United States Patent

Aono et al.

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[54] **ACCELERATION ACTUATING DEVICE FOR FUEL INJECTION SYSTEM**

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Oct. 22, 1969	Japan	44/84540

[52] **U.S. Cl.** .... **123/32 EA,** 123/127, 123/119 R, 123/139 E

[51] **Int. Cl.** **F02b 3/00,** F02m 13/04

[58] **Field of Search** .... 123/32 EA, 148 BA

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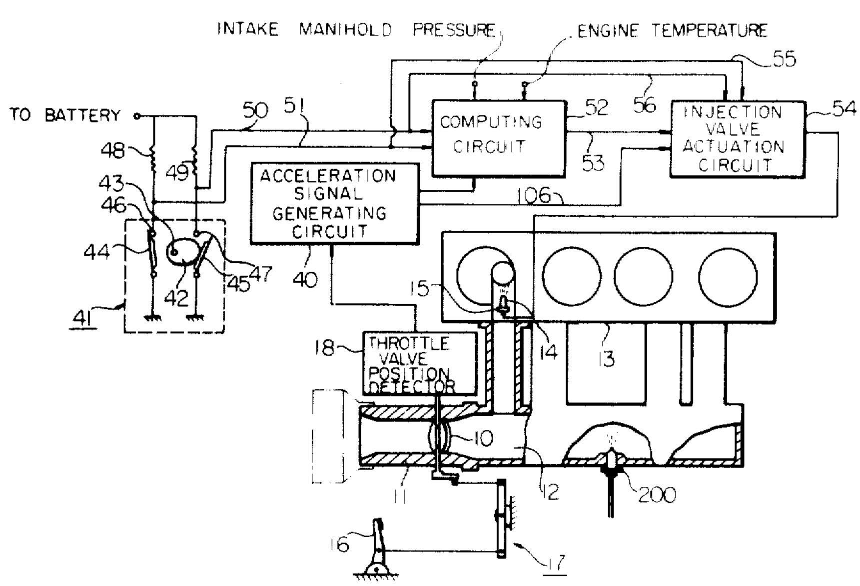
[57] **ABSTRACT**

An acceleration device adapted for incorporation into an automobile fuel injection system so as to provide for an instantaneous increase in the quantity of injection fuel supplied to the individual cylinders. A throttle valve position detector or intake pressure sensor is adapted to detect the driver's effort to effect acceleration. An acceleration signal generating circuit is connected to the throttle valve position detector or intake pressure sensor, so that upon detection of the driver's effort the circuit generates a first and second acceleration signals. The first acceleration signal is supplied to an injection valve actuation circuit so as to energize the injection valve, thereby providing an enriched air-fuel mixture for acceleration. The second acceleration signal is applied to a computing circuit to increase the width of an injection pulse signal generated thereby. The increase in the width of the injection pulses also causes the increase in the quantity of injection fuel supplied to the cylinders. The acceleration signal generating circuit may include a low temperature compensating unit comprising a thermistor and adapted to further enrich the air-fuel mixture for acceleration during the warming-up process. A starting injection valve may be actuated for acceleration purposes in response to the first acceleration signal.

7 Claims, 16 Drawing Figures



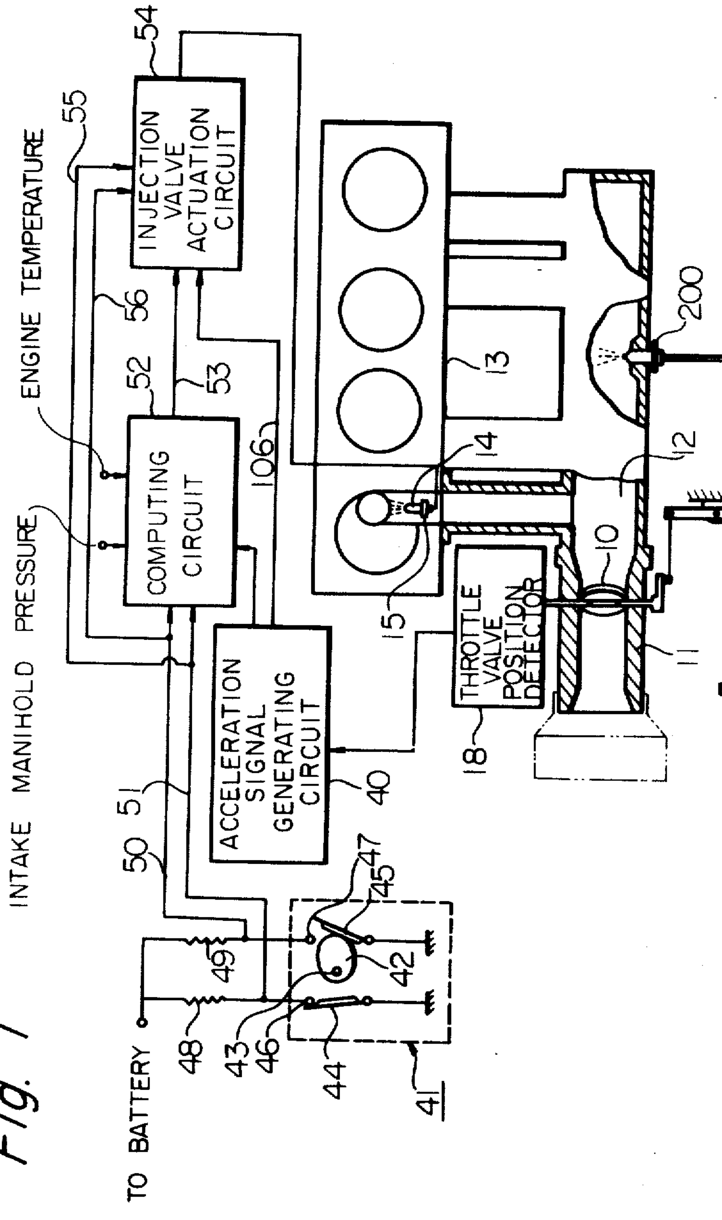


Fig. 1

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Fig. 2

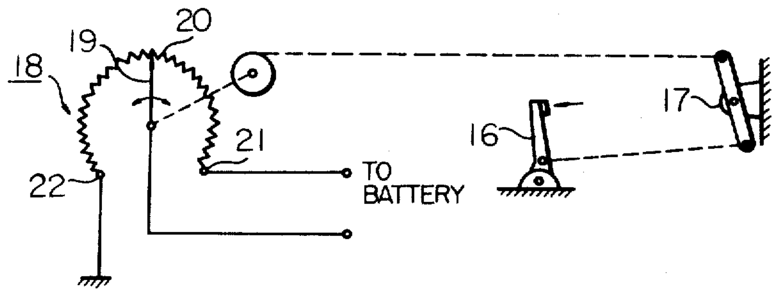


Fig. 3

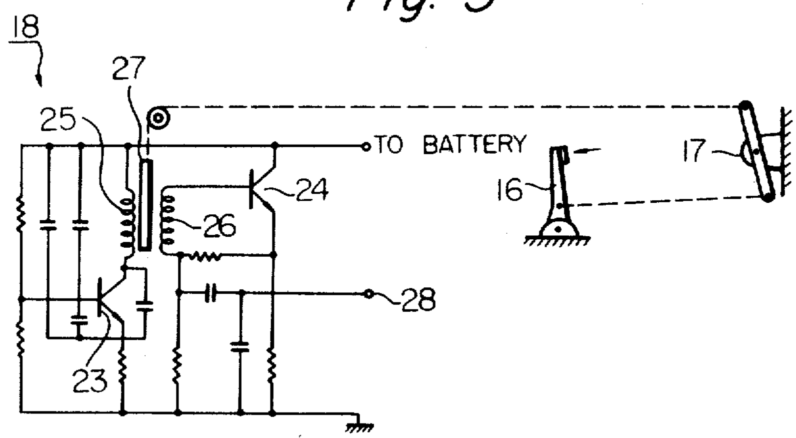
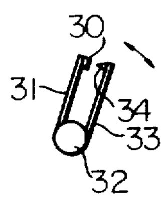


Fig. 4

(a)



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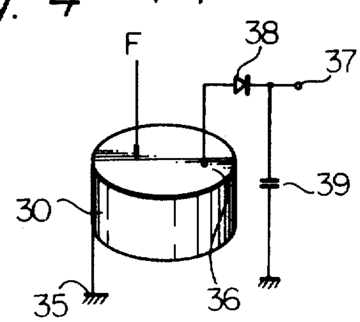

