May 5, 1931. L. O. FRENCH 1,803,666

FUEL FEEDING SYSTEM

Filed Jan. 28, 1928

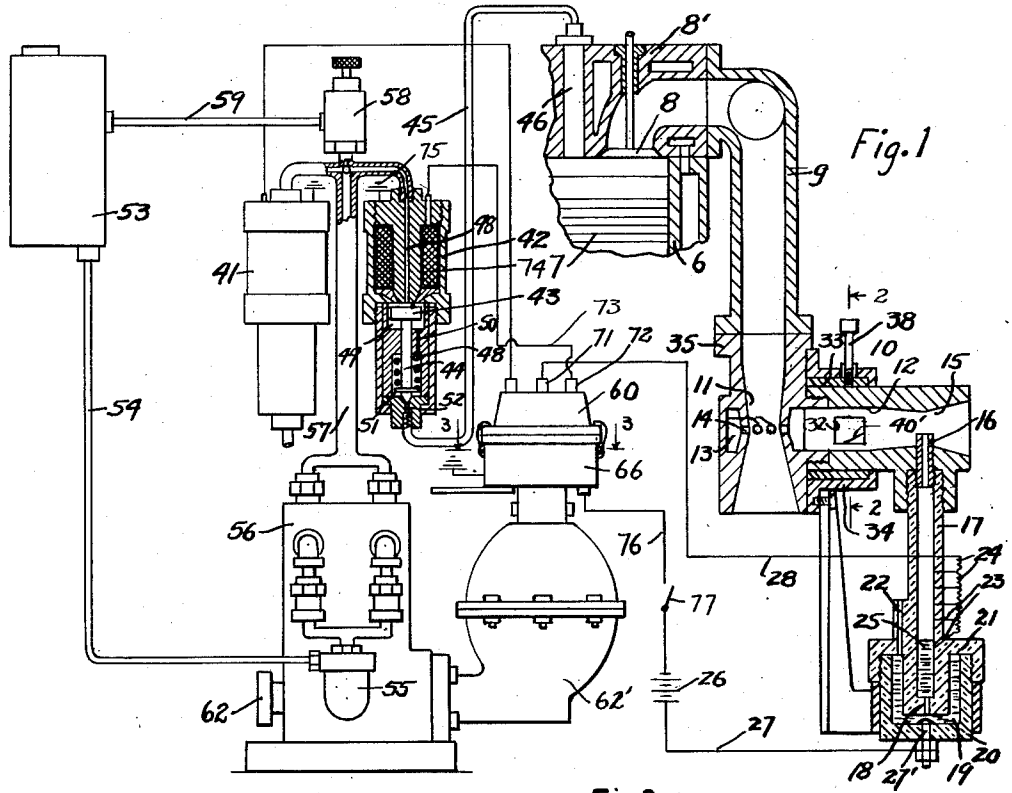


Fig. 1

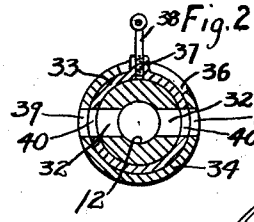


Fig. 2

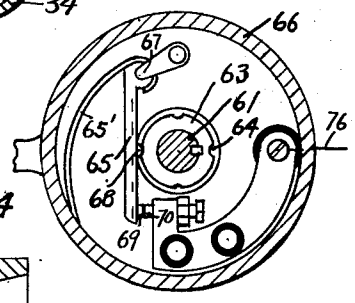
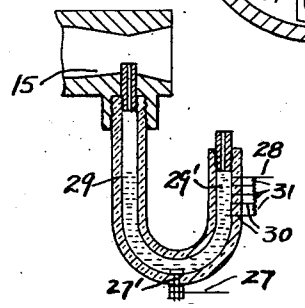


Fig. 3

Fig. 4



INVENTOR

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UNITED STATES PATENT OFFICE

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FUEL FEEDING SYSTEM

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The invention relates to fuel feeding systems.

