United States Patent

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[54] **ENGINE STARTER AND TEMPERATURE CONTROL SYSTEM**
15 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **290/37**
[51] **Int. Cl.** **F02n 11/08**
[50] **Field of Search** .... 290/36—38, 41, 48; 307/10

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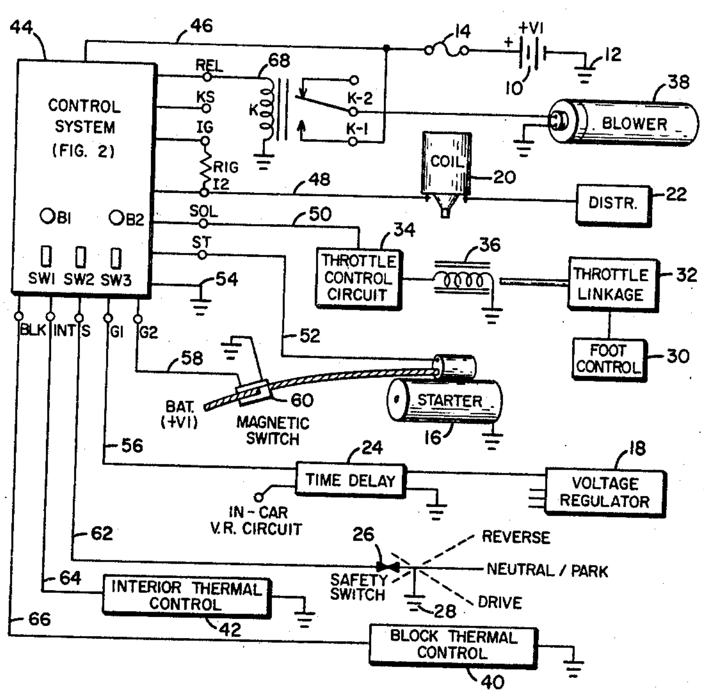
ABSTRACT: An improved automatic engine starter and control system is described, wherein the control system utilizes temperature sensing apparatus for determining when an engine should be started for warming either the engine, or some controlled area. The automatic starter system utilizes an electronic control system having a holding circuit for providing standby power, an indicator circuit for indicating the selection of the temperature condition that is controlling, an electronically controlled master relay circuit, and a starter control relay circuit for initiating starter action in response to the signals provided from the master relay circuit. Additionally, an electronic timer circuit is provided for limiting the total amount of time that the starter will be activated should the engine fail to start, with the timer circuit deactivating the holding circuit and disengaging the starter should the nonstarting time period exceed the predetermined amount. An electronic control circuit is also provided for controlling the activation of a heating or cooling device in response to a signal indicating that the engine has been started. Electronic time delay circuits are also shown for providing a predetermined time delay following engine die-out before restarting can again be initiated in order to assure the engine has slowed nearly to a stop for preventing damage to the starting mechanism. An electronic safety switch is also described for completely deactivating the control system in the event the gear selection lever is moved out of the neutral or park position. Circuitry is also described for determining when the engine is self-running for removing control of the automatic control system. Circuits are also described for controlling the throttle setting during starting and idling periods.