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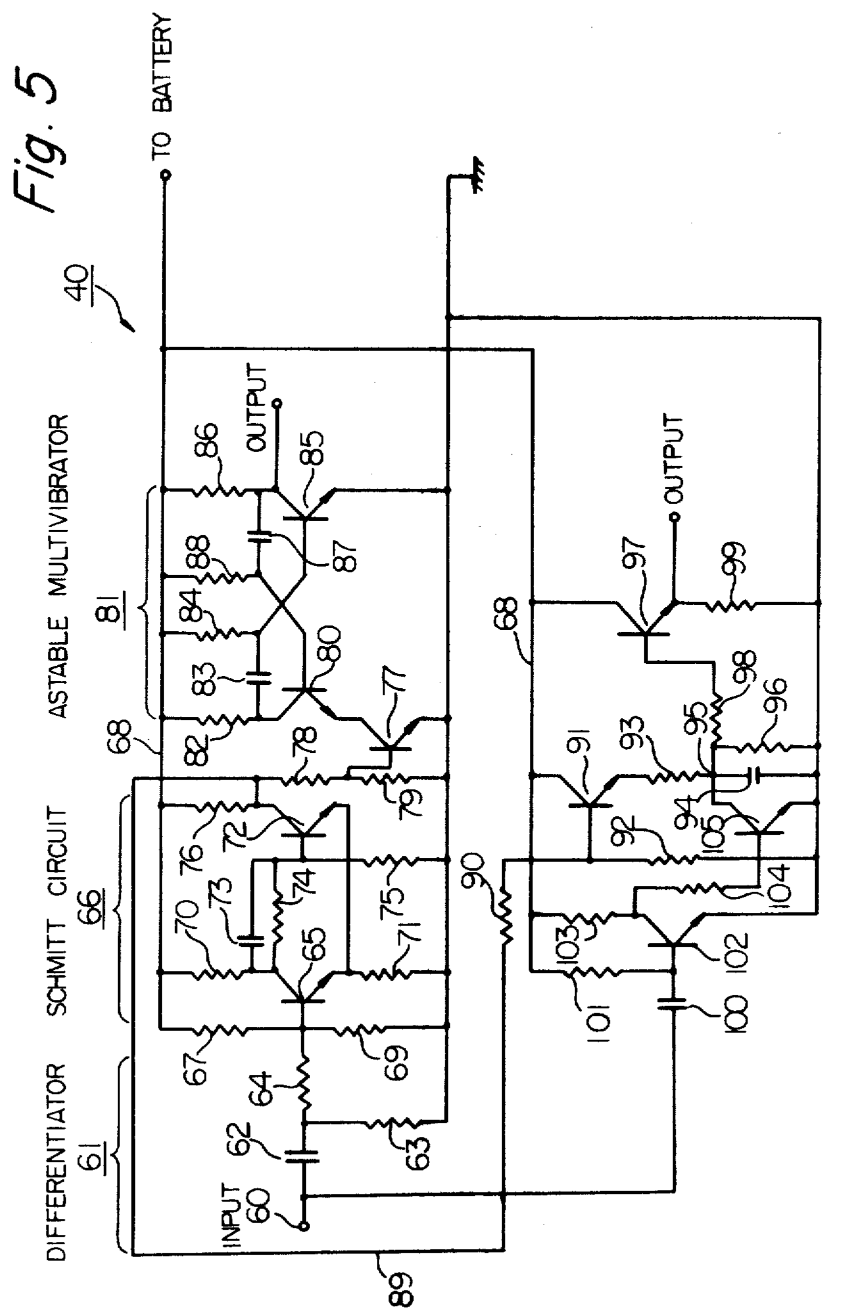

Fig. 5

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Fig. 6

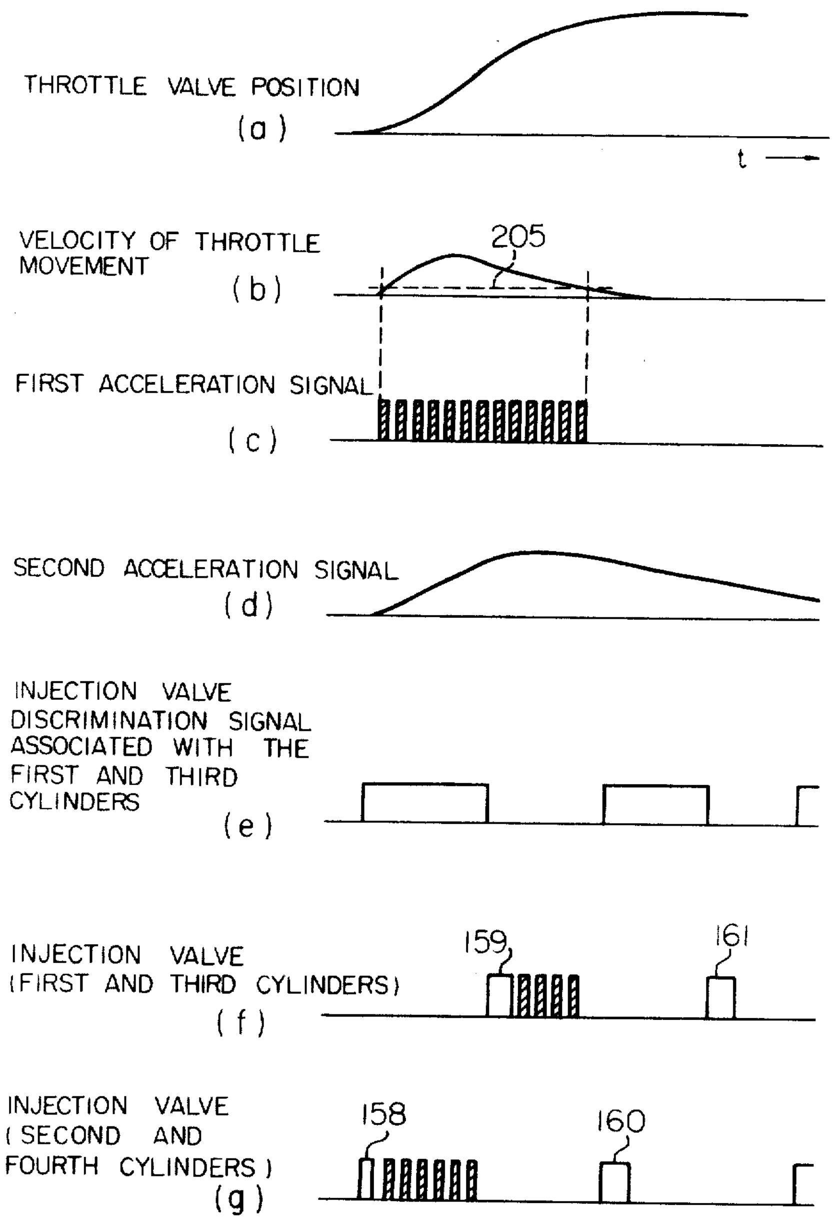

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Fig. 7

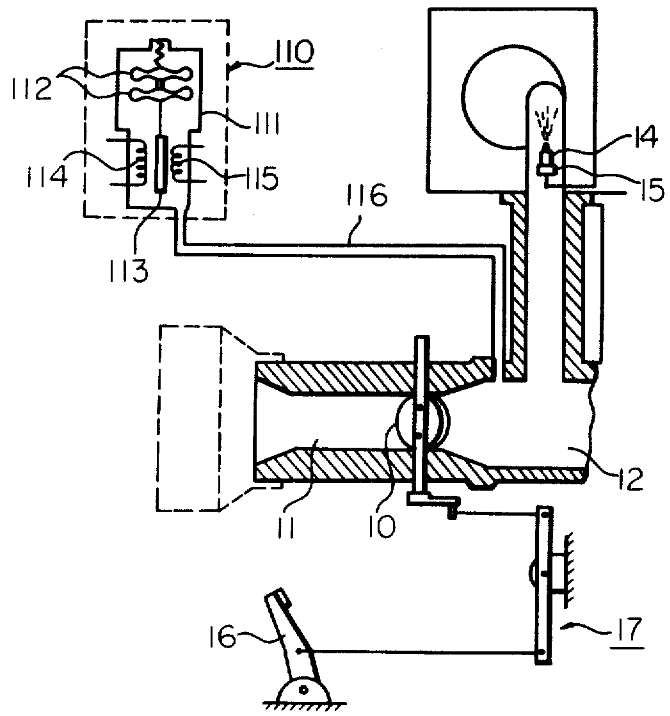
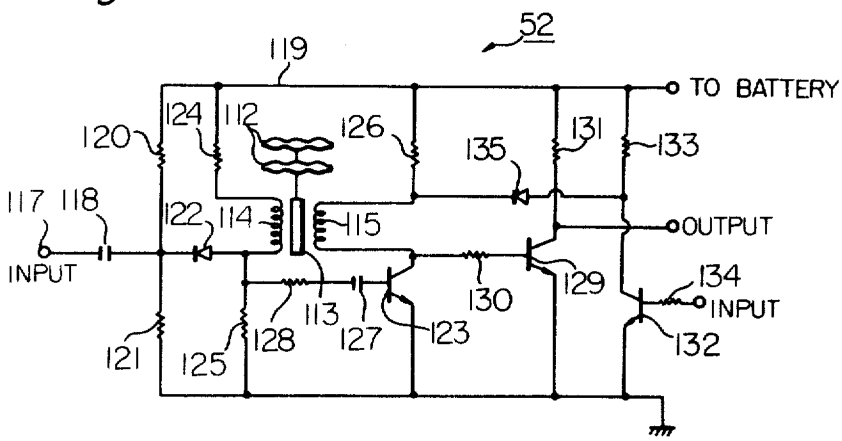


