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[54] **ELECTRIC FUEL INJECTION CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINES**

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[51] **Int. Cl.** **F02b 3/00**
[58] **Field of Search** ..... 123/32 EL, 32 E

[56] **References Cited**

UNITED STATES PATENTS

2,859,738	11/1958	Campbell	123/32
2,911,966	11/1959	Pribble	123/32
2,936,744	5/1960	Paule	123/32
2,981,246	4/1961	Woodward	123/32
3,435,809	4/1969	Bassot	123/32
3,504,657	4/1970	Eichler	123/32
3,548,791	12/1970	Long	123/32
3,011,486	12/1961	Pribble	123/32 EA
3,593,692	7/1971	Scholl	123/32 EA

FOREIGN PATENTS OR APPLICATIONS

1,243,288	1/1959	France	123/32
1,125,718	4/1962	Germany	123/32
1,126,677	4/1962	Germany	123/32

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[57] **ABSTRACT**

In internal combustion engines, where the fuel injection valves are electromagnetically operated, at the time of engine acceleration the amount of fuel injected is increased by converting sudden changes in such parameters as the negative pressure in the engine intake manifold into corresponding changes of the mechanical type, such as by the displacement of a diaphragm, according to which mechanical changes an electric fuel injection control is operated. Thus, a delay time is involved, resulting in an insufficient response characteristic. In the specification, there is disclosed an electric fuel injection system for internal combustion engines, comprising; a means to generate electric signals corresponding to the speed of motion of the throttle of the engine or particularly when the speed of the throttle motion exceeds a predetermined value; and a means to increase the amount of fuel delivered for acceleration by so controlling fuel injection valves upon reception of the signal from the first means.

