

[54] COLD START AUXILIARY CIRCUIT FOR ELECTRONIC FUEL CONTROL SYSTEM

[72] Inventors: John R. Nagy, Detroit, Mich.; Todd L. Rachel, Elmira, N.Y.

[73] Assignee: The Bendix Corporation

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[58] Field of Search.....123/32 AE, 32 EA, 119 R, 139 E, 123/187.5

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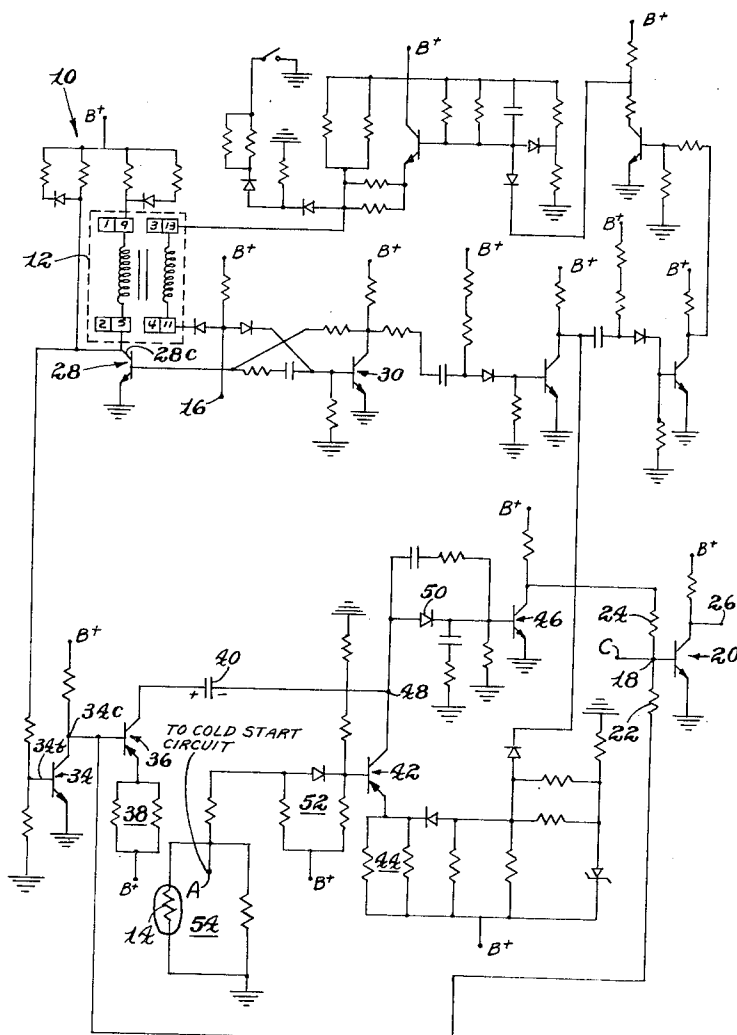
Primary Examiner—Laurence M. Goodridge