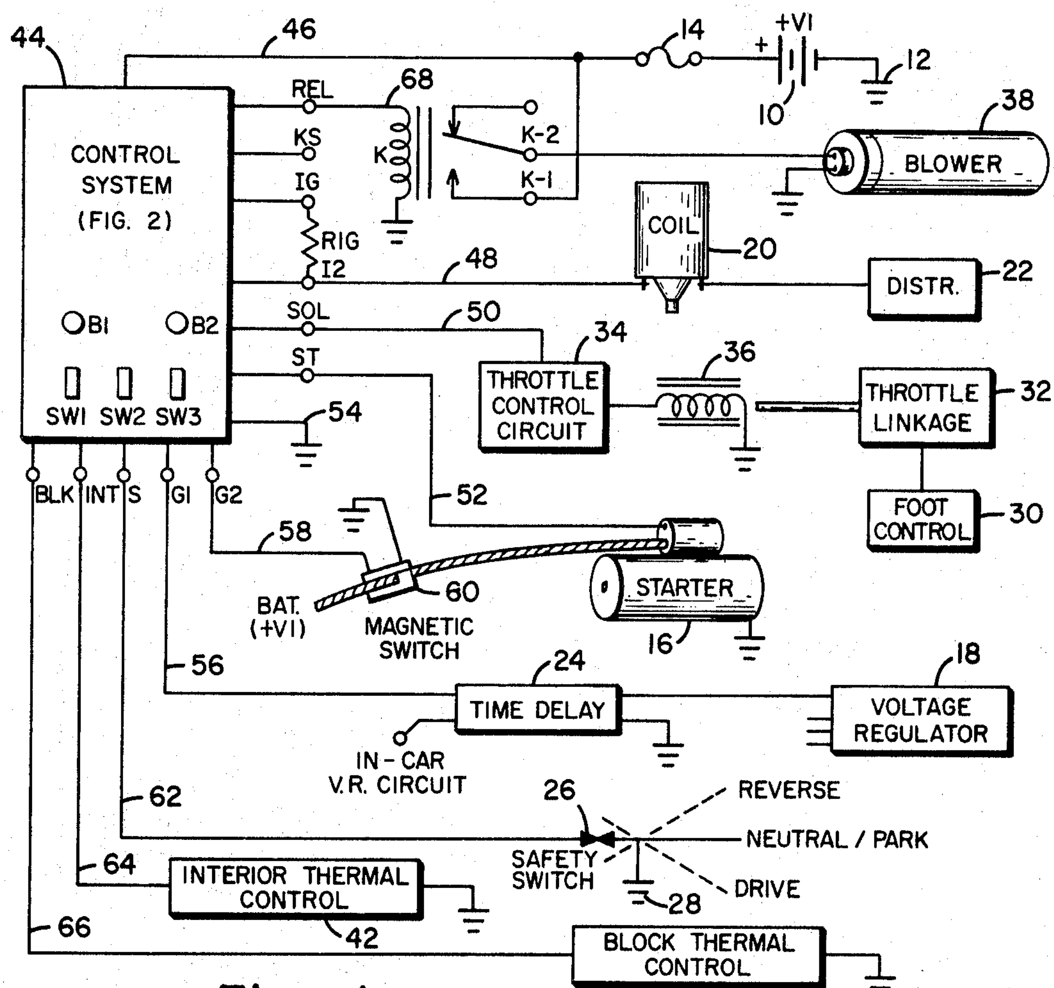


Fig. 1

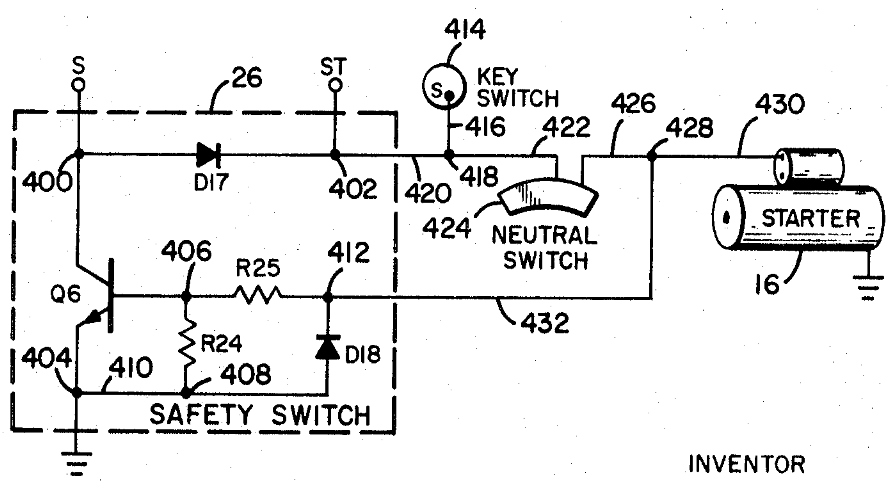


Fig. 4

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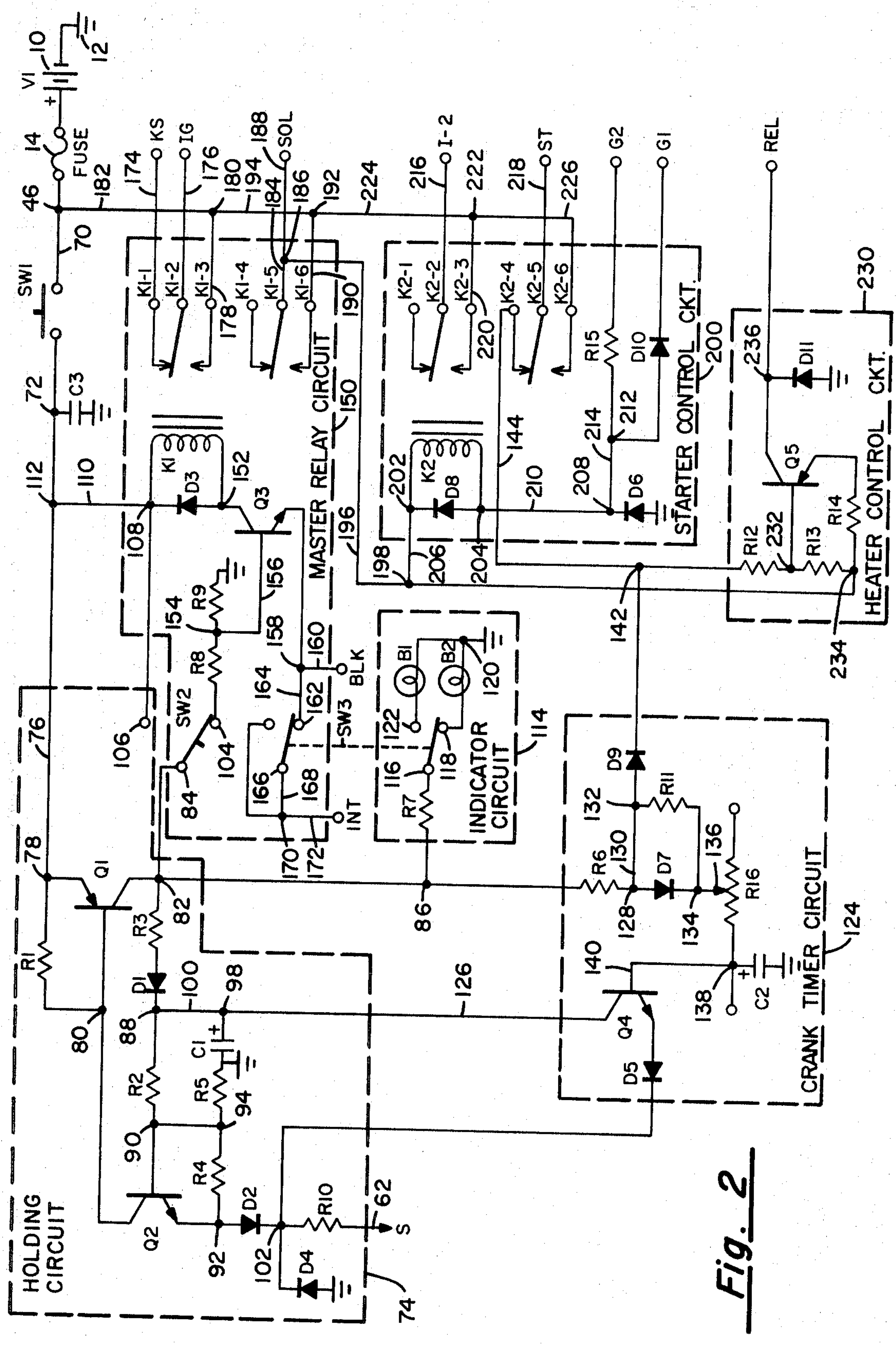
HOLDING CIRCUIT
MASTER RELAY CIRCUIT
INDICATOR CIRCUIT
STARTER CONTROL CKT.
HEATER CONTROL CKT.
CRANK TIMER CIRCUIT
FUSE
SW1
SW2
SW3
KS
IG
SOL
I-2
ST
G2
G1
REL
BLK
INT
S
V1
Q1
Q2
Q3
Q4
Q5
K1
K2
B1
B2
C1
C2
C3

