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Suda

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[54] **INJECTION TYPE FUEL FEEDER**

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[30] **Foreign Application Priority Data**

Dec. 12, 1969 Japan 44/99435

[52] **U.S. Cl.... 123/32 EA,** 123/119 R, 123/140 MP

[51] **Int. Cl.** **F02d 5/00**

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

[56] **References Cited**

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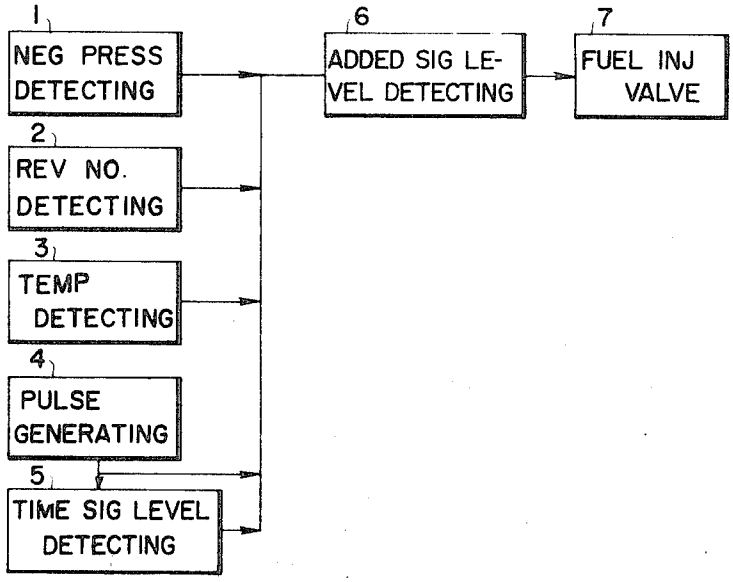
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Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Cort Flint
Attorney—Craig, Antonelli, Stewart & Hill

[57] **ABSTRACT**

An injection type fuel feeder for automotive vehicles in which the injection time of the fuel is computed on the basis of conditional signals from the engine, which include engine revolutions per minute, temperature, etc., in combination with a saw-tooth current, characterized in that the rate of change of the saw-tooth current is controlled in accordance with the engine manifold negative pressure and the temperature of the engine, whereby compensation of the engine output and temperature can be accomplished in proportion to the other conditional signals.

