

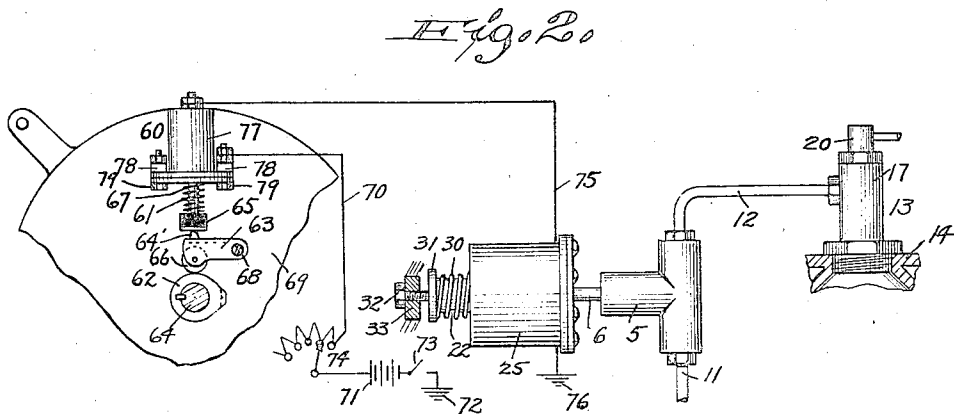
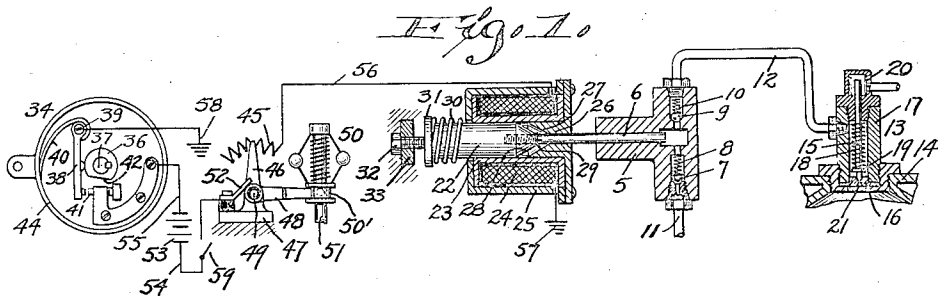
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FUEL INJECTION SYSTEM

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INVENTOR

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FUEL-INJECTION SYSTEM

Application filed April 17, 1926. Serial No. 102,811.

The invention relates to fuel feeding systems.

The general object of the invention is to provide a fuel feeding system wherein the expressing member of a fuel pump is electrically operated in cyclic synchronism with the engine and controlled so that its stroke is varied to supply the engine with the required amount of fuel.

A further object of the invention is to provide a fuel feeding system wherein the stroke of the fuel pump is controlled by means including a variable resistance which in one instance is shown as associated with control switch mechanism and in another instance as forming the primary control for the active operation of the pump.

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 view, partly diagrammatic and partly in section, of a fuel feeding system;

Fig. 2 is a view similar to Fig. 1, showing a modified form of system.

Referring to the drawings, in each instance the numeral 5 designates the body or casing of the pump, 6 the expressing member, here shown as a plunger reciprocating in a bore in said casing, 7 an inlet valve which may be moved to closed position either by its own weight or by a spring 8, 9 a discharge valve which may be moved to closed position by its own weight or by a spring 10, 11 a supply pipe which may communicate with a supply tank or with a priming pump (not shown), 12 a discharge pipe leading to the fuel injector valve 13 mounted in the engine head or cylinder 14. The valve 13 may be of any suitable construction but is preferably of the type opened by fuel pressure and is here shown as of the differential-pressure-needle type, including the needle valve 15 associated with a nozzle member 16 and working in a casing 17, and normally held to its seat by a spring 18 interposed between a shoulder 19 on the stem of the valve and a cap and stem guide member 20 secured to the upper end of the casing. During the expressing stroke of the

pump fuel is forced through the discharge pipe 12 into the casing 17 where acting on the valve 15, due to the difference in pressure between the lower end of the valve and the outer stem portion projecting through the member 20, it lifts said valve against the action of the spring 18 and consequently fuel passes into the engine through the discharge opening 21 in the nozzle member 16.