Fig. 2

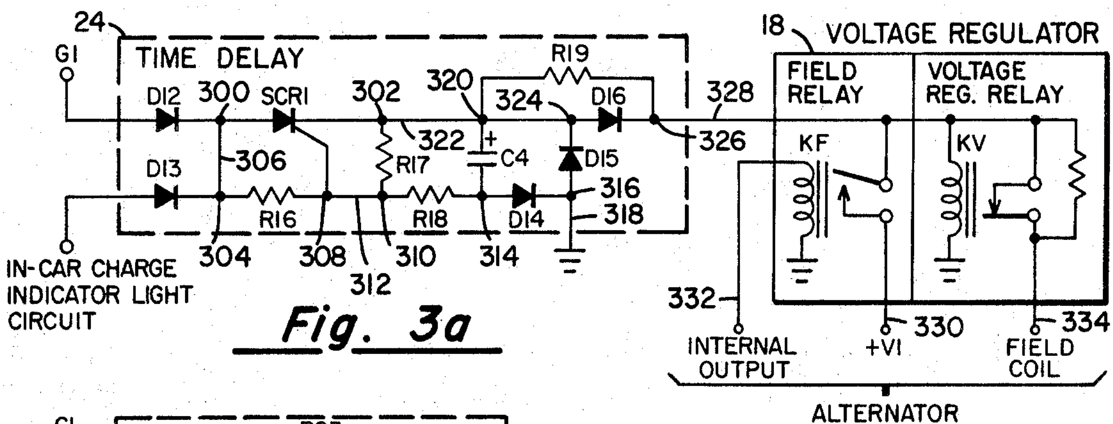

Fig. 3a

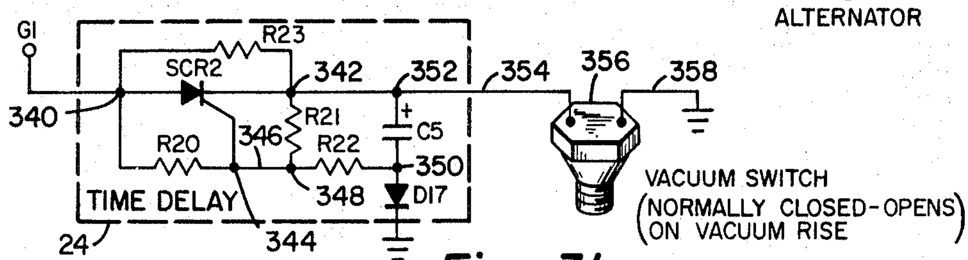

Fig. 3b

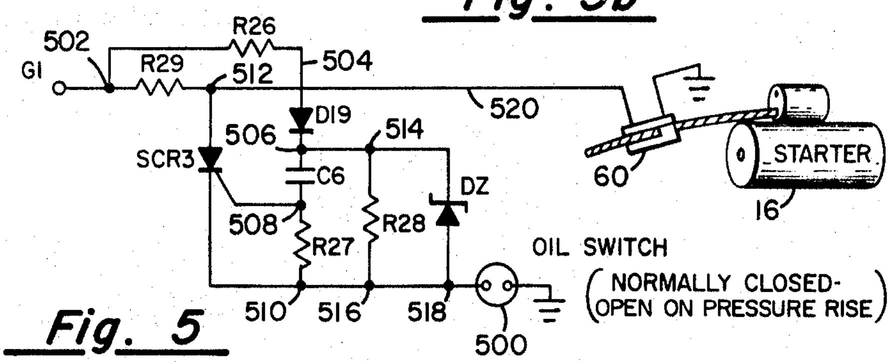

Fig. 5

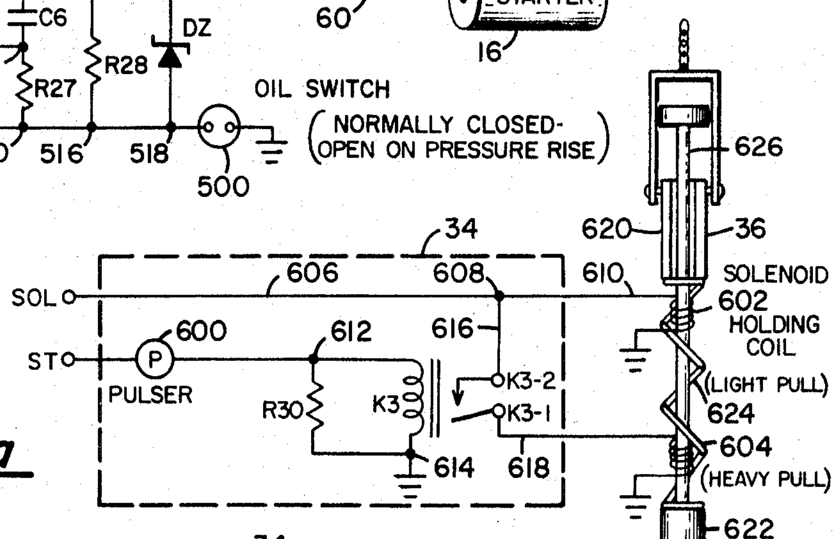

Fig. 6a

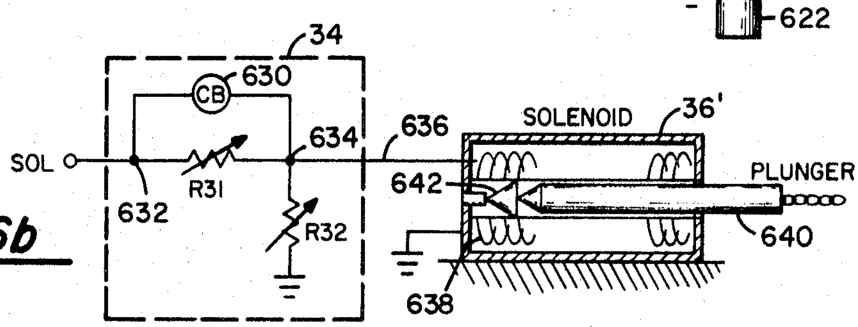

Fig. 6b

ENGINE STARTER AND TEMPERATURE CONTROL SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of apparatus relating to engine starter and temperature control apparatus for automotive vehicles of the character wherein the engine of the vehicle is set in operation in response to alterations in temperature, or at predetermined times, and caused to be turned off in response to sensed temperature alterations.

