

2,075,877

2 Sheets-Sheet 1

Brooks Walker

April 6, 1937.

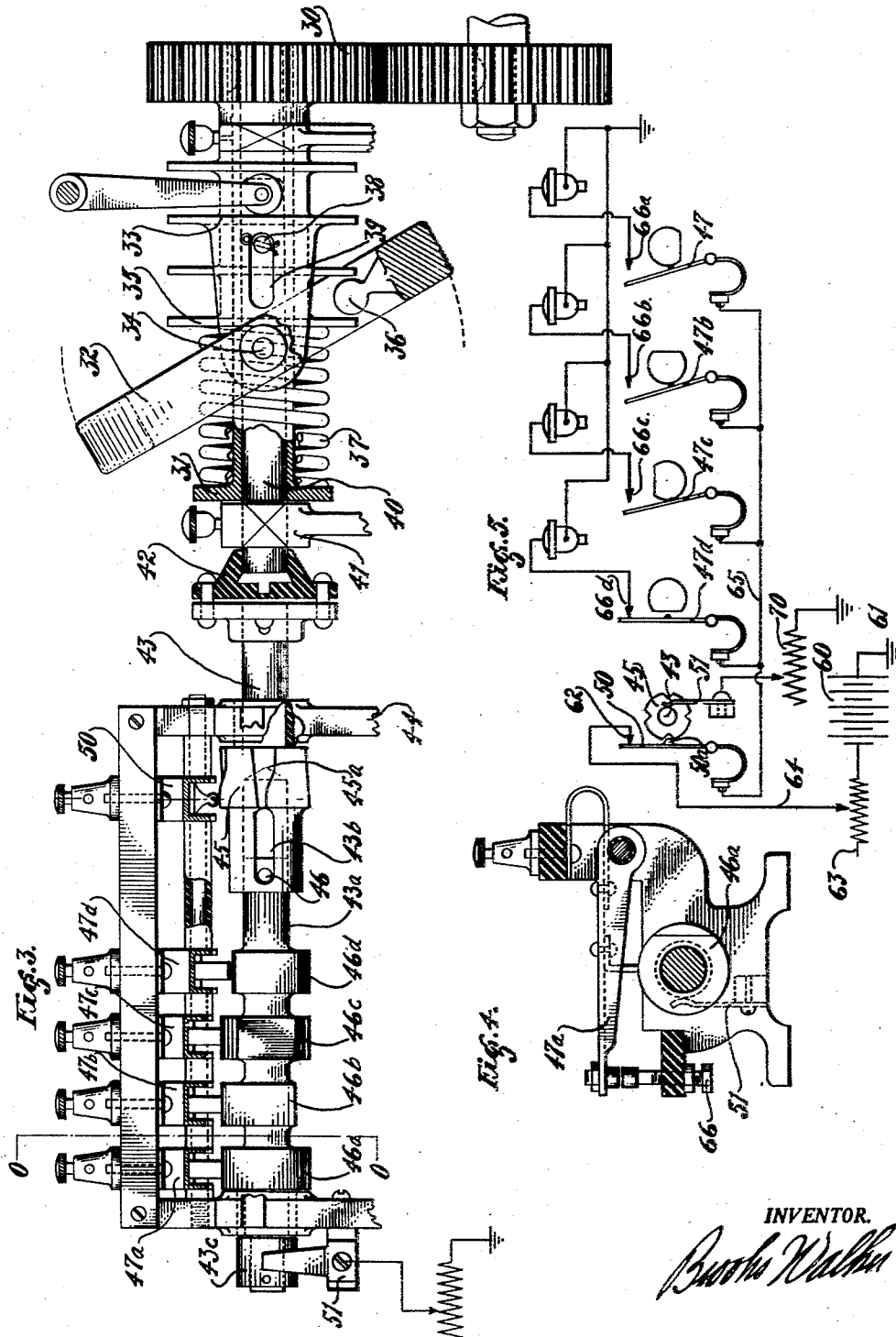
B. WALKER

2,075,877

FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 20, 1930

2 Sheets-Sheet 2



INVENTOR.

B. Walker

UNITED STATES PATENT OFFICE

2,075,877

FUEL INJECTION SYSTEM FOR INTERNAL
COMBUSTION ENGINES

Brooks Walker, Piedmont, Calif.

