# United States Patent [19]

**Luchaco**

[11] **3,792,693**

[45] **Feb. 19, 1974**

[54] **STORED TEMPERATURE COLD START AUXILIARY SYSTEM**

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[22] Filed: **Sept. 10, 1971**

[21] Appl. No.: **179,390**

[52] **U.S. Cl.** .......................... **123/32 EA**, 123/179 L
[51] **Int. Cl.** ... **F02m 51/00**, F02b 3/00, F02n 17/00
[58] **Field of Search** ......... 123/32 EA, 179 L, 179 G

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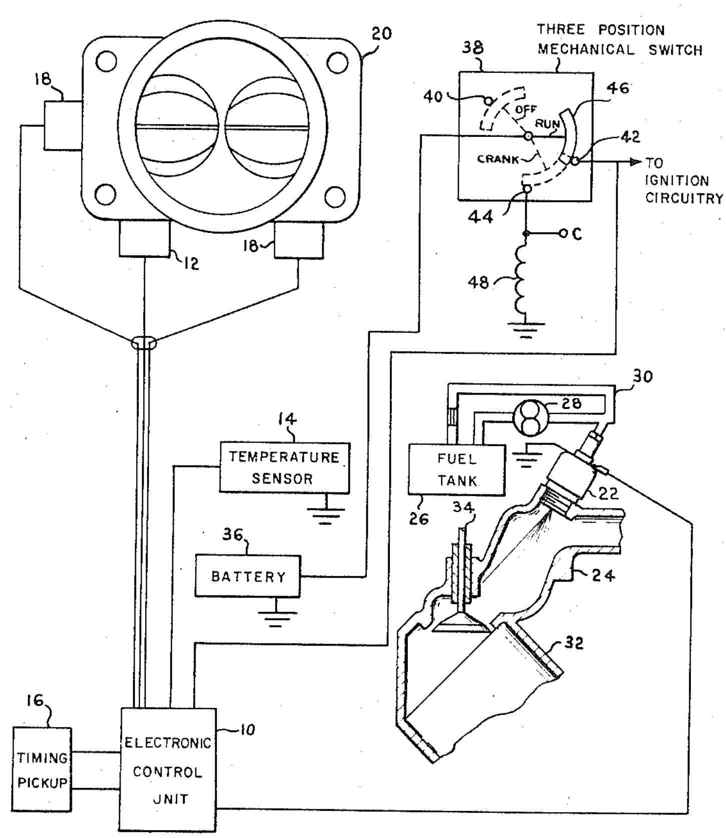
[57] **ABSTRACT**

A cold start auxiliary circuit for use in conjunction with an electronically controlled fuel supply system is disclosed herein. The cold start auxiliary circuit is comprised of a first circuit which receives and stores a signal indicative of instantaneous engine temperature during the time period when the electrical system energization of the vehicle is substantially stable and a second circuit which is energized by the vehicle electrical system and is triggered upon the initiation of engine cranking but which is otherwise not influenced by the electrical energization fluctuation incident to the cranking cycle. The cold start circuit produces an output signal which is substantially proportional to the difference between the sensed engine temperature and an established reference upon triggering of the second circuit.

