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[54] **ACCELERATION ENRICHMENT CIRCUIT FOR ELECTRONIC FUEL CONTROL SYSTEMS**

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

[51] **Int. Cl.** **F02b 3/00**, F02m 39/00

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

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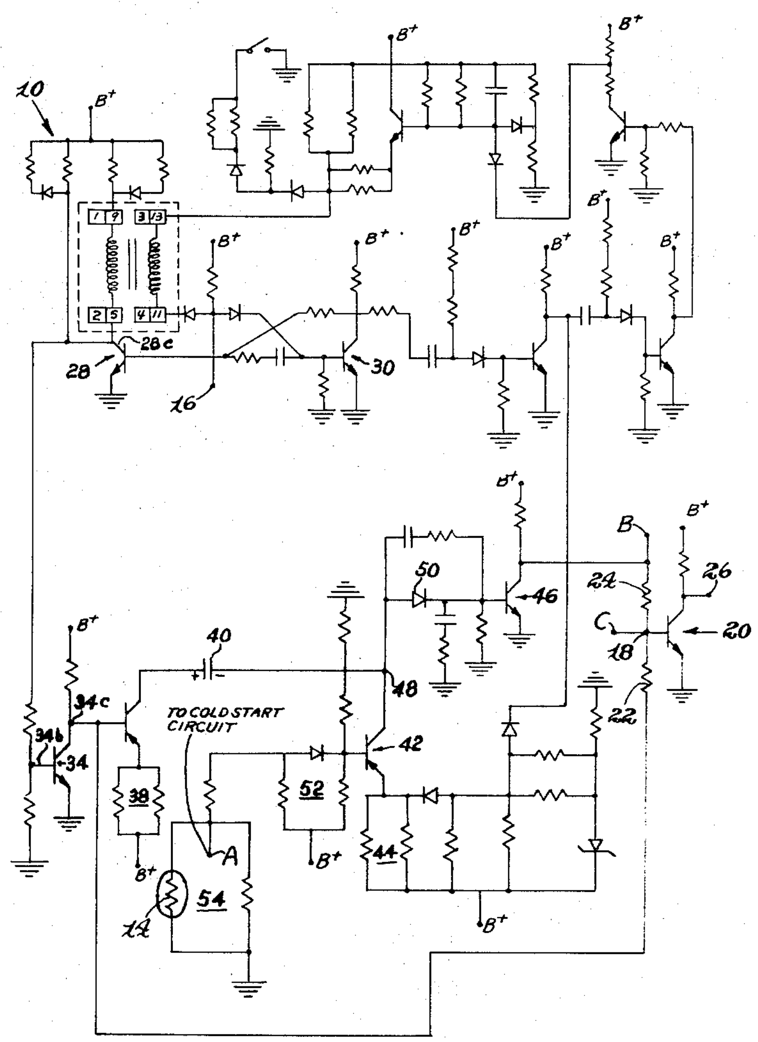
[57] **ABSTRACT**

An acceleration enrichment circuit is disclosed which is operative to sense a demand for engine acceleration and which subsequently lengthens the duration of the fuel injection command to reduce or eliminate response time largs. The circuit includes a first circuit to provide an immediate pulse of fuel to the injector group most recently energized and a second circuit to lengthen the injection commands to each injector for a period of time sufficient to accomplish the desired acceleration.