The expressing member 6 is electrically operated and controlled. For this purpose the plunger, which is preferably of bronze or other non-magnetic material, is secured to the solenoid plunger 22 of magnetic material which works within the non-magnetic spool 23 surrounded by a suitably insulated energizing coil 24. The solenoid is preferably of the iron-clad type, including a shell or partial shell 25 of magnetic material associated with a stop 26 of similar material. The plunger 6 works in a bore in the stop 26 and the face 27 of this stop and the adjacent end 28 of the plunger 22 are correspondingly cone-shaped so as to increase the magnetic effect of the solenoid as much as possible by decreasing the air gap between these parts for a relatively long movement of the plunger 22. A very thin shoulder 29 is provided on the non-magnetic plunger 6 adjacent the plunger 22 so as to just prevent contact between said plunger and said stop when said plunger is at the end of its expressing stroke and thus prevent any possibility of freezing. The plungers 6 and 22 are moved on their expressing stroke by the energization of the solenoid and on their suction stroke by a spring 30 interposed between a shoulder 31 on the plunger and the shell 25, and an adjustable stop-screw 32 mounted in a fixed support 33 limits the outward movement of said plungers.

The control means shown in Fig. 1 for the solenoid-operated pump, includes engine-controlled switch mechanism 34 and a variable resistance 45. The switch mechanism may be of any suitable construction adapted to effect a make-and-break of the solenoid-control circuit, and is here shown as including a timing cam 36 mounted on a shaft 37 either driven by the engine or rotated in cyclic synchronism therewith and associated with a

movable contact member 38 pivoted at 39 and normally urged into operative contact with the cam by a spring 40, said member 38 being adapted to engage a suitably insulated fixed contact 41 when a relief 42 on said cam passes by the projection on the member 38. The contact members 38 and 41 are carried by a case 44 mounted for rotation relative to the cam for varying the timing to advance or retard the time of energization of the solenoid. Further details of switch mechanism suitable for use in this system will be found in my copending applications Serial No. 26,676, filed April 29, 1925, and Serial No. 88,406, filed Jan. 27, 1926, and Serial No. 97,637, filed Mar. 26, 1926.

The variable resistance may be of any suitable form and is here shown as including the resistance element 45 and the movable arm 46 which may be manually or governor operated. As shown, the arm 46 is insulated from its pivot support 47 and from another arm 48 to which it is connected to form a bell-crank lever pivotally mounted at 49 on said support. The arm 48 has forked ends associated with a collar 50' mounted on a shaft 51 of the engine governor. A more detailed showing of a governor-controlled variable resistance will be found in my copending applications Serial No. 88,406, and Serial No. 97,637, above referred to.

A brush 52 is associated with the arm 46 and is connected with one terminal of a battery 53, or other suitable source of electrical energy, by a conductor 54, the other side of said battery being connected by a conductor 55 to the fixed contact 41.

A conductor 56 leads from the resistance element 45 to one terminal of the solenoid coil 24, while the other terminal of the coil is grounded at 57, and the circuit is completed through ground at 58 to the contact 38. A manually-controlled cut-out switch 59 is shown in the conductor 54.

When the switch 59 is closed and the engine is running the switch mechanism 34 will act to periodically establish current flow through the coil of the solenoid through the circuit connection above described, and when the coil 24 is energized the plunger 22 will be drawn toward the stop 26, both by the solenoid and magnetic effects, and thus cause the plunger to make its fuel-expressing stroke to deliver fuel to the engine cylinder. The extent of this stroke will depend largely upon the strength of the energizing current and this is controlled by the adjustment of the variable resistance, as cutting out of resistance in the control circuit will increase the current strength and hence the stroke of the pump, and cutting in of resistance will decrease the stroke. In this way the amount of fuel delivered to the engine through the injector will be varied.

Where a governor is associated with the

variable resistance, it may be made to function to gradually increase the amount of resistance with increase of engine speed so as to decrease the stroke of the pump and hence the supply of fuel to the engine under these conditions, or it may be adjusted to provide for a full stroke of the pump up to a predetermined speed, through its inaction, to effect a constant stroke and hence the delivery of constant quantity fuel charges to the engine through wide range of speed, and then become operative to include resistance above this speed to decrease the amount of fuel charge and finally cut in so much resistance that at a predetermined maximum speed the current passing through the solenoid is insufficient to move the plunger and thus the fuel supply to the engine is cut off until the speed drops below this maximum designed speed for the engine.

