

[54] **AUXILIARY CIRCUIT FOR
ELECTRONIC FUEL CONTROL
SYSTEMS TO FACILITATE COLD
STARTING**

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[51] Int. Cl. F02m 51/02

[58] Field of Search.....123/32 AE, 32 EA, 119, 179 A

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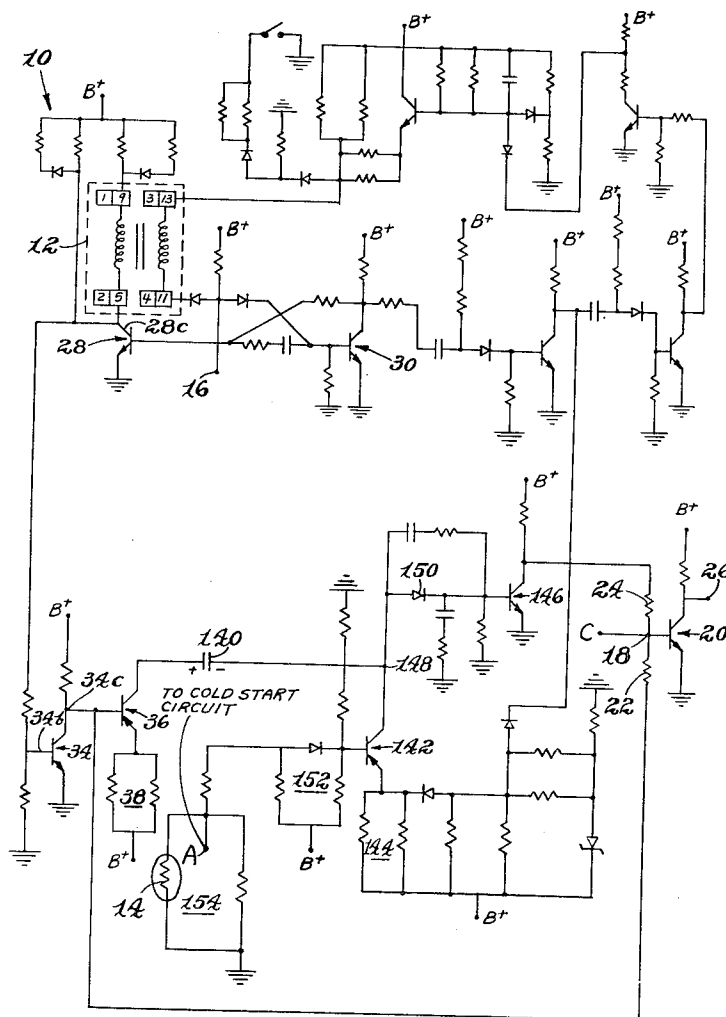
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[57] **ABSTRACT**

An auxiliary circuit is disclosed herein for controlling actuation of injector valve means to provide fuel for cold starting of an engine. The circuit is comprised of an interconnected pair of multivibrators and is adapted to produce an injector means control signal for a period of time representative of the fuel requirement for cold starting of the associated internal combustion engine. In order to permit the fuel to be pressurized, a time delay period is provided.