3 Claims, 2 Drawing Figures



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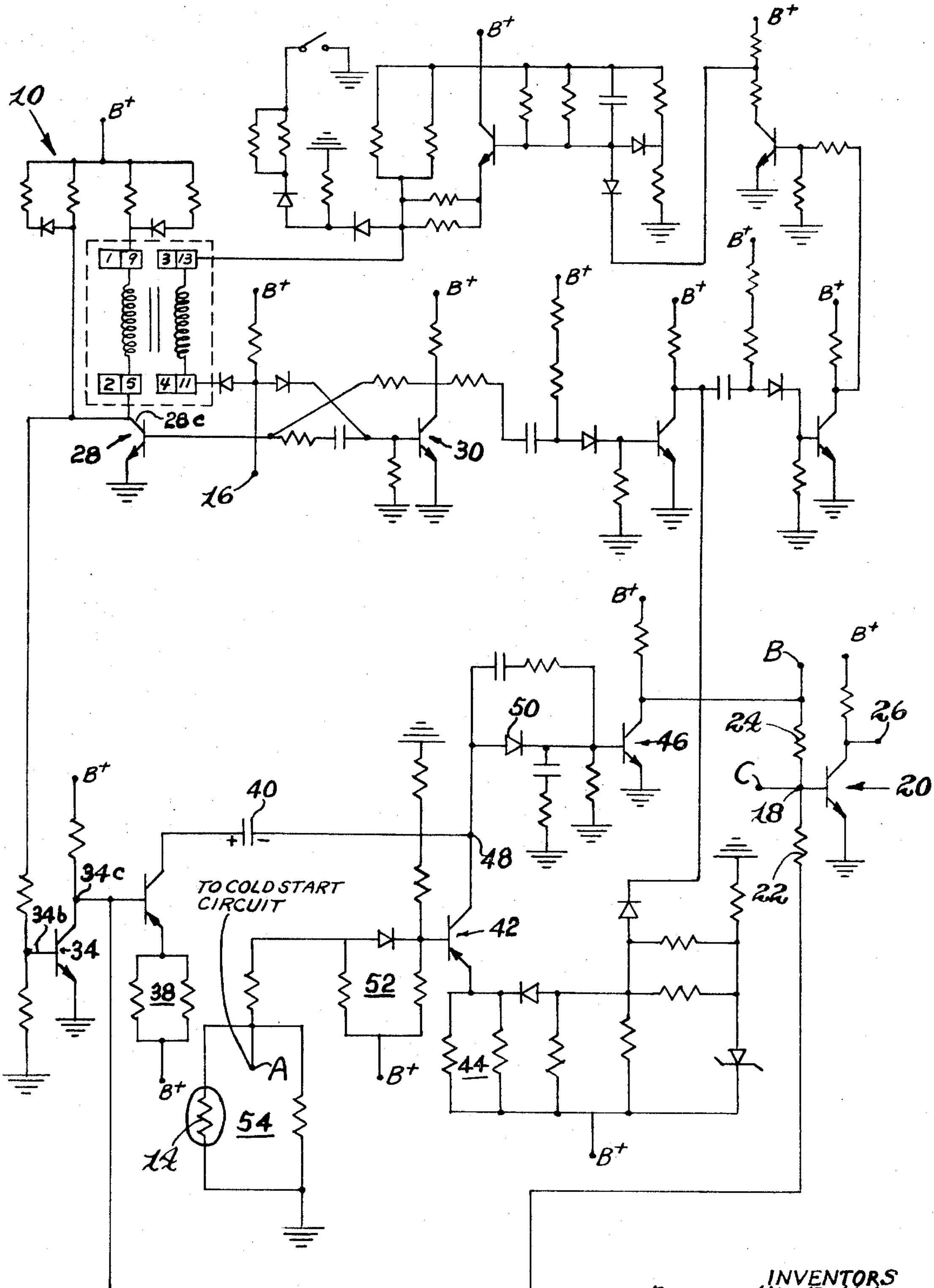