1 Claim, 4 Drawing Figures

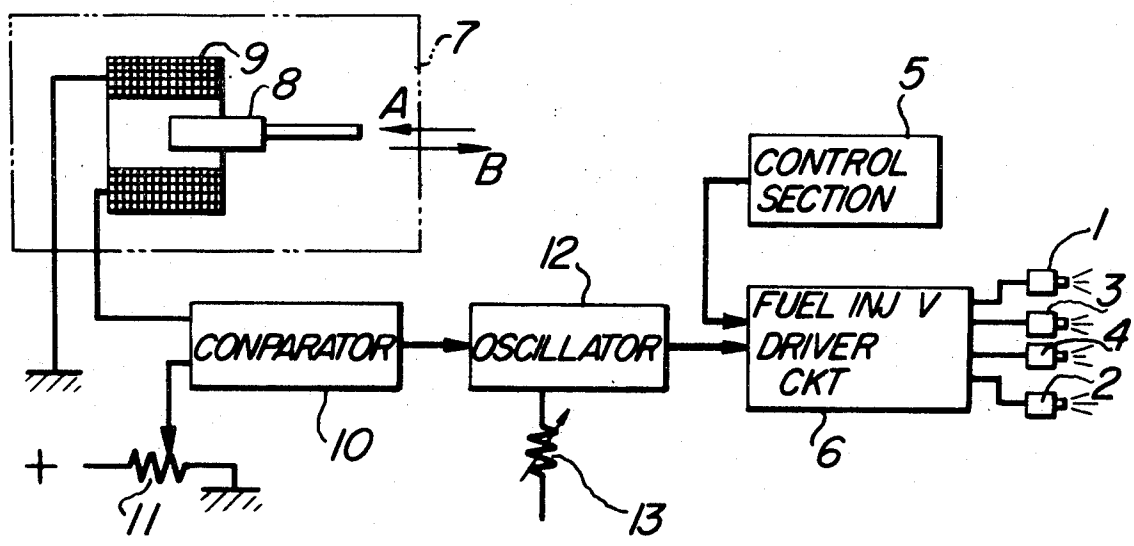


FIG. 1

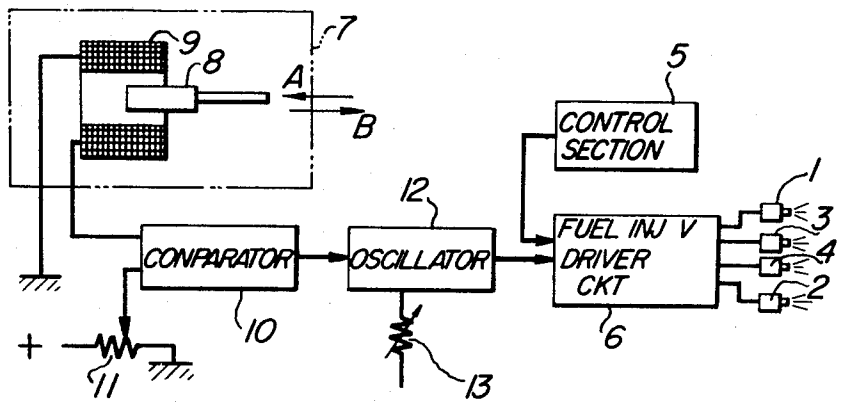
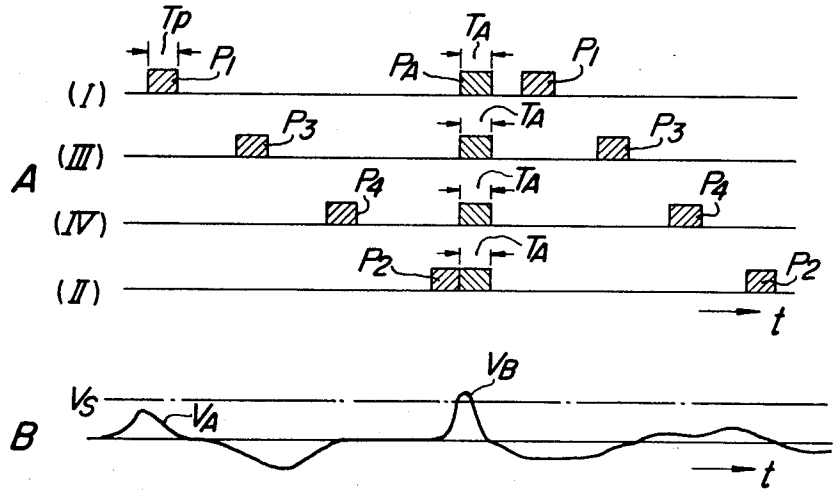


FIG. 2



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FIG. 3

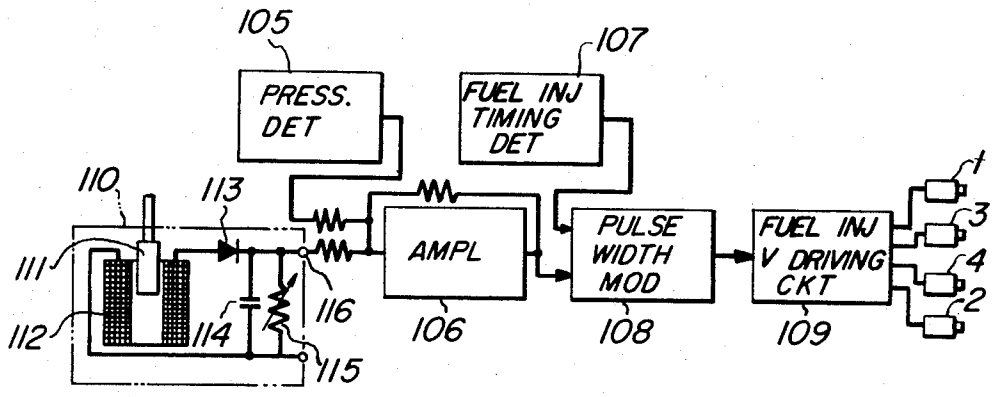
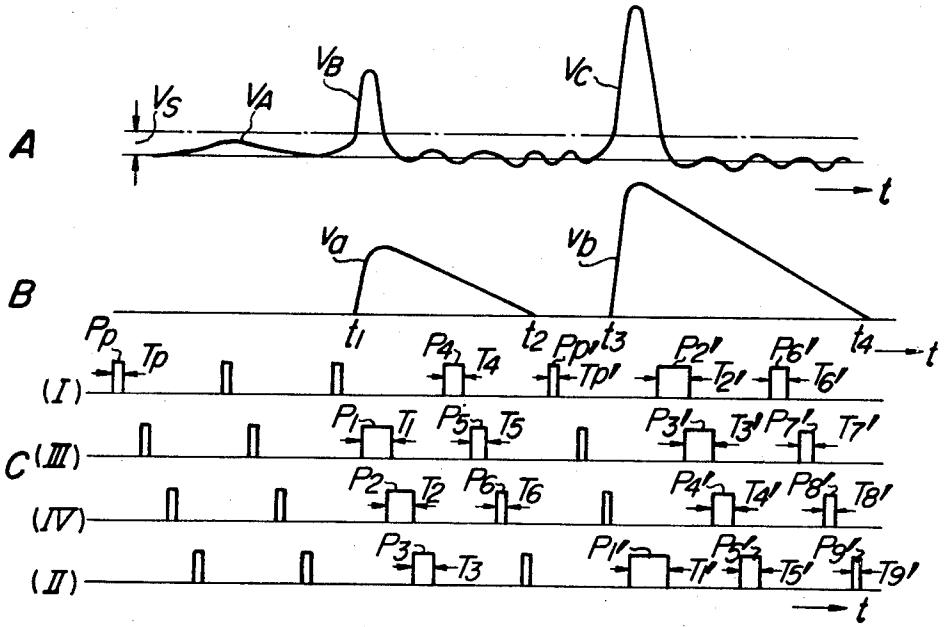