11 Claims, 10 Drawing Figures



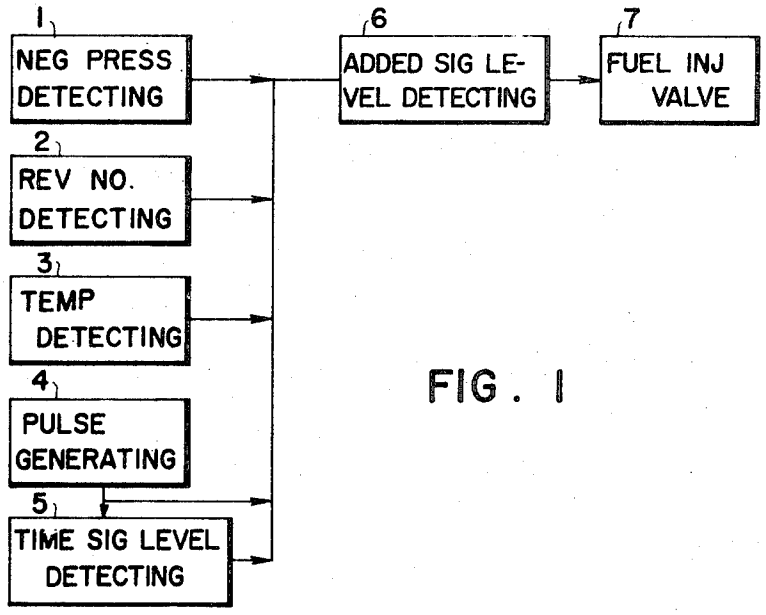


FIG. 1

FIG. 2

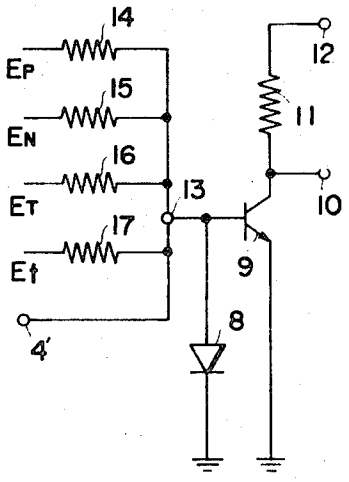
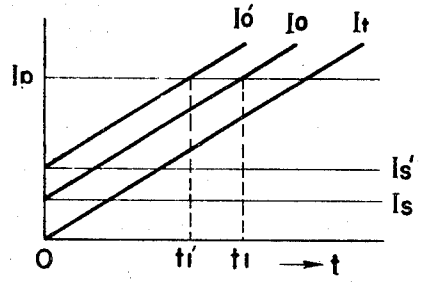


FIG. 3a



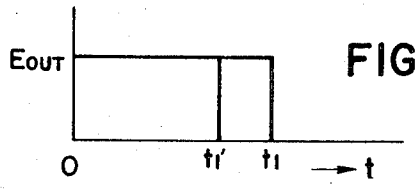


FIG. 3b

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FIG. 4

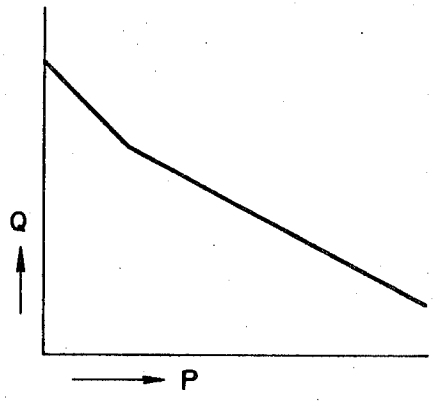


FIG. 6

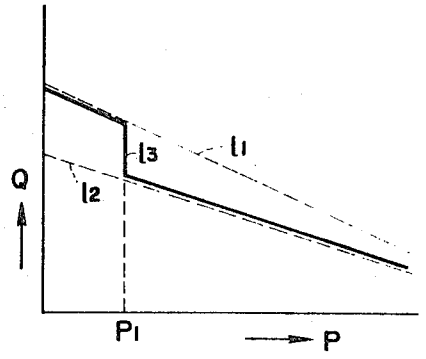
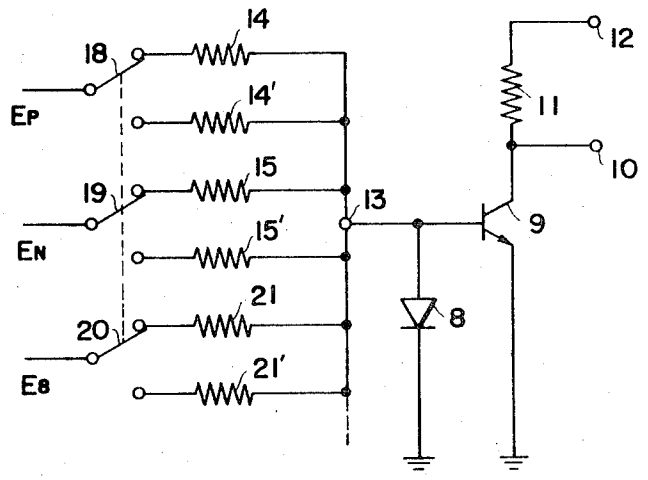