Application August 20, 1930, Serial No. 476,625

8 Claims. (Cl. 123—32)

This invention relates in general to explosive engines of that class in which the fluid which forms the basis of the explosive mixture is admitted to the explosion chamber of the engine in proper quantities for each successive charge, and more especially to the means for controlling and regulating an electromagnetic fuel metering valve with the ultimate object of regulating the speed and power of the engine over a relatively wide range of speed and torque variations.

The object of the invention is to improve such means in a way that correct metering will be accomplished, particularly at full torque throughout a wide range of speed variations. A further object of the invention is to prevent the possibility of the engine being flooded with an excess amount of fuel at low speeds or when the engine is stopped. Another object is to provide means for controlling both the quantity injected per cycle to affect throttling, and also to provide a control of the timing of the injection for the most beneficial operation.

A further object of this invention is to provide a circuit whereby a constant source of voltage may be utilized, such as the ordinary battery, and still maintain correct metering throughout a wide range of speed variations, and also obtain a wide range of injection duration to affect throttling without the necessity of breaking a large quantity of current at the contacts. The structures now known in this art require a variation in the quantity of current that must be broken at the contact when the throttle is changed, this is due to the higher value to which the current builds before breaking, this variation in the magnitude of the current to be broken imposes an unduly heavy load on the contacts at the higher values. The operation of these electro-magnetically actuated metering valves depends on the very accurate control of the duration of current flow on the individual impulses which energize the valves. This control is determined by the condition in which the contact surfaces can be maintained and the degree to which arcing at the contacts can be eliminated since in practice the valve is held open during any time in which an arc exists. From this consideration it is apparent that the system which requires the breaking of the least current at the contacts will be the most durable and satisfactory operating system in actual practice, all other things being equal.

A further object of this invention is to provide a system for operating an electro-magnetically actuated metering valve wherein a decided

economy of operating current is effected as compared to the systems previously used in this art. This is accomplished by supplying the minimum current input to the electro-magnet per energizing impulse regardless of throttle position or frequency of operation. A satisfactory throttle is effected by controlling the decline of flux in the magnetic structure to control the time during which the valve is held open after the energizing current is discontinued. This is accomplished in my structure by providing a switch mechanism driven by the engine which closes a circuit with the electro-magnet and the source of current supply for a substantially constant period of time throughout a relatively wide range of engine speed, and subsequently connects a variable resistance across the electro-magnetic winding to control the rate of decline of the flux in the magnetic structure. This control is attained without the addition of any more supply current than is necessary to just lift the valve. A control of this type is possible because of the difference in the values of the current necessary to lift the valve against the unbalanced fluid pressure prevalent in magnetic valve structures and against a relatively large air gap, and the current values necessary to hold the valve lifted in a balanced fluid condition and with a very much reduced air gap. In practice a valve was found to lift on 1.5 volts steadily applied and to drop at .2 volts steadily applied. From these figures and from an engine actually operating on this system it was found that a wide range of control was available for throttling. A means for controlling the decline of magnetic flux has been shown wherein a rectifier was placed in series with a variable resistance across the valve winding in the copending application Serial No. 458,739, filed May 31, 1930, now Patent No. 1,892,917, granted January 3, 1933, entitled "Magnetic valve" by Brooks Walker and Harry E. Kennedy, of which I am a co-inventor. This application discloses means for controlling the decline of flux in a single valve to vary one valve relative to another for equalization in a multi-cylinder engine and shows no way in which a single throttle means could be applied to a multi-cylinder engine.

A further object of this invention is to provide an electrical control circuit inherently capable of maintaining the timing of the start of injection relative to the crankshaft a constant at any given engine speed throughout a wide range of throttle changes, this is effected by leaving the lifting current unchanged and con-

trolling the rate of decline and hence the point of cut-off of injection. This characteristic of unchanged timing of the start of injection during throttle changes at a given engine speed is desirable for economic engine operation and is accomplished by this invention inherently and without the mechanical connections employed in the copending application Serial No. 375,153, filed July 1, 1929, for "Fuel metering or injecting and controlling system for internal combustion engines", by Brooks Walker and Harry E. Kennedy, of which I am a co-inventor.