2. Description of the Prior Art

Various types of engine starting apparatus and arrangements are known to the prior art. These prior art systems have generally failed to utilize the speed and reliability of electronic components, tending primarily to rely on relays and the like, and have failed generally to provide adequately for control of the throttle during starting and idling. Further, prior art systems have generally tended to have inadequate means for determining when the engine is self-running, and have failed to provide adequately for recycling time control required when the engine starts and immediately dies out.

The purpose of the invention, then, is to provide an improved automatic system for commencing operation of an internal combustion engine in response to sensed temperature conditions, and to cause the engine to be shut off in response to sensed alterations in temperature, and wherein will be incorporated various novel and improved features and characteristics of construction devised to render the system an improvement over apparatus of the same general character heretofore known. As disclosed in the drawings and hereinafter described, commencement of operation of the engine can be in response to lowering of the temperature thereof below a predetermined temperature level, with engine operation being turned off in response to elevation of the temperature thereof above a predetermined level. Alternatively, commencement of operation of the engine can be in response to lowering of the temperature of a predetermined control space, such as the interior of an automobile, with the operation of the engine being shut off in response to elevation of the temperature of the control space above a predetermined level. Another mode of operation can be the automatic starting of an engine in response to elevation of temperature in a controlled space, again such as an interior of a vehicle, together with the turning on of air-conditioning equipment, followed by shutting off the engine automatically in response to the lowering of the temperature in the controlled spaced below a predetermined temperature level. It is of course apparent that initiation of actuation of the starting and stopping of the engine can be accomplished in response to phenomena other than falling or rising temperature, such as by timing mechanisms, or remote control, and that various combinations of temperature sensing control can be utilized. Additional objects are to provide other circuits and control devices for enhancing the starting and idling operation automatically, including providing an improved electronic throttle control, an improved engine self-running detector, an improved electronic time delay for controlling sequencing of the automatic starting operation, and an improved electronic safety switch for assuring that the entire automatic system will be deactivated should the gear selector be switched out of neutral or park.

SUMMARY

In summary, then, this invention includes an automatic control system having an electronic holding circuit for providing standby power to the automatic starting system, a cranking period timer for controlling the total duration permitted to crank the engine without detecting that it has started, an indicator circuit for visually indicating which of a plurality of control parameters is selected for controlling the holding circuit, a master power circuit for controlling ignition and engine speed controlling circuit, a cranking activating circuit, and control circuitry for controlling the activation of external devices such as heaters or air conditioners. The control system is arranged for operation with external parameter sensing devices such as thermostatic switches, for providing the activation thereof. The control system also provides signals to an external throttle control circuit for controlling the throttle of the engine during starting and during idle periods, an electronic safety switch is coupled to the control system for deactivating the automatic control in the event the gear selector is shifted out of neutral or park. An engine self-running sensing circuit is provided for terminating the application of power to the starter when it is determined that the engine is self-running. An electronic time delay circuit is utilized in conjunction with the self-running sensing circuit for prohibiting the control system from reengaging the starter for a predetermined time after it has been sensed that the engine has started, but followed by die-out of engine operation.

A primary object of this invention, then, is to provide an improved automatic engine starting and temperature control system. Yet another object of this invention is to provide an automatic engine starting system that includes an electronic holding circuit for providing standby power for automatically recycling the starting and stopping operation in response to externally sensed conditions. Still a further object of this invention is to provide an improved engine starting and temperature control system utilizing an electronic timer circuit for limiting the duration of applied crank power without the engine starting. Still a further object of this invention is to provide an improved throttle control circuit for use with an engine starting and temperature control system. Yet another object is to provide an improved time delay circuit for preventing damage to the starting mechanism when it is determined that an engine has started, but has died out, that might result from attempting to reengage the starter before the engine has sufficiently slowed down. Yet another object of this invention is to provide an improved sensing circuit for determining when the engine is self-running.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other more detailed and specific objectives will become apparent from a consideration of the following detailed description of the preferred embodiment when viewed in light of the drawings in which: FIG. 1 is a schematic block diagram of the novel engine starter and control system of this invention; FIG. 2 is a schematic diagram of the control system; FIGS. 3A and 3B are schematic diagrams of alternative embodiments of time delay circuits; FIG. 4 is a schematic diagram of an electronic safety switch; FIG. 5 is a schematic diagram of one embodiment of an engine self-running detecting circuit; and FIGS. 6A and 6B are schematic diagrams of alternative embodiments of automatic throttle control circuits.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a schematic block diagram of the novel engine starter and control system of this invention. It is understood that this system is to be utilized with an engine and its associated fuel supply system and electrical system, but since these elements are well known and conventional, they are not illustrated herein. Common elements in the electrical system include a battery **10**, providing a voltage V1 commonly in the order of 12 volts DC, and having a terminal coupled to ground **12** and a positive terminal coupled to safety devices such as fuse **14** or circuit breakers; a starter **16**; a voltage regulator **18**; a coil **20**; and a distributor **22**; and an in-car circuit coupled to a time delay **24**. A safety switch **26** is provided for assuring a grounding path to ground **28** only when the gear selector is in neutral or park, with the safety switch **26** being open when in any of the drive positions or in reverse. The control of the injection of fuel into the engine and carburetor (not shown) is under the control of a foot control **30** during operator control, thereby controlling a throttle linkage **32**. A throttle control circuit **34** is utilized to control a solenoid **36** for controlling the throttle linkage 32 during automatic starting and stopping under the control of this inventive system. A heater blower 38 is under the control of relay K wherein positive voltage is applied through contact K-1 through wiper K-2 to the blower 38 when the relay coil K is energized. A block thermal control device 40 is attached to the block of the engine (not shown) and operates in response to temperature, to provide a closed circuit path to ground up to a certain temperature, and to break the circuit path to ground above a certain temperature. Similarly, an interior thermal control device 42 is arranged in the interior of a vehicle for sensing the temperature therein. The interior thermal control device operates to provide a circuit path to ground up to a certain temperature, and to break the circuit path to ground above the predetermined temperature.