Fig. 8



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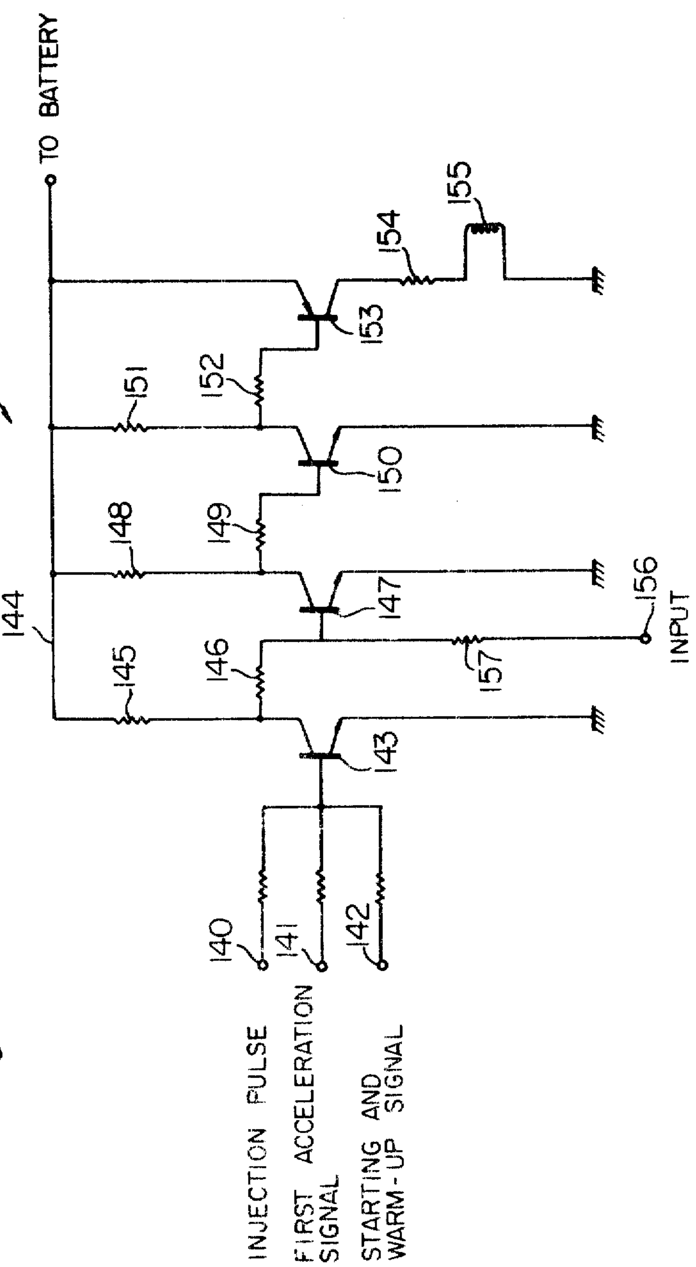

Fig. 9

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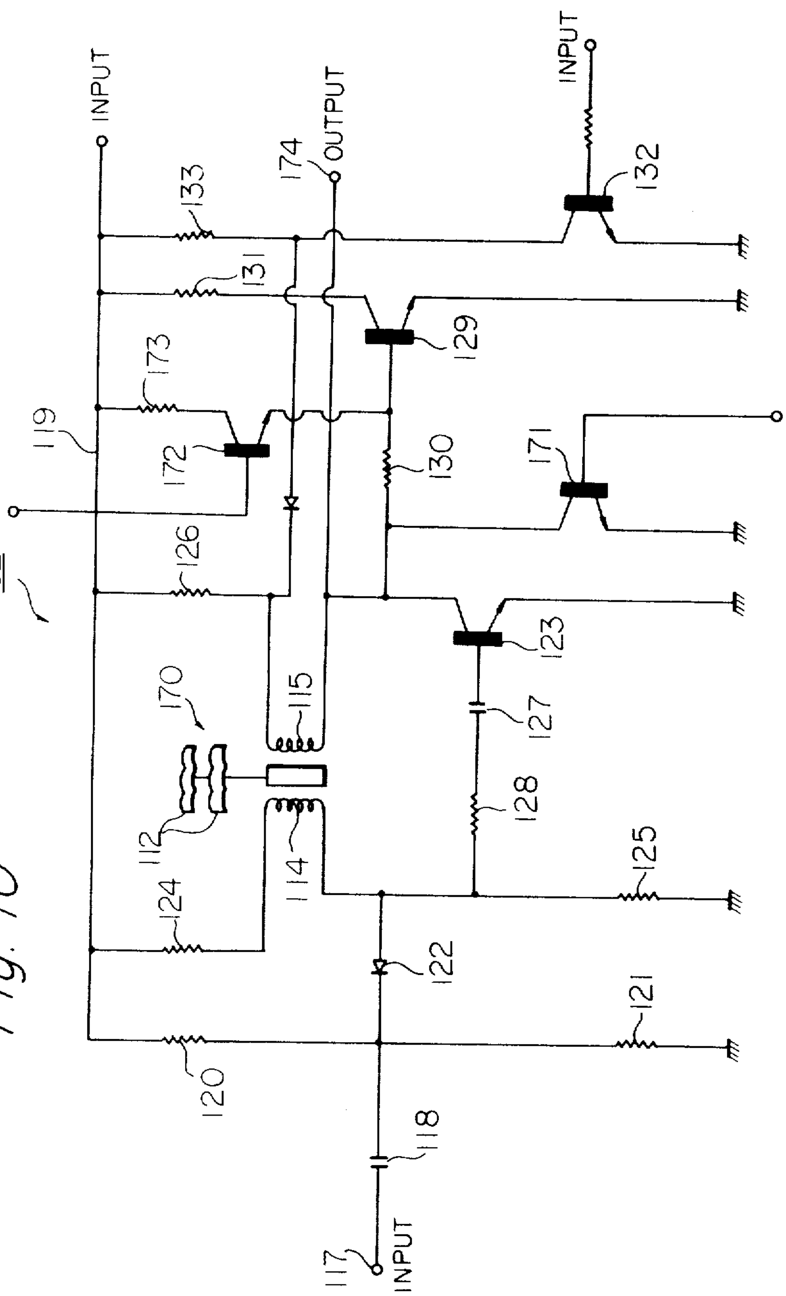

