attract the armature 23 and thus move the valve 22 to open position so that fuel under pressure passes through the nozzle 25 into the cylinder of the engine at the desired time and by reason of the cam 31, hereinafter described, in the desired amount. Then as the engine continues to rotate the contact 30 will again move into circuit-closing relation with the contact 29 when the brush 31 has moved into engagement with the other distributor contact so that the other cylinder of the engine will receive its fuel charge at the proper time in the cycle.

In case it is desired to reverse the engine, shifting the lever 50 and thereby rotating the case 51 will cause the contacts 30 and 29 to be moved angularly relative to the cam 31 and this will necessarily change the cyclic timing of the charge. Thus, for a two cycle engine of the port scavenging type, if we assume that the fuel is being injected near the end of the compression stroke and the engine is running in one direction, throwing out the engine clutch and pressing on the plunger 48 to separate the contact 47 from the contacts 45 and 46 cuts off the supply of fuel and allows the engine to slow down. When the engine has slowed down sufficiently the lever 50, with the switch 44 still held open, is turned so as to advance the time of closing of the contacts 30 and 29 to the beginning of the compression stroke and the switch 44 is then al-

lowed to close so that the control circuit is rendered operative to inject a charge of fuel at the beginning of the compression stroke, with the result that before the piston completes its compression stroke a preignition will occur which will drive the piston downwardly and thus turn the engine over in the opposite direction. As soon as this reversal takes place the operator opens switch 44 and moves the lever 50 back to a running position which will again cause the fuel to be delivered near the end of the compression stroke with the engine running regularly in the reverse direction. Thus, by providing the switch 44 for operation in conjunction with the means for changing the timing of the control switch the fuel injection period may be changed to reverse the direction of the engine. In the case of a four cycle engine it will, of course, be understood that the timing of the inlet and exhaust valves for effecting a reversal by well-known mechanisms for this purpose which are commonly used on Diesel type engines would be used in conjunction with the changing of the time of fuel injection to effect a reversal of the engine, but as the present invention is directed to the fuel injection system alone no special form of valve-operating mechanism for four cycle engines has been shown.

Referring to Figs. 1 and 2, wherein a control switch mechanism is shown in detail, the numeral 63 designates a two-part casing, and 51 a switch casing mounted on the casing 63 for angular adjustment relative thereto, as by means of screws 64 in casing 51, having pin projections extending into an annular groove 65 in the casing 63, and 66 a cover secured to said switch casing by clips 67.

The shaft 28 has a tight fit in the inner race of the ball-bearing 68, with a shoulder 69 adjacent said ring, and the other race ring is fitted to the casing 63, whereby the shaft is journalled in the casing and prevented from moving upwardly.

The shaft 28 has a keyway 70 formed therein and a key 71 is connected at its upper end to the cam 31 and at its lower end to a sleeve 72 slidably mounted on the shaft 28. Thus, the shaft 28, cam 31 and sleeve 72 rotate together and the cam 31 may be moved lengthwise of said shaft by the lengthwise movement of said sleeve. This movement may be effected by a manually-controlled lever or by a speed responsive device. As shown, a spider 73 is secured to rotate with the shaft 28 by screws 74 and has a bore 75 in which the sleeve 72 is free to move within the limits determined by a longitudinal slot 76 in said sleeve, and a pin 77 on the hub of the spider 73. The sleeve movement is effected by any suitable governor associated with the spider 73. As shown the oppositely disposed arms of the spider have levers 78 pivotally mounted thereon, their forked ends 79 being provided with pins 80 mounted in an annular groove 81 formed in the upper part of the sleeve, their outer ends carrying the weights 82. A spring 83, acting in opposition to the governor weights, is interposed between the upper end of the sleeve 72 and a manually-controlled collar 84 slidably mounted on the shaft 28. The collar is moved manually by a lever 85 pivotally mounted on the casing and having forked ends 86, provided with pin projections engaging in the groove of said collar, and an exteriorly disposed operating arm.

A ball-bearing 87 is located between the hub of the spider and the casing 63.