The automatic starting and stopping control system of this invention is shown as control system block 44. The details of this control system will be set forth in more detail with regard to FIG. 2. The control system 44 has at least two indicator lights B1 and B2, and at least three switches SW1, SW2, and SW3. Conductor 46 provides voltage plus V1 to the control system. The control system 44 contains several circuits that will be described in detail below, but generally can be considered to include set and hold circuit, a cranking period timer circuit, indicator circuits, power circuit for ignition and engine speed actuation, cranking and ignition boost power circuit, and heater or other accessory cutout circuit. These circuits connect to the appropriate external devices and circuits.

The ignition, identified as IG and not illustrated, is connected to the terminal IG. An ignition boost terminal I-2 from the control system 44 is coupled through power resistor RIG to the IG terminal to drop the current in line 48 to the ignition coil 20 when running, to a level that will give sufficient ignition firing voltage, while remaining low enough to maximize the life of the distributor points during running of the engine. This arrangement allows the wire 48 to be placed directly to the ignition coil and in series with resistor RIG to drop the coil current to a level lower than would be normally provided by the in-car ballast.

A special circuit is provided within control system 44 in conjunction with terminal KS, for use in the event that any feedback to the ignition terminal of the in-car key switch would be detrimental. To utilize this option, the ignition wire from the key switch is wired to the KS terminal; and the wire removed from the key switch is connected to the IG terminal. For this alternative, no added ballast resistor RIG is used. For the configuration wherein ignition boost is required during cranking, the I-2 terminal is connected by wire 48 directly to the coil 20. The SOL output terminal is coupled over wire 50 to the throttle control circuit 34. This circuit arrangement is utilized for controlling engine speed during the starting and running operations. It should be understood that the throttle control circuit 34 need not necessarily be utilized, and that wire 50 can be coupled directly to solenoid 36, which in turn is linked to the throttle linkage 32. If adjusted to an appropriate desired speed of run and idle, the solenoid 36 alone will be satisfactory. However, if it is desired to manipulate the throttle linkage 32 during the cranking and starting operation, it is advantageous to utilize the throttle control circuit 34 in conjunction with the solenoid 36. The details of the throttle control circuit 34 will be described below. The ST terminal is coupled through wire 52 directly to starter 16. A connection is provided through wire 54 to ground. Terminal G1 is wired through wire 56 to the time delay circuit 24, and in an alternative embodiment to an engine speed sensor, as will be described below. The G2 terminal can be wired through wire 58 to an engine speed sensor, if utilized, such as magnetic switch 60. The terminal S is utilized for providing contact through wire 62 to the safety switch 26. The terminal INT is coupled by wire 64 to the interior thermal control device 42. This circuit provides a grounding path to the control system 44 for various other types of sensed temperature conditions that may be measured. For example heating of the interior of a vehicle would utilize an interior thermal control device 42 that would close the ground path at temperatures drifting below the comfort level, and open the circuit at some predetermined temperature level. Alternatively, for use in controlling the operation of air-conditioning of the interior of the vehicle, the interior thermal control device 42 would be set to provide the grounding path at some elevated temperature for causing the engine to be started for running the air-conditioning unit (not shown) for cooling the interior of the vehicle. Of course any appropriate sensor could be utilized, for example time delay sensors for providing starting at timed intervals, or any other desired type of control function. The terminal BLK is coupled through wire 66 to block thermal control device 40, with the thermostatic control device 40 being coupled to the block or some other physical portion of an engine. This thermostatic circuit arrangement results in providing grounding to the control system 44 under conditions when there is a demand for heat. Normally, the block thermal control device 40 would be set to turn on at temperature levels that assure consistent starting of the engine. Normally, the range of operation of the block thermal control device 40 would be selected such that it would open, or turn off, at a temperature level that will provide maximum warmup of the engine without opening the water thermostat of the engine, if one is used, thereby only running the engine long enough to maintain its temperature level without requiring the running of the engine for a period of time to completely warm all of the coolant that may be utilized with an engine. The thermal REL is utilized for providing power to a wire 68 that is coupled to the relay K for providing power to the heater blower 38. It should be understood that this terminal can be changed to provide the enabling of power to such other devices as air conditioners, or any other type of accessory that may be controlled by the control system 44.

Having considered the various associated elements that may be utilized in conjunction with an engine to be controlled, and the couplings to the control system, attention is directed to FIG. 2 which is a schematic diagram of the novel control system. In this circuit, the battery 10 provides voltage V1 to the fuse 14 and thence to conductor 46. One terminal of the battery 10 is coupled to ground 12. Switch SW1 provides a master cutoff of power to all of the control circuits. Switch SW1 has one terminal coupled to junction wire 46 by lead 70, with the other terminal coupled to junction 72. Capacitor C3 is coupled between ground and junction 72 and operates to provide bypass of any short duration voltage peaks that may result in damage to the transistors in the control system 44, and to provide a path for current surges if the grounding of the control system is inadvertently omitted. Switch SW1 is normally closed, and would normally only be opened to disable the unit for long periods of time, during repair of the associated vehicle, or to deter others from operating the system. This switch can be left closed during normal operation of the vehicle.