Fig. 10

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Fig. 11

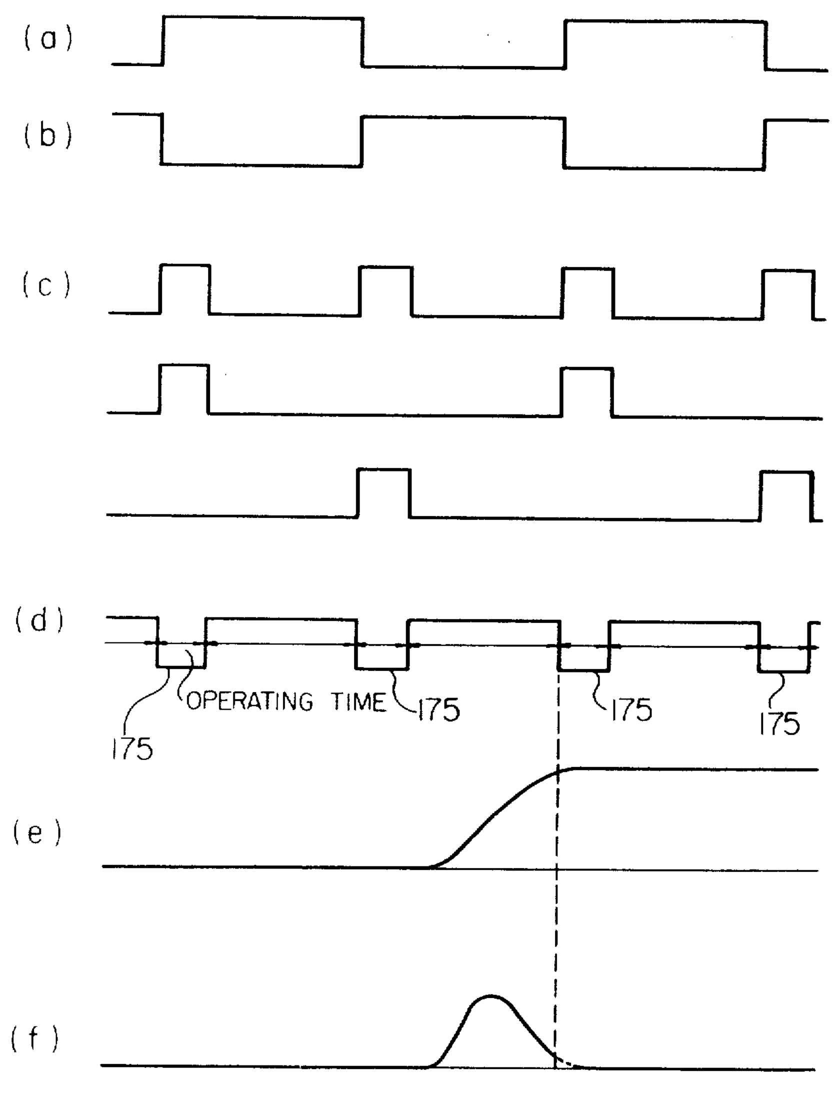

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Fig. 12

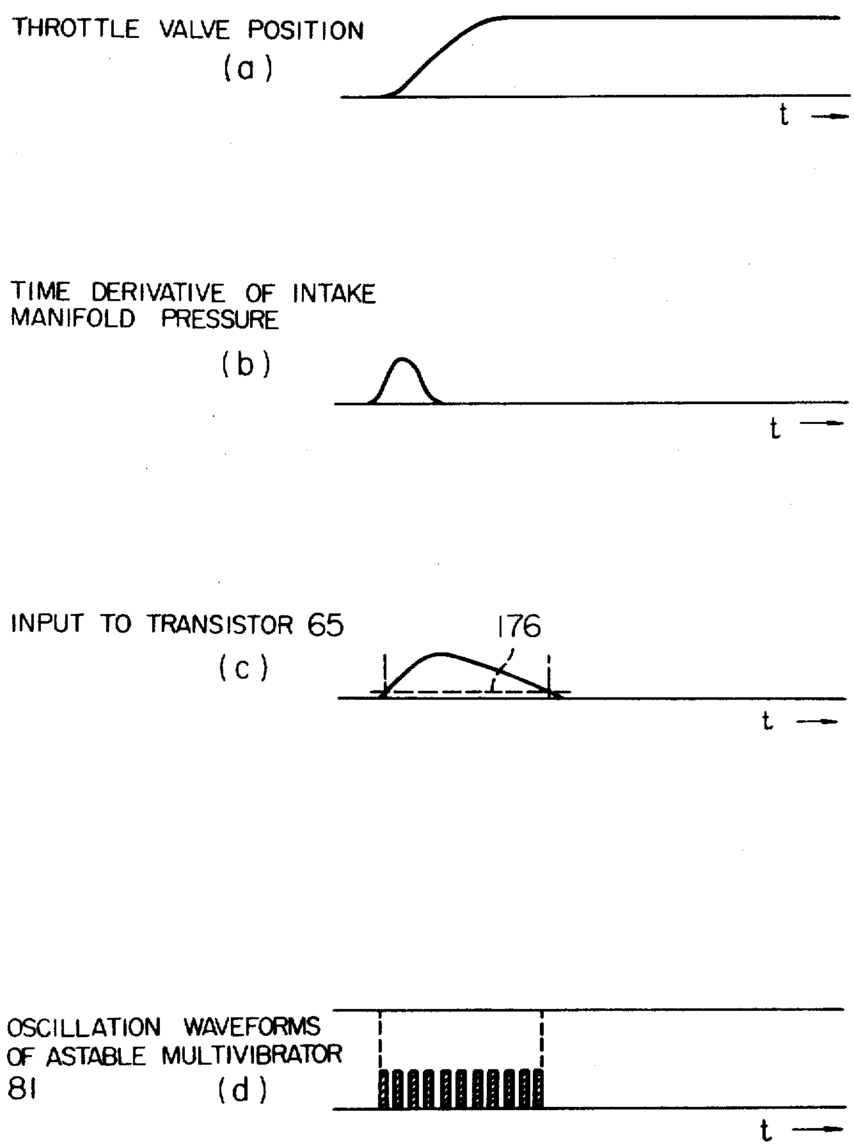

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Fig. 13

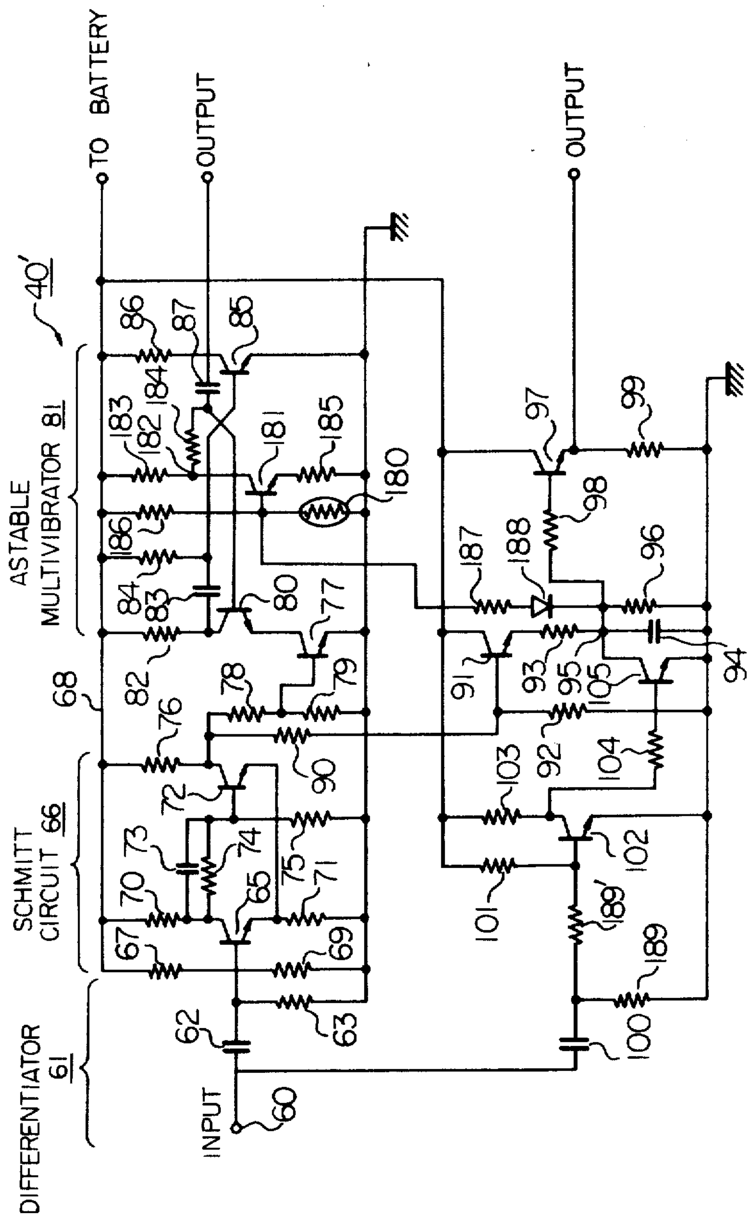

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Fig. 14

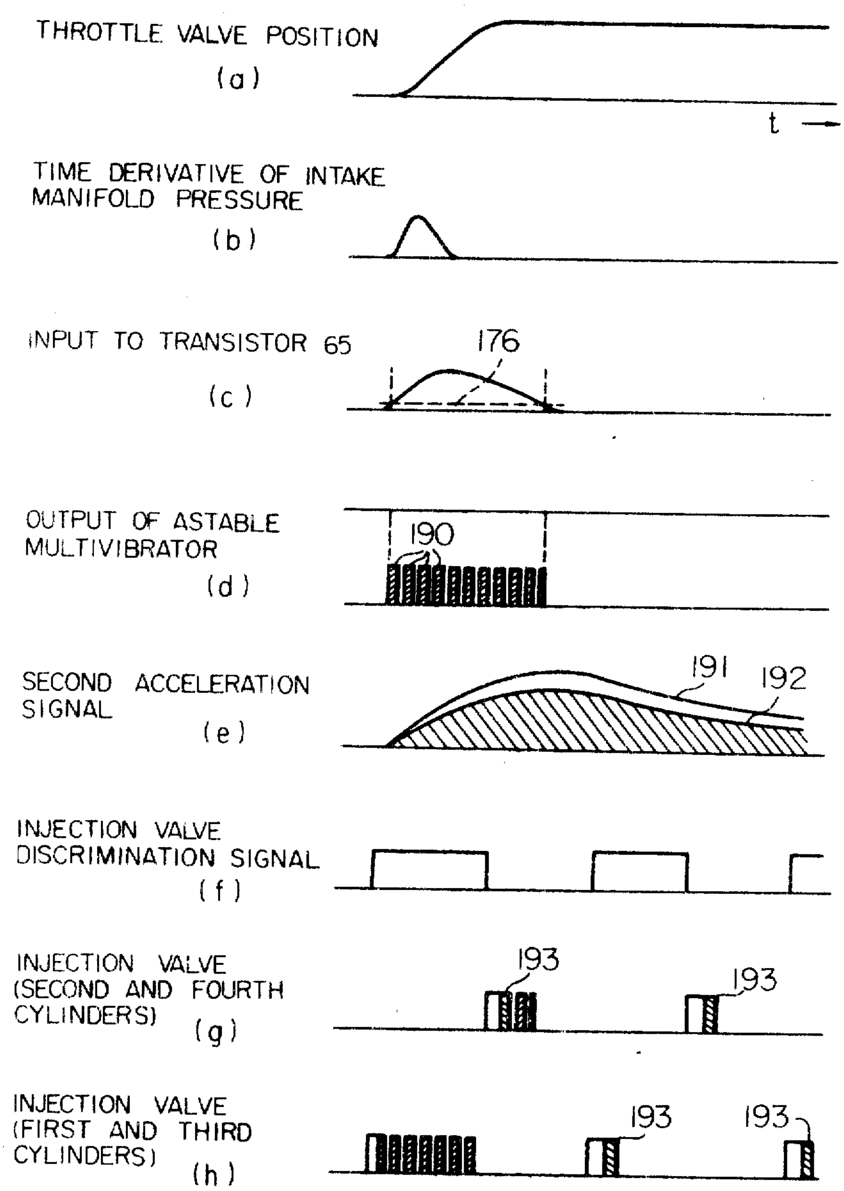

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Fig. 15

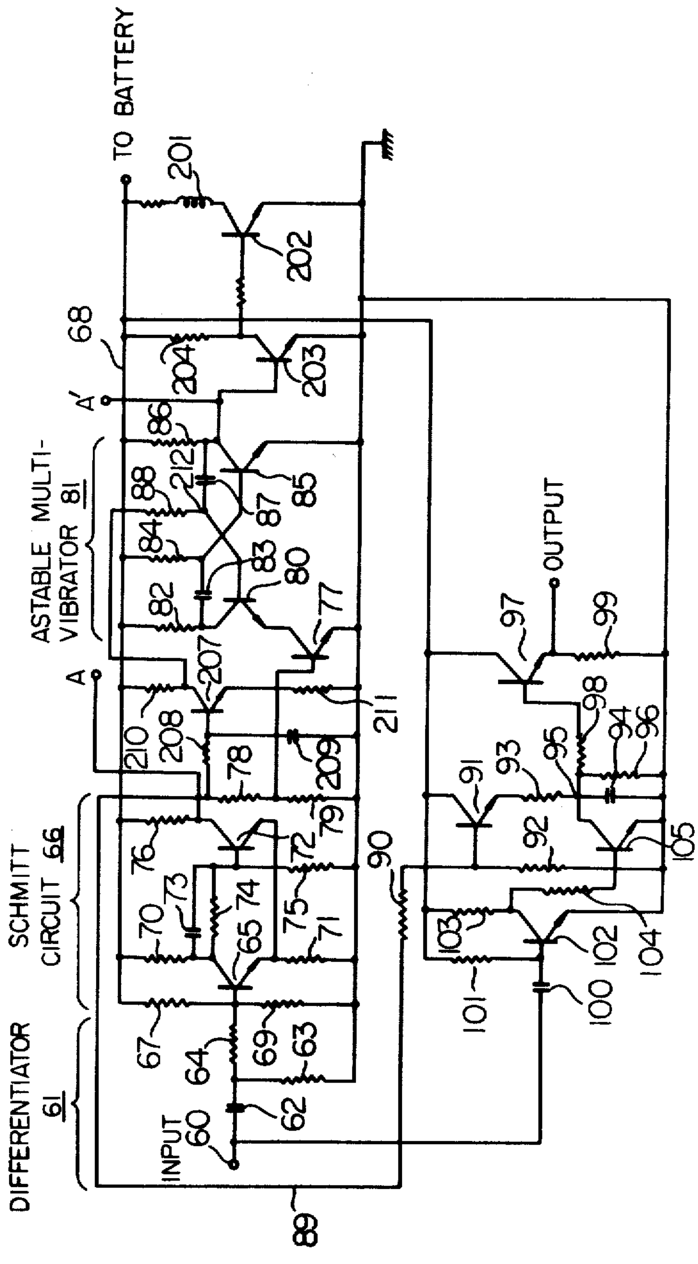

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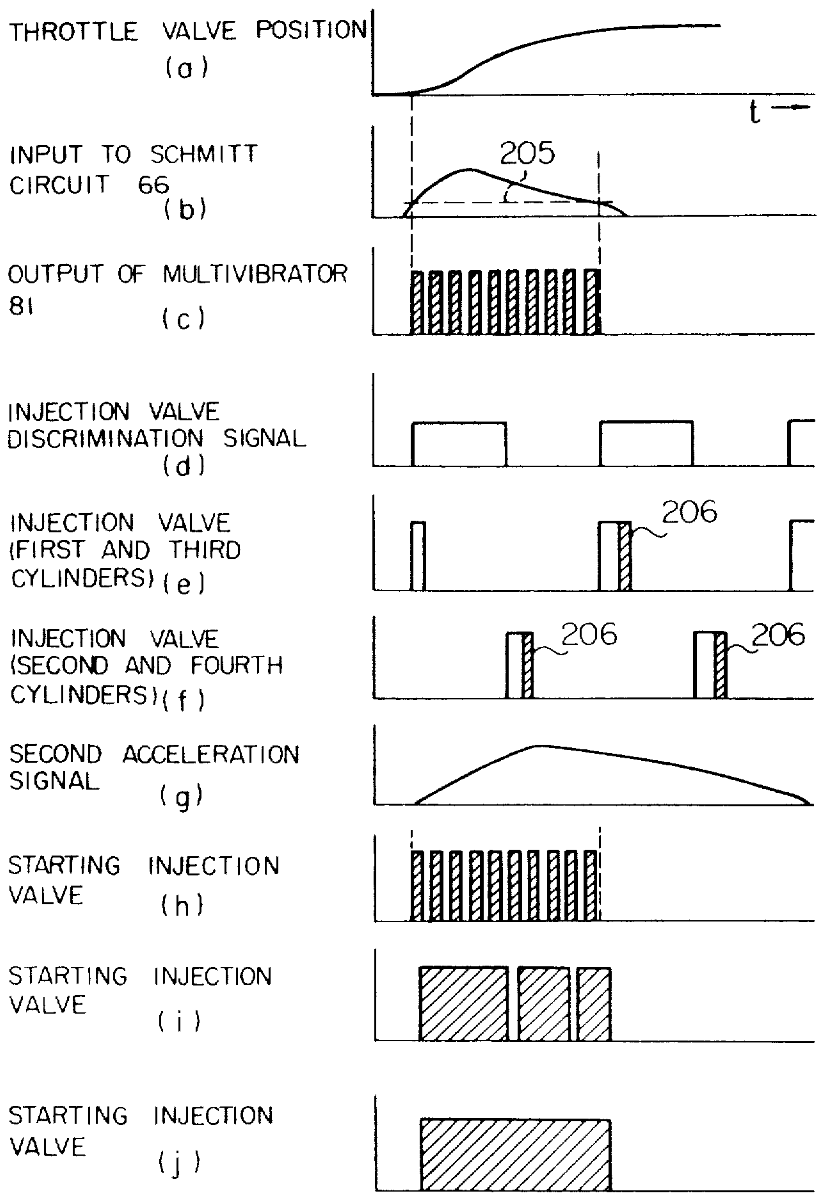
Fig. 16



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ACCELERATION ACTUATING DEVICE FOR FUEL INJECTION SYSTEM

This invention relates generally to a fuel injection system for a multicylinder internal combustion engine and more particularly to an acceleration actuating device adapted for incorporation into such a system as to provide for an instantaneous increase in the quantity of injection fuel supplied to the individual cylinders.

For acceleration, it is necessary to provide an increased supply of fuel to the cylinders. An improper air-fuel ratio during acceleration will cause a misfire or irregular combustion, resulting in the failure to effect desired acceleration. In a conventional carburettor-type fuel supply system, an accelerator-pump is employed which temporarily enriches the air-fuel mixture for acceleration by supplying additional fuel when the throttle valve is turned to the "open" position by an acceleration controlling member. This invention provides for a fuel injection system an acceleration device, which functions to instantaneously increase the amount of injection fuel in response to detection of the driver's effort for effecting acceleration, thereby to provide a temporary increase in the quantity of injection fuel supplied.

According to this invention, there is provided an acceleration actuating device adapted for use in a fuel injection system of a motor vehicle, comprising means for detecting the driver's effort to effect acceleration, means connected to the first named means to generate a first acceleration signal, means responsive to the first acceleration signal to increase the quantity of injection fuel supplied to the individual cylinders, means connected to the first named means to generate a second acceleration signal, and means responsive to the second acceleration signal to increase the width of an injection pulse signal generated by a computing circuit thereof.

It is, therefore, an object of this invention to provide an acceleration device adapted to provide a temporary increase in the quantity of injection fuel supplied during acceleration.

It is another object of this invention to provide an acceleration device having a throttle valve position detector which detects the driver's effort to effect acceleration.

It is a further object of this invention to provide an acceleration device employing an intake manifold pressure sensor which functions not only to transmit a signal indicating intake manifold pressure to a computing circuit of the fuel injection system but also to sense sudden changes in the intake manifold pressure caused by the driver's effort to effect acceleration.

It is still a further object of this invention to provide an acceleration device which provides for a marked increase in the quantity of injection fuel supply for acceleration before the engine has warmed up to a normal operating temperature.

It is yet another object of this invention to provide an acceleration device which actuates a starting injection nozzle to cause a discharge of fuel therefrom for acceleration purposes.

IN THE ACCOMPANYING DRAWINGS