Fig. 1

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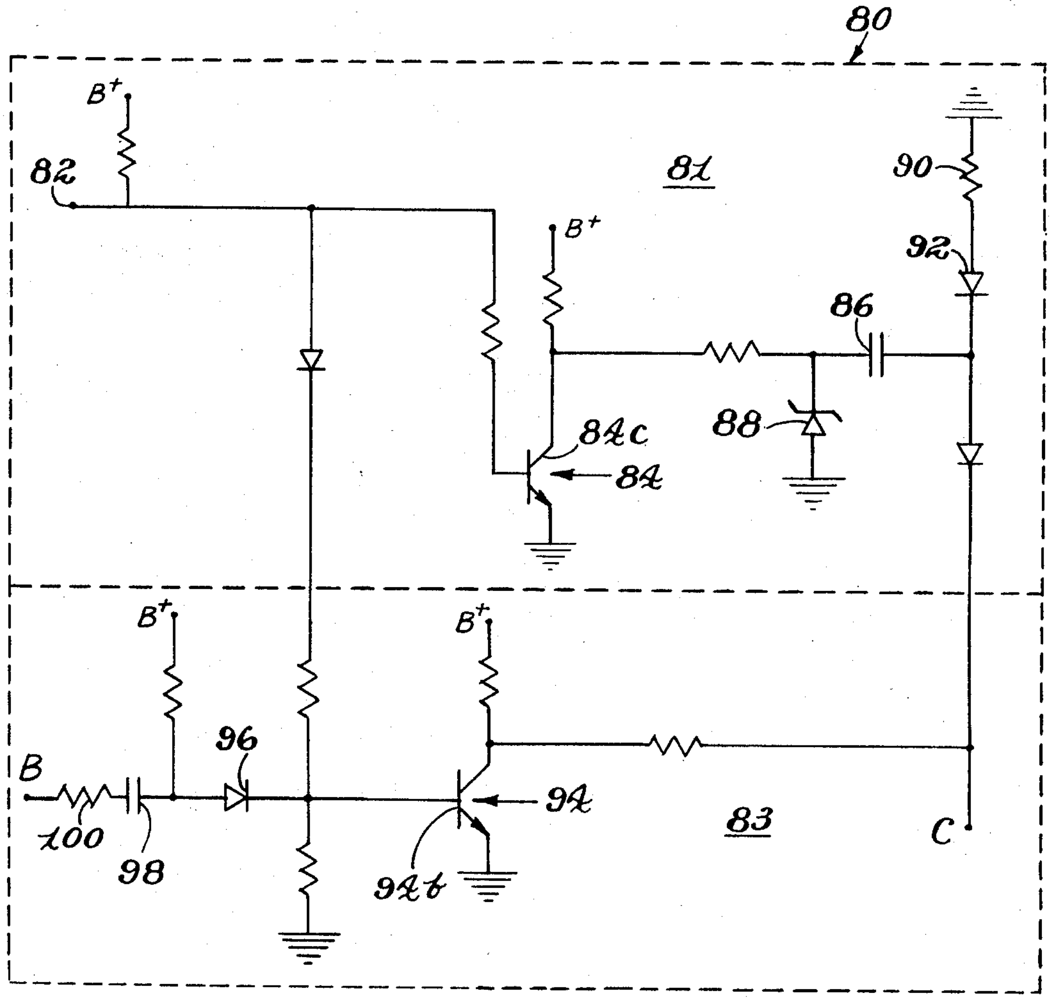

Fig.2

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ACCELERATION ENRICHMENT CIRCUIT FOR ELECTRONIC FUEL CONTROL SYSTEMS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to improvements in electronic fuel control systems and particularly to improvements in automotive electronic fuel control systems whereby an acceleration enrichment function is provided.

2. Description of the Prior Art

The known electronic fuel control systems currently rely upon the input information from their various parameter sensors to provide information required by an electronic fuel control system to provide acceleration enrichment. These sensors, generally, sense the engine temperature, which may be the temperature of the water jacket, to indicate the operating temperature of the engine, the engine speed to determine timing and engine fuel requirements, the intake manifold pressure to sense the load on the engine and various other parameters as needed or desired.

The prior art also teaches that acceleration enrichment may be provided in the form of an additional resistance in the time duration controlling portion of the electronic fuel control circuits. Since the circuits generally use a variable RC network to determine the length of the injection pulse, it was felt to be sufficient to provide an additional resistance (either in series or parallel) with the regular resistance of the RC network which additional resistance could be appropriately shunted or short-circuited when not necessary to the operation of the electronic fuel control circuit. This, however, produced a problem with the recovery time of the RC circuit which rendered this approach inadequate. It is, therefore, an object of this invention to provide an acceleration enrichment circuit for electronic fuel control systems which does not alter the operational characteristics of the main electronic fuel control computing means. It is a still further object of the present invention to provide an acceleration enrichment circuit which varies the injection time by adding a pulse to the injection pulse rather than by lengthening regularly generated injection pulses.

It has been determined that the present electronic fuel control systems as applied to automotive systems, demonstrate a marked time delay between the time the throttle is depressed and the time the engine begins to accelerate. Oscillograms of engine speed versus time after throttle opening for an engine equipped with an electronic fuel control system show a substantial response lag, on the order of 200 to 300 milleseconds, as compared with a similar engine equipped with a carburetor. In addition, some tests have shown that engine speed actually decreases during the time lag interval. Results of further tests have shown that the response lag is due to two factors. The first of these factors is the group injection concept itself which causes fuel to be delivered to a plurality of injectors as a function of the engine operating parameters at the time of injection. Since this is immediately prior to the time of opening of the intake port of the first cylinder in the group to be ignited, the fuel provided to subsequent cylinders in the group might not be in the proper amount. Acceleration commands or needs would, therefore, lag until the time of injection of the next group. Group injection is the combining of selected injectors into groups with

each member of the group being simultaneously activated and different groups being activated sequentially.