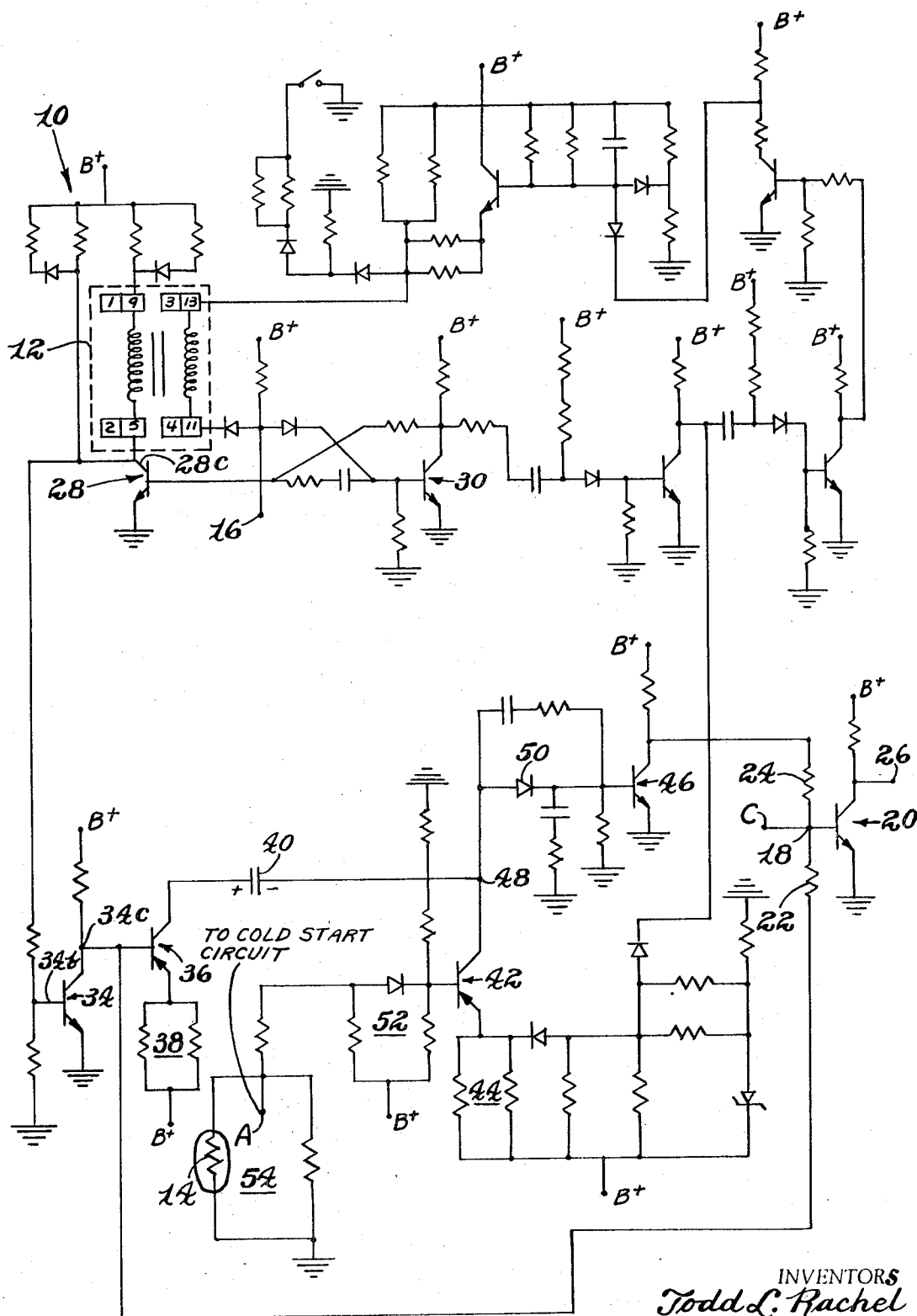
Attorney—Robert A. Benziger and Plante, Hartz, Smith and Thompson

[57] ABSTRACT

An auxiliary circuit means is disclosed herein for controlling actuation of an injector valve means to provide for cold starting of an engine. The circuit and injector means are energized when a vehicle ignition system is energized and the fuel for cold starting is provided during the period of time required for a selected voltage value to raise to a threshold value. The threshold value is determined by a voltage divider including a temperature responsive element sensing engine temperature. Means are provided to prevent noise and supply voltage variations from affecting the capability of the circuit to compute a cold start injection pulse of requisite duration.