FIG. 1 is a schematic diagram of a fuel injection system having an acceleration device constructed in accordance with one embodiment of this invention;

FIG. 2 is a schematic diagram of a potentiometer-type throttle valve position detector employed in the acceleration device of FIG. 1;

FIG. 3 is a schematic diagram of an oscillator-type throttle valve position detector;

FIGS. 4(a) and (b) are schematic diagrams of a piezo-electric throttle valve position detector;

FIG. 5 is a circuit diagram of an acceleration signal generating circuit shown in FIG. 1;

FIGS. 6(a) to (g) illustrate the time relationships between throttle valve position, velocity of throttle movement and occurrence of various signals at different points of the acceleration device;

FIG. 7 is a schematic diagram of an intake pressure sensor connected to the intake manifold by means of a conduit;

FIG. 8 shows a circuit diagram of a computing circuit of FIG. 1;

FIG. 9 shows a circuit diagram of an injection valve actuation circuit of FIG. 1;

FIG. 10 is a modification of the computing circuit employed in the fuel injection system of FIG. 1;

FIGS. 11(a) to (f) are diagrams explaining the operation of the computing circuit of FIG. 10;

FIGS. 12(a) to (d) are diagrams explaining the operation of the acceleration device;

FIG. 13 is a modification of the acceleration signal generating circuit having a low temperature compensating property;

FIGS. 14(a) to (h) are diagrams explaining the operation of the acceleration signal generating circuit of FIG. 13;

FIG. 15 is another modification of the acceleration signal generating circuit which is adapted to actuate a starting injection nozzle for acceleration purposes; and

FIGS. 16(a) to (j) are diagrams explaining the operation of the acceleration signal generating circuit of FIG. 15.

Referring to the drawings and more particularly to FIG. 1, a fuel injection system having an acceleration device according to one embodiment of this invention is shown. In FIG. 1, numeral 10 designates a throttle valve adapted to be turned in an intake air passage 11 to allow more or less air to flow therethrough. The air passage 11 communicates with an intake manifold 12 mounted on the side of a cylinder block 13. A fuel injection nozzle 14 is mounted in the intake manifold 13 to discharge fuel thereinto in a sprayed form. While the fuel injection nozzle 14 is shown as located in the intake manifold, it is to be understood that the nozzle 14 could equally well be located downstream of the throttle valve 10 to discharge directly into the individual cylinders of the engine. Although not shown, a pump is adapted to deliver fuel under pressure from a fuel reservoir to a pressure regulator which controls the pressure of the fuel supplied to the nozzle 14. The fuel spurting from the pressure regulator is conducted to the nozzle 14 which is controlled by an injection valve 15. In the following description, a 4-cylinder engine is considered employing the firing order of 1–3–4–2 cylinders.

The throttle valve 10 is operatively associated with an accelerator pedal 16 in the driver's compartment through a mechanical linkage 17. A throttle position detector 18 is operatively associated with the accelerator pedal 16 so as to produce a d.c. voltage dependent on the position of the throttle valve 10. FIG. 2 diagrammatically shows one such example of the throttle position detector 18 which is of potentiometer type having a sliding contact 19 that slides back and forth on a resistance 20 as the throttle valve 10 is tilted. The resistance 20 has its one end 21 connected to a constant d.c. voltage source such as a battery and the other end thereof 22 being grounded. The d.c. voltage dependent upon the throttle valve position is derived from the sliding contact 19.