FIG. 4



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ELECTRIC FUEL INJECTION CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to improvements in electric fuel injection control systems for internal combustion engines to provide for effectively increasing the amount of the delivered fuel at the time of acceleration without time delay.

2. Description of the Prior Art

In internal combustion engines having the usual electric fuel injection control system capable of increasing the fuel delivery at the time of acceleration of the engine, sudden changes of the pressure in the intake manifold of the engine as the result of the accelerating operation are first mechanically detected by such pressure-sensitive mechanisms as a diaphragm as corresponding displacements and by the detected signal corresponding to a displacement the switching elements in an electrical circuit are controlled to extend the pulse width of the pulse signal fed to the injector valves so as to correspondingly prolong the open-position time of the injector valves, thereby increasing the fuel amount delivered at the time of acceleration.

Therefore, with the conventional system of this type a time delay is involved from the instant of actuating the accelerating means, for instance, upon depressing the accelerator pedal, until the increased fuel delivery actually results, during which delay time the pressure in the intake manifold first changes, the change in this pressure is then detected as a displacement of the mechanical means and thereafter the detection signal corresponding to the displacement drives the switching elements, so that the response time is very inferior. So long as the above response steps are involved, it is extremely difficult to improve the response time by any means available at present. Thus, the above conventional system is disadvantageously incapable of exactly following the demand of the engine for an increased fuel supply at the time of acceleration without delay, so that it cannot fully achieve the intended object.

In another aspect, the operating point, at which the function of increasing the fuel delivery is brought about by detecting the accelerating operation through the pressure-sensitive mechanism such as a diaphragm for accelerating the engine, substantially depends upon a point, at which the above pressure-sensitive mechanism such as the diaphragm detecting the sudden change in the engine intake manifold pressure as the result of the accelerating operation starts to undergo mechanical displacement to control the switching elements, and it is fixed as the displacement starting point is determined by structural factors in the design such as the dimensions and configuration of the pressure-sensitive mechanism, mechanical constants involved and design specifications. Therefore, if the aforementioned operating point to bring about the action of increasing the fuel delivery for the acceleration of the engine is to be changed, the design specification for the pressure-sensitive mechanism such as the diaphragm should be fundamentally changed, which is extremely disadvantageous, as well as providing no compatibility with engines having different ratings.

SUMMARY OF THE INVENTION

An object of the invention is to provide an electric fuel injection control system for use in internal combustion engines, where injector valves are controlled by an electric control system in accordance with an operating parameter for the engine, thereby being capable of increasing the amount of fuel delivered at the time of accelerating the engine without time delay.

Another object of the invention is to provide an electric fuel injection control system for use in internal combustion engines, which enables readily changing the operating point to bring about the action of increasing the fuel delivery for the acceleration of the engine and provides compatibility with engines of different ratings.