A second cause for the response lag is the lag in response at the intake manifold pressure sensor which lag is necessitated by the fact that the actual pressure varies, or ripples, over a wide range during an engine cycle. This variation occurs as intake ports open and air is drawn into the engine cylinders whereas some weighted average pressure signal is required by the electronic fuel control system. The pressure sensor is, therefore, damped to respond sluggishly to pressure variations. It is an object of the present invention to provide an electronic circuit means for overcoming at least a portion of the abovenoted response lag. It is a still further object of the present invention to provide such a circuit which operates to overcome that portion of the pressure lag caused by group injection. It is a still further object of the present invention to provide a circuit means which serves to substantially overcome that portion of the response lag caused by the sluggishness of the intake manifold pressure sensor. It is a still further object of the present invention to provide a circuit means for overcoming that portion of the response lag caused by both group injection and intake manifold pressure sensor sluggishness. It is yet another object of the present invention to provide a circuit for attaining the above enumerated objectives which is reliable in operation with automotive engine operating parameters.

SUMMARY OF THE PRESENT INVENTION

The present invention provides a special function auxiliary circuit for an electronic fuel control system capable of providing acceleration enrichment. The acceleration enrichment auxiliary circuit senses the need for such enrichment and then provides (1) an injection pulse of predetermined duration for application to that group of injector nozzles which has most recently been energized and (2) an additional pulse of predetermined duration for addition to each injector command pulse for a period of time following the initial pulse. The first pulse is operative to overcome that portion of the response lag due to group injection while the added pulses serve to lengthen the injection time period during that period of time when the manifold pressure sensor has not yet responded to the pressure change in the manifold.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows, in diagrammatic circuit form, an electronic fuel control system computation circuit as adapted, for instance, for automotive use.

FIG. 2 shows, in diagrammatic circuit form, an auxiliary circuit according to the present invention for providing the acceleration enrichment function.

DETAILED DESCRIPTION

Referring now to FIG. 1, an electronic fuel control system computation circuit **10** is shown. The circuit is shown as being energized by a voltage supply designated as B+ at the various locations noted. In the application of this system to an automotive engine fuel control system, the voltage supply could be the battery and/or battery charging system conventionally used as the vehicle's electric power source. The man skilled in the art will recognize that the electrical polarity of the voltage supply could readily be reversed.

The circuit 10 receives, along with the voltage supply, various voltage signal sensory inputs indicative of various operating parameters of the associated engine. Intake manifold pressure sensor 12 supplies a voltage indicative of manifold pressure, temperature sensor 14 is operative to vary the voltage across the parallel resistance to provide a voltage signal indicative of engine temperature and voltage signals indicative of engine speed are received at circuit input port 16. This signal may be derived from any source indicative of engine crank angle but is preferably from the engine's ignition distributor, not shown.

The circuit 10 is operative to provide two consecutive pulses, of variable duration, through sequential networks to circuit location 18 to thereby control the "on" time of transistor 20. The first pulse is provided via resistor 22 from that portion of circuit 10 having inputs indicative of engine crank angle and intake manifold pressure. The termination of this pulse initiates a second pulse which is provided via resistor 24 from that portion of the circuit 10 having an input from the temperature sensor 14. These pulses, received sequentially at circuit location 18, serve to turn transistor 20 "on" (that is, transistor 20 is triggered into the conduction state) and a relatively low voltage signal is present at circuit output port 26. This port may be connected, through suitable inverters and/or amplifiers (not shown) to the injector means (also not shown) such that the selected injector means are energized whenever the transistor 20 is "on". It is the current practice to use switching means to control which of the injector valve means are coupled to circuit location 26 when the system is used to actuate less than all injector valve means at any one time. Because the injector valve means are relatively slow acting, compared with the speed of electronic devices, the successive pulses at circuit point 18 will result in the injector valve means, not shown, remaining open until after the termination of the second pulse.