FIG. 3 diagrammatically shows another embodiment of the throttle valve position detector 18. The left-hand half portion of the circuit as shown having a transistor 23, includes an oscillation circuit having a fixed oscillation frequency. The output of the oscillation circuit is fed to a d.c. conversion circuit having a transistor 24 through two inductively coupled coils 25 and 26. Situated between the two inductance coils 25 and 26 is a shielding plate 27 which is operatively associated with the accelerator pedal 16 in such a manner as to give minimum shielding when the accelerator pedal 16 is fully depressed, that is, the throttle valve is fully open. Thus, a d.c. voltage which depends upon the throttle valve position is derived from an output terminal 28 of the conversion circuit.

FIGS. 4(a) and (b) illustrate a further embodiment of the throttle valve position detector 18 employing a piezo-electric element 30. As shown in FIG. 4(a), the piezo-electric element 30 is secured to the tip portion of a lever 31 which is not attached to a throttle valve shaft 32. Another lever 33 is mounted on the throttle valve shaft 32 for rotation therewith and carries a projection 34 in opposed relationship to the piezo-electric element 30. When the accelerator pedal 16 is depressed, the throttle valve shaft 32 rotates in a counterclockwise direction as seen in FIG. 4(a), causing the projection 34 to exert a pressure on the piezo-electric element 30. FIG. 4(b) shows an electrical connection of the piezo-electric element 30. One electrode formed on one surface of the piezo-electric element 30 is grounded as shown at a portion 35 and the other surface electrode 36 is connected to an output terminal 37 by way of a diode 38. A capacitor 39 is connected between the output terminal 37 and ground. Upon acceleration a force F is applied onto the surface of the piezo-electric element 30, generating a positive voltage at the output terminal 37.

Turning back to FIG. 1, the d.c. voltage signal dependent upon the degree of opening of the throttle valve is supplied to an acceleration signal generating circuit 40, the function of which is to generate first and second acceleration signals when the circuit 40 detects the accelerative throttle valve movement.

The fuel injection system as shown in FIG. 1 includes an engine driven triggering device 41 which is incorporated in a conventional ignition distributor housing (not shown). The engine driven triggering device 41 comprises a cam 42 mounted on an engine driven shaft 43 and two triggering switches 44 and 45 adapted to be alternately actuated by rotation of the cam 42 in dependence on engine speed. The stationary contacts 46 and 47 of the triggering switches 44 and 45 are connected to a battery through resistors 48 and 49, respectively. Thus, when the cam 42 is rotated by the engine driven shaft 43 in dependence on the engine speed, a pulse signal having a repetition rate proportional to the engine speed is generated at the stationary contacts 46 and 47. The pulse signal indicating engine speed is supplied through leads 50 and 51 to a computing circuit 52 which, in response to the engine speed and other engine operating conditions such as intake manifold pressure and engine temperature, computes a proper pulse width of an injection pulse generated by the computing circuit 52. The injection pulse from the computing circuit 52 is fed via a lead 53 to an injection valve actuation circuit 54 and thence to the injection valve 15. The pulse signal indicating the engine speed is also applied as an injection valve discrimination signal to the injection valve actuation circuit 54 via leads 55 and 56.

FIG. 5 shows the acceleration signal generating circuit 40 according to one embodiment of this invention. In FIG. 5, numeral 60 designates an input terminal of the circuit 40 to which terminal is applied the d.c. voltage dependent upon the throttle valve position. The input terminal 60 is connected to a differentiator 61 consisting of a capacitor 62 and a resistor 63, the point between which is connected via a resistor 64 to the base of a transistor 65 which forms part of a Schmitt circuit 66. The base of the transistor 65 is connected via a resistor 67 to a bus line 68 connected to a battery and is also connected to ground via a resistor 69. The transistor 65 has its collector connected to the bus line 68 via a resistor 70 and its emitter grounded via a resistor 71. The collector of the transistor 65 is also connected to the base of a transistor 72 through a parallel connection of a capacitor 73 and a resistor 74. The base of the transistor 72 is grounded by way of a resistor 75. The transistor 72 has its collector connected to the bus line 68 via a resistor 76 and its emitter grounded by way of the resistor 71. The function of the Schmitt circuit 66 is to compare an input voltage with a predetermined voltage level and to thereby generate an output signal when the input voltage is above the predetermined level. The output of the Schmitt circuit 66 is applied to a switching transistor 77 by means of a voltage divider consisting of two resistors 78 and 79. The transistor 77 has its emitter grounded and its collector connected to the emitter of a transistor 80 which forms part of an astable multivibrator 81. The transistor 80 has its collector connected to the bus line 68 via a resistor 82. The collector is also connected to the bus line 68 through a capacitor 83 and a resistor 84, a point between the capacitor 83 and resistor 84 being connected to the base of still another transistor 85. The transistor 85 has its collector connected to the bus line 68 via a resistor 86 and its emitter directly grounded. The collector of the transistor 85 is also connected to the bus line 68 through a capacitor 87 and a resistor 88, a point between the capacitor 87 and resistor 88 being connected to the base of the transistor 80. The first acceleration signal of the circuit 40 is derived from the collector of the transistor 85.

The collector of the transistor 72 is connected via a lead 89 to a resistor 90 which in turn is connected to the base of a transistor 91. The transistor 91 has its collector connected to the bus line 83, the base thereof being grounded via a resistor 92. The emitter of the transistor 91 is connected to an integrator consisting of a resistor 93 and a capacitor 94. A point 95 between the resistor 93 and capacitor 94 is grounded by way of a resistor 96 and is also connected to the base of a transistor 97 by way of a resistor 98. The transistor 97 has its collector connected to the bus line 68 and its emitter connected to ground via a resistor 99. The second acceleration signal of the circuit 40 is obtained from the emitter of the transistor 97.

The input terminal 60 of the acceleration signal generating circuit 40 is also connected to a differentiator consisting of a capacitor 100 and a resistor 101 which is in turn connected to the bus line 68. The output of the differentiating circuit is connected to the base of a transistor 102 whose collector is connected to the bus line 68 via a resistor 103, the emitter thereof being grounded. The collector of the transistor 102 is also connected via a resistor 104 to the base of a transistor 105 having its emitter grounded. The collector of the transistor 105 is connected to the point 95 between the resistor 93 and capacitor 94.

In the operation of the acceleration signal generating circuit 40 shown in FIG. 5, the d.c. voltage signal dependent upon the throttle valve position is supplied from the throttle valve position detector 18 (FIG. 1) to the input terminal 60 of the circuit 40 and is then applied to the differentiator 61 consisting of the capacitor 62 and the resistor 63. When the throttle valve position is changed as shown in FIG. 6(a), the velocity of throttle valve movement varies as shown in FIG. 6(b), so that a d.c. voltage proportional to the velocity is generated by the differentiator 61 and is applied to the base of the transistor 65. When the d.c. voltage is below the threshold level of the Schmitt circuit 66, the transistor 65 is nonconductive and the transistor 72 is conductive. Therefore, there is no output signal at the output of the Schmitt circuit 66. When the d.c. voltage reaches the threshold level the transistor 65 is rendered conductive, causing the transistor 72 to stop conducting. Therefore, the potential at the collector of the transistor 72 rises, rendering the transistor 77 conductive. This starts the oscillation of the astable multivibrator 81. As shown in FIG. 6(c), the multivibrator 81 continues to oscillate while the transistor 77 remains conductive, that is, when the d.c. input voltage applied to the input of the Schmitt circuit 66 is above its threshold level. The oscillation output of the astable multivibrator 81, that is, the first acceleration signal is derived from the collector of the transistor 85 and is applied to the following injection valve actuation circuit 54 by means of a lead 106 (shown in FIG. 1).

The output of the Schmitt circuit 66 is also applied to the base of the transistor 91 by means of the lead 89 and the resistor 90. Thus, when the input voltage of the Schmitt circuit 66 rises above the threshold level, the transistor 91 is rendered conductive, establishing a current path through the resistor 93 and capacitor 94. Once the current path is established, the capacitor 94 begins to charge, causing the potential at the point 95 to build up. The increasing voltage signal is amplified by the transistor 97. When the d.c. input voltage of the Schmitt circuit 66 falls below the threshold value, the transistor 91 stop conducting, cutting off the current path through the resistor 93 and capacitor 94. It follows that the capacitor 94 commences to discharge by way of the resistor 96, causing a reduction in the potential at the point 95. The voltage wave form obtained at the emitter of the transistor 97 has the character as shown in FIG. 6(d). This output signal or second acceleration signal is supplied to the computing circuit 52 so as to responding increase the width of the injection pulse. The transistor 102 is normally conducting because the base thereof is connected to the bus line 68 by way of the resistor 101. When the throttle valve is tilted to the "closed" position for deceleration, a negative-going pulse is applied to the base of the transistor 102, causing it to stop conducting. With the transistor 102 nonconductive, the transistor 105 is rendered conductive to connect the point 95 to ground, thereby discharging the capacitor 94 instantaneously. This prevents the second acceleration signal from widening the injection pulses.

FIG. 7 diagrammatically shows an intake manifold pressure sensor 110 which is adapted to transmit a signal indicating intake manifold pressure to the computing circuit 52. The intake pressure sensor 110 includes a housing 111, two bellows 112 accommodated therein, an iron core 113 attached to the bellows 112 for axial movement therewith and two inductively coupled coils 114 and 115. The housing 111 is communicated with the intake manifold 12 by means of a conduit 116. The bellows 112, which contain gas at a constant pressure, expand and contract, depending upon the intake manifold pressure, to move the iron core 113 axially.