**5 Claims, 4 Drawing Figures**



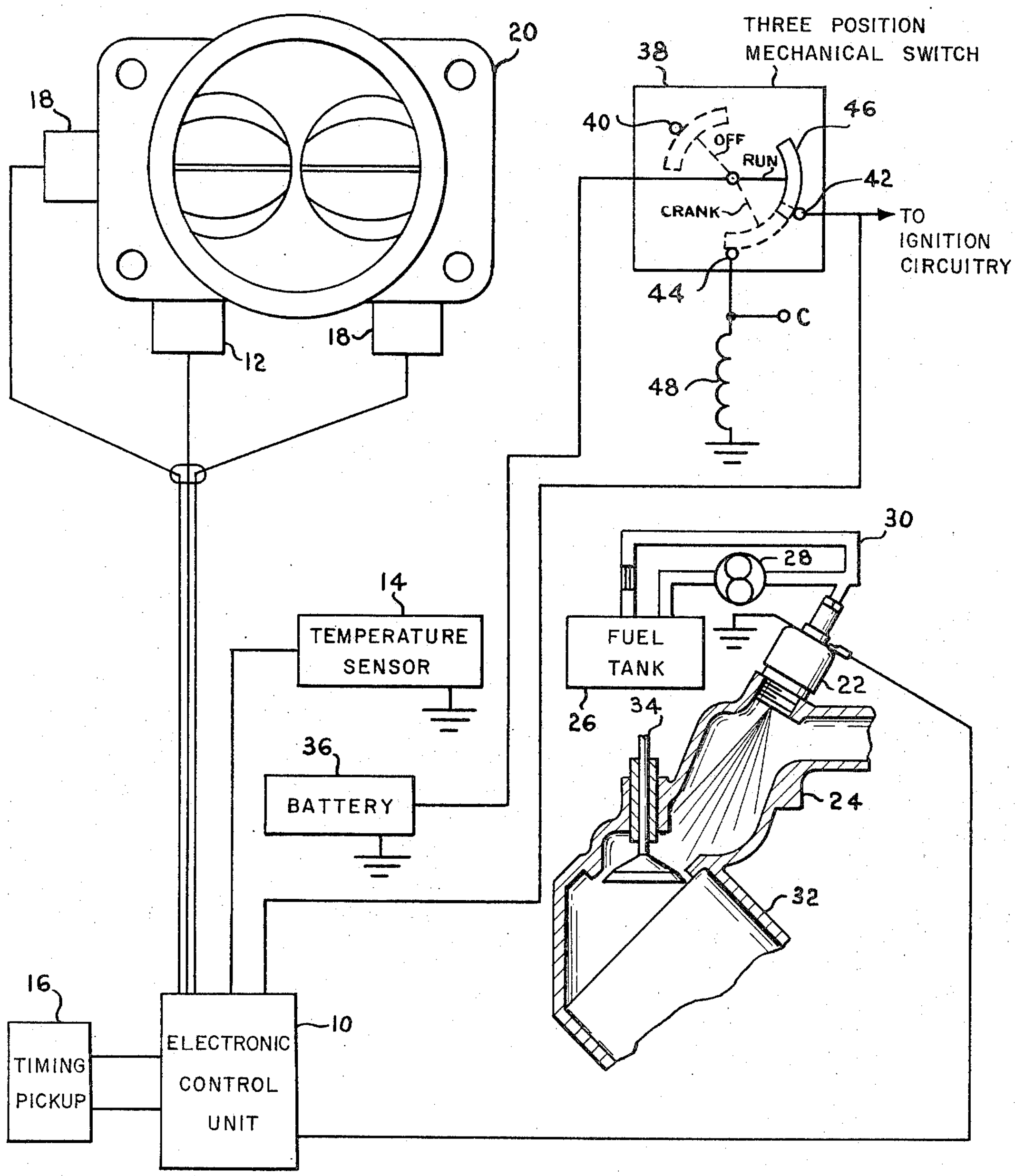



FIGURE 1

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