The control means shown in Fig. 2 includes an engine-controlled variable resistance 60 which is preferably of the pressure type, and details of two forms of this device are more particularly shown and described in my copending application Ser. No. 170,328, filed Feb. 23, 1927, as a continuation in part of my application Serial No. 99,325, filed April 2, 1926, said resistance having resistance material either of disk or powdered form associated with a thrust member 61 which may be directly actuated by a timing cam 62, or preferably through a lever 63 which has a part 64 engageable with the insulated head 65 of said member and a roller 66 riding on the cam and held thereagainst by a spring 67. The lever 63 is pivoted at 68 upon a support 69 rotatable relative to the came for advancing or retarding the time of cutting out resistance. The came 62 is preferably one having a variable lift and shiftable along the shaft 64, either manually or by a governor, to vary the amount of resistance cut out as shown and explained in said application Serial No. 170,328.

One side of the variable resistance 60 is connected by a conductor 70 with one side of a battery 71 whose other side is grounded at 72, a cut-out switch 73, and a manually-controlled variable resistance 74 being associated with said conductor, said variable resistance being used to modify the action of the engine-controlled variable resistance 60. The other side of the resistance 60 is connected by a conductor 75 with one terminal of the energizing coil of the pump-operating magnet, and the other terminal of said coil is grounded at 76. The insulated case 77 of the variable resistance device is secured to posts 78 on the support 69 by bolts 79 insulated therefrom.

When the switch 73 is closed and the engine is running the cam 62 acts to periodically diminish the resistance so that during the period determined for injection enough cur-

rent flows through the solenoid to produce the desired movement of the plungers 22 and 6, and by varying the resistance included in the circuit by shifting the came 62 relative to the lever 63 the stroke of the pump plunger, and hence the amount of fuel delivered by the pump, is varied. Furthermore, the variable resistance in the circuit may be manually varied to modify the action of the engine-controlled resistance.

Where the cam 62 is associated with the governor, as shown in my copending application Serial No. 170,328, the cam may be used thereby to gradually increase the amount of resistance with increase of engine speed so as to decrease the stroke of the pump and hence the supply of fuel to the engine under these conditions, or the governor may be adjusted to provide for a full stroke of the pump up to a predetermined speed, through its inaction, to effect a constant stroke and hence the delivery of constant quantity fuel charges to the engine through a wide range of speed, and then become operative to include more resistance above this speed to decrease the amount of fuel charge, and finally cut in so much resistance that at a predetermined maximum speed the current passing through the solenoid is insufficient to move the plunger and thus the fuel supply to the engine is cut off until the speed drops below this maximum designed speed for the engine.

It will be understood that shifting the cam 62 relative to the lever 63 varies the action of the variable resistance 60, and that the variable resistance 74 by modifying the effective action of the variable resistance 60 varies its action.

While the systems have been more particularly described with reference to direct current, it will be understood that alternating current with a variable resistance, either ohmic or inductive, could be used, and that the 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.

What I claim as my invention is:

1. In a fuel feeding system, the combination with a fuel pump having a fuel-expressing member, of an electromagnet for controlling and operating said member, and control means for said electromagnet including a variable resistance for varying the stroke of the pump to vary the fuel charges delivered to the engine.

2. In a fuel feeding system, the combination with a fuel pump having a fuel-expressing member, of an electromagnet for controlling and operating said member, and control means for said electromagnet including a governor-controlled variable resistance for varying the stroke of the pump to vary the fuel charges delivered to the engine.

3. In a fuel feeding system, the combination with a fuel pump having a fuel-expressing member, of an electromagnet for controlling and operating said member and control means for said electromagnet including circuit control mechanism controlled by the engine and a variable resistance associated with said circuit control mechanism to vary the stroke of the pump.

4. In a fuel feeding system, the combination with a fuel pump having a fuel-expressing member, of an electromagnet for controlling and operating said member, an engine-controlled variable resistance for periodically causing the active operation of said electromagnet, and means for varying the action of said variable resistance to vary the stroke of the pump.

5. In a fuel feeding system, the combination with a fuel pump having a fuel-expressing member, of an electromagnet for controlling and operating said member, an engine-controlled timing variable resistance for periodically causing the active operation of said electromagnet, means for varying the action of said variable resistance to vary the stroke of the pump, and a variable resistance to modify the action of said timing resistance.

6. In a fuel feeding system, the combination with a fuel pump having a fuel-expressing member, of an electromagnet for controlling and operating said member, an engine-controlled timing variable resistance for periodically causing the active operation of said electromagnet, and a variable resistance for modifying the action of said timing resistance.

7. In a fuel feeding system, an electromagnetically-operated pump comprising a pump casing, a pump plunger working in said casing, a solenoid electromagnet having a magnetic stop through which the plunger works, a solenoid plunger working in the core of said electromagnet and connected with said pump plunger, and a non-magnetic stop between said plungers.

In testimony whereof, I affix my signature.

LOUIS O. FRENCH.

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