FIG. 8 shows one example of the computing circuit 52 including the two inductively coupled coils 114 and 115 of the intake manifold pressure sensor 110 of FIG. 7. The input terminal 117 of this circuit 52 is connected to one of the stationary contacts 46 and 47 of the engine driven triggering device 41, so that the pulse signal indicating engine speed triggers or energizes the circuit 52. Connected to the input terminal 117 is a capacitor 118 which in turn is connected to a bus line 119 via a resistor 120 and to ground via a resistor 121. The capacitor 118 is also connected to a diode 122 which is polarized in such a direction as to allow only a negative-going pulse to be transmitted therethrough. The diode 122 is connected to a blocking oscillator including two inductively coupled coils 114 and 115 and a transistor 123. One of the coils 114 has its one end connected to the bus line 119 via a resistor 124, the other end thereof being grounded via a resistor 125.

The other coil 115 has its one end connected to the bus line 119 via a resistor 126 and the other end connected to the collector of the transistor 123, the emitter thereof being grounded. The base of the transistor 123 is connected to the other end of the coil 114 by way of a capacitor 127 and a resistor 128. The output of the blocking oscillator is derived from the collector of the transistor 123 and is applied to an amplifying transistor 129 by way of a resistor 130. The transistor 129 has its collector connected to the bus line 119 via a resistor 131 and its emitter grounded. The output of the computing circuit 52 in the form of square pulses, that is, an injection pulse signal is derived from the collector of the transistor 129 and is then applied to the following injection valve actuation circuit 54. The computing circuit 52 also includes a transistor 132 having its emitter connected to the bus line 119 via a resistor 133 and its collector grounded. The base of the transistor 132 is connected to the emitter of the transistor 97 of the acceleration signal generating circuit 40 (shown in FIG. 5) by way of a resistor 134. The collector of the transistor 132 is connected to a diode 135 which in turn is connected to the one end of the coil 115. The emitter of the transistor 132 is directly grounded. Operation of the computing circuit 52 is such that each time a pulse signal indicating the engine speed triggers the blocking oscillator it generates a pulse signal, the width of which is determined by the engine speed and intake manifold vacuum. When the throttle valve is moved to "open" position for acceleration, the acceleration signal generating circuit 40 produces the second acceleration signal at the emitter of the transistor 97, which signal is applied to the base of the transistor 132, causing it to stop conducting. This causes a current flow from the bus line 119 through the resistor 133, diode 135 and coil 115 to the collector of the transistor 123, thereby increasing the width of the injection pulse generated by the blocking oscillator.

FIG. 9 is the injection valve actuation circuit 54 of the fuel injection system shown in FIG. 1. As shown, this circuit 54 has three input terminals 140, 141 and 142 connected to the base of a transistor 143, one of which is connected to the output of the computing circuit 52, another of which is connected to the acceleration pulse generating circuit 40 so as to receive the first acceleration signal, and the remaining one of which is connected to means for generating a positive-voltage signal during the starting and warm-up operation (not shown). The transistor 143 has its collector connected to a bus line 144 via a resistor 145 and its emitter grounded. The collector of the transistor 143 is also connected via a resistor 146 to the base of a transistor 147 whose collector is connected via a resistor 148 to the bus line 144, the emitter thereof being grounded. The collector of the transistor 147 is connected to a resistor 149 which in turn is connected to a transistor 150 at the base thereof. The collector of the transistor 150 is connected via a resistor 151 to the bus line 144 and the emitter thereof is grounded. The collector of the transistor 150 is connected via a resistor 152 to the base of a transistor 153 which is different in type from the transistors 143, 147 and 150, that is, of the PNP-type (as shown). The emitter of the transistor 153 is connected to the bus line 144 and the collector thereof is connected to a resistor 154 which in turn is connected to one end of the solenoid 155 associated with, for example, the first and third injection valves. The other end of the solenoid 155 is grounded.

The injection valve actuation circuit 54 has another input terminal 156 connected via a resistor 157 to the base of the transistor 147. This input terminal 156 is connected to one of the stationary contacts 46 and 49 of the engine driven triggering device 41 so as to receive an injection valve discrimination signal associated with the first and third injection valves. The discrimination signal has the waveform as shown in FIG. 6(e). In operation, when a positive voltage signal is applied at any one of the three input terminals 140, 141 and 142 of the circuit 54, the transistor 143 is rendered conductive, so that the potential at the collector thereof decrease to substantially zero. Under such conditions, if the injection valve discrimination signal is at "0" level, the transistor 147 is kept nonconductive, causing the transistor 150 to conduct. With the transistor 150 conducting, the transistor 153 is conducting, so that current flows through the transistor 153, resistor 154 and solenoid 155. Therefore, the solenoid 155 is actuated by the injection valve actuation circuit 54 only when a positive-voltage signal is applied at any of the inputs 140, 141 and 142 during the time that the injection valve discrimination signal remains at 0 level, as shown in FIG. 6(f). FIG. 6(g) shows the manner of actuation of the solenoid (not shown) associated with the second and fourth injection valves.

In FIGS. 6(f) and (g), the pulses shown as hatched are those which result from the first acceleration signal; the pulses without hatching, as indicated at 158, 159, 160, 161, ... , are those which are generated by the injection pulses. As shown, the width of the pulses resulting from the injection pulses is varied in accordance with the amplitude of the second acceleration signal shown in FIG. 6(d). The increase in the number and width of the pulses causes an increase in the duration of injection, resulting in a temporary increase in the quantity of fuel supply.

FIG. 10 shows a modification 52' of the computing circuit 52 employing an intake pressure sensor 170 which functions not only to transmit a signal indicating intake manifold vacuum to the computing circuit 52' but also to detect a sudden change in the pressure which is caused by the driver's effort to effect acceleration. In this embodiment, the intake manifold vacuum, which is most sensitive to changes in engine operating conditions and load conditions, is utilized to detect the driver's effort to effect acceleration. This circuit is similar to that of FIG. 8 except that it further includes two switching transistors 171 and 172. The one transistor 171 has its collector connected to the collector of the transistor 123 and its emitter grounded. The other transistor 172 has its collector connected via a resistor 172 to the bus line 119 and its emitter connected 173 the base of the transistor 129. The computing circuit 52' has another output terminal 174 connected to one end of the inductance coil 115, from which terminal is obtained a signal indicating a sudden change in the intake manifold vacuum which is caused by the driver's effort to effect acceleration.

FIGS. 11(a) to (f) are diagrams explaining the operation of the computing circuit 52' shown in FIG. 10. FIGS. 11(a) and (b) represent the waveforms of the trigger signal generated by the engine driven triggering device 41. In response to the trigger signal, the computing circuit 52' generates an injection pulse signal, the width of which is determined by the engine speed and intake manifold vacuum, as shown in FIG. 11(c). Under normal operating conditions, the pulse width varies from about 2/1,000 to 10/1,000 sec. Thus, the computing operation is effected in this circuit for a very short duration corresponding to the pulse width. In this embodiment, the intake manifold vacuum sensor is adapted to detect the sudden change in the intake manifold vacuum during the time other than the operating time. To effect the above-described function, a signal shown in FIG. 11(d) is applied to the bases of the two switching transistors 171 and 172. During the operating time, a zero voltage, indicated at 175 is applied to the bases of the transistors 171 and 172 to keep them nonconductive. Upon termination of the operating time, a positive voltage is applied to the bases, rendering the transistors 171 and 172 conductive. With the transistors 171 and 172 conducting, the potential at the collector of the transistor 123 drops to zero, so that a combination of the resistor 126 and inductance coil 115 continuously detects the intake manifold pressure to generate a voltage signal corresponding to the pressure level at the output terminal 174. The output terminal 174 is connected to the input terminal 60 of the acceleration signal generating circuit 40 as shown in FIG. 5. FIG. 11(e) represents the change in the intake manifold vacuum which is caused by the driver's effort to effect acceleration and FIG. 11(f) represents the time derivative thereof.

In the operation of the embodiment shown in FIGS. 10 and 11, when the throttle is moved to the open direction for acceleration as shown in FIG. 12(a), the time derivative of the intake manifold vacuum varies as shown in FIG. 12(b), so that a voltage signal, as shown in FIG. 12(c), which is generated by the differentiator 61, is applied to the base of the transistor 65 which forms part of the Schmitt circuit 66. When the voltage at the base of the transistor 65 is above the threshold level 176 of the Schmitt circuit 66, as shown in FIG. 12(c), the transistor 72 is rendered nonconductive, keeping the astable multivibrator 81 in the oscillating conditions, as shown in FIG. 12(d). The oscillation output of the multivibrator 81 is fed to the injection valve actuation circuit 54.

In FIG. 13, there is shown another embodiment 40' of the acceleration signal generating circuit 40 having a low temperature compensating property. This circuit 40' is different from the circuit 40 of FIG. 5 in that it includes an additional temperature compensating unit comprising a thermistor 180 and a transistor 181.

The collector of the transistor 181 is connected to the point 182 between two resistors 183 and 184 which are serially connected between the bus line 68 and the capacitor 87. The transistor 181 has its emitter connected to ground via a resistor 185 and its base connected to the bus line 68 via a resistor 186. The thermistor 180 is connected between the base of the transistor 181 and ground. The base of the transistor 181 is also connected to the point 95 between the capacitor 94 and the resistor 93 by way of a resistor 187 and a diode 188 which is polarized in a direction to allow only a positive voltage signal to be transmitted from the thermistor 180 to the point 95. To the base of the transistor 102 is connected two resistors 189 and 189' which in turn are connected to the input 60 via the capacitor 100.