12 Claims, 3 Drawing Figures



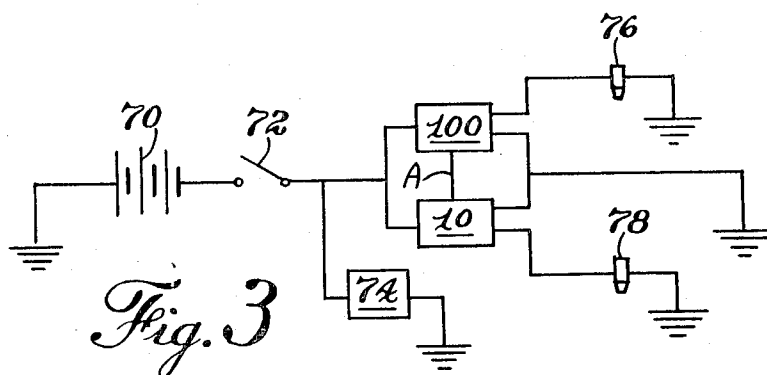
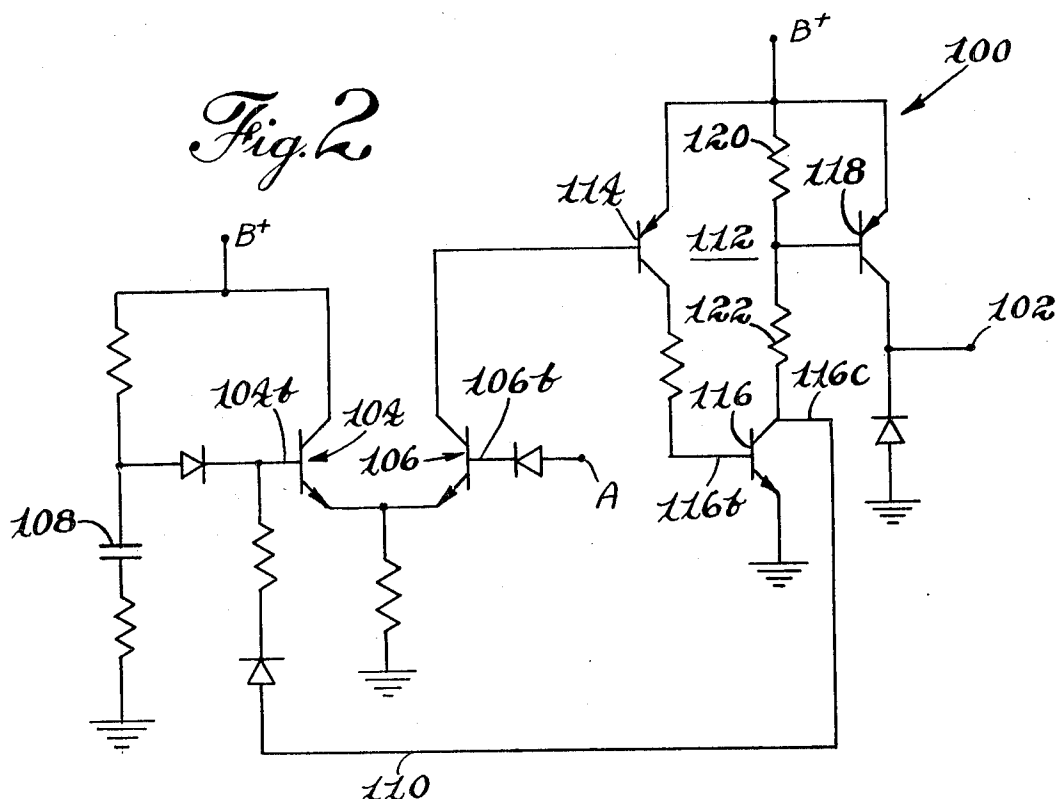


WITNESS:

Esther M. Stockton

Fig. 1

INVENTORS
Todd L. Rachel
 BY *John R. Nagy*
Robert A. Beniger
 ATTORNEY



WITNESS:

Esther M. Stockton

INVENTORS
Todd L. Rachel
John R. Nagy
 BY

Robert A. Beniger
 ATTORNEY

COLD START AUXILIARY CIRCUIT FOR ELECTRONIC FUEL CONTROL SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

This invention is related to application Ser. No. 46,705, "Auxiliary Circuit for Electronic Fuel Control Systems to Facilitate Cold Starting," by John R. Nagy, 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. In particular, the present invention provides a cold start circuit which is more reliable than previous circuits in that it is resistant to variations in the supply voltage and to false triggering.