FIG. 5



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FIG. 7a

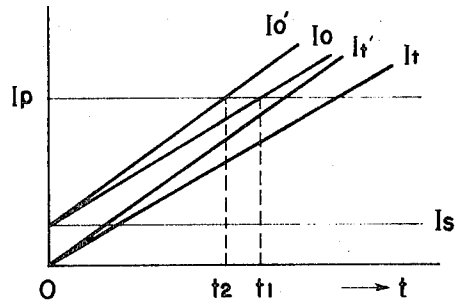


FIG. 7b

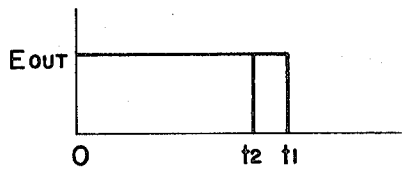
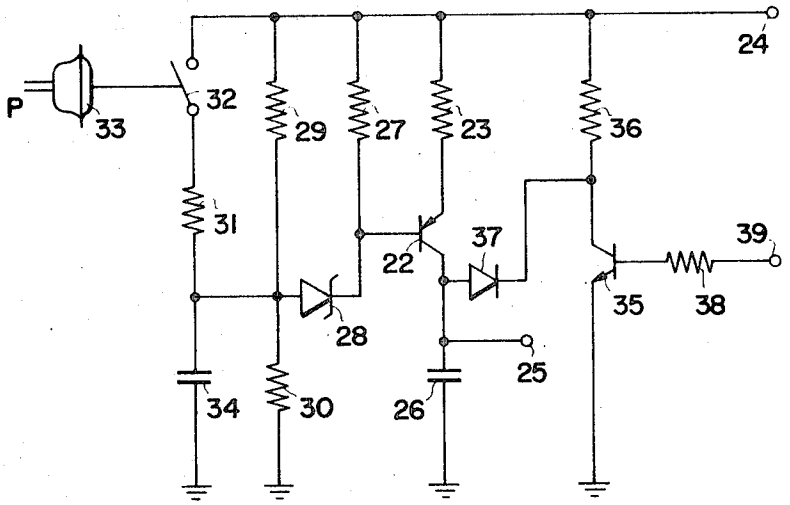


FIG. 8



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INJECTION TYPE FUEL FEEDER

BACKGROUND OF THE INVENTION

This invention relates to injection type fuel feeders for automotive vehicle engines and more specifically to injection fuel feeders capable of effectively adjusting the fuel feed from an economical output region to the high output region of such engines to compensate for various engine conditions.

Generally, the injection fuel feeder associated with electrical control means is operated in such a manner that the conditions for determining the fuel feed to an internal combustion engine are converted into electric signals, from which an output signal having a time width corresponding to the amount of fuel to be supplied to the engine is derived through computation, the fuel injection valve then being opened by said output signal to insure that an adequate amount of fuel is supplied to the engine based on a function of time.

The present invention provides such an injection fuel feeder arrangement which serves to control the amount of fuel supplied to the engine as a function of time in accordance with such engine conditions as engine speed in revolutions per minute, engine temperature and manifold pressure. More particularly, the present invention provides such control over the fuel injection by relatively simple and reliable means which effect a smooth control on a continuous basis between respective feed rates based on manifold pressure.

It is an object of the present invention to provide a fuel injection control system of the type described which provides for improved performance over those systems known heretofore.

It is another object of the present invention to provide a fuel injection control system which is capable of effecting smooth control on a continuous basis with switching between first and second fuel rates in response to manifold pressure.

It is a further object of the present invention to provide a fuel injection control system which is capable of response to a plurality of conditions, but is simple, reliable and inexpensive.

These and other objects, features and advantages of the present invention will become more apparent from the following detailed description thereof when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a block diagram showing a conventional electric control system for an injection type fuel feeder;

FIG. 2 is a schematic circuit diagram showing a conventional control computing means;

FIGS. 3(a) and 3(b) are characteristic diagrams explaining the operation of the circuit of FIG. 2;

FIG. 4 is a diagram showing the characteristics of fuel feed versus engine manifold negative pressure;

FIG. 5 is a schematic circuit diagram showing another conventional control computing means;

FIG. 6 is a diagram showing the fuel feed characteristics of an injection fuel feeder embodying this invention;

FIG. 7(a) and 7(b) are diagrams which aid in explanation of the control operation characteristics of the present invention; and