In the operation of the acceleration signal generating circuit 40' shown in FIG. 13, when the engine is still cold during the warm-up operation, the thermistor 180 represents a relatively large resistance by which the potential at the base of the transistor 181 is increased so that a current flow through the resistor 183, the collector-emitter path of the transistor 181 and the resistor 185 is increased. Consequently, the potential at the point 182 drops, with the resulting increase in the width of the pulse generated by the astable multivibrator 81, as shown by the dark portions 190 of FIG. 14(d). The increase in the width of the acceleration pulse causes an increase in the quantity of fuel supplied to the individual cylinders, thereby improving the engine performance during the warm-up operation. When the engine has warmed up, the thermistor 180 represents a relatively small resistance, so that the potential at the point 182 rises. The rise in the potential at the point 182 causes a reduction in the width of the acceleration pulse.

During the warm-up operation, the relatively high voltage at the base of the transistor 181 is applied to the point 95 between the capacitor 94 and the resistor 93 by way of the resistor 187 and the diode 188. This voltage provides for an increase in the amplitude of the second acceleration signal which is derived from the emitter of the transistor 97. In FIG. 14(e), numeral 191 designates the second acceleration signal amplified by the low temperature compensating unit; numeral 192 designates the signal without compensation. The second acceleration signal is applied to the computing circuit 52 so as to increase the width of the injection pulse. In FIG. 14(g) and (h), the dark portions 193 represent the increases in the width, which result from the increase in the amplitude of the second acceleration signal.

In FIG. 15, there is shown still another modification 40'' of the acceleration signal generating circuit which is adapted to actuate a starting injection valve for acceleration purposes. As shown in FIG. 1, the starting injection valve 200 is mounted in the intake manifold 12 so as to discharge additional fuel thereinto during starting, thereby facilitating starting of the engine. In this embodiment, this starting valve 200 is used to increase the richness of the air-fuel mixture during the accelerating operation. In the circuit 40'' of FIG. 15, a solenoid 201 of the starting injection valve 200 is connected between the bus line 68 and the collector of a transistor 202. The output of the astable multivibrator 81 is connected to the base of a transistor 203 having its collector connected to the bus line 68 via a resistor 204 and its emitter grounded. The collector of the transistor 203 is also connected to the base of the transistor 202. Thus, when the multivibrator 81 oscillates, the oscillation output is amplified by the transistors 202 and 203 to energize the solenoid 201.

In the operation of the embodiment shown in FIG. 15, a voltage signal indicating the drive's effort to effect acceleration is applied to the input terminal 60 and is differentiated by the differentiator 61. When the differentiated input is above the threshold level 205 of the Schmitt circuit 66 as shown in FIG. 16(b), it generates an output signal at the collector of the transistor 72, which signal in turn is applied to the base of the transistor 77 via the resistor 78. During application of the output signal, the transistor 77 remains conductive, causing the astable multivibrator 81 to oscillate. FIG. 16(c) represents the oscillation output which is utilized to actuate the starting injection valve, as shown in FIG. 16(h). In FIGS. 16(e) and (f), the dark portions 206 represent the increase of the pulse width which contributes to the second acceleration signal.

This acceleration signal generating circuit include means for varying the width of the oscillation pulse signal. The collector of the transistor 72 is connected to the base of a transistor 207 via an integrator consisting of a resistor 208 and a capacitor 209. The transistor 207 has its collector connected to the bus line 68 via a resistor 210 and its emitter connected to ground via a resistor 211. The collector of the transistor 207 is also connected to the point 212 between the capacitor 87 and the base of the transistor 80 by way of the resistor 88. When the input voltage of the Schmitt circuit 66 exceeds its threshold level 205, the circuit generates an output signal having a fixed amplitude, which signal is integrated by the integrator, causing the potential at the base of the transistor **207** to build up. The increase in the potential at the base of the transistor **207** invites a drop in the potential at the collector thereof and accordingly in the potential at the point **212**, with the resultant gradual decrease in the width of the acceleration pulse signal, as shown in FIG. **16**(i). An acceleration signal as shown in FIG. **16**(j), which keeps the starting injection valve **200** energized while the Schmitt circuit **66** generates its output, is obtained by connecting the collector of the transistor **72** to the base of the transistor **203**, that is, by connecting A to A' terminals.

What is claimed is:

1. An acceleration actuating device for a fuel injection system of an internal combustion engine having a throttle valve comprising, in combination, electric means for producing a voltage signal dependent upon the position of said throttle valve; a first electric circuitry having a switching transistor and being electrically connected to said electric means; said first electric circuitry being responsive to said voltage signal for producing a first acceleration signal; a second electric circuitry electrically connected to said electric means and to said first electric circuitry through said switching transistor, said second electric circuitry being responsive to said voltage signal and to a signal received from said first electric circuitry through action of said switching transistor for producing a variable second acceleration signal; a triggering device driven by said engine for producing a pulse signal with a repetition rate proportional to the speed of said engine; a computer circuit electrically connected to said triggering device and to said second electric circuitry, said computer circuit being responsive to said pulse signal and to said second acceleration signal for producing an injection pulse with a width dependent thereupon; an injection valve actuating circuit electrically connected to each of said computer circuit, said engine driven triggering device and said first electric circuitry, said injection valve actuating circuit being responsive to said injection pulse, to said pulse signal and to said first acceleration signal for producing an injection valve actuation signal; said injection valve actuation signal from said first acceleration signal being separate from the injection valve actuation signal produced by said pulse signal and said injection pulse an injection valve mounted in an engine intake manifold, and a fuel injection nozzle controlled by said injection valve, said injection valve being electrically connected to said injection valve actuating circuit and responsive to said injection valve actuation signal to cause fuel injection into a cylinder of said engine for a period of time corresponding to the width of said injection valve actuation signal.

2. An acceleration actuating device according to claim 1, wherein said engine has an accelerator pedal which is associated with said throttle valve, and wherein said electric means is an oscillator-type throttle valve position detector and includes an oscillation circuit with a fixed oscillation frequency, the output of said oscillation circuit being coupled to a d.c. conversion circuit and the degree of the coupling being varied by a shielding plate which moves in response to displacement of said accelerator pedal.

3. An acceleration actuating device according to claim 1, wherein said first electric circuitry includes a first differentiator consisting of a first capacitor and a first resistor and receiving said voltage signal; a Schmidt circuit electrically connected to said first differentiator and an astable multivibrator electrically connected to said Schmidt circuit through said switching transistor, said astable multivibrator serving to oscillate so as to produce said first acceleration signal when said switching transistor is rendered conductive by said Schmidt circuit.

4. An acceleration actuating device according to claim 1, wherein said second electric circuitry includes a second differentiator consisting of a second capacitor and a second resistor and receiving said voltage signal; a first transistor connected at its base to said Schmidt circuit to receive said signal from said first electric circuitry; an integrator circuit consisting of a third capacitor and a third resistor connected in series to the emitter of said first transistor; a second transistor connected at its base to said third capacitor and said third resistor, said first transistor conducting so as to cause said third capacitor to charge when the input voltage to said Schmidt circuit is above its threshold level and when said input voltage is below said threshold level, said first transistor being rendered nonconductive to cause said third capacitor to discharge so as to result in variation in the voltage at the emitter of said second transistor, the emitter voltage being said second acceleration signal, and wherein said second electric circuitry further includes a third transistor which is normally conducting, said third transistor being connected to said second differenciator; a fourth transistor connected at its base to the collector of said third transistor, at its collector to the base of said second transistor and having its emitter grounded, said third transistor being rendered nonconductive when said voltage signal applied to said second differentiator is below a predetermined level, whereby said fourth transistor is rendered conductive causing instant discharge of said third capacitor.

5. An acceleration actuating device according to claim 1, wherein said computer circuit includes a fourth capacitor connected to said triggering device; a first diode connected to said fourth capacitor; a blocking oscillator connected to said fourth capacitor; a blocking oscillator connected to said first diode; an engine intake manifold pressure sensor communicating with the intake manifold and adopted to transmit a signal indicating intake pressure; a fifth transistor connected to said blocking oscillator; and a fifth capacitor on a line connecting said diode to said fifth transistor said second acceleration signal being fed to said blocking oscillator through a sixth transistor and a second diode to produce an injection pulse with a width dependent on intake manifold pressure and repetition rate dependent of engine speed.

6. An acceleration actuating device according to claim 1, wherein said injection valve actuating circuit includes seventh, eighth and ninth transistors of the same type and a tenth transistor of a different type, said seventh transistor receiving at its base said injection pulse, said first acceleration pulse, a starting and warm-up signal at its collector and said pulse repetition rate signal, the collector of said seventh transistor being connected to the base of said eighth transistor, the collector of which is connected to the base of said ninth transistor, the collector of which is connected to the base of said tenth transistor, said seventh, eighth and ninth transistors being grounded at their emitters, and a solenoid connected between said tenth transistor and ground for causing said injection valve to open for fuel injection for said period of time corresponding to the width of said injection valve actuation signal.

7. An acceleration actuating device according to claim 3, further including a temperature compensating unit consisting of a thermistor for sensing the engine temperature and an eleventh transistor connected to said thermistor at the base thereof, said eleventh transistor being connected at its collector to a point between a fourth resistor and a fifth transistor connected to the output of said astable multivibrator through a capacitor said thermistor having a relatively high resistance, when the engine is cold, to increase the potential at the base of said eleventh transistor whereby said eleventh transistor is rendered conductive to decrease the potential at the point between said fourth and fifth resistors for thereby increasing the width of the pulse generated by said astable multivibrator.

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