I will describe the nature of my invention more explicitly with reference to the convenient and practical embodiments thereof, which I have shown in the accompanying drawings in which:

Fig. 1 is a diagrammatic view of a mechanism embodying the invention.

Fig. 2 is a view of the contacting mechanism used, illustrated in Fig. 1, but shown in different position.

Fig. 3 is a side elevation, partly in section, of an alternative construction embodying the invention.

Fig. 4 is an end view, partly in section, of Fig. 3, through section 0-0.

Fig. 5 is a diagrammatic view of the circuit which may be used in connection with Figs. 3 and 4.

Similar numerals of reference refer to corresponding parts in the several views and the accompanying drawings.

Referring to the accompanying drawings, and particularly to Fig. 1, my apparatus includes the electromagnetic fuel valve 1, such as described in my co-pending application Serial No. 458,739, filed May 31, 1930, or any other well known type. A fuel inlet pipe 2, delivers fuel from any suitable source of pressure. A section of the engine cylinder is indicated at 3.

A source of electromotive force is, in this case, indicated as the battery 5, though it is to be understood that any source of substantially constant-electromotive force such as a constant voltage generator, will also be satisfactory. The battery is connected through the variable resistance 4, to screw 7, having a contacting point 7a. This forms a part of the double contacting switch mechanism actuated by the engine ratchet shaft 10, which may preferably be automatically advanced by a speed sensitive means as the speed of the engine is increased in a manner not here illustrated, but common to this type of contactor.

The rotation of the ratchet shaft 10, pulls the trigger 11, against the action of the spring 12, to a point where it is forced out of engagement with the ratchet of 10; and is returned against the stop 13, by the spring 12. During this return the point 11a, of the trigger intercepts the point of the hammer 14, and causes it to swing over against the double contacting spring elements 8 and 9, as best illustrated in Fig. 1. The spring element 9, is connected with the electromagnetic valve 1, through the distributor 16, which will preferably be driven from an extension of the shaft 10, in actual practice, and will alternately communicate with different valves. The circuit is completed through an electromagnetic valve 1, to ground as at 17, which forms the return path to the grounded end 6, of the current source 5. The spring contact element 8, is connected through a variable resistance 20, to ground as at 21.

This contactor operates as follows in connection

with the valves: when the contact point 9a, is in contact with point 7a, the battery will be connected through the valve to ground, which will cause the valve to lift. The construction of this switch mechanism is such as to form a contact for a fixed period of time, throughout a wide range of engine speed, due to the substantially constant time that the trigger 11 requires to return to the stop 13 regardless of the speed of rotation of cam 13. The action of the trigger 11 on the hammer 14 causes the hammer to swing at a given period against the contact spring 8, causing a constant time contact between the contacts 7a and 9a while contacts at the end of springs 8 and 9 are separated. The voltage impressed on the valve is adjusted to the minimum that will cause it to lift through the operation of the contactor, and the variable resistance 4. As the hammer 14 swings back against its stop 13, the contact between 7a and 9a is broken, as illustrated in Fig. 2, but a new contact is made between the ends of the springs 8 and 9, which places the variable resistance 20, across the valve coil. This has been found to maintain the valve open for varying periods of time, depending upon the resistance of this circuit, as it controls the rate of decline of flux in the electromagnetic valve, and consequently the lower the resistance 20, the longer will be the duration of the valve opening, and therefore the greater the amount of fuel injected in the engine cylinder per cycle. A condenser 22, may be placed across the points 9a and 7a, to decrease sparking.

From the foregoing it is obvious that this structure provides a means whereby the minimum of current is broken at the contact points 7a and 9a, and that this current remains fixed throughout a wide range of speed and throttle variations.