The object of the invention is to provide an apparatus for controlling the supply of fuel to an internal combustion engine and more particularly where a metered amount of fuel is supplied to the engine whereby the charge or charges of fuel supplied to the engine may be readily regulated through a wide range of speed and load and wherein the metering is controlled by the suction pressure of the air entering the engine cylinders. In electrically-controlled fuel injection systems the control embodying the invention may be utilized to act in conjunction with the timing circuit control mechanism to maintain substantially constant quantity metered fuel charges through a wide range of engine speeds or to vary the quantity of such charges. By its action it is possible to control the supply of fuel to an injection type engine with the same facility that exists in the well known carburettor type engine with the further advantage, however, of obviating the necessity of throttling the air charge. More particularly, the control embodies a suction-controlled variable resistance and in its preferred embodiment the suction-operated means takes the form of a column of conducting liquid, such as mercury, the height of either end of which is varied by the suction pressure to decrease or increase the resistance in the control circuit for the fuel-metering device.

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 injection system embodying the invention;

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

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

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

Referring to the drawings, the numeral 6 designates one of the cylinders of a multi-cylinder engine, 7 the piston working therein, 8′ the cylinder head, 8 the inlet valve, 9 the inlet manifold and 10 the control means embodying the invention.

This control means comprises a passage 11, preferably of Venturi form, at the entrance end of the manifold 9 and preferably open, though a throttle valve may be associated therewith, if desired. A conduit 12 communicates with an annular passage 13 surrounding the throat of said venturi, with openings 14 leading therefrom into the throat. This conduit 12 has a Venturi passage 15 communicating therewith and a tube 16 projects up into the throat of the venturi and forms the upper end of a tube 17 of insulating material, which tube has a restricted passage 18 at its lower end communicating with a chamber 19 or other leg of the tube. The walls of this chamber are formed by a cup 20 of insulating material and a flanged portion 21 of the tube forms a cap in threaded engagement with said tube and has an atmospheric vent 22 leading to the chamber 19. This construction forms, in effect, a U-tube, open to atmosphere on one leg and open to passage 15 at the upper end of its other leg. The cup and a portion of the tube is filled with a suitable electrical conducting liquid, such as mercury, and at intervals along the tube conductor wires 23 lead into the tube. Adjacent conductor wires are connected together by sections of resistance elements 24 and while the spacings of the leads 23 are shown quite wide apart, in practice they are close together so that a small change in the height of the mercury column 25 in the tube 16 will effect a change in resistance in the control circuit, it being noted that the lower conductor wire is always in contact with said mercury column and that current flows from a battery 26, or other suitable source of current, through a conductor 27 connected to a terminal 27′ extending into the cup 20 and thence through the mercury column and the resistance 24 to a conductor 28 of the control circuit.

With this construction air passing through the venturi 11 will exert a suction effect on

air passing into the throat of said venturi from the venturi 15 and consequently a suction effect is produced at the upper end of the tube 16, 17 and as the speed of the engine, and hence the suction pressure, increases the height of the mercury column in the tube 17 increases and this acts to cut out resistance in the control circuit, depending upon the height, since the mercury establishes successive contacts with the wires 23 as it rises. Where it is desired to increase the resistance in the control circuit with increase in suction, I have shown, in Fig. 4, a U-tube 29 of insulating material associated with the venturi 15 with the leads 30 extending into the atmospheric leg of said tube and associated with the resistances 31 so that as the suction increases the height of the mercury column 29′ in said leg drops, thus cutting resistance into the circuit including the conductors 27 and 28 and terminal 27′.

The insulating material for the tubes previously described may be of any suitable kind resistant to mercury, such as glass, hard rubber, a suitable phenol condensate product or fibre, and the lead wires are preferably associated therewith during the process of molding and curing material such as rubber or suitable phenol condensate product. The restriction 18 is provided to prevent surging of the column and may be used in connection with the tube 29.

In order to vary the suction effect of the venturi 15 valve-controlled air inlet ports 32 are provided between said venturi and the passages 14. As shown, a sleeve valve 33 rotatably fits over the outer surface of the tube forming the passage 12 and is maintained in operative position by a flanged tube 34 secured to the casing 35, said collar having an arcuate slot 36 therein through which a boss 37 on the sleeve 33 projects, said boss carrying an operating arm 38 adapted to be operated either manually or by a governor through any suitable linkage connection therewith. The collar 34 has openings 39 alined with the ports 32 and the sleeve 33 has similar openings 40 which may be tapered, as indicated at 40′, to produce a gradual increase in port opening. When the valve 33 is in open position there will be little or no suction effect created on the mercury column, since the engine then takes a portion of its air from in front of the venturi 15 and the rest from the main passage 11 but as the valve 33 is closed the suction effect in the venturi 15 will be gradually increased to effect the control of the resistance, it being noted that this change in suction effect is produced without throttling the supply of air to the engine so that the volumetric efficiency is not impaired, as is the case with the usual carburettor type engine.