A holding circuit is shown enclosed within dashed block 74, and is comprised of transistors Q1 and Q2, resistors R1, R2, R3, R4, R5 and R10, capacitor C1, and diodes D1, D2, and D4, and a portion of switch SW2. Battery voltage is applied over lead 76 to junction 78, which is a common point of the emitter of transistor Q1 and one terminal of resistor R1. Junction 80 is a common connection to the other terminal of resistor R1, the base of transitor Q1, and the collector of transistor Q2. The collector of transistor Q1 is coupled to junction 82, which is a terminal point for one lead from resistor R3, and couples to terminal 84 on switch SW2. This connection point 82 is also common to connection point 86. The other terminal of resistor R3 couples through diode D1 to junction point 88. Resistor R2 is coupled between junction point 88 and junction point 90, with junction 90 being coupled directly to the base of transistor Q2. The emitter of transistor Q2 is coupled to junction 92, with resistor R4 being coupled between junction points 92 and 94. Lead 96 couples junction points 90 and 94 together. One terminal of resistor R5 is coupled to junction point 94, the other being coupled to ground and to a first terminal of capacitor C1. The other terminal of capacitor C1 is coupled to junction point 98, with lead 100 coupling junctions 88 and 98 together. Diode D2 is coupled between junction points 92 and 102, with resistor R10 coupling junction 102 to lead 62. Diode D4 is coupled between junction 102 and ground. The switch SW2 is spring loaded, with the wiper terminal 84 normally connected to terminal 104. When depressed, the terminal 84 is in contact with terminal 106, thereby providing a conductive path to junction 108. Junction 108 is coupled by wire 110 to junction 112, which is the battery supply path.

To set the holding circuit 74, the S terminal must be coupled through the safety switch 26 (see FIG. 1) to ground. Momentarily depressing switch SW2 so that wiper terminal 84 is conductively coupled to terminal 106 results in the battery supply voltage plus V1 being applied to junction 82 and to the collector of transistor Q1. The voltage applied at junction 82 is such that when applied to the biasing network coupled to the base of transitor Q2 results in a voltage level being charged on capacitor C1. After C1 charges, a bias voltage is applied to the base of transistor Q2 causing transitor Q2 to conduct. In this arrangement, current flows through the emitter to the base of transistor Q1, and through resistor R1, through the collector-emitter circuit of transitor Q2, and through diode D2 and resistor R10 to ground. Upon release of switch SW2, this conduction continues, with the emitter-collector current of transistor Q1 providing standby power for later activation of the control circuits. Resistor R3 provides a small time delay in charging capacitor C1, for preventing this charging surge from overloading transitor Q1 causing its undesired cutoff. Capacitor C1 is a stabilizing capacitor that bridges short duration voltage drops caused during engine cranking. Diode D1 is arranged for preventing discharge of capacitor C1 through other control circuits, and provides a more precise control of the function of capacitor C1. Resistors R2 and R5 provide a voltage divider for providing the appropriate bias voltage for transistor Q2, and will act as a reference voltage for the cranking timer (to be described in more detail below). Diode D2 and resistor R4 are arranged for preventing the breakdown of the base-emitter junction of transistor Q2 in the event a reverse voltage is placed on this junction. Additionally, diode D2 adds a fixed voltage drop, slightly variable with temperature, to balance the reference voltage with the crank timer voltage. Resistor R10 is a current limiter for transistors Q1 and Q2 and the crank timer. Diode D4 provides a clamping voltage level for clamping inductive surges caused by turning of the starter by the key switch. Without this clamping arrangement, starting transients would tend to drive current through capacitor C1, resistor R2, transistor Q2, diode D2, and resistor R10, which would cause the holding circuit 74 to turn on.

Enclosed within dashed block 114 is an indicator circuit including resistor R7, a portion of switch SW3, and indicator lights B1 and B2. Resistor R7 is coupled between junction point 86 and wiper terminal 116 of SW3. Indicator light B2 is coupled between terminals 118 and junction point 120, with junction 120 being coupled to ground. Bulb B1 is coupled between terminal 122 and common point 120.

The operation of the indicator circuit 114 is such that when transistor Q1 is placed in conduction, current will flow either through indicators B1 or B2 to ground depending upon the position of switch SW3. The switch SW3 is utilized also for selecting the temperature function that is being monitored for controlling the control system, as will be described in more detail below. The indicator that is lit, then, will provide a visual indication of the function for which the control system is set. Resistor R7 is a surge limiter for preventing overloading of the current conducting capabilities of transistor Q1, and results in an extended life of the indicator lights B1 and B2.

Shown enclosed within dashed block 124 is a crank timing circuit comprised of transistor Q4, resistors R6, R11, and R16, diodes D5, D7, and D9, and capacitor C2. The collector of transistor Q4 is coupled through wire 126 to common junction 98. The emitter of transistor Q4 is coupled through diode D5 to junction 102. Resistor R6 is coupled between junctions 86 and 128, with wire 130 coupling junction 128 to junction 132. Diode D7 is coupled between junctions 128 and 134, with resistor R11 coupled between junctions 132 and 134. The wiper 136 of resistor R16 is coupled to junction 134. One end of resistor R16 is coupled to junction 138. The base of transistor Q4 is coupled by wire 140 to junction 138, and the capacitor C2 couples junction 138 to ground. Diode D9 is coupled between junctions 132 and 142, with junction 142 being coupled by lead 144 to the K2-4 terminal of relay K2, the normally closed contact, and thence to the ST terminal and to the starter (see FIG. 1).

When the crank timer circuit 124 is not activated, current flowing from the collector of transistor Q1 is passed through resistor R6, and diode D9 to the normally closed contact of relay K2, and through the starter to ground. Diode D9 prevents current feedback from the starter circuit when the starter is activated by the key switch, thereby preventing any inadvertent activation of the holding circuit. When the engine is cranking under control of the control system 44, collector current flows from transistor Q1 through resistor R6, diode D7, resistor R16, for charging capacitor C2. This network is the timing circuit, with the period of time to charge capacitor C2 controlled to a great degree by variable resistor R16. It can be seen that the collector of transistor Q4 is connected through junction 98 to capacitor C1, the stabilizing capacitor of the holding circuit 74. Also, the emitter of transistor Q4 is connected through diode D5 to the junction 102 in the holding circuit. The arrangement is such that when the voltage charge of capacitor C2 approximately equals the voltage applied on the base of transistor Q2, transistor Q4 will be turned on, with current flowing through transistor Q4 through diode D5 and resistor R10 to ground. Such current flow replaces the current flow through transistor Q2 normally provided by transistor Q1, thereby causing transistor Q1 to switch off. With transistor Q1 switched off, the turnoff current through transistor Q4 will continue until both capacitors C1 and C2 are discharged. It can be seen, therefore, that if the engine fails to start during the timed period that the holding circuit 74 will be switched off and the control system 44 will be deactivated until again reinitiated by the depression of switch SW2 for resetting the holding circuit 74.