FIG. 8 is a schematic circuit diagram of a control arrangement in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, there is shown a fuel feeder including a plurality of engine condition detectors comprising a negative pressure detector 1 for converting the engine manifold negative pressure P into an electric condition signal; an engine speed detector 2 for converting the number of engine revolutions per minute (r.p.m.) N into an electric condition signal; a temperature detector 3 for converting the engine temperature T into an electric condition signal; a trigger pulse generator 4 for generating a signal at a desired time for triggering the condition signals of detectors 1, 2 and 3 to start fuel injection into the engine; and a time signal generator 5 actuated by the trigger signal of generator 4 to generate a sawtooth wave time signal. An adding signal level detector 6 receives the outputs from the detectors 1, 2 and 3, and is also supplied with the time signal from the generator 5, thus producing an output with a time width starting from the time at which the trigger signal is generated to the time at which the sum of the condition signals and time signal reaches a particular detection level. A fuel injection valve 7 is opened in response to the output signal from the detector 6, whereby the necessary amount of fuel is supplied to the engine.

In the above-described arrangement, a circuit comprising an Esaki diode 8 and a transistor 9, as shown in FIG. 2, is effectively used for said level detector 6. The Esaki diode 8 is connected in parallel between the base and emitter of the grounded-emitter transistor 9 with the same polarity direction. The collector of transistor 9 is connected to an output terminal 10 and also to a power source circuit 12 via a resistor 11; and, the base of the transistor is connected to an input terminal 13, to which a negative detection signal voltage E_p, revolution number detection signal voltage E_N, temperature detection signal voltage E_T and time signal voltage E_t are applied via resistors 14, 15, 16, and 17. In addition, a trigger signal terminal 4' receiving the output of pulse generator 4 is connected to the input terminal 13.

When the current flowing to the base of transistor 9 and through diode 8 due to the conditional signal voltages relating to the engine conditions being monitored is smaller than the peak value of the Esaki diode 8, the forward impedance of the Esaki diode will be very small and, accordingly, the current due to the conditional signals can be added together without interfering with each other. Also, because the terminal voltage across the diode is small, compared with the barrier voltage of the transistor 9, the collector voltage will be high, and an output voltage can be derived from the output terminal 10.

In the above circuit, when the time signal voltage E_t is made zero by the trigger signal at a desired time for starting fuel injection and, at the same time, the current flowing in the Esaki diode due to the combined conditional signal voltages is maintained at a level lower than its peak value, an output signal is derived at the output terminal 10 and the fuel injection valve 7 is opened. However, when the combined current flowing due to the added conditional signal voltages and the time signal voltage E_t, which increases with time, becomes more than the peak value of the Esaki diode 8, the transistor 9 immediately becomes sufficiently biased to turn on and thus becomes conductive, whereby the supply fuel is stopped because the output voltage at the output

terminal **10** which controls the fuel injection valve **7** vanishes. Thus, the duration of the fuel feeding period depends on the level of the conditional signal current, and hence, the amount of the injected fuel supply can be controlled according to the conditions of the engine. This operation will be more specifically described with reference to FIGS. **3**(a) and **3**(b).

In FIG. **3**(a), it is assumed that I_t denotes the signal current flowing for the period t from the time at which the fuel injection is desired to be started, and I_s indicates the conditional signal current. Then, the combined current $(I_t + I_s)$ flowing into the Esaki diode **8** form the input terminal **13** should become I_o. When the time is zero at the start of fuel injection, operated in the region within the peak value I_p by the trigger signal. Therefore, an output signal voltage E_{OUT} is delivered at the output terminal **10** as shown in FIG. **3**(b), in the region wherein the combined current I_o is smaller than the peak value I_p. When the combined current I_o reaches the peak value I_p of the Esaki diode **8**, the terminal voltage across the Esaki diode **8** is rapidly increased, and the base-emitter bias of the transistor **9** becomes sufficiently large to render the transistor **9** conductive. At this time t_1 the output signal voltage E_{OUT} vanishes. Thus, the amount of fuel supply can be determined as a function of time t_1.