According to the invention, there is provided an electric fuel injection control system for internal combustion engines comprising a means to generate an electric signal derived from the action of the throttle or a movable part associated with the throttle valve of the engine when the speed of motion of the throttle in the direction of opening thereof exceeds a predetermined value, and a means to control injection valves to increase the amount of fuel delivery in response to the electric signal from the first means, whereby said control system is capable of meeting the requirements of the engine characteristics to increase the fuel delivery at the time of acceleration with good response, readily changing the operating point to bring about the action of increasing the fuel delivery for the acceleration of the engine as well as affording compatibility with engines of different ratings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic block diagram of an embodiment of the electric fuel injection control system according to the invention;

FIG. 2 shows the operating characteristics of the embodiment of FIG. 1;

FIG. 3 is a schematic block diagram of another embodiment of the invention; and

FIG. 4 shows the operating characteristics of the embodiment of FIG. 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention will now be described in conjunction with preferred embodiments thereof with reference to the accompanying drawing.

EMBODIMENT 1

Referring now to FIG. 1, showing an embodiment of the invention as applied to a four-cylinder engine (not shown), numerals 1 to 4 designate electromagnetically operated fuel injection valves provided, for instance, in respective first to fourth cylinders [I], [II], [III] and [IV]. Numeral 5 designates a control section generating fuel injection pulse signals, which have a pulse width conforming to the operating parameters of the engine such as the intake manifold pressure, temperature of the engine and atmospheric pressure, and are synchronized to the timing of the valve opening or fuel injection for each cylinder. The fuel injection pulse signal from the control section 5 is fed to a fuel injec-

tion valve driver circuit 6, which energizes a corresponding fuel injection valve to drive it open and hold it in the open position for a time interval equal to the pulse width of the received signal. Thus, the amount of fuel injected is proportional to the pulse width (open- or on-period). Shown enclosed within a broken-line rectangle 7 is an acceleration fuel-increase signal generator to generate an electric output signal for increasing the fuel supply at the time of accelerating the engine, which comprises a permanent magnet 8 linked to the throttle or a movable part associated with the throttle valve of the engine and a coil 9 surrounding the permanent magnet 8 such that the magnet 8 is capable of reciprocal movement relative thereto. The movement of the permanent magnet 8 in the direction of the arrow A as the throttle is rotated in the opening direction causes a positive voltage to be induced in the coil 9, while the movement of the magnet 8 in the direction of arrow B as the throttle is rotated in the closing direction induces a negative voltage in the coil 9. Thus, the voltage induced in the coil 9 is at a level proportional to the speed of motion of the throttle or a movable part associated with the throttle valve. A positive voltage induced in the coil 9 is compared with a reference voltage preset by means of a resistor 11 by a comparator 10, which produced output signal only when the former voltage is higher than the latter. The value of the reference voltage given by the movable resistor 11 corresponds to the operating point to start increasing the amount of fuel delivery for accelerating the engine. The output signal from the comparator 10 is fed to an oscillator 12 consisting of a mono-stable multi-vibrator, for instance. Every time the comparator 10 produces output, the oscillator 12 generates a pulse signal of a constant pulse width determined by the resistance of a timing adjustment variable resistor 13 and circuit constants of the oscillator 12. The output pulse signal from the oscillator 12 is impressed on the fuel injection valve driver circuit 6 independently of the fuel injection pulse signals from the control section 5. The fuel injection valve driver circuit 6, upon reception of the output pulse signal from the oscillator 12, energizes and opens the fuel injection valves 1 to 4 at one time independently of and in addition to their control in accordance with the fuel injection pulse signal from the control section 5.

The operation of the system of the above construction will now be described in detail with reference to the graphs of FIG. 2, in which the abscissa is commonly taken for time t, and which shows at (A) the fuel injection pulses generated for successive impression on the injection valves 1, 3, 4 and 2 for the respective first, third, fourth and second cylinders, as respectively indicated from the top downwards at [I], [III], [IV] and [II], and at (B) the voltage induced in the coil 9.