14 Claims, 3 Drawing Figures



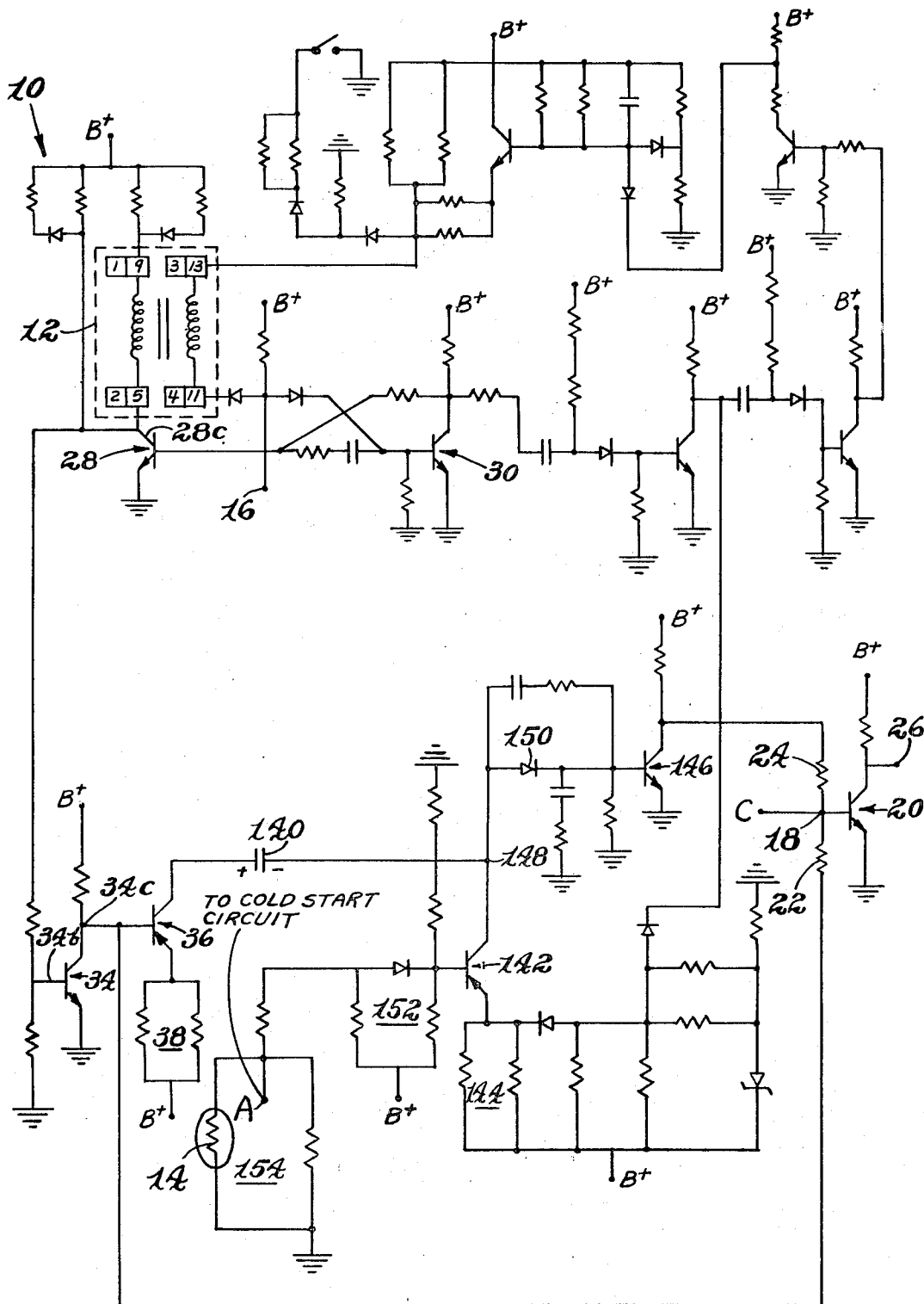


Fig. 1

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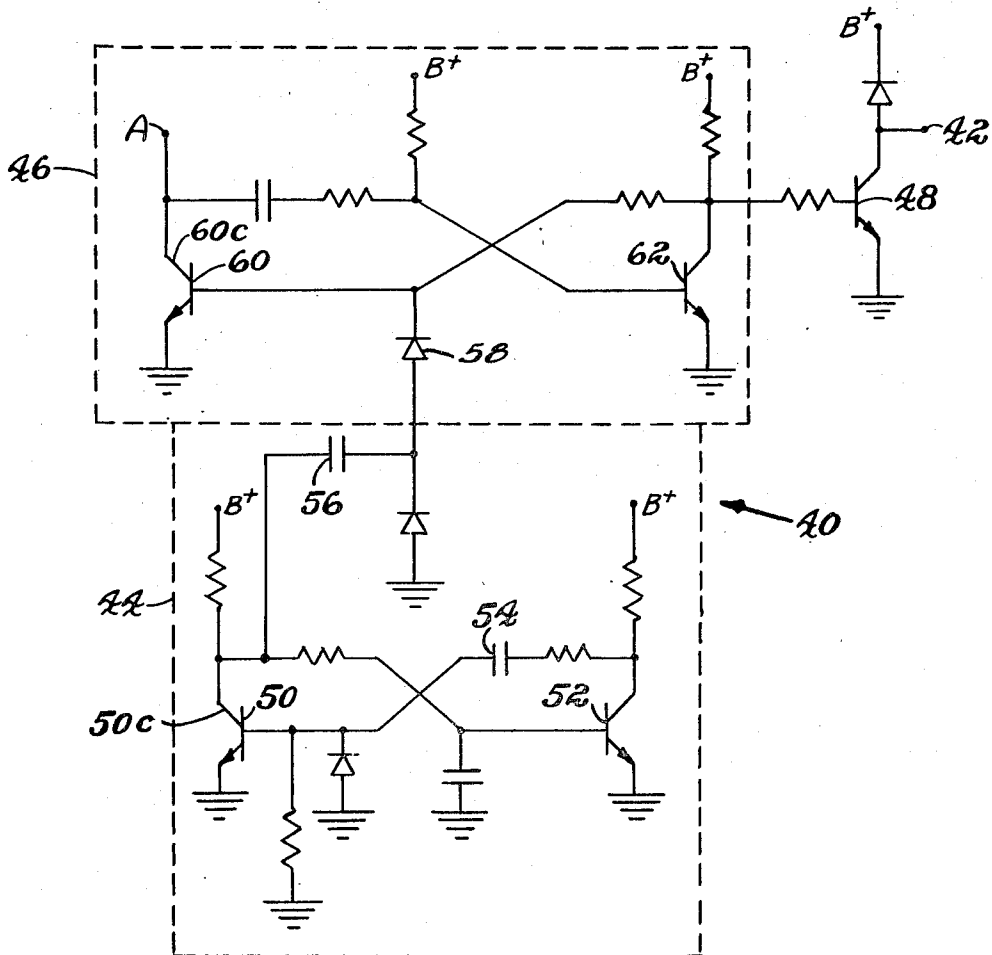
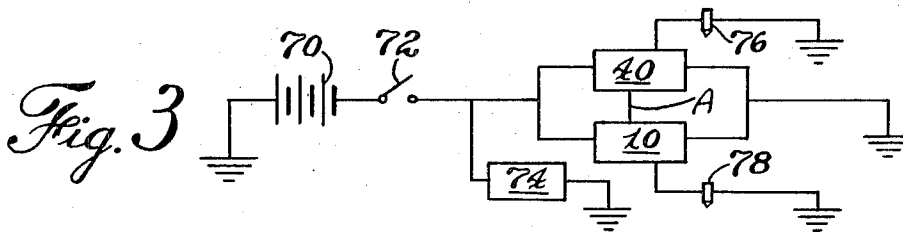


Fig. 2

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AUXILIARY CIRCUIT FOR ELECTRONIC FUEL CONTROL SYSTEMS TO FACILITATE COLD STARTING

CROSS-REFERENCE TO RELATED APPLICATIONS

This invention is related to application Ser. No. 46,681 "Cold Start Auxiliary Circuit for Electronic Fuel Control System" by John R. Nagy et al. filed on June 16, 1970 and to application Ser. No. 46,706 "Cold Start Auxiliary Circuit for Electronic Fuel Control System" by Todd L. Rachel filed on June 16, 1970, both assigned to the assignee hereof.

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 the cold start 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 the information required by an electronic fuel control system to provide cold start 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.

For the purpose of this specification a "cold" engine is one which, in attempting to assume ambient air temperature, has cooled to a temperature below a selected level. This selected level may be empirically determined and is the temperature below which the difficulty of starting is increased beyond the capability of the main computing system to efficiently handle. The present electronic fuel control systems rely upon the engine temperature sensor input (or an equivalent such as ambient air temperature and cylinder head temperature) to vary the duration of injector valve open time sufficiently to provide fuel for the startup of the engine when the engine is cold. However, investigation has shown that this means of providing sufficient fuel for cold starting of an associated engine is not always adequate. It is, therefore, an objective of the present invention to provide control circuitry in addition to the electronic fuel control system to control provision of sufficient quantities of fuel for cold starting of an associated engine. It is a further object of the present invention to provide control circuitry, for addition to an electronic fuel control system, which is capable of providing sufficient fuel for starting of an associated engine over a broad range of environmental temperatures.

One of the principal difficulties with the presently proposed methods of providing a cold starting charge of fuel is that failure of the engine to start will permit excess quantities of fuel to be injected, resulting in engine flooding. It is, therefore, an object of the present invention to provide a cold start auxiliary circuit which will not cause a flooding problem. More particularly, it is a further object of the present invention to provide such a circuit which is adapted to energize an injector valve means a predetermined number of times for each energization of the starting motor. It is a still further object of the present invention to provide control circuitry to control the injection of a quantity of fuel sufficient to permit starting of a cold engine, which quantity of fuel may vary as a function of the temperature drop below a predetermined threshold value but which is independent of engine cranking.