When the conditional signal current T_s is changed to a conditional signal current I_s' due to a condition change of the engine, the combined current I_o is accordingly changed to I_o'. As a result, the time t_1 taken for the Esaki diode **8** to reach its peak value I_p is changed to t_1', and the amount of fuel supply is also changed due to the resulting variation in the period of opening of the injection valve **7**. In other words, the fuel feed is controlled according to engine conditions.

The fuel feed Q at an engine manifold negative pressure P should be controlled so as to be increased in the region of small engine manifold negative pressure P, as seen in FIG. **4**. More specifically, the region in which the engine manifold negative pressure P is relatively large represents the medium output region or, in other words, this region is the normal operating region of the motor vehicle engine. In this region, the fuel feed Q is determined from an economical point of view. On the other hand, the region in which the engine manifold negative pressure is small is indicative of the need for a large output form the engine. In this region, therefore Q is determined so as to be able to deliver the maximum output without taking requirements of economy into consideration.

The desired characteristics for a fuel feed operation as described above can be obtained through the arrangement as illustrated in FIG. **5**, wherein the resistors **14** and **15** for applying a negative pressure detection signal voltage E_p and revolution number detection signal voltage E_N to the input terminal **13** are changed over to the resistors **14'** and **15'**, respectively, by the switching contacts **18** and **19** actuated in accordance with the engine manifold negative pressure P, and the fuel feed is controlled according to the resistance values of the resistors **14'** and **15'**. In this arrangement, the conversion coefficient of the conditional signal current can be changed by changing said resistance values. On the other hand, however, the absolute value of the conversion coefficient is inevitably changed abruptly with this arrangement to thereby cause a skip in the control and introduce a shock into the normal flow of fuel.

To avoid this, it is necessary to provide an arrangement wherein a bias signal voltage E_B, in addition to the conditional signal, is applied thereto and this bias signal voltage is switched from the resistor **21** to the resistor **21'** by way of contact **20**, whereby the skip is reduced. This arrangement, however, requires a large number of switching contacts and is unavoidably complicated in composition and short in life. Furthermore, this type of conventional device is undesirable from the standpoint of reliability because shocks are still generated due to this discontinuous operation.

The principles and an embodiment of the present invention will be described below by referring to FIGS. **6** through **8**. The fuel feed characteristics which have been described by referring to FIG. **4** are ones determined from design requirements. Substantially, the fuel feed characteristics at the engine manifold negative pressure P for the maximum output is indicated by the dotted line l_1, and for the economical output by the dotted line l_2, as shown in FIG. **6**. Therefore, to change over the operating characteristics from for the maximum output to another for economical output at the engine manifold negative pressure P_1, it is ideal to employ the characteristic shown by the full line l_3. It is desirable that the characteristic change-over from the dotted lines l_1 to l_2 be done continuously with a certain time lag so as not to cause an operating shock. This fuel feed characteristic change-over can be realized by suitably determining the conversion coefficient of the time signal versus time lapse in the manner described above with reference to FIGS. **1** through **3**. For example, the conversion coefficient of the time signal is changed over at the engine manifold negative pressure P_1 so that the time signal current I_t is switched to I_t' as shown in FIG. **7**(a), and the conversion coefficient of the time signal current I_t is determined so that the fuel feed characteristics at the engine manifold negative pressure P take the form of the dotted line l_1, and that of I_t' is determined so that the fuel feed characteristics take the form of l_2. By this arrangement, the time taken for the Esaki diode **8** to reach its peak value I_p from the combined current I_o of the conditional current I_s and time signal current $I_t(I_t')$ at the engine manifold negative pressure P_1 is changed over to t_2 from t_1, and thus an output signal voltage E_{OUT} as shown in FIG. **7**(b) is obtained.

When the time signal current I_t is changed over to I_t' continuously with a time lag, then the characteristic change-over can be accomplished without causing a shock.