Under normal driving with the throttle at a predetermined normal position, the permanent magnet 8 assumes a predetermined position and does not move, causing no voltage to be induced in the coil 9, so that the fuel injection valve driver circuit 6, receiving successive fuel injection pulses P_1, P_2, P_3 and P_4 generated by the control section 5, all having a pulse width T_p (shown at (A) in the Figure) conforming to an operating parameter of the engine, drives the respective fuel injection valves 1 to 4 open in accordance with the corresponding pulses and maintains these valves open for a period equal to the pulse width T_p, during which the fuel is injected into the intake manifold or directly into each cylinder for the normal operation of the engine meeting the requirement characteristics of the engine under normal-driving conditions. The order of driving the fuel injection valves depends upon the distributing function of the fuel injection driver circuit 6, consistent with the order of firing the cylinders, for instance in the order of first cylinder [I], third cylinder [III], fourth cylinder [IV] and second cylinder [II]. The pulse width of the fuel injection pulse signal generated by the control section 5 varies with a variable operating parameter such as the manifold pressure, engine temperature and pressure and so forth.

The movement of the permanent magnet occurs even when slowly accelerating the engine. It also occurs in case of the normal operation where there is no positive action of accelerating the engine, for instance due to engine vibrations tending to move the throttle or a movable part associated with the throttle in the direction of opening the throttle valve. In such cases, voltage is induced in the coil 9, but such induced voltages are at an extremely low level, for instance as indicated at V_A at (B) in FIG. 2, and well below the reference voltage V_s given from the variable resistor 11, so that the comparator 10 does not generate any output signal and hence the oscillator 12 generates no output pulse signal. Thus, the fuel injection valves 1 to 4 are operated only in accordance with the fuel injection pulses P_1, P_2, P_3 and P_4 from the control section 5 with a pulse width conforming to an operating parameter of the engine, the valves being opened in the predetermined order for a period equal to the pulse width, during which the fuel is injected.

When acceleration is applied to the engine, for instance by suddenly depressing the accelerator pedal, to move the throttle into the full position, the permanent magnet 9 moves, inducing a voltage in the coil 9 with a maximum level V_B exceeding the reference voltage level V_S as given by the resistor 11, as shown at (B) in FIG. 2, so that the comparator 10 generates an output signal to cause the oscillator 12 to generate a pulse signal having a constant pulse width determined by the variable resistor 13 and the internal circuit constants of the oscillator 12. If the pulse signal is generated immediately after the fuel injection by the injection valve 2 for the second cylinder [II], for example, the fuel injection valve driver circuit 6 energizes all the fuel injection valves 1 to 4 at one time in response to the output pulse signal P_A from the oscillator 12, as shown at (A) in FIG. 2, and temporarily holds the valves in the open position for a period equal to the constant pulse width to cause the fuel injection from all the fuel injection valves during this period. The fuel thus injected is added to the fuel injected as the individual fuel injection valves for the respective cylinders are successively brought into the open position under the control of the control section 5, thus supplying the respective resultant amount of fuel to each cylinder. In this manner, the engine is smoothly operated by increasing the amount of fuel supply at the time of accelerating the engine.

As has been made apparent, even when acceleration is suddenly applied to the engine right after the fuel in-

jection in response to one of the fuel injection pulses generated one by one at a constant time interval by the control section **5**, it is possible to energize and open all the fuel injection valves **1** to **4** at the same time in response to the output pulse signal from the oscillator **12** based on the output signal from the acceleration fuel-increase signal generator **7**, that is, on whether the output voltage exceeds the reference voltage V_s, which output voltage appears as the result of the sudden action of accelerating the engine, to inject fuel simultaneously from all the fuel injection valves into the intake manifold for increasing the fuel ratio in the fuel-air mixture for acceleration without any time delay involved. It will thus be appreciated that as the action of increasing the fuel delivered for acceleration is brought about independently of the fuel injection pulses generated from the control section **5** and is solely based on the level of the voltage output from the acceleration fuel-increase signal generator **7**, the response characteristic for increasing the amount of fuel delivered for rapid acceleration of the engine is very excellent.

In case the throttle valve is suddenly closed for rapid deceleration of the engine, a negative voltage is induced in the coil **9**, so that the comparator **10** generates no output signal and hence the oscillator generates no output pulse signal, thus bringing about no action of increasing the fuel ratio.

The amount of the fuel to be increased may be varied to meet the requirements of the engine characteristics by appropriately varying the resistance of the variable resistor **13** and the internal circuit constants of the oscillator **12** so as to have a suitable pulse width of the output pulse signal from the oscillator **12**.