The duration of the first pulse is controlled by the monostable multivibrator network associated with transistor 28 and 30. The presence of a pulse received via input port 16 will trigger the multivibrator into its unstable state with transistor 28 in the conducting state and transistor 30 blocked (or in the nonconducting state). The period of time during which transistor 28 is conducting will be controlled by the voltage signal from manifold pressure sensor 12. Conduction of transistor 28 will cause the collector 28c thereof to assume a relatively low voltage close to the ground or common voltage. This low voltage will cause the base 34*b* of transistor 34 to assume a low voltage below that required for transistor 34 to be triggered into the conduction state, thus causing transistor 34 to be turned off. The voltage at the collector 34*c* will, therefore, rise toward the B+ value and will be communicated via resistor 22 to circuit location 18 where it will trigger transistor 20 into the "on" or conduction state thus imposing a relatively low voltage at circuit port 26. As hereinbefore stated, the presence of a low voltage signal at circuit port 26 will cause the selected injector valve means to open. When the voltage from the manifold pressure sensor 12 has decayed to the value necessary for the multivibrator to relax or return to its stable condition, transistor 30 will be triggered "on" and transistor 28 will be turned "off". This will, in turn, cause transistor 34 to turn "on", transistor 20 to turn "off" and thereby remove the injector control signal from circuit port 26.

During the period of time that transistor 34 has been held in the non-conducting, or "off" state, the relatively high voltage at collector 34*c* has been applied to the base of transistor 36, triggering the transistor 36 "on". The resistor network 38, connected to the voltage supply, acts, with transistor 36 as a current source and current flows through the conducting transistor 36 and begins to charge capacitor 40. Simultaneously, transistor 42 has been biased "on" and, with the resistor network 44 constitutes a second current source. Currents from both sources flow into the base of transistor 46 thereby holding this transistor "on" which results in a low voltage at the collector 46*c*. This low voltage is communicated to the base of transistor 20 via resistor 24.

When transistor 28 turns "off" signalling termination of the first pulse, transistor 34 turns on and the potential at the collector 34*c* falls to a low value. The current from the current source, comprised of transistor 36 and resistor network 38, now flows through the base of transistor 36 and the capacitor 40 ceases to charge. The capacitor will then have been charged, with the polarity shown in FIG. 1, to a value representative of the duration of the first pulse. However, the potential at the collector of transistor 36 will be only slightly positive with respect to ground since only several pn junctions separate it from ground. This will impose a negative voltage on circuit location 48 which will reverse bias diode 50 and transistor 46 will be turned "off". This will initiate a high voltage signal from the collector of transistor 46 to circuit location 18 via resistor 24 which signal will re-trigger transistor 20 "on" and a second injector means control pulse will appear at circuit port 26. The time duration between first and second pulses will be sufficiently short so that the injector means will not respond to the brief lack of signal.

While the diode 50 is reverse biased, the current from the current source comprised of transistor 42 and resistor network 44 will be flowing through circuit location 48 and into the capacitor 40 to charge the capacitor to the point that circuit location 48 will again be positive. This will then forward bias diode 50 and transistor 46 will turn back on. This will terminate the second pulse and the injector valve means, not shown, will subsequently close.

The duration of the second pulse will be a function of the time required for circuit location 48 to become sufficiently positive for diode 50 to be forward biased. This, in turn, is a function of the charge on capacitor 40 and the magnitude of the charging current supplied by the current source comprised of transistor 42 and resistor network 44. The charge on capacitor 40 is, of course, a function of the duration of the first pulse. However, the rate of charge (i.e., magnitude of the charging current) is a function of the base voltage at transistor 42. This value is controlled by the voltage divider networks 52 and 54 with the effect of network 54 being variably controlled by the engine temperature sensor 14.