A master relay circuit is shown enclosed within dashed block 150, with the master relay circuit including relay K1 and its associated contacts, transistor Q3, resistors R8 and R9, diode D3, a portion of switch SW2, and a portion of switch SW3, and is controlled in part by the thermostatic control function circuits to ground connected to the INT terminal and the BLK terminal. In this arrangement, diode D3 is coupled between junctions 108 and 152, with the relay coil K1 also coupled to these junctions. The collector of transistor Q3 is also coupled to junction 152. Resistor R8 is coupled between terminal 104 of switch SW2 and junction point 154. Resistor R9 is coupled between junction 154 and ground. The base of transistor Q3 is coupled by wire 156 to junction 154. The emitter of transistor Q3 is coupled to junction 158, as is the BLK input terminal through wire 160. Contact 162 of switch SW3 is coupled by wire 164 to junction 158. Terminal 166 is coupled by wire 168 to junction 170, with the INT terminal coupled by wire 172 to junction 170. The normally closed contact K1-1 is coupled by wire 174 to the KS terminal. The wiper contact terminal K1-2 is coupled by wire 176 to the IG terminal. The normally open contact terminal K1-3 is coupled by wire 178 to junction 180, with junction 180 coupled to junction 46 by lead 182. Wiper terminal K1-5 is coupled by wire 184 to junction 186, with junction 186 coupled by wire 188 to the terminal SOL. Normally open contact K1-6 is coupled by wire 190 to junction 192, with wire 194 coupling junction 192 to junction 180. Wire 196 couples junction 186 to junction 198.

With the wiper of switch SW2 in contact with terminal 104, the master relay circuit 150 is under the control of the holding circuit and receives current flow from the collector of transistor Q1. With the battery supply voltage plus V1 at terminal 108, and the other terminal of relay coil K1 coupled to the junction 152 at the collector of transistor Q3, it can be seen that the operation of relay K1 will depend upon the conductive state of transistor Q3. The base of transistor Q3 is biased by the coupling to junction 154 in a manner such that when the emitter is grounded there will be conduction through the collector-emitter circuit of transistor Q3. As described in the consideration of FIG. 1, the terminals INT and BLK are under control of the interior thermal control device 42 and the block thermal control device 40, respectively. With the setting of switch SW3 as shown, either of the devices can ground the emitter of transistor Q3. That is, the control can be generated by the interior thermal control device 42 if it reaches a condition such that the grounding path is made prior to the block thermal control device 40 reaching a like conductive state. However, with switch SW3 switched to the condition wherein wiper terminal 166 is not in contact with terminal 162, it can be seen that only the terminal BLK will be conductive circuit with the emitter of transistor Q3. Therefore, only the block thermal control device 40 can control the starting of the engine. At this point, it can be pointed out, that light B2 will indicate the joint control of transistor Q3, while light B1 will indicate that the control device coupled to the BLK terminal is controlling transistor Q3. With ground applied to the BLK terminal, and transistor Q3 in a state of conduction, the voltage drop across the collector-emitter circuit of Q3 will drop such that common point 152 will be taken to a relatively more negative potential. This condition will cause current flow through the relay coil K1 and will cause the wiper contacts K1-2 and K1-5 to be switched into contact with contacts K1-3 and K1-6 respectively. Since both terminals K1-3 and K1-6 are coupled to the battery potential plus V1, the switching of the relay will cause the battery voltage to be applied out to the IG terminal and to the SOL terminal. In this arrangement, resistor R9 stabilizes the base-emitter circuit of transistor Q3, and diode D3 bypasses the coil K1 for bypassing inductive current of relay coil K1 when the circuit is turned off, thereby preventing destruction of the transistor Q3 that would result from these inductive transients.

Shown enclosed in dashed block 200 is a starter control circuit including relay K2 and its associated contacts, diodes D6, D8 and D10, and resistor R15. Diode D8 is coupled to junction 202 and 204, as is the coil of relay K2, Wire 206 couples junction 198 to junction 202. Diode D6 is coupled between junction 208 and ground, with wire 210 coupling junction 204 to junction 208. Diode D10 is coupled between junction 212 and the G1 terminal. Resistor R15 is coupled between junction 212 and the G2 terminal, with wire 214 coupling junction 212 to junction 208. Wire 216 couples wiper contact terminal K2-2 to the I-2 terminal, and wire 218 couples wiper terminal K2-5 to the ST terminal. Normally open contact terminal K2-3 is coupled by wire 220 to junction 222, with wire 224 coupling junction 192 to junction 222. Normally open contact terminal K2-6 is coupled by wire 226 to junction 222.

The starter control circuit 200, together with the crank timer circuit 124 and the master relay circuit 150 provides activation of the starter. In order for the starter control circuit 200 to be operative, it is necessary that the time delay device 24 couple to ground through terminal G1, or that the speed sensing device 60 couple to ground through the terminal G2. When relay K1 is activated, thereby switching wiper contact K1-5 into contact with normally open contact K1-6, the battery voltage plus V1 is provided on wire 196 to junction 198. This voltage applied to the relay K2, when either terminals G1 or G2 are grounded, results in the switching of the contacts associated with relay K2. This switching causes wiper terminal K2-2 to be brought into contact with normally open contact terminal K2-3, and results in battery voltage plus V1 being applied to the I-2 ignition boost terminal. Further, the terminal K2-5 is switched into contact with normally open contact K2-6, and provides the battery voltage plus V1 to energize the