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 main computing 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 handle efficiently. 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 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.

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.

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. This problem also occurs upon too frequent actuation of the cold start injector valve means. 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 also an object of the present invention to provide a cold start circuit which prevents too frequent actuation of the cold start injector valve means.

In the commonly assigned copending application Ser. No. 46,705, a circuit for providing the desired cold start function is shown and described. However, the embodiment described therein, which includes two successively triggered monostable multivibrators, is known to be sensitive to variations in the level of the B+ voltage and to be susceptible to plural or premature (i.e., false) triggering. These difficulties arise out of the use of successively triggered multivibrators so that it becomes a still further object of the present invention to provide a cold start circuit having the above-described advantages which does not employ multivibrators. It is an object of the present invention to provide a cold start auxiliary circuit whose output signal is relatively insensitive to variation of the supply over a wide range of voltages. It is still a further object of the present invention to provide a cold start auxiliary circuit which is insensitive to false triggering signals. In order to accomplish the last enumerated objective, it is an object of the present invention to provide a cold start auxiliary circuit for electronic fuel injection in which a substantial period of "off", or inactive, time is required to enable the circuit to be reenergized.

SUMMARY OF THE PRESENT INVENTION

The present invention provides a special function (cold start) auxiliary circuit for an electronic fuel control system capable of providing the improved cold start function. The cold start auxiliary circuit is adapted to provide an output signal of variable duration with the duration being a function of the drop of engine temperature below a selected level. The signal can be applied to an injector nozzle or valve which may be situated independently from the main injector nozzles of the associated engine. The circuit is further adapted to be self-disabling after generating a predetermined number of pulses (which is preferably a single pulse) for each energization of the starting circuit of the associated engine to thereby prevent flooding of the engine. The inventive circuit is characterized by providing an output signal whose duration is substantially independent of the supply voltage. The circuit is further characterized by the fact that the circuit can be activated to energize the associated injector means only once for each application of supply voltage, after which time the supply voltage must be removed for a period of time. By providing a "self-locking" feature, the circuit is rendered insensitive to variations in the supply voltage. Specifically, the cold start circuit of the present invention includes a means, responsive to controlled switching of solid state switching means, to apply the supply voltage to a control electrode of the cold start injection time computing means to render said computing means insensitive to false triggering which may be produced by "noise" in the associated electronics. Thus, a readily controllable amount of fuel may be injected for cold starting of the engine to be started and the circuit may henceforth be deenergized so that further cold start valve actuation, which may be caused by false triggering, will be prevented. This will prevent further actuations from causing excess quantities of fuel to be injected, which quantities of fuel would increase the exhaust emissions of the associated engine.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows, in diagrammatic circuit form, an electronic fuel control system main 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 main 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 sensory inputs, in the form of voltage signals in this instance, 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 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 state, 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 state, 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 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 46c. 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 40 ceases to charge. The capacitor will then have been changed, 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, thus making the positive side of capacitor 40 only slightly positive with respect to ground since 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 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 injection means 78 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, a circuit 100 is shown for providing the desired cold start characteristic. The circuit 100 is also energized by B+ as noted. Circuit 100 receives a temperature input at circuit location A from the correspondingly designated portion of control circuit 10. Alphabetic designations are used herein to denote points common to circuits in several 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 100

is adapted to provide a single injection control pulse at circuit location 102 to control energization of the cold start injector valve means, shown as 76 in FIG. 3, which is preferably physically remote from the main electromechanical valve means.