It is believed that many of the difficulties encountered by the present method of cold starting are caused by the low r.p.m. of the associated engine during the cranking cycle and the proximity of the main injector nozzles to the intake ports of the engine to be started. It is, therefore, an object of the present invention to provide a circuit, in addition to the main electronic fuel control computing circuit, responsive to temperature for controlling an injector nozzle or valve means

which may be situated independently of the main injector nozzles. It is a still further object of the present invention to provide a cold start fuel controlling circuit which may control the provision of a charge of fuel to the engine to be started independent of the engine cranking speed.

It is known that the fuel pumps currently in use with internal combustion piston engines do not pressurize the fuel to be pumped in a regular or uniform fashion. In order for the cold-starting charge of fuel to be metered with some degree of precision, it is necessary to provide a means of compensating of variations in fuel pump pressurization. It is, therefore, an object of the present invention to provide an auxiliary circuit for electronic fuel control systems to facilitate cold starting of the associated engine and which includes means to provide stabilization of fuel delivery. It is a still further object of the present invention to provide an electronic time delay circuit which delays energization of the injector valve means (for cold starting) until the fuel has become pressurized so that the charge injected is not affected by fuel pressure variations.

SUMMARY OF THE PRESENT INVENTION

The present invention provides an auxiliary circuit for electronic fuel control systems to facilitate cold starting of the associated engine. In order to provide a circuit which will function independently of engine speed and which may be arranged to energize injector valve means separate from the main injector valve means, the present invention is comprised of a monostable multivibrator which will be triggered into the unstable stage by a signal associated with turning on of the ignition switch and will remain in the unstable state for a period of time which represents the cold-starting fuel requirement and which will control energization of the injector valve means for injection of the cold starting charge of fuel. To provide for stabilization of the charge delivered, the invention comprises a second monostable multivibrator which is arranged to be in its unstable state for a predetermined period of time of sufficient duration for the fuel pump to pressurize the fuel system and which will trigger the first-mentioned multivibrator only upon return to the stable state.

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 cold start function.

FIG. 3 shows the relationship of the present invention to an automotive electrical system.

DETAILED DESCRIPTION

Referring now to FIG. 1, an electronic fuel control system computation circuit 10 useful for controlling delivery of fuel to an internal combustion engine, not shown, 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 sensory inputs, in the form of voltage signals in this case, 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 associated therewith 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 (shown as 78 in FIG. 3) 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 for actuation of 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 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 transistors 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 34b of transistor 34 to assume a low voltage below that required for transistor 34 to be triggered into the conduction stage, thus causing transistor 34 to be turned off. The voltage at the collector 34c 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 nonconducting, or "off" state, the relatively high voltage at collector 34c 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 140. Simultaneously, transistor 142 has been biased "on" and with the resistor network 144, constitutes a second current source. Currents from both sources flow into the base of transistor 146 thereby holding this transistor "on," which results in a low voltage at the collector of transistor 146. 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 34c 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 140 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, at the end of the pulse, when transistor 34 is turned on, the collector base junction of transistor 36 is forward biased making the positive side of capacitor 140 only slightly positive with

respect to ground since several PN-junctions separate it from ground. This will impose a negative voltage on circuit location 148 which will reserve bias diode 150 and transistor 146 will be turned "off." This will initiate a high voltage signal from the collector of transistor 146 to circuit location 18 via resistor 24 which signal will retrigger 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 150 is reverse biased, the current from the current source comprised of transistor 142 and resistor network 144 will be flowing through circuit location 148 and into the capacitor 140 to charge the capacitor to the point that circuit location 148 will again be positive. This will then forward bias diode 150 and transistor 146 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 148 to become sufficiently positive for diode 150 to be forward biased. This in turn is a function of the charge on capacitor 140 and the magnitude of the charging current supplied by the current source comprised of transistor 142 and resistor network 144. The charge on capacitor 140 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 142. This value is controlled by the voltage divider networks 152 and 154 with the effect of network 154 being variably controlled by the engine temperature sensor 14.