This control may be associated with any suitable electrically-controlled fuel supply device, such as a pump or a valve, and for the purpose of illustration I have shown the same associated with electrically-controlled fuel metering valves 41. These valves may be of any suitable construction and in the present instance I have shown the valves more particularly described in my United States Letters Patent No. 1,664,616, issued April 3, 1928. Briefly, this valve construction embodies an ironclad electromagnet 42 whose poles are associated with an armature 43 on the metering valve 44 controlling passage of fuel direct to the engine, as in the aforesaid patent, or to a conduit 45 associated with any suitable injection nozzle 46 delivering fuel to the engine cylinder, said valve being held closed either by the fuel pressure alone or assisted by a spring 47, the fuel passing down through a passage 48 in the magnet core to chamber 49, passage 50, chamber 51, to the valve-controlled outlet passage 52.

In injection type engines the fuel is supplied under pressure and in the present instance the fuel from a supply tank 53 passes by way of pipe 54, strainer 55 to a pump 56, preferably engine-driven, of the double or triple acting type and is discharged therefrom into a standpipe 57 having branch sections communicating with the passages 48 of the valves, in which it is maintained at the desired pressure by a suitable pressure valve 58 or accumulator from which excess fuel flows by way of pipe 59 back to the tank 53.

Thus, during the time the current is on or is of sufficient strength to life the armature 43 and hence the valve, fuel will flow from the pipe 57 through the valve, pipe 45, nozzle 46 into the engine cylinder and, dependent upon the strength of the current under these conditions, the valve will be lifted for a greater or less period of time so that a greater or smaller amount of fuel will be delivered to the engine, it being noted that the variable resistance functioning as previously described acts to increase or diminish the current strength.

In injection type engines the fuel is delivered to the engine cylinders in proper cyclic sequence during a predetermined period and for this purpose any suitable timing circuit control mechanism may be used. Mechanisms suitable for this purpose have been shown and described in detail in my United States Patents No. 1,664,611, 1,664,615 and 1,679,159, and parts of one of these mechanisms have been shown herein in Figs. 1 and 2, as an example, wherein 60 designates a distributor, shown in detail in said Patent No. 1,664,611, and 61 designates the timer shaft driven by the engine at the proper cyclic speed, here shown from the pump drive shaft 62 through a suitable gearing

connection therewith (not shown) within the casing 62'. A cam 63 is keyed to said shaft 61 and is preferably mounted to slide longitudinally thereon and is provided with tapered recesses 64. A breaker arm 65 is pivotally mounted on the rotatable timer casing 66 at 67 has a projection 68 held against said cam by a spring 65' and a contact 69 engageable with a fixed contact 70 suitably insulated from said casing. With such a form of circuit control mechanism and that of the tapered cam form of Paten No. 1,679,159, as the speed of the engine increases the relative time of the circuit closing period decreases for any given setting of the cam so that the metering valve will be opened for shorter periods of time at high speeds than at lower engine speeds and hence less fuel will be delivered to the engine and yet under some conditions it is desirable to keep the fuel supply constant for wide ranges of speed, which is satisfied, in the construction shown in Fig. 1, by automatically cutting resistance out of the control circuit to provide a greater relative period of opening of the metering valve at higher speeds to compensate for the interval contact, since the suction effect of air passing through the venturi 15 and acting on the mercury column 25 is proportional to the speed. As shown in said Patent No. 1,664,611, and as indicated in Fig. 1, the current passes from conductor 28 to the terminal 71 associated with the rotating brush (not shown) by which current is successively made with contacts associated with the terminals 72 and passes by way of conductor 73 to one of the terminals of the energizing coil 74 of the magnet, the other terminal being shown grounded at 75. The current then passes through ground to the grounded breaker arm 65, contacts 69 and 70 to a conductor 76 connected with the other terminal of the battery 26 which with the other connections previously described completes the circuit through the magnet and causes the lift of the valve 43 so long as the circuit is closed. A cut-out switch 77 may be located in the circuit, as in the conductor 76. When used with the circuit closer having a timing cam of the form shown in my United States Patents No. 1,664,611, it will be noted that when the engine is being started the time of closing the circuit is relatively long and while a heavy charge of fuel is desirable under these conditions, too heavy a charge is prevented by the inclusion of all the resistances 24 and thereafter as the speed of the engine increases the valve 48 is closed off to permit the successive cutting out of resistances at higher speeds. Furthermore, at any given speed the supply of fuel may be decreased by partially closing the valve 33 to decrease the amount of resistance in the control circuit, or it may be increased by increasing the period of energization by moving the cam 61 higher. When the engine reaches its rated speed the time of active current flow may be decreased until the circuit is broken at a predetermined maximum speed. The movement of the cam may be under manual or governor control. Instead of a circuit closure the variable resistance timer of my United States Patent No. 1,679,159, may be used to control the timing of the current flow.