Specifically, the cold start circuit 100 is comprised of an electronic computing means in the form of an emitter coupled pair of transistors 104 and 106 having a pair of control electrodes 104b and 106b, capacitor 108, locking circuit means 110 and switching means 112. The switching means 112 include solid state switches 114, 116 and 118. The circuit shown also includes various resistors and diodes provided to establish desired voltage and current bias values.

When power is initially applied at B+, as for instance by turning on of the ignition switch, the base 104b of transistor 104 will be at the ground potential. The base 106b of transistor 106 will be at some positive voltage level due to the temperature indication signal applied at point A due to the thermistor network shown as 54 in FIG. 1. This will cause transistor 106 to be conducting while transistor 104 is in the nonconducting state. The conduction of transistor 106 will cause a voltage drop across the emitter base junction of transistor switch 114, thereby causing transistor 114 to conduct. The conduction of transistor 114 will cause current to flow into the base 116b of transistor 116, causing transistor 116 to conduct. Conduction of transistor 116 will cause current to flow through resistors 120 and 122 and this current will cause a voltage drop to appear across resistance 120 and across the emitter base junction of transistor switch 118. Transistor 118 will, therefore, be in a conducting state and a high-voltage signal will appear at circuit port 102 signalling the need for cold start injection. Conduction of transistor 116 will also cause the collector 116c thereof to assume a low potential.

The application of power to the circuit 100 will also cause capacitor 108 to begin to charge up in response to current flow. The rate of charging of capacitor 108 will depend upon the various resistive values in the circuit branch as well as the capacitance of capacitor 108. The potential at base 104b of transistor 104 will, therefore, increase exponentially as the capacitor 108 charges. At some predeterminable point in time, the potential at base 104b will be greater than the potential at base 106b and transistor 104 will begin to conduct while transistor 106 will become nonconductive. Thus, the electronic computing means will determine that sufficient time for cold start injection has elapsed. Transistor switch 114 will turn "off" causing transistor switch 116 to turn "off" which, in turn, causes transistor switch 118 to turn "off". The cold start injection signal will thereby be removed from the circuit 102 and the voltage there will fall to the ground potential. When transistor switch 116 turns "off", the potential at collector 116c will rise toward the B+ level and this voltage will be coupled to the base 104b of transistor 104 by the locking circuit means 110. Capacitor 108 will continue to charge to the B+ value but will not further influence the voltage at base 104b. The voltage at base 104b will therefore be sufficiently high to resist any false triggering signals which might otherwise cause fuel in excess of that required for cold starting to be injected into the engine, not shown.

When the circuit is deenergized the voltage at collector 116c will be removed and locking circuit means 110 will no longer control the voltage at the base 104b of transistor 104. However, capacitor 108 will be charged up to the B+ value and this voltage will hold transistor 104 in the conduction state for a brief period of time following circuit deenergization. Thus, if the operator in starting his vehicle encounters a false start, immediate reenergization of the vehicle's electrical system will not cause an additional cold starting charge of fuel to be injected and the engine will not become flooded.

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 100 are shown as being connected to a vehicle battery 70 through switching means 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 switching means 72 will energize computing circuit 10, cold starting circuit 100 and fuel pumping means 74. Circuits 10 and 100 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 cold start circuit will be in a "locked" configuration and injector valve means 76 will not be reenergizable until after the circuit 100 has been deenergized for a period of time, as for instance by opening switch 72. While injector valve means 76 and 78 have been shown in FIG. 3 as separate means, in suitable fuel system configurations, a single injector valve means could accomplish both functions and the present invention would be of utility in such a system.

The cold start injection auxiliary circuit accomplishes its stated objectives. An output pulse is generated at circuit location 102 for application to the cold start injector valve means 76. The pulse duration is a function of the temperature drop of the associated engine below a selected level, independent of the supply voltage. Furthermore, the circuit is insensitive to false triggering since the circuit must be without power from the voltage supply (B+) for a period of time sufficient to permit stored energy to be drained off before the cold start injector valve control switches 114, 116 and 118 may be switched back on.