Referring now to FIGS. 1 and 2, and particularly to FIG. 2, a circuit 40 is shown for providing the desired cold start characteristic. The circuit 40 is also energized by B+ as noted and the application of the supply voltage B+ to circuit 40 may be controlled by the ignition switch of the associated engine or by any convenient switching means which will energize circuit 40 in conjunction with energization of the main electrical circuits of the vehicle as illustrated by FIG. 3. The circuit 40 receives a temperature input at circuit location A from the correspondingly designated portion of computation circuit 10. The alphabetic designation is used herein to denote a point common to the circuits in both figures. The temperature input, or signal, is comprised of a variable voltage whose value is controlled by the engine temperature sensor 14, shown as a thermistor in FIG. 1. The cold start circuit of this figure is adapted to provide at circuit location 42 a single injection control pulse for each application of the supply voltage to the circuit 40 to control energization of the injector valve means, which may be either the main fuel injection valve means or a separate cold start injection valve means. The cold start auxiliary circuit 40 is comprised of a first circuit means 44 operative to insure stabilization of the fuel pressure, and a second circuit means 46 operative to generate a voltage pulse of variable duration, said variable duration pulse being a function of the temperature drop below a selected temperature level. The first circuit means 44 is comprised of a monostable multivibrator operative to produce a fixed period of delay following the application of power to the circuit, as for instance would occur upon the switching on of a vehicle ignition switch. The second one-shot multivibrator 46 is operative to produce an output pulse of variable duration which controls the transistor 48.

Transistors 50 and 52 and their associated components form the first monostable multivibrator, or "one-shot," which provides the fixed delay. Upon application of power, transistor 50 turns on and transistor 52 is held off by cross-coupling from the collector 50c of transistor 50. Transistor 50 remains on until capacitor 54 charges up to a level where the base drive of transistor 50 is limited. The rising voltage at the collector 50c of transistor 50 then turns on transistor 52, which regeneratively turns off transistor 50. The rising voltage at the collector 50c of transistor 50 is then applied, via capacitor 56 and diode 58, to the base of transistor 60 to trigger the second monosta-

ble multivibrator, or "one-shot," 46 formed by transistors 60 and 62 and their associated components.

The supply voltage for the collector 60c of transistor 60 is derived from circuit location A and is indicative of the engine temperature. The relationship between the voltage at A and the engine temperature is such that the signal at circuit location A rises as engine temperature decreases. The specific relationship is a function of the particular engine. Triggering of the multivibrator 46 turns transistor 60 on, which couples a turnoff signal to transistor 62. Turning off of transistor 62 holds transistor 60 on and also turns transistor 48 to "on," permitting a current flow at circuit point 42 whereby an associated injector, not shown, may be energized. The duration of the "on" time of transistor 60 and hence of the multivibrator 46 is a function of the voltage at the collector 60c of transistor 60 and the RC time constant of the circuit. For operating conditions where engine temperature is sufficiently high that the cold start circuit is not necessary, the voltage applied to the collector 60c will be sufficiently low that transistor 60 will not turn on and transistor 48 will not draw current. The voltage at circuit location A is derived from the voltage divider network, including the engine temperature sensor 14, and is inversely related to engine temperature.

Referring now to FIG. 3, the relationship of my invention to an automotive electrical system is illustrated. The computing circuit 10 and the cold starting auxiliary circuit 40 are shown as being connected to a vehicle battery 70 through switch 72 which may be, for instance, the vehicle ignition switch. In addition, fuel-pumping means 74 is also shown as being connected to the electrical system such that closure of switch 72 will energize computing circuit 10, cold starting circuit 40 and fuel-pumping means 74. Circuits 10 and 40 are shown connected to fuel injector means 76 and 78 and control the energization thereof. As will be apparent from a consideration of FIGS. 2 and 3, once the injector valve means 76 has been energized and turned off, the second circuit means 46 will be in a stable configuration and injector valve means 76 will not be reenergizable until after the circuit 40 has been deenergized, as for instance, by opening switch 72.

The cold start auxiliary circuit illustrated in FIG. 2 accomplishes the stated objectives. A single output pulse of variable duration is provided to energize a cold start injector with the pulse being initiated a fixed period of time after energization of the circuit. This fixed delay permits the fuel pump to build up sufficient pressure for injection and the variable injection pulse is related to the difference in temperature between the engine temperature and a preselected temperature value. After the second monostable multivibrator 46 has been triggered to the stable, or "off" state, both multivibrators are maintained in the stable state until such time as the cold start auxiliary circuit is deenergized and reenergized again. In this fashion the cold start injector valve means 76 will be disabled to prevent flooding after injecting a quantity of fuel sufficient to start the associated engine.

We claim:

1. In combination with an energizable internal combustion engine fuel control system of the type having engine operating parameter sensors including triggering means responsive to engine crank angle operative to generate signals indicative of engine crank angle and engine temperature sensor means operative to generate a signal having a level which increases in response to decreases in sensed temperature, a computing means responsive to the engine sensors for controlling the actuation of injector valve means whereby the quantity of fuel delivered to the engine is controlled, the improvement comprising circuit means responsive to the engine temperature sensor operative to produce an output pulse having a duration directly related to the level of sensed signal whereby the injector valve means may be actuated by the pulse to provide a quantity of fuel in proportion to pulse duration for cold starting of the engine, and including means operative to limit pulse production to a predeterminable maximum number of pulses per fuel system energization and without regard to the triggering means signals.