The reference voltage level V_S in the above example, which is intended to avoid malfunctioning of the system due to such causes as engine vibrations, and which constitutes the operating point to bring about the action of increasing the fuel delivery for acceleration of the engine, may be selected to a suitable preset value by suitably varying the resistance of the variable resistor **11**. The reference voltage V_S may be determined not only through the variable resistor **11**, but also through such means as a diode, a constant voltage diode and a transistor.

As is described, the foregoing embodiment, that comprises a means to generate an electric output signal at a level corresponding to the speed of rotation of the throttle of the engine as detected directly from the throttle or through a movable member linked to the throttle, a means to generate an output pulse signal only when the electric output signal from the first means exceeds a predetermined value and a means to energize and open the fuel injection valves in response to the output pulse signal from the second means and independently of the pulse signal conforming to the operating parameter of the engine, has excellent effects that no delay time is involved between the instant of applying acceleration to the engine to drive the throttle toward the full position and the instant to actually start increasing the fuel delivery, that upon the action taken to accelerate the engine the fuel delivery may be immediately increased independently of the pulse signal conforming to the operating parameter of the engine, and that the fuel delivery is immediately increased even when the action to accelerate the engine is suddenly taken immediately after the fuel injection responding to one of the fuel injection pulses conforming to the operating parameter of the engine.

The system embodying the invention can feature further excellent advantages that the operating point to bring about the action of increasing the fuel delivery may be very readily changed by a simple process of merely changing the afore-mentioned preset variables to provide for compatibility with engines of different ratings, and that it is possible to ensure the prevention of malfunctioning of the system due to such causes as vibration of the engine. It features a still further excellent advantage in that the amount of the fuel to be increased for acceleration may be readily changed to meet the requirements of the engine characteristics independently of the pulse signal conforming to the operating parameter of the engine but by merely changing the pulse width of the pulse signal based on the action of accelerating the engine.

EMBODIMENT 2

Referring now to FIG. **3**, which shows another embodiment of the invention, there are shown fuel injection valves **1** to **4**, which are electromagnetically operated and provided in respective first to fourth cylinders [I] to [IV]. Numeral **105** designates a pressure detector to detect the pressure in the intake manifold, which is one of the operating parameters of the engine, as a corresponding DC voltage. The output voltage from the pressure detector **105** is amplified by an amplifier **106**. Numeral **107** designates a fuel injection timing detector to generate signal pulses in synchronism with the timing of the opening of the intake valves of the respective cylinders [I] to [IV] or the fuel injection timing of the fuel injection valves **1** to **4**. The pulses may be generated as a function of the rotation angle of the cam shaft, for example. The output from the amplifier **106** and from the fuel injection timing detector **107** are fed to a pulse width modifier **108**, which generates fuel injection pulses synchronous with the output pulse signal from the fuel injection timing detector **107** and having a pulse width corresponding to the output voltage from the amplifier **106**, that is, the pressure in the intake manifold. A fuel injection valve driving circuit **109** receives the fuel injection pulse signal from the pulse width modulator **108** and energizes a corresponding one of the fuel injection valves **1** to **4** to hold it in the open position for a time interval equal to the pulse width, which is proportional to the amount of fuel injected. Shown within a broken-line rectangular section **110** is an acceleration fuel-increase signal generator to generate an electric signal for increasing the fuel supply for accelerating the engine, which comprises a permanent magnet **111** linked to the throttle of the engine or to a movable member associated to the throttle, a coil **112** disposed within the magnetic field established by the permanent magnet **111**, a diode **113**, a capacitor **114** and a variable resistor **115**. A voltage induced in the coil **112** by the movement of the permanent magnet **111** which accompanies the rotation of the throttle in the opening direction charges the capacitor **114** through the diode **113**.

It will be appreciated that the voltage induced in the coil **112** is at a level proportional to the speed of mo-

tion of the throttle or the movable part associated with the throttle. The capacitor **114** is discharged through the variable resistor **115** within a time interval determined by the time constant for the circuit consisting of the resistor **115** and the capacitor **114**. The voltage on the output terminal **116** of the acceleration fuel-increase signal generator **110**, that is, the terminal voltage across the capacitor **114**, is fed in superposition upon the voltage of the output from the pressure detector **105** to the amplifier **106**.