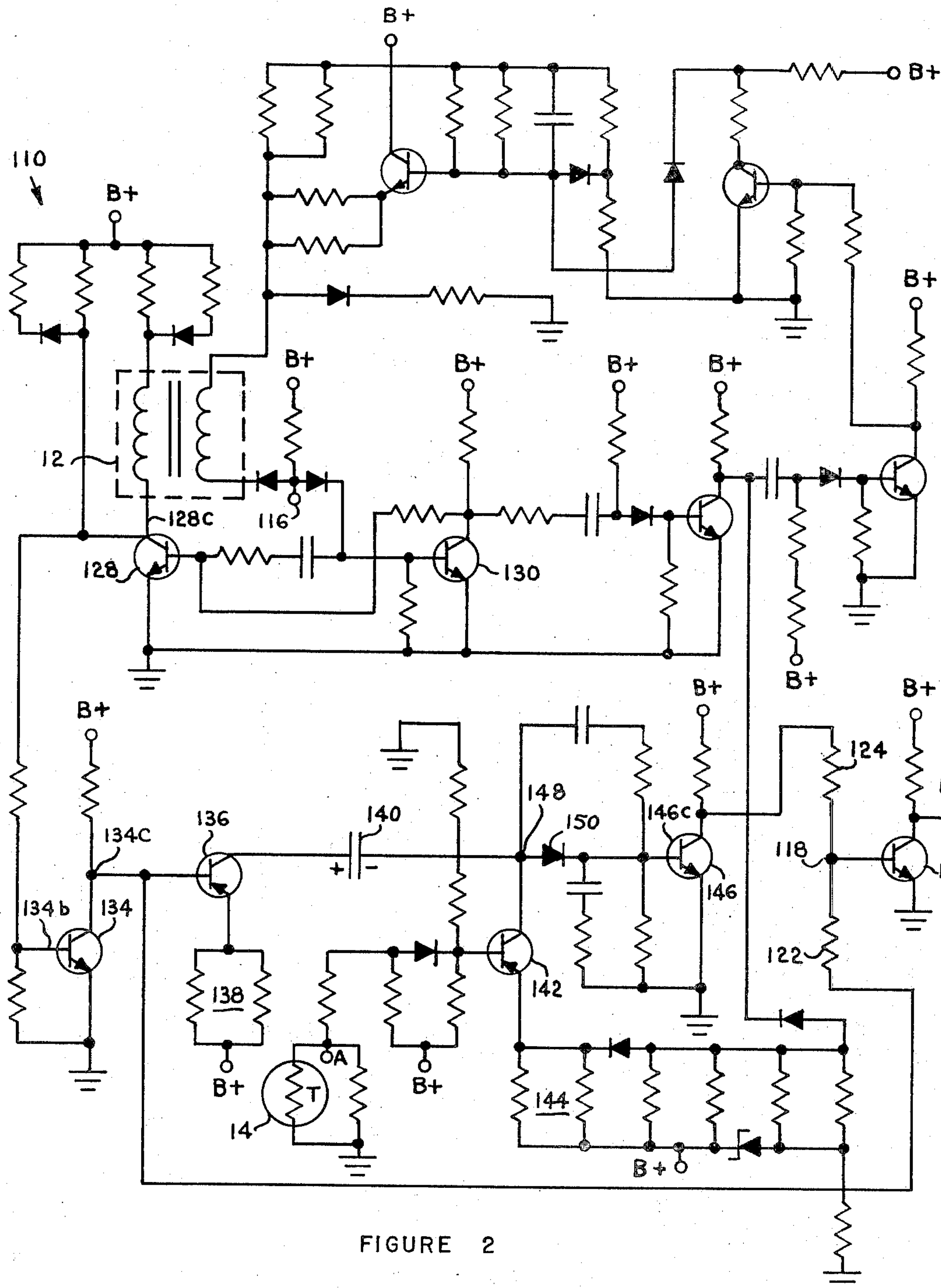


FIGURE 2

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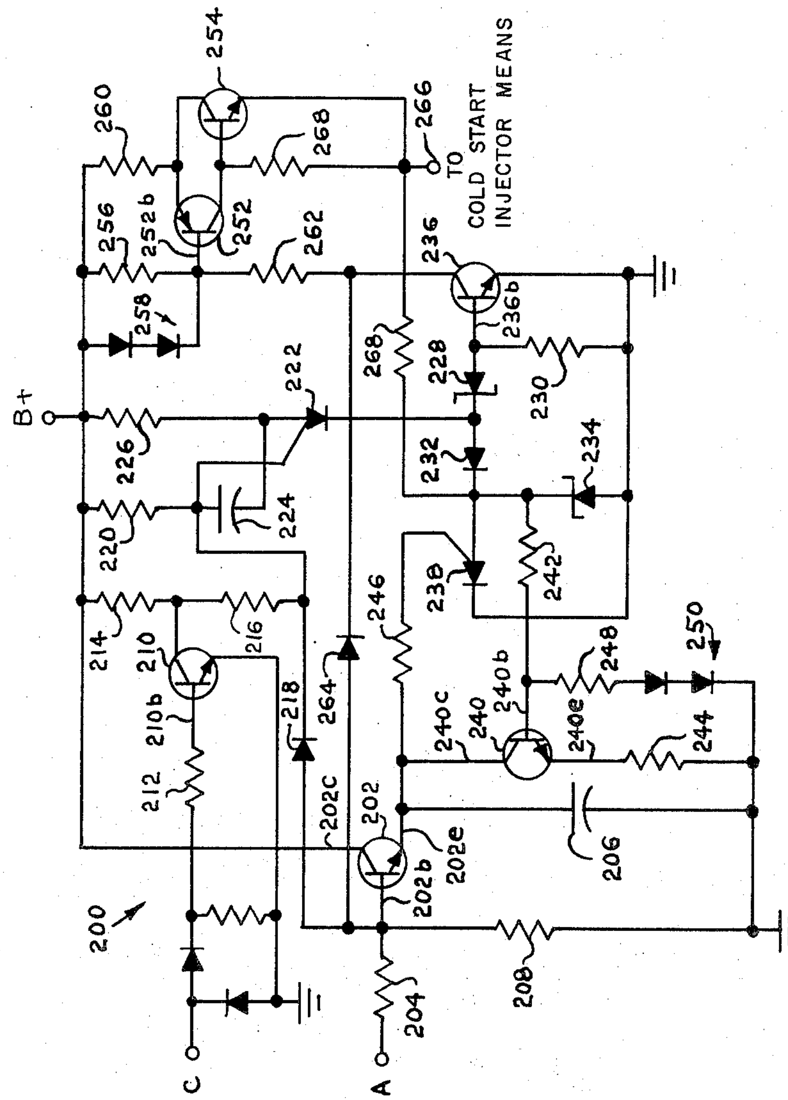