The cam 31 has one or more, the number depending upon the number of engine cylinders, tapered reliefs 88 formed therein with one side, the advancing side, preferably parallel with the axis of the cam so that for any given angular adjustment of the casing 51 the circuit closing period will begin at the same time. The contact 30 is suitably pivoted at 89 and is normally urged against the cam by a spring 90 and has a spherical projection 91 engaging said cam. It will be noted from the drawings that the reliefs 88 gradually taper outwardly from the upper end 92 to an intermediate point and then taper toward a point 93 at their lower ends. These tapered reliefs permit the contact 30 to remain in engagement with the contact 29 for longer or shorter relative periods of time, depending upon the position of the cam 31, and hence the duration of current flow in the control circuit or circuits may be varied with the result that the electromagnets are energized for varying periods of time so that the valves are held open for corresponding periods and thus varying amounts of fuel are delivered to the engine cylinders in proper cyclic sequence through the connection of this switch mechanism with the brush 31 and contacts 32. As shown the brush 31 is mounted on, but insulated from, the shaft 28, and is urged by a spring 92 against the commutator track 93 having the contacts 32 inset therein, and the brush receives its current from a brush 94 urged by a spring 95 against the brush 31 and mounted in a member 96 provided with terminal connections 97. The contacts 32 have studs 98 secured thereto provided with terminal connections 99. The current to the contact 29 is led in through the terminal support 100 insulated from the case 51 and connected with the conductor 56.

As the speed of the engine increases the cam 31 will be moved longitudinally of the shaft 28 by the action of the governor weights swinging outwardly and the sleeve 72 moving upwardly so that different por-

tions of the tapered reliefs 88 will be brought into operative relation with the cam to vary the amount of fuel injected, and at any given speed the quantity of fuel may be increased by the downward movement of the collar 84, and this movement also puts increased tension on the spring 83 and thus acts to accelerate the speed of the engine. As the upper end 92 of the relief of the cam is relatively short, the engine may be turned over slowly, as in starting by hand, without furnishing excessive amounts of fuel to the engine. Furthermore, it will be noted that the cam may be designed so that greater quantities of fuel are furnished at intermediate speeds than at the higher speeds where the cam is operated by the governor, and this is desirable for certain kinds of power work.

From the foregoing description it will be noted that I have provided means for preventing feeding of fuel to the engine cylinder until the engine is actually being started; means for preventing an excessive charge when the engine is turned over slowly during starting; and means permitting of the ready reversal of the engine by preignition.

I desire it to be understood that this invention is not to be limited to any specific 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 of a fuel injector valve, an electromagnet controlling the operation of said valve, a control circuit for said electromagnet including circuit control mechanism controlled by the engine, means for supplying fuel to said injector, and automatically-operating switch means for preventing operation of the control circuit until the engine is being started.

2. In a fuel injection system wherein the fuel injector valve is operated by an electromagnet receiving current from a control circuit including circuit control mechanism controlled by the engine, and the fuel is delivered to said valve from a pressure system including a pump, the combination with such system, of fuel-pressure-controlled switch mechanism in said control circuit to render said circuit inoperative until the fuel pressure builds up in said system during the starting of the engine.

3. In a fuel injection system, the combination with a fuel-metering device for controlling the supply of fuel delivered to the engine, of an electromagnet controlling the operation of said device, a control circuit for said electromagnet including circuit control means and a manually-operated member for varying the timing of said circuit control means, and switch means in said control circuit mechanically associated with said manually-operated member whereby the operator may open said control circuit as he moves said manually-operated member to permit reversal of the engine by the injection of a preigniting charge of fuel into the engine cylinder.

4. In a fuel injection system, circuit control mechanism for a metering control electromagnet, comprising a switch including a movable contact, an engine-driven cam for operating said contact, a governor, means operated by said governor for adjusting the came and switch relative to each other to vary the duration of the circuit-closing periods of said switch, said cam having a relief surface controlling the closing of the switch contacts and preventing excessive quantities of fuel being delivered to the engine during starting and before the governor takes up its action.

In testimony whereof, I affix my signature.

LOUIS O. FRENCH.