This change-over operation will be more specifically described by referring to FIG. **8** wherein an exemplary embodiment of the detector **5** in accordance with this invention is illustrated. The reference **22** denotes a PNP transistor controlled at a constant current. The emitter of this transistor is connected to a power source line **24** via a resistor **23**, and the collector is connected to an output terminal **25** and also to ground via a capacitor **26**. The base of transistor **22** is connected to the power source line **24** via a resistor **27** and also to the voltage dividing point between voltage dividing resistors **29** and **30** via a zener diode **28**, the resistors **29** and **30** being connected in series between the power line **24** and ground. A compensating resistor **31** is connected in parallel to the voltage dividing resistor **29** through switch **32**, which is closed when the engine manifold negative pressure P is below the value P_1 by a dia-

phragm 33 operated by the engine manifold negative pressure P. A delay capacitor 34 is connected in parallel to the voltage dividing resistor 30. The purpose of this delay capacitor is to prevent abrupt voltage variation produced at the voltage dividing point when the switch 32 is actuated. The numeral 35 represents an NPN transistor for returning the voltage at the time signal output terminal 25 to zero at a desired time so as to start fuel injection again; the collector is connected to the power line 24 via a resistor 36 and is connected in the forward direction to the collector of the transistor 22 via a diode 37. The base of the transistor 35 is connected to a trigger input terminal 39 via a resistor 38.

In the region in which the engine manifold negative pressure P is larger than the set value P_1, the terminal voltage of the voltage dividing resistor 29 is large. Accordingly, the base potential of the transistor 22 to which the voltage divided through the resistor 27 and zener diode 28 is applied is kept constant at a relatively small value. Now, since the emitter of the transistor 22 is connected to the power line 24 via a resistor 23, the collector current takes the form of a constant current from which the capacitor 26 is charged. Under this condition, when a positive pulse voltage is applied to the terminal 39 from generator 4 at a desired time so as to restart the fuel injection, the transistor 35 is rendered conductive and the charge across the capacitor 26 is discharged to ground via the diode 37 and the transistor 35. As a result, the time signal voltage E_{OUT} at the output terminal 25 becomes zero. Then, when the transistor 35 becomes nonconducting, the capacitor 26 is charged by the constant collector current of the transistor 22, the terminal voltage is increased, and the time signal voltage E_{OUT} is delivered as a function of time from the time signal output terminal 25.

Following this operation, when the engine manifold negative pressure P is reduced below the set value P_1, the diaphragm device 33 is actuated to close the switch 32, the resistor 31 is connected in parallel to the voltage dividing resistor 29, and the terminal voltage of the resistor 31 is reduced. The reduced value of this terminal voltage serves to increase the base potential of the transistor 22. Consequently, the set value of the constant current flowing in the collector of the transistor 22 is reduced, the voltage charge across the capacitor 26 (namely, the output voltage E_{OUT} at the output terminal 25) is also reduced, and thus the time signal current conversion from I_t to I_t' occurs, as shown in FIG. 7(a). However, with this operation, the voltage variation at the voltage dividing point of the resistors 29 and 30 is not changed abruptly, but is delayed by the capacitor 34. In other words, by suitably determining the value of the capacitor 34, it becomes possible to smoothly change over the fuel feed characteristics without causing shock.

In the foregoing circuit an Esaki diode and transistors are used as the adding level detector 6. Instead, a circuit, such as an operational amplifier circuit, capable of adding a plurality of input signals, such as a conditional signal or signals and a time signal, may be used as the level detecting circuit 6 with the present invention, or a circuit in which either the time signal or conditional signal is used for biasing the detected level may be used.

Also, the time signal generating means used for the above-described embodiment may be modified according to the requirements of a particular application other than the one mentioned herein.

According to this invention, as has been described, the conversion coefficient of the time signal versus time lapse is changed by the use of a specific engine manifold negative pressure, and thus the fuel feed characteristics can be compensated by simple procedures.