FIGURE 3

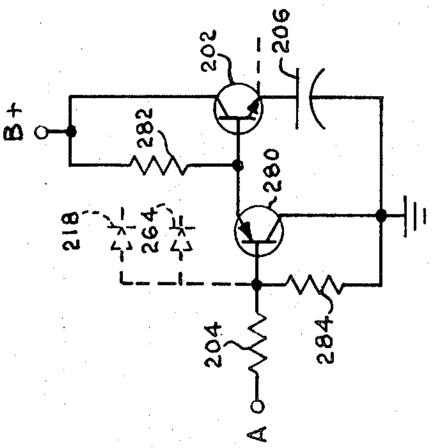


FIGURE 4

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## STORED TEMPERATURE COLD START AUXILIARY SYSTEM

### BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of electronically controlled fuel supply systems for internal combustion engines, and more particularly to that portion of the above-noted field which is concerned with auxiliary circuits to control the provision of fuel to the engine for transient operating conditions which is in addition to that provided by the main electronic fuel control system. In particular, the present invention is directed toward cold starting auxiliary circuits which provide additional fuel to assist in rapid and efficient starting of the engine.

2. Summary of the Prior Art

It is well known within the prior art to provide additional charges of fuel to an engine residing at a comparatively low ambient temperature in order to facilitate the starting of that engine. In addition, it is also known within the art to provide such additional fuel charges in the form of injector valve energizing pulses generated by circuitry which operates in cooperative association with an electronic fuel control system. Circuitry such as is illustrated in pending applications Ser. Nos. 46,681, 46,705, and 46,706, and in U.S. Pat. Nos. 3,504,657 and 3,533,381, represent several of the techniques of generating the additional fuel providing pulses. However, the circuitry for accomplishing this function has a common failing. The prior art circuitry makes use of the engine temperature sensor which is typically an electrically powered thermistor deriving its energy from the vehicle electrical system. The output characteristics of such thermistors are a function of the temperature of their environment and of the voltage level energization which they receive. In operating the starting cycle of an automotive engine, the vehicle electrical system is subject to large fluctuations in battery voltage which occur as the starter system of that engine is energized. This occurs because of the large amounts of electrical current required to energize the starting motor and the starting shift solenoid. As a consequence, the prior art cold starting assist systems are subject to the generation of erroneous output signals which occur primarily as a result of the above-noted fluctuations of the battery voltage. It is therefore an object of the present invention to provide a cold starting assist circuit which is substantially free from erroneous signals caused by battery voltage variations during operation. It is a further object of the present invention to provide such a system in which the temperature signal to be used by the cold starting assist circuit is derived prior to energization of the starting motor and the starting shift solenoid. It is a further object of the present invention to provide such a circuit in which the temperature information is received and stored prior to energization of the starter motor and starter shift solenoid and which stored information is later used to control the duration, in time, of the cold start assist signal. It is a still further object of the present invention to provide such a cold start assist system which makes use of successively triggered bistable switches to control the initiation and termination of an injector valve means control pulse in response to a time base signal derived from an electrical storage device which has been charged to a value representative of engine temperature independently of the starting motor and starting shift solenoid of the associated engine.

The prior art systems also were arranged to initiate fuel delivery in a timed relation with energization of the vehicle electrical system. However, I have determined that best results (minimum emissions and most reliable rapid starting) occur when the delivery of the additional cold starting charge occurred in relationship to the initiation of cranking. It is therefore a still further object of the present invention to provide a cold starting assist circuit which initiates delivery of the additional fuel charge in a timed relationship with engine cranking and which is thereafter substantially free from cold starting assist signal variations caused by fluctuations in the supply voltage.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates, in a schematic diagram form, an electronic fuel control system for a reciprocating piston internal combustion engine.

FIG. 2 illustrates one form of an electronic control unit for use in a fuel control system according to FIG. 1.

FIG. 3 shows the preferred embodiment of a circuit according to the present invention for use in a fuel control system according to FIG. 1.