The operation of this embodiment will now be described in detail with reference to the graphs of FIG. **4**, in which the abscissa is commonly taken for time t, and which shows at (A) the voltage induced in the coil **112**, at (B) the terminal voltage across the capacitor **114** and at (C) the fuel injection pulses for impression on the individual fuel injection valves **1**, **3**, **4** and **2** provided respectively in the first, third, fourth and second cylinders as indicated respectively from the top downwards at [I], [III], [IV] and [II].

In the normal engine operation with the throttle held at a predetermined normal position, the permanent magnet **111** assumes a predetermined position and does not move, causing no voltage to be induced in the coil **112**, so that the fuel injection valve driver circuit **109**, receiving successive fuel injection pulses generally indicated at P_p generated by the pulse width modulator **108**, which pulses have a pulse width (as generally indicated at T at (C) in FIG. **4**) conforming only to the output voltage from the pressure detector **105** and which are synchronized with the output pulse signal from the fuel injection timing detector **107**, drives the respective fuel injection valves **1** to **4** in accordance with the corresponding pulses P_p and holds these valves open for a period equal to the pulse width T_p, during which the fuel is injected, for the normal operation of the engine conforming to the requirements of the engine characteristics under normal driving conditions. The order of driving (fuel injection of) the fuel injection valves depends upon the distributing function of the fuel injection valve driver circuit **109**, and is consistent with the order of firing the cylinders, for instance in the order of first cylinder [I], third cylinder [III], fourth cylinder [IV] and second cylinder [II].

When the permanent magnet **111** moves in accompaniment to the accidental movement of the throttle or the movable member associated thereto due to such causes as vibration of the engine during the normal engine operation without any action taken for accelerating the engine, voltage is induced in the coil **112** as indicated at V at (A) in FIG. **4**, but such induced voltage is at levels lower than the level of the reference voltage V_S determined by the forward voltage drop across the diode **113**, so that the capacitor is not charged.

When acceleration is applied to the engine, for instance by depressing the accelerator pedal, to move the throttle toward the full position, the permanent magnet **111** moves, inducing a voltage in the coil **112** with a maximum level exceeding the reference voltage V_S, as indicated at V_B at (A) in FIG. **4**, thus charging the capacitor **114** through the diode **113**, as shown at (B) in FIG. **4**. After the operation of opening the throttle valve is stopped, voltage is no longer induced in the coil **112**, and the charge accumulated on the capacitor **114** is discharged through the resistor **115** within a time determined by the time constant for the circuit of the parts **114** and **115**. As the terminal voltage across the capacitor **114** is fed in superposition upon the output signal from the pressure detector **105** to the amplifier **106**, the output voltage from the amplifier **106** has a component accounting for the terminal voltage across the capacitor **114** changing in accordance with a charging-and-discharging characteristic as indicated at V_a at (B) in FIG. **4** in addition to the component accounting for the output voltage from the negative pressure detector **105**. Accordingly, the pulse widths of the fuel injection pulses P_1 to P_6 produced during charging and discharging of the capacitor **114** until time t_2 are increased, as indicated at T_1 to T_6 at (C) in FIG. **4**, in correspondence to the level of the voltage produced after amplification of the terminal voltage across the capacitor **114** by the amplifier **106**. Thus, the amount of the fuel injected is increased in proportion to the pulse widths T_1 to T_6, thus smoothly accelerate the engine.

After the capacitor **114** is discharged through the resistor **115**, the pulse width T_p of the fuel injection pulse signal from the pulse width amplifier **108** is again determined solely by the voltage output from the detector **105**.

When quicker or more forceful accelerating action is applied to the engine, a higher voltage exceeding the reference voltage V_S, as indicated at V_c at (A) in FIG. **4**, is induced in the coil **112**, and a corresponding higher terminal voltage, as indicated at V_b at (B) in FIG. **4**, is built up across the capacitor **114**. Accordingly, the pulse widths of the fuel injection pulses P_1' to P_9' occurring during a time interval from instant t_3, at which the charging of the capacitor **114** starts, until instant t_4, at which the discharging of the capacitor **114** ends, are further increased, as indicated at T_1' to T_9' at (C) in FIG. **4**, in correspondence to the level of the terminal voltage across the capacitor **114** in accordance with the charging-and-discharging characteristic of the capacitor **114**. In addition to the increase in the pulse width, in this acceleration the number of times the injection of an increased amount of fuel is made, which is **6** in the previous case, is increased to **9**.