While the principles of the invention have been described above in connection with a specific embodiment and particular modifications thereof, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

What is claim is:

1. A fuel feed control system for controlling the supply of fuel fed to an engine in accordance with at least one engine operating condition, comprising

condition detecting means for generating an electrical condition signal corresponding to the level of engine manifold pressure,

timing means for periodically generating a timing signal having a linearly increasing amplitude with time, and

level detecting means responsive to the sum of said condition and timing signals for generating a fuel control signal whose duration equals the time required for the sum of said condition and timing signals to reach a prescribed value,

said timing means including control means responsive to one given value of engine manifold pressure forming a critical point between the economical output region and the high output region of the engine operating characteristic for adjusting the rate of change of said timing signal from a first value to a second value.

2. A fuel feed control system as defined in claim 1, wherein said level detecting means includes summing means for summing said condition signal and said timing signal and switching means responsive to said summed signal value for providing said fuel control signal for all levels of said summed signal value below a given limit.

3. A fuel feed control system as defined in claim 2, wherein said condition detecting means generates a plurality of condition signals relating to different engine conditions and said summing means sums all of said condition signals with said timing signal.

4. A fuel feed control system as defined in claim 1, wherein said control means in said timing means includes delay means for gradually adjusting the rate of change of said timing signal upon detection of said given value of engine manifold pressure.

5. A fuel feed control system as defined in claim 4, wherein said timing means includes a pulse generator and a timing signal generating circuit responsive to the output of said pulse generator for generating a sawtooth wave timing signal.

6. A fuel feed control system as defined in claim 5, wherein said timing signal generating circuit includes a timing capacitor connected to a constant current source and means responsive to the output of said pulse generator for periodically discharging said timing capacitor, said control means including means responsive to said change in engine manifold pressure for changing the level of the current generated by said constant current source.

7. A fuel feed control system as defined in claim 6, wherein said level detecting means includes summing means for summing said condition signal and said timing signal and switching means responsive to said summed signal value for providing said fuel control signal for all levels of said summed signal value below a given limit.

8. A fuel feed control system as defined in claim 7, wherein said condition detecting means generates a plurality of condition signals relating to different engine conditions and said summary means sums all of said condition signals with said timing signal.

9. A fuel feed control system as defined in claim 1, wherein said level detecting means comprises a plurality of resistances connecting a plurality of input terminals to a common summing point, an Esaki diode connected between said summing point and ground, and a transistor having its base connected to said summing point, its collector connected through a resistance to a power source and its emitter connected to ground, said timing means being connected to apply said timing signal to one of said input terminals and said condition detecting means applying a plurality of condition signals relating to different engine conditions to the remaining input terminals.

10. A fuel feed control system as defined in claim 9, wherein said timing means comprises a timing capacitor connected in series with a transistor constant current source, a pulse generator, a transistor switch connected to said pulse generator and said timing capacitor for periodically discharging said timing capacitor, and means for changing the level of said constant current source including a delay capacitor for effecting a delay in the change of current level of said constant current source.

11. A fuel feed control system for controlling the supply of fuel fed to an engine in accordance with at least one engine operating condition, comprising

condition detecting means for generating an electrical condition signal corresponding to said engine operating condition, said condition signal corresponding to a condition selected from the group consisting of manifold pressure, engine temperature and engine speed,

timing means for periodically generating a timing signal having a linearly increasing amplitude with time, said timing means including a pulse generator and a timing signal generating circuit responsive to the output of said pulse generator for generating a sawtooth wave timing signal, and

level detecting means responsive to the sum of said condition and timing signals for generating a fuel control signal whose duration equals the time required for the sum of said condition and timing signals to reach a prescribed value,

said timing means further including control means responsive to one given value of engine manifold pressure forming a critical point between the economical output region and the high output region of the engine operating characteristic for adjusting the rate of change of said timing signal from a first value for said economical output region to a second value for said high output region, said control means including delay means for gradually transferring the rate of said timing signal upon detection of said critical point from said first value for said economical output region to said second value for said high output region.

* * * * *