FIG. 4 shows a modification which may be applied to the circuit of FIG. 3 in order to permit that circuit to accept an unstable input temperature signal.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, an electronic fuel control system is shown in schematic form. The system is comprised of a computing means **10**, a manifold pressure sensor **12**, a temperature sensor **14**, an input timing means **16** and various other sensors denoted as **18.** The manifold pressure sensor **12** and the assorted other sensors **18** are mounted on throttle body **20.** The output of the computing means **10** is coupled to an electromagnetic injector valve member **22** mounted in intake manifold **24** and arranged to provide fuel from tank **26** via pumping means **28** and suitable fuel conduits **30** for delivery to a combustion cylinder **32** of an internal combustion engine, otherwise not shown. While the injector valve member **22** is illustrated as delivering a spray of fuel toward an open intake valve **34**, it will be understood that this representation is merely illustrative and that other delivery arrangements are known and utilized. Furthermore, it is well known in the art of electronic fuel control systems that computing means **10** may control an injector valve means comprised of one or more injector valve members **22** arranged to be actuated singly or in groups of varying numbers in a sequential fashion as well as simultaneously.

The computing means **10** is illustrated here as being energized by battery **36** through the switching means **38.** Switching means **38** is illustrative of the typical automotive ignition switch having OFF, RUN, and CRANK positions. The switching means **38** has contacts **40, 42, 44,** which correspond to the three positions, respectively, and a rotatable slider member **46** which is coupled to battery **36** and which is arranged to contact various of the contacts **40, 42, 44** upon rotation. Contact **40** is electricaly isolated and corresponds to the OFF position while contacts **42** and **44** are the electrically active contacts and are coupled to various operating circuitry of the associated engine and vehicle. Slider **46** is adapted to have stable positions in contact with contacts **40** and **42** and to be biased out of contact with contact **44.** Slider **46** is further adapted to have the bias controllably overcome and to thereafter contact both contacts **42** and **44.** Contact **42** is coupled to the ignition circuitry, not shown, and to the computing means **10.** Contact **44** is coupled to the engine starter system illustrated as coil **48.** This is intended to be illustrative of the starting system of an engine which may include starter motor, starter shift solenoid, and various relay and contact mechanisms. Contact **44** is also coupled to circuit location C and the significance of this will be explained hereinbelow.

Referring now to FIGS. **1** and **2** and particularly to FIG. **2,** an illustrative electronic fuel control system main computation circuit **110** 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 **36** and/or battery charging system conventionally used as the vehicle's electric power source, and would be transmitted to the circuit **110** through contacts **42, 46** of switch means **38.** For convenience, switch means **38** has been omitted. The man skilled in the art will recognize that the electrical polarity of the voltage supply could readily be reversed.

The circuuit **110** 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 associatd 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 from input timing means **16** at circuit input port **116.** This signal may be derived from any source indicative of engine crank angle, but is preferably from the engine's ignition distributor.

The circuit **110** is operative to provide two consecutive pulses, of variable duration, through sequential networks to circuit location **118** to thereby control the ON time of transistor **120.** The first pulse is provided via resistor **122** from that portion of circuit **110** 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 **124** from that portion of the circuit **110** having an input from the temperature sensor **14.** These pulses, received sequentially at circuit location **118,** serve to turn transistor **120** ON (that is, transistor **120** is triggered into the conduction state) and a relatively low voltage signal is present at circuit output port **126.** This port may be connected, through suitable inverters and/or amplifiers to the injector valve means (shown in FIG. **1**) such that the selected injector valve means are energized whenever the transistor **120** is ON. It is the current practice to use switching means to control which of the injector valve means are coupled to circuit location **126** 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 **118** 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 **128** and **130.** The presence of a pulse received via input port **116** will trigger the multivibrator into its unstable state with transistor **128** in the conducting state and transistor **130** blocked (or in the nonconducting state). The period of time during which transistor **128** is conducting will be controlled by the voltage signal from manifold pressure sensor **12.** Conduction of transistor **128** will cause the collector **128***c* thereof to assume a relatively low voltage close to the ground or common voltage. This low voltage will cause the base **134***b* of transistor **134** to assume a low voltage below that required for transistor **134** to be triggered into the conduction state, thus causing transistor **134** to be turned off. The voltage at the collector **134***c* will, therefore, rise toward the B+ value and will be communicated via resistor **122** to circuit location **118** where it will trigger transistor **120** into the ON or conduction state thus imposing a relatively low voltage at circuit port **126.** As hereinbefore stated, the presence of a low voltage signal at circuit port **126** will cause the selected injector valve means to open. When the voltage signal from the manifold pressure sensor **12** has decayed to the value necessary for the multivibrator to relax or return to its stable condition, transistor **130** will be triggered ON and transistor **128** will be turned OFF. This will, in turn, cause transistor **134** to turn ON, transistor **120** to turn OFF and thereby remove the injector control signal from circuit port **126.**

During the period of time that transistor **134** has been held in the nonconducting, or OFF state, the relatively high voltage at collector **134***c* has been applied to the base of transistor **136,** triggering the transistor **136** ON. The resistor network **138,** connected to the voltage supply, acts with transistor **136** as a current source and current flows through the conducting transistor **136** 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 **146***c*.