Referring now to FIGS. 1 and 2, and particularly to FIG. 2, the acceleration enrichment aixuliary circuit 80 is illustrated. The acceleration enrichment auxiliary circuit is comprised of a pair of interconnected circuits 81, 83 the first of which, 81, is operative to produce a single injection command of fixed duration immediately upon receipt of a signal indicative of a demand for acceleration enrichment, and the second of which is operative to produce a sequence or series of injection command pulses which serve to increase the total injection time (and hence total fuel injected) for a period of time following the production of the single pulse. As illustrated in FIGS. **1** and **2**, the acceleration enrichment auxiliary circuit **80** receives input signals at circuit locations **82** and B (not to be confused with B+). Circuit location **82** is connected to receive a first command signal indicative of a need for acceleration enrichment. In this configuration, the signal is the appearance at circuit location **82** of ground which may be achieved by a contact closure at a switch, not shown, to a grounded lead. This signal operates to turn transistor **84** off. The resulting positive voltage step at the collector **84***c* of transistor **84** is applied, through the resistor, capacitor, diode network, to circuit location C and turns on transistor **20** (FIG. **1**) which then energizes the electromechanical injector valve means which are currently coupled to the collector of transistor **20** at circuit location **26**, that is, the group of injector valve means most recently energized. This is of advantage in the case of fuel injection systems utilizing the group injection method since this additional pulse to the injector valve means will serve to provide an increment of additional fuel to those injector valve means of the group associated with cylinders which have not yet drawn in their combustion charge. Transistor **20** will remain on until the coupling capacitor **86** (FIG. **2**) charges up to the limiting voltage set by the zener diode **88**. Resistor **90** in series with the diode **92** limits the discharge rate to prevent false triggering which may be produced by contact bounce during the make or break action at the switch, not shown, thereby preventing the generation of signal pulses at frequencies above a selected frequency.

The first command signal (received at circuit location **82**) is also operative to enable the second circuit, **83**, to generate the sequence of pulses necessary to provide the lengthened injection command pulses for a period of time following receipt of the signal indicative of the need for acceleration enrichment. The second circuit **83** is enabled by removing the slight positive voltage at the base **94***b* of transistor switch **94**. The base **94***b* is coupled through diode **96**, capacitor **98** and resistor **100** to circuit location B which is common with a similarly designated portion of the FIG. **1** circuit which generates the second pulse of the computed injection command. As the trailing edge of the second pulse passes through circuit location B it turns transistor **20** off and also causes transistor **94** to turn off thereby imposing a positive voltage on the collector **94***c* of transistor **94** which initiates a positive voltage pulse to turn transistor **20** back on again. The turning off of transistor **20** followed very closely by its turning back on will cause the electromechanical injector valve means coupled to circuit location **26** to remain open because the interval during which transistor **20** is turned off is again too short for the relatively sluggish electromechanical injector valve means to respond. The length of each of the added acceleration injection commands is determined by the charging rate of capacitor **98**. The duration of application of the added acceleration injection command pulses is controlled by the length of time that the acceleration enrichment command is received at circuit location **82** since an absense of that command will permit the base **94***b* of transistor **94** to rise to the positive value which will reverse-bias diode **96** and disable the second circuit **83**.

As can be readily seen, the acceleration enrichment circuit accomplishes its stated objectives. An acceleration enrichment circuit is provided which is comprised of two intercoupled circuits to provide an extra quantity of fuel to that group of electromechanical injector valve means which have most recently provided fuel to the engine while a second circuit lengthens or stretches the injection time of an incremental amount for each injection command pulse for a period of time corresponding to the need for acceleration enrichment.

We claim:

1. A fuel control for engines comprising:

sensor means responsive to engine operating parameters operative to generate signals having variable characteristics indicative of the engine operating parameters;

computation circuit means responsive to said sensor means signals operative to generate a first output signal having a variable characteristic indicative of the engine demand for fuel and adapted to actuate injector valve means to control fuel delivery to the engine in accord with the output signal variable characteristic;

means for generating a signal whose presence is indicative of a demand for engine acceleration and whose absence is indicative of a lack of a demand for engine acceleration; and

acceleration circuit means mutually responsive to the acceleration signal and to selected variations in the first output signal variable characteristic operative to generate acceleration output signals having a variable characteristic which resembles the first output signal variable characteristic and which is independent of the characteristics of the acceleration signal including means to additively combine the first output signal variable characteristic and the acceleration output signal variable characteristic to form an injector valve means signal having a variable characteristic.

2. The system as claimed in claim **1** wherein said variable characteristics are variable time duration pulses and said acceleration circuit means are mutually responsive to the acceleration signal and the termination of said computation circuit means pulse to produce an acceleration output pulse whose origin substantially coincides in time with the termination of the computation circuit means pulse.

3. The system as claimed in claim **2** wherein said computation circuit means is adapted to sequentially actuate the injector valve means in a predetermined manner and including further a secondary circuit responsive to the acceleration signal and operative to produce an output signal having a predetermined duration and means for communicating said output signal to the computation circuit means whereby the most recently actuated injector valve means is a re-actuated for a period of time corresponding to said predetermined duration output signal.

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