In Figs. 3 and 4, I have shown an alternative type of contactor driven by engine means through the gears 30, which drive the hollow shaft 31. On the extension of a collar 33, which is rigidly attached to the hollow shaft 31, the governor weight 32, is pivotally mounted by means of the pins 34. The central plane of this governor weight 32, lies on an angle with respect to the axial plane of the shaft 31. This weight is operatively associated with a movable collar 35, by means of the ball extension 36. This collar 35, is slidably mounted on the exterior of the shaft 31, and is yieldably urged against the fixed collar 33, by the spring 37, acting against a flange on the opposite end of the shaft 31. The collar 35, is provided with a pin 38, rigidly attached thereto and passing through the slot 39, in the extension of the collar 35, and through a similar slot in the hollow shaft 31. The pin 38, in turn, is rigidly attached to the interior shaft 40, which is slidably mounted within the hollow shaft 31, and through the supporting bearing 41. At the outer end of the shaft 40, is rigidly attached an insulating coupling 42, forming a driving connection with the cam shaft 43, of the contact device. This shaft 43, passes through a supporting bearing 44, and is provided with an actuating cam 45, which periodically actuates the contact arm 50. The shaft 43, is further provided with a slot 43b, through which a pin 46 passes. This pin 46, is rigidly attached to the distributor cam shaft 43a, so that a lengthwise movement of the shaft 43, will not cause a similar movement of the shaft 43a. However, both shafts will be kept in a driving relation to each other. Shaft 43a, is provided with distributor actuating cams 46a, 46b, 45c, and 46d, which in turn, actuate

the distributing contact arms 47a, 47b, 47c, and 47d. The outer end of the shaft 43a, is provided with a collector ring 43c, on which a brush 51, bears.

5 In Fig. 4, it will be noticed that the distributing arms and contacting arms are connected to binding posts shown directly above them.

The operation of this contactor is best described in connection with the circuit diagram shown in Fig. 5, in which the source of electromotive force 60, has one end grounded at 61, and the other end connected to the contact point 62, by means of a variable resistance 63, and the wire 64. The contact arm 50, periodically makes contact with the point 62, for an angle of shaft rotation, determined by the width of the depression 45a, in the cam 45, at the point where a metallic rider of the timer arm 50, rides. This binding post of this contacting arm 50, is connected by means of the common lead 65, to the binding posts of the distributor arms 47a, 47b, 47c, and 47d, respectively. These distributor arms make contact with the valve contact points 66a, 66b, 66c, and 66d, in correct sequence for the proper operation of the valves with respect to the engine. As the valves have been opened by the passage of current through this circuit, the cam 45 operates the contact arm 50, to break contact with the point 62, but simultaneously makes contact through its metallic rider 50a, with the cam 45. This shaft is electrically connected through the collector ring 43c, and the brush 51, to the variable resistance 70, which has one end grounded. The cam 45, and the cams 46a, 46b, 46c, and 46d, are so arranged that while this contact is made between the arm 50, and the cam 45, one of the valves will still be connected through their respective contacts. A variable resistance 70, is provided, which determines the rate of decline of magnetic flux in the electromagnetic structure, and thereby provides varying durations of continued opening after the contact with the point 62, has been broken, and since this decline is relatively independent of the speed of rotation (since the valve is assumed to close in all cases before the distributor disconnects that particular valve from the circuit) it will be seen that a substantially constant quantity of fuel will be delivered to the cylinder per cycle at full throttle setting, over a wide range of speed variations. In order that the duration of the contact with the point 62, shall be a substantially constant time period through the operating range of engine speeds, the depressions 45a, are so formed as to provide this substantially constant closed period through the longitudinal action imparted to the cam 45, by the action of the governor weight 32, as its axial plane moves to correspond with its plane of rotation, thereby causing the shaft 43, and the cam 45, to move towards the distributor, as the engine speed increases. It will be further noted that the leading edge 45a, is so cut as to provide an advance in the time of closing of the contact 62, as the engine speed increases. This is of such an angle as to provide the best operating conditions for the motor.

From the foregoing it is apparent that I have provided a circuit inherently capable of maintaining the timing of the start of injection constant at a given engine speed for throttle changes which vary the duration of injection by varying the point of cut-off. This is accomplished without auxiliary mechanical connections to the

throttle control means. I have further provided the minimum load on the contacts relative to the magnitude of the current to be broken by the contacts. I have provided a system well adapted to the current requirements of a circuit supplying the energy to operate fuel metering valve as applied to an engine.