When transistor **128** turns OFF signaling termination of the first pulse, transistor **134** turns ON and the potential at the collector **134***c* falls to a low value. The current from the current source comprised of transistor **136** and resistor network **138** now flows through the base of transistor **136** and the capacitor **140** ceases to charge. The capacitor will then have been charged, with the polarity shown in FIG. **2,** to a value representative of the duration of the first pulse. However, at the end of the first pulse when transistor **134** is turned ON, the collector-base junction of transistor **136** is forward biased, thus making the positive side of capacitor **140** only slightly positive with respect to ground as a result of being separated from ground by only a few pn junctions. This will impose a negative voltage on circuit location **148** which will reverse bias diode **150** and transistor **146** will be turned OFF. This will initiate a high voltage signal from the collector of transistor **120** ON and a second injector valve means control pulse will appear at circuit port **126.** The time duration between the first and second pulses will be sufficiently short so that the injector valve 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 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. 2 and 3, and in particular to FIG. 3, the cold start auxiliary circuit 200 of the present invention is illustrated. Circuit 200 is illustrated as being energized by B+ and this energization is derived through contacts 42, 46 of switch 38. For convenience, this connection has not been illustrated. Circuit 200 also receives inputs at input terminals A and C. These terminals correspond to the similarly designated terminals A (in FIG. 2) and C (in FIG. 1). Input terminal A is connected to the base 202*b* of input transistor 202 through resistor 204. The emitter 202*e* of transistor 202 is connected to one side of capacitor 206 while the collector 202*c* of transistor 202 is connected to B+. Registor. 208 interconnects the base 202*b* with the other side of capacitor 206.

Input terminal C is coupled to the base 210*b* of control transistor 210 through base resistor 212. The collector of transistor 210 is coupled to the B+ supply voltage by resistor 214 and is also coupled to the base 202*b* of transistor 202 by way of resistor 216 and diode 218. The interconnection of diode 218 and resistor 216 is coupled to the B+ supply voltage by way of resistor 220 and is also coupled to the control electrode of bistable switch 222. A capacitor 224 interconnects the control electrode of bistable switch 222 with the anode thereof. A resistor 226 connects the anode of the bistable switch 222 with the B+ supply voltage. The cathode of bistable switch 222 is connected to ground by way of zener diode 228, resistor 230, diode 232, and zener diode 234. A transistor 236 is connected with its base or control electrode 236*b* connected to the junction of zener diode 228 and resistor 230 with its base-emitter junction in parallel with resistor 230.

A second bistable switch 238 is connected in parallel with zener diode 234 so that the anode of switch 238 is connected to the cathode of zener diode 234 while the cathode of bistable switch 238 is connected to the anode of zener diode 234. A capacitor discharge transistor 240 is connected so that its base 240*b* is connected to the cathode of zener diode 234 by way of resistor 242 and with its collector 240*c* connected to the one side of capacitor 206 while its emitter 240*e* is connected through resistor 244 to the other side of capacitor 206. The control electrode of bistable switch 238 is connected to the collector 240*c* by way of resistor 246. The base 240*b* of transistor 240 is also connected to ground through resistor 248 and diode means 250.

The power output stage of the circuit 220 is comprised of a pair of transistors 252, 254. The base 252*b* of transistor 252 is connected to the collector of transistor 254 and both are connected to the source of electrical supply by resistor 260. The base 252*b* is also connected to the collector of transistor 236 by way of resistor 262 and to the base 202*b* of transistor 202 by way of diode 264. The collector of transistor 252 is connected to the base of transistor 254 and to output terminal 266 by way of resistor 268. The emitter of transistor 254 is connected directly to output terminal 266. The cathode of zener diode 234 is connected to output terminal 266 by way of resistor 268.