2. The system as claimed in claim 1 wherein said circuit means comprise first and second circuit, said first circuit operative to inhibit operation of said second circuit for a predetermined period of time and said second circuit operative to produce an output pulse having a duration indicative of the cold starting fuel requirement.

3. The system as claimed in claim 2 wherein said first circuit is comprised of a monostable multivibrator having a fixed-time period of instability and said second circuit is a monostable multivibrator having a variable time period of instability.

4. The system as claimed in claim 1 wherein said circuit means comprise means for receiving a signal having a magnitude which is related to the difference between a selected temperature and the temperature of the engine and monostable multivibrator means responsive to said signal to produce an output pulse having a time duration proportional to the magnitude of said signal.

5. A fuel control system for engines having an energizable electrical system comprising:

sensory means operative to sense operating parameters of the engine and to produce signals representative of sensed parameters, including means responsive to engine crank angle operative to generate signals indicative thereof;

at least one of said sensory means being engine temperature sensor means operative to produce a signal having a signal level indicative of engine temperature;

computing circuit means energizable in relation to the energization of the engine electrical system responsive to said sensory means operative to generate an output signal indicative of an engine demand for fuel and adapted to control injector valve means to thereby control the delivery of fuel to the engine; and

cold start circuit means responsive to said engine temperature sensor means signal when said signal level is indicative of a need for additional fuel operative to generate a pulse signal having a duration which varies in response to variations in the temperature signal level indicative of the cold-starting fuel requirement and adapted to actuate injector valve means and including means responsive to said computing means energization operative to limit maximum additional fuel delivery to a predeterminable amount for each computing means energization and without regard to the engine crank angle signal.

6. The system as claimed in claim 5 wherein the engine fuel system includes a fuel-pumping means and said second circuit means includes a first circuit for establishing a fixed time delay operative to permit pressurization of the fuel-pumping means.

7. The system as claimed in claim 6 wherein said second circuit means includes a second circuit energizable after the fixed time delay and operative to produce an output signal having a duration which is a function of temperature drop below a selected temperature and means for applying an energization signal to said separate injector valve in response to said output signal.

8. The system as claimed in claim 5 wherein said second circuit means comprises signal generator means responsive to the engine temperature sensor operative to produce an output signal having a duration which is a function of temperature drop below a selected value.

9. The system as claimed in claim 8 wherein said signal generator means comprise a monostable multivibrator energized by a voltage whose magnitude is inversely related to the temperature drop below the selected value.

10. The system as claimed in claim 1 wherein said predeterminable maximum number is one.

11. In an internal combustion engine electronic fuel control system of the type comprising injector valve means actuable to discharge fuel upon receipt of an activation signal, energizable computing means operative to generate activation signals having a duration corresponding to the engine demand for fuel and a frequency in excess of the frequency of energization of the computing means, sensory means operative to provide signals for the computing means indicative of the engine de-

mand for fuel, including engine temperature sensor means responsive to engine temperature to produce a signal having a level which varies in response to variations in sensed engine temperature, and circuit means intercommunicating the injector valve means and computing means and the sensor means, the improvement comprising cold start circuit means responsive to said engine temperature sensor means operative to generate an output pulse having a duration directly related to the engine temperature sensor signal level, means for communicating said pulse to the injector valve means, and inhibiting means operative to limit said circuit means output pulse productions to a predetermined maximum number of pulses per energization of the computing means.

12. The system as claimed in claim 11 wherein said cold start circuit means comprise a first and second circuit, said first circuit operative to inhibit operation of said second cir-

cuit for a predetermined period of time and said second circuit operative to produce an output pulse having a duration indicative of the cold starting fuel requirement.

13. The system as claimed in claim 12 wherein said first circuit is comprised of a monostable multivibrator having a fixed-time period of instability and said second circuit is a monostable multivibrator having a variable time period of instability.

14. The system as claimed in claim 11 wherein said cold start circuit means comprise means for receiving a signal having a magnitude which is related to the difference between a selected temperature and the temperature of the engine and monostable multivibrator means responsive to said signal to produce an output pulse having a time duration proportional to the magnitude of said signal.

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