Instead of a circuit closer whose timing intervals may vary with increase in engine speed, a circuit closer having a timing interval substantially constant for all ranges of speed may be used, as shown in my United States Patent No. 1,664,615, in which instance the timing interval is sufficient for starting purposes with full current on and is decreased when the engine is running regularly by the cutting in the resistances 24 into the control circuit so as to decrease the duration of lift of said metering valve or it may be increased when desired by the opening of the valve 33.

Thus, it will be apparent that the suction-controlled variable resistance will act in conjunction with the timing circuit control mechanism to either compensate for or vary its effect and that this suction control itself may be varied by the opening or closing of the valve 33, and that the air supply to the cylinders of the engine is not diminished so that the engine will operate efficiently on light loads as its compression pressure per stroke will be substantially constant under variable loads.

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

What I claim as my invention is:

1. In a fuel supply system, the combination with the engine and a fuel-control electromagnet, of a variable resistance controlled by the suction of the engine for controlling the action of said electromagnet.

2. In a fuel supply system, the combination with a fuel-metering valve, of an electromagnet controlling said valve, and means controlling the operation of said electromagnet including a variable resistance controlled by the suction pressure of the engine for varying the current supplied to said electromagnet and thus vary the duration of lift of said valve and consequently the amount of fuel furnished the engine.

3. In a fuel supply system, the combination with a fuel-metering control electromagnet, of a variable resistance for controlling the action of said electromagnet, suction-controlled means for varying said resistance, and means for independently vary-

ing the action of said suction-controlled means.

4. In a fuel supply system, the combination with a fuel-metering control electromagnet, of a variable resistance for controlling the action of said electromagnet, and suction-controlled means for varying said resistance including a column of electrically conductive liquid.

5. In a fuel supply system, the combination with a fuel-metering control electromagnet and the inlet manifold of the engine having a main air supply passage, of a supplemental air supply passage including a Venturi passage, a variable resistance for controlling the action of said electromagnet, and suction-controlled means associated with said venturi for varying said resistance.

6. In a fuel supply system, the combination with a fuel-metering control electromagnet and the inlet manifold of the engine, of a Venturi passage forming the entrance end of said manifold, a supplemental air passage communicating with the throat of said Venturi passage and having a Venturi passage in communication therewith, a variable resistance for controlling the action of said electromagnet, and suction-controlled means associated with said last-named Venturi passage for varying said resistance.

7. In a fuel supply system, the combination with a fuel-metering control electromagnet and the inlet manifold of the engine having a main air supply passage, of a supplemental air supply passage including a Venturi passage, a variable resistance for controlling the action of said electromagnet, suction-controlled means associated with said venturi for varying said resistance, and valve-controlled ports in said supplemental air passage in advance of said venturi for varying its effect on said suction-controlled means.

8. In a fuel supply system, the combination with a fuel-metering control electromagnet of a variable resistance for controlling the action of said electromagnet, suction-controlled means for varying said resistance, and means for supplying air to said engine without throttling.

9. In a fuel supply system, the combination with the engine and a fuel-control electromagnet, of suction-controlled means for controlling the action of said electromagnet.

In testimony whereof, I affix my signature.

LOUIS O. FRENCH.