## OPERATION

In the operation of a vehicle having an internal combustion engine with a fuel control system which incorporates the present invention, the turning of switch 38 from the OFF position through the RUN position to the CRANK position will result in the application of electrical energy through contacts 46, 42 to the circuit 200 and to the circuit 110 in such a manner that an electrical signal appears at terminal A prior to the application of any signal to terminal C. The signal received in terminal A willl be an electrical voltage which is substantially inversely proportional to the temperature of the engine at the moment slide 46 contacts contact member 42. The presence of this voltage signal at terminal A coupled with the application of B+ supply voltage through switch means 38 to circuit 200 will result in the conduction of transistor 202 so that capacitor 206 will receive and store an electrical signal which is equivalent to the signal received at A reduced by one emitter-base junction voltage drop so that the signal received and stored by capacitor 206 will be indicative of the engine temperature. The remaining portion of the circuit will be substantially inactive due to the fact that transistor 210 requires receipt of a signal at terminal C before it can become active and all other active devices within circuit 200 depend upon the conduction of transistor 210 following circuit energization to become active. By suitably arranging the electrical values of resistors 204 and 208 and capacitor 206, the circuit can be adapted to charge capacitor 206 up to the level permitted by the signal received at terminal A in the amount of time it will take the normal operator to rotate switch 38 through the RUN to the CRANK position. Upon entry of the switch into the CRANK position, a high-voltage signal will appear at terminal C and this signal will be applied to the base 210*b* of transistor 210 by way of resistor 212. Receipt of this high-voltage signal will cause transistor 210 to go into conduction. The effect of conduction of transistor 210 will be to cause the voltage appearing between resistors 214 and 216 to drop. This will cause current to flow through resistors 220 and 216 to ground through transistor 210 and thereby causing the voltage appearing at the gate electrode of bistable switch 222 to drop. Bistable switch 222 is selected such that it will be nonconducting following energization of circuit 200. Until such time as the voltage applied to the gate electrode of bistable switch 222 drops to a value 1 diode voltage drop below that applied to the anode the switch 222 will be open. Upon initial energization of circuit 200, the voltage applied to both the gate and anode electrodes of device 222 will be substantially B+ value since no current will be flowing through the various associated electrical elements. However, application of a reduced voltage to the gate electrode by way of current flow through resistor 220 and resistor 216 will cause bistable switching device 222 to go into conduction. Device 222 is further selected to remain conductive for all values of voltage applied to the gate electrode thereafter so long as a minimal value of current is flowing through the device. The device illustrated is known as a programmable unijunction transistor (PUT). However, an SCR would also be suitable for the purpose and other devices well known in the industry may also be utilized. Capacitor 224 operates to prevent an instantaneous voltage change between the gate electrode and the anode electrode so as to prevent transient voltage spikes or differentials from inadvertently triggering the switching device 222 and also prevents turn on by the "rate effect" following circuit energization. The presence of the low voltage signal applied to the gate of switching device 222 will cause the voltage appearing at base 202*b* to drop to a relatively low value, thereby switching off transistor 202. This is operative to thereafter isolate memory device 206 from the source of temperature input signal and hence end variations resulting from battery voltage variations.

When switching device 222 goes into conduction, a current will flow through zener diode 228, resistor 230, conventional diode 232, and zener diode 234. The two zener diodes will operate to provide selected voltage drops thereacross so as to provide suitable voltage signals to the transistors whose bases are connected to the zener diodes. The application of the proper voltage signal to the base of transistor 236 will cause it to go into conduction so that current will flow down through resistors 256 and 262. The voltage drop appearing across resistor 256 will be sufficient to trigger resistor 252 into conduction and this in turn will trigger transistor 254 into conduction so that an output current signal will appear at output terminal 266. Again, by suitable selection of the resistive values of resistors 260 and 268, the amount of current appearing at terminal 266 can be calculated to be sufficient to controllably energize a selected injector valve means.