In case the throttle valve is suddenly closed for rapidly decelerating the engine, a negative voltage is induced in the coil **112**, so that the capacitor **114** is not charged, thus generating no signal for increasing the fuel delivery.

The number of times the injection of an increased amount of fuel is made may be preset to meet the requirements of the engine characteristics by making variable at least one of the capacitance of the capacitor **114** and the resistance of the resistor **115** or by selecting suitable values of these quantities. The voltage level to be established for avoiding malfunctioning of the system due to such causes as vibration of the engine or the operating point to start increasing the fuel delivery for accelerating the engine, that is, the reference voltage V_S in the above embodiment, is determined by the forward voltage drop across the single diode **113**. It may as well be preset by a plurality of diodes connected in series, a constant-voltage diode having a certain breakdown voltage, a transistor and so forth.

Also, in this embodiment only the pressure in the intake manifold, which is one of the operating parameters of the engine, is used for determining the pulse

width of the fuel injection pulse signal. Other operating parameters such as the engine temperature, atmospheric temperature and pressure may as well be used to modulate the pulse width of the fuel injection pulse signal.

As is described, with this embodiment including the acceleration fuel-increase signal generator to generate an electric output signal at a level corresponding to the speed of motion of the throttle or the movable member associated thereto of the engine when such speed exceeds a predetermined value and a means to extend the time, during which the fuel injection valve is open, in accordance with the level of the output signal from the acceleration fuel-increase signal generator, it is possible to increase the fuel delivered with excellent response characteristics.

Also, by the incorporation of a means to gradually decrease the level of the output signal from the acceleration fuel-increase signal generator with time according to the above embodiment, the amount of the fuel to be increased and the period and the number of times of the injection of the increased fuel may be so determined as to meet the requirements of the engine characteristics, thus providing for further smoother acceleration of the engine.

Similar to the previous first embodiment, this embodiment can also feature the excellent effects that the operating point to start increasing the fuel delivery may be readily changed to meet compatibility with engines of different ratings is provided, and that the malfunctioning due to such causes as vibration of the engine is prevented.

The means to obtain an electric output signal corresponding to the speed of motion of the throttle or the movable member associated thereto of the engine is not limited to the combination of permanent magnet (**8** or **111**) and coil (**9** or **112**) as in the preceding first and second embodiments, but other means such as a semiconductor element and a magnetostriction element may also be used. As the movable member associated with the throttle may serve an accelerator ring, the accelerator pedal and so forth. Further, though the preceding embodiments are concerned to the four-cylinder engine, the invention may of course be applied to the single cylinder engine and other multi-cylinder engines.

We claim:

1. An electric fuel injection control system for an internal combustion engine having electromagnetic valves for operating fuel injection valves of the engine, and operative to inject fuel in response to injection pulses each having a pulse width varying as a function of operating parameters of said engine and for energization of said electromagnetic valves, comprising:

means for detecting the rate of engine acceleration and producing a first signal when that rate exceeds a predetermined level,

means for receiving said first signal and responsive to said first signal for generating a fuel injection signal having a controlled pulse width,

means for applying said injection signal to said valves to operate said fuel injection valves for an interval corresponding to said controlled pulse width, in addition to operation dependent upon engine operating parameters, and

means for independently adjusting said predetermined level and said controlled pulse width,

wherein said producing and generating means includes a permanent magnet movable in response to the operation of the throttle valve of the engine, an induction coil electrically coupled to said permanent magnet for producing an output voltage upon operation of the throttle valve, and means for comparing said output voltage with a reference voltage having said predetermined level, and wherein said adjusting means includes a first variable resistor for adjusting said reference voltage; and wherein said generating means includes an oscillator means for receiving an output of said comparing means and producing said fuel injection signal, said oscillator means including a time-constant circuit for determining said controlled pulse width and wherein said adjusting means includes a second variable resistor for adjusting said time-constant circuit,

and further including a means for detecting an engine operating parameter and producing a sequence of parameter injection pulses which each have a width which varies as a function of said engine operating parameter and wherein said applying means applies said parameter injection pulses as well as said injection signals to said valves,

wherein said applying means includes means for causing all of said valves to inject fuel simultaneously while said injection signal is being applied.

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