While these figures and illustrations of the invention have been applied to a four cylinder motor, it is obvious that the various changes may be made as to the number of cylinders, and the arrangement, contour, and structure of the various parts within the scope of this invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is:

1. The combination of a reciprocable device, an electromagnet including a coil which operates said device, a circuit including said coil which moves said device in one direction, means which moves said device in the other direction, a second circuit with a variable resistance including said coil for controlling the rate of decline of flux in the electromagnet, and switch means which periodically breaks the first circuit and makes the second circuit.

2. The combination of a reciprocable device, an electromagnet including a coil which operates said device, a circuit including said coil which moves said device in one direction, means which moves said device in the other direction, a second circuit with a variable resistance including said coil for controlling the rate of decline of flux in the electromagnet, and switch means which periodically breaks the first circuit and makes the second circuit, said first circuit being formed for a substantially constant time over a wide range of frequency of formation.

3. The combination of a reciprocable device, an electromagnet including a coil which operates said device, a circuit including said coil which moves said device in one direction, means which moves said device in the other direction, a second circuit with a variable resistance including said coil for controlling the rate of decline of flux in the electromagnet, and switch means which periodically makes the second circuit before it breaks the first circuit.

4. The combination of a reciprocable device, an electromagnet including a coil which operates said device, a circuit including said coil which moves said device in one direction, means which moves said device in the other direction, a second circuit with a variable resistance including said coil for controlling the rate of decline of flux in the electromagnet, and switch means which periodically breaks the first circuit and makes the second circuit, said first circuit being formed for a substantially constant time over a wide range of frequency of formation, said second circuit being connected for a time period that decreases with an increase in frequency of connection and vice versa, said second circuit being formed before said first circuit is broken.

5. In combination, an electromagnet, a source of electromotive force, a variable resistance, a rotary power driven distributor associated with an automatic two circuit switch, one circuit of said switch associated with said variable resistance, and the other circuit of said switch associated with said source of electromotive force and both said circuits associated with said electromagnet, said distributor being driven at variable speeds, said automatic switch first forming a circuit with said electromagnet and said source of

electromotive force for a substantially constant time period throughout a wide range of distributor driving speeds, said automatic switch forming a second circuit with said electromagnet and said variable resistance for a decreasing arc of contact duration as the distributor speed increases and vice versa, said distributor connecting said second circuit before breaking said first circuit.

6. In combination, a rotary power driven distributor, associated with an automatic two circuit switch, an electromagnet, a source of electromotive force, a variable resistance, both circuits of said switch electrically associated with said electromagnet, the first of said circuits forming a closed circuit with said resistance and said electromagnet, and the second circuit connecting said electromagnet with said source of electromotive force, said second circuit being formed for an increasing arc of duration with an increase of distributor speed of rotation and said first circuit being formed for a decreasing arc of duration with an increase of distributor speed of rotation and vice versa, said first circuit being formed before said second circuit is broken.

7. In combination, a rotary power driven distributor, associated with an automatic double switch, an electromagnet, a source of electromotive force, a variable resistance, both portions of said double switch electrically associated with said electromagnet, said double switch capable of

forming two different circuits with said electromagnet, the first of said circuits being formed with said resistance for a decreasing arc of duration with an increase of distributor speed of rotation and the second circuit being formed with said source of electromotive force for a constant period of time throughout a wide range of distributor speeds of rotation, said second circuit being formed before said first circuit is broken.

8. In combination, a rotary power driven distributor, associated with an automatic double switch, several electromagnets, a source of electromotive force, a variable resistance, both portions of said double switch electrically associated with one of said electromagnets, said double switch capable of forming two different circuits with one of said electromagnets, the first of said circuits being formed with said source of electromotive force for an increasing arc of duration with an increase of distributor speed of rotation and the second circuit being formed with said resistance for a decreasing arc of duration with an increase of distributor speed of rotation and vice versa, the second said circuit being formed before said first circuit is broken, said distributor connecting said switch to one of said electromagnets for the formation of both said circuits then connecting said switch to another of said electromagnets for connections with said same circuits.

BROOKS WALKER.

Patent No. 2,075,877

Granted April 6, 1937

BROOKS WALKER

The above entitled patent was extended July 24, 1951, under the provisions of the act of June 30, 1950, for 6 years and 214 days from the expiration of the original term thereof.

Commissioner of Patents.