The voltage appearing at the cathode of zener diode 234 will be applied to the base of transistor 240 by way of resistor 242, and due to the action of resistor 248 and diode means 250, will be of sufficient value to cause transistor 240 to go into conduction. Conduction of transistor 240 will operate to drain electrical energy from capacitor 206 in the normal capacitor discharge fashion, and the voltage appearing at the collector of transistor 240 will decay. This voltage value is communicated by resistor 246 to the gate electrode of second bistable switching device 238. In this instance, the device is illustrated as being of the same type as the previously described bistable switching device 222. It may also be dissimilar so long as the operational characteristics are substantially as described with reference to device 222. When the voltage received by the gate electrode of bistable switch 238 drops to a value which is one diode drop below the regulated value established by zener diode 234, bistable switch 238 will go into conduction and current will flow therethrough. Since the combined resistance of diode 232 and bistable switch 238, in conduction, can be readily arranged to be substantially lower than that of zener diode 228 combined with resistor 230, the amount of current flowing into the base of transistor 236 can be substantially reduced to a value less than that required to maintain transistor 236 in conduction and this device will turn off. The turning off of transistor 236 will be operative to turn off transistors 252 and 254 in cascade fashion and the current signal appearing in terminal 266 will cease. During the time that transistor 236 is in conduction the low voltage signal appearing at the collector thereof will be operative, through diode 264, to maintain the base 202*b* of transistor 202 at a low value of voltage further insuring isolation of the storage element 206 and eliminating the possibility that charging of capacitor 224 could inadvertently terminate the isolation provided by diode 218. Resistor 268 is operative to provide a current flow path between the power output stage and zener diode 234 to provide additional current for that zener diode to insure that it operates well into its regulation range without drawing excess current through switch 222.

Referring now to FIG. 4, an input stage for interconnecting the input terminal A with the memory and storage device 206 is illustrated. This figure illustrates a second transistor 280 whose emitter is coupled to the base 202*b* of transistor 202 and whose base is connected to resistor 204. An additional resistor 282 connects the emitter of transistor 280 to the B+ supply which is, for the purposes intended herein, the same B+ supply as is illustrated and commented on with regard to FIG. 3. The base of transistor 280 is coupled through resistor 284 to the collector which is grounded. Terminal A of the FIG. 3 embodiment may be coupled directly to the temperature responsive element which is herein illustrated in FIG. 2 as thermistor 14. However, where convenience has dictated that terminal A be remote from the temperature sensor element by one or more diode junctions as, for instance, when a transistor is interposed therebetween, a transistor 280, as illustrated in FIG. 4, may be coupled into the input stage. Such additional transistor should be selected to be a pnp transistor if the intervening transistor is an npn transistor so that the temperature effects of the respective base-emitter pn junctions will be mutually self-compensating.

What is claimed is:

1. In an internal combustion engine fuel control system having means for electronically injecting fuel into the engine, and an energizable electrical system with a three-position switch having OFF, RUN, and CRANK positions, the improvement comprising cold starting assist means for providing an injection signal having a duration determined by engine temperature comprising:

temperature sensor means for providing a signal having a magnitude inversely proportional to engine temperature;

means for receiving and storing the signal provided by said temperature sensor means;

signal providing means responsive to the switch entering the CRANK position for initiating an injection output signal;

means responsive to the initiation of an injection signal for discharging said signal storing means, the time required to reduce the stored signal to a predetermined level being determined by the magnitude of the signal received from said temperature sensor means; and

level detecting means for terminating said output signal when said stored temperature indicating signal drops to a predetermined magnitude.

2. The fuel control system as claimed in claim 1 wherein:

the fuel control system includes voltage supply means subject to voltage fluctuations during engine start up that vary the magnitude of the temperature indicating signal provided by said temperature sensor means; and

the cold starting assist means further include means responsive to the initiation of an output signal for isolating said signal storing means from said temperature sensor means during the time that an injection output signal is provided to thereby prevent voltage fluctuations from altering the duration of said output signal.

3. A circuit for generating an output pulse having a duration which is proportional to the difference between a sensed signal and an established reference for positive differences and which is zero for all other relationships, said signal to be generated in response to actuation of a control switch having at least two active positions comprising:

a first circuit responsive to the sensed signal and to the switch being in the first position operative to receive and store the sensed signal; and

a second circuit responsive to said first circuit and to the switch entering the second position operative to compare said stored sensed signal with a preselected reference signal and to generate an output signal having a starting point in time which coincides with entry of the switch into the second position and a duration proportional to the positive difference between the sensed stored signal and the preselected reference signal.

4. The circuit as claimed in claim 3 wherein said second circuit includes first and second serially connected bistable switches, said switches triggerable to switch from the nonconducting state to the conducting state and operative to thereafter remain in the conducting state until current flow through the switch decays below a predeterminable minimum, said first switch adapted to be triggered by entry of the control switch into the second position and the second switch is operative to compare the stored signal with the preselected reference signal.

5. The circuit as claimed in claim 4 including amplifier means having a control electrode, said control electrode coupled to the interconnection of said serially connected switches, said amplifier responsive to the conductive condition of the first switch to initiate an output control pulse and further responsive to the conductive condition of the second switch to terminate the output control pulse.

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