We claim:

1. In combination with an internal combustion engine fuel control system of the type having energizable computing means, a means to generate a signal indicative of engine temperature and injector valve means, the improvement comprising energizable circuit means responsive to the signal indicative of engine temperature and to its own energization and having a control electrode, operative to generate an output signal having a characteristic indicative of the engine cold starting fuel requirement, injector valve means responsive to said signal operative to deliver a quantity of fuel for cold starting of the engine in relation to the magnitude of the output signal variable characteristic and feedback-locking means coupled to said control electrode response to said output signal operative to bias said control electrode to prevent further actuation until said circuit has been deenergized for a predeterminable period of time.

2. The system as claimed in claim 1 wherein said locking means comprise means for applying a high-voltage potential to a portion of said circuit to render said portion of said circuit insensitive to false triggering.

3. The system as claimed in claim 2 wherein said circuit means includes an emitter coupled pair of transistors and said portion of said circuit comprises the base of one of said emitter coupled pair of transistors.

4. A fuel control system for engines having energizing means comprising in combination:

sensory means operative to sense at least one operating parameter of the engine, including engine temperature sensor means operative to generate a signal having a level which varies in relation to sensed engine temperature;

first energizable circuit means responsive to said sensory means operative to generate an output signal, said signal being comprised of a plurality of pulses having a duration indicative of the engine fuel requirement;

injection valve means;

at least a portion of said injection valve means adapted to receive said output signal and to be periodically intermittently energized in response thereto whereby fuel delivery to the engine may be controlled; and

second energizable circuit means including means responsive to the engine temperature signal and means responsive to second circuit energization to generate a signal having a characteristic which varies with elapsed time from the moment of energization by the energizing means to receive and compare said temperature signal and said

elapsed time signal and bistable switching means operative to be in one stable state when the temperature signal exceeds the elapsed time signal and to be in the other stable state when the elapsed time signal exceeds the temperature signal;

said second circuit means further including latching means interconnecting said switching means and said comparison means operative to apply a bias signal to override said elapsed time signal whenever said switching means are in a selected one of their stable states whereby false triggering is prevented.

5. A fuel system as claimed in claim 4 wherein said second circuit comprises:

means for receiving a variable signal indicative of engine temperature;

means for receiving a time-varying signal;

means for comparing said signals;

said switching means responsive to said comparing means operative to produce an injector valve means control signal while said engine temperature signal exceeds said time-varying signal; and

said disabling means are responsive to the termination of said control signal and are operative to apply a blocking signal to said comparing means.

6. The system as claimed in claim 5 wherein said switching means comprise a plurality of solid state switches having an "on" state and an "off" state and said disabling means are responsive to the change of state of one of said plurality of switches.

7. The system as claimed in claim 6 wherein said disabling means comprise:

means for receiving a high voltage input signal; and

means for communicating said signal to said comparing means.

8. The system as claimed in claim 5 wherein said comparing means comprise a pair of electronic devices and said time-varying signal and said high-voltage signal are applied to a control electrode of said pair of electronic devices.

9. The system as claimed in claim 8 wherein said time-varying signal is generated by the time required for the voltage across a capacitor to rise to a selected value whereby said capacitor accumulates electrical energy, said accumulated electrical energy operative to prevent switching of said switching means until said first and second circuit means have been deenergized for a predetermined period of time.

10. The system as claimed in claim 4 wherein said elapsed time signal-generating means comprise capacitive means chargeable in response to energization of said second circuit means and said comparison means comprise an emitter coupled pair of transistors having a pair of control electrodes arranged to receive on one control electrode the elapsed time signal and on the other control electrode the engine temperature signal.

11. The system as claimed in claim 10 wherein said switching means comprise electronic switches operative to change state when the state of conduction of the transistors in said emitter coupled pair reverses.

12. The system as claimed in claim 11 wherein said latching means interconnect said switching means with the elapsed time signal-receiving control electrode.

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