starter 16 when the engine is self-running, the self-running sensor, such as magnetic switch 60, blocks the flow of current to ground flowing through coil K2. This results in relay K2 being deactivated and causes reswitching of wipers K2-2 and K2-5 back to the illustrated position. Referring briefly to FIG. 1, the magnetic switch 60 is coupled to the cable that leads from the battery 10 to the starter 16. It operates such that when a heavy current flow is directed to the starter, thereby causing a large electric field around the wire, that the switching element is switched so that cable 58 is coupled to ground. When the engine starts, and the starter is kicked out, the current flow to starter 16 reduces and permits the magnetic switch 60 to open the circuit to ground. It is of course apparent, that other speed sensing devices can be utilized. Diode D8 is a clamping diode across relay coil K2, and is arranged to dissipate the inductive voltage built up across relay coil K2 that results when the relay is deenergized. Diode D6 is a clamping diode to ground, and provides for providing current to the SOL terminal when relay K1 is deenergized. Similarly, diode D6 provides a discharge path through resistor R15 or diode D10 for any inductive circuit through which self-running condition of the engine is being sensed, for example the field of the alternator (not shown). As indicated, terminals G1 and G2 are utilized with different means of coupling to self-running sensors. Diode D10 effectively includes only the coil impedance of relay coil K2 in such a sensing circuit, while preventing feedback from circuits such as generation voltage that would cause the engine speed solenoid 36 to activate whenever there was generation if not blocked by diode D10. Terminal G2 provides only a resistive drop to limit current to sensors that require lower levels of current flow. When relay K2 is deenergized, wiper terminal K2-5 is returned to contact with normally closed contact K2-4, and couples the ST terminal to the crank timer circuit 124.

A heater control circuit is shown enclosed within dashed block 230, and includes transistor Q5, diode D11, and resistors R12, R13, and R14. As shown in FIG. 1, the REL terminal is coupled through a relay coil K to ground. Resistor R12 is coupled between common points 142 and 232, and resistor R13 is coupled between common points 232 and 234. The base of transistor Q5 is coupled to common point 232. Resistor R14 is coupled between the emitter of transistor Q5 and common point 234. Diode D11 is coupled between common point 236 and ground, with the collector of transistor Q5 also coupled to common point 236. The heater control circuit 230 is so constructed that current is provided to the external relay K only when the starter is not cranking. To accomplish this, it can be seen that resistors R12 and R13 form a voltage divider network coupled to the base of transistor Q5. Resistor R12 is coupled to the normally closed contact K2-4, and will provide a path to ground through the starter only when the relay K2 is deenergized. When relay K2 is energized, the wiper terminal K2-5 is out of contact with normally closed terminal K2-4 and results in transistor Q5 being biased off. When relay K1 is energized, relay contact K1-5 will be in contact with normally open contact terminal K1-6, and will provide the battery voltage to common point 234. This arrangement prevents the heater, or other auxiliary device that may be under control from being energized during the engine cranking, thereby inhibiting undue draining of the battery 10 of power needed for cranking the engine. The values of resistors R12 and R13 are chosen to prevent excessive reverse voltage from being applied to the base-to-emitter circuit of transistor Q5 when the starter is activated by the key switch and the terminal SOL is not activated. Resistor R14 is of a relatively low resistive value, and is used as a current limiter for preventing destruction of transistor Q5 in the instance that the terminal REL would be inadvertently grounded. Diode D11 is a clamping diode to ground, and is utilized for preventing excessive inductive voltages from being imposed on the collector junction of transistor Q5 by the coil of relay K when the circuit is deactivated.

A trend in automotive development is to reduce the unburned hydrocarbon content of exhaust. This reduction requires operating the gasoline-fueled engine with less enrichment at all speeds. The reduced enrichment in combination with changes in timing characteristics of spark and valving, results in a situation that makes starting more difficult, and when the engine does start, it may die back several times before becoming smoothly self-running. It has been recognized that these tendencies to die back during the starting operation can cause starter drive or flywheel damage if the self-run sensing system is immediately responsive to engine speed. That is, if as the engine is starting, the starter attempts to reengage while the engine is turning at too fast a rate, the starter drive assembly will tend to damage the teeth of the flywheel by failing to engage smoothly. As described in FIG. 1, this problem has been attacked by including a time delay device 24 for providing an engine slow down period in the event the engine fails to start, before the control system 44 attempts to reactivate the starter. Alternative time delay devices 24 are illustrated in FIGS. 3A and 3B, with these illustrations being in the form of schematic diagrams.

Directing attention to FIG. 3A first, it can generally be summarized that the function of the circuit is such that when the self-running sensor has switched, the circuit then stores a charge that acts as a bias to prevent restoration of the grounding circuit even after the grounding circuit is restored in the sensor. Basically, this is done by discharging a capacitor in reverse through the firing circuit of a switching semiconductor, such as a silicon controlled rectifier. In this embodiment, the time delay circuit 24 is comprised of a silicon controlled rectifier SCR1, capacitor C4, diodes D12, D13, D14, D15, and D16, and resistors R16, R17, R18, and R19. Diode D12 is coupled between the G1 terminal and common point 300, with the conductive leads of SCR1 coupled between common point 300 and common point 302. Diode D13 is coupled to the in-car charge indicator light circuit and to common point 304. Wire 306 couples common points 300 and 304 together. Resistor R16 is coupled between common points 304 and 308, with the gate lead terminal of silicon controlled rectifier SCR1 also coupled to common point 308. Resistor R17 is coupled across common points 302 and 310 with wire 312 coupling common points 308 and 310 together. Resistor R18 is coupled to common point 310 and common point 314, with diode D14 coupled between common points 314 and 316. Lead 318 couples common point 316 to ground. Capacitor C4 is coupled between common terminals 314 and 320, with lead 322 coupling common points 302 and 320 together. Diode D15 is coupled between common points 316 and 324, with diode D16 coupled between common points 324 and 326. Resistor R19 is coupled across common terminals 320 and 326. Common terminal 326 is coupled by lead 328 to the field relay KF in voltage regulator 18, and to the voltage regulator relay KV, also in the voltage regulator 18. The voltage regulator 18 is coupled at terminal 330 to plus V1, and at terminal 332 to the internal output of the alternator, and at terminal 334 to the field coil of the alternator. In this embodiment, there is shown an alternator circuit in which an external injection of current through its field circuit is used to create an initial generation once the field is rotating, and once the build up of output voltage is sufficient, a feedback from the alternator locks in the field relay KF that places battery voltage on the field regulating circuit. This closure of the field relay KF places battery voltage plus V1 between the lead 328 and ground, thereby interrupting the grounding path and causing the alternator system to act as a self-running speed sensor.

In operation, then, it can be seen that current from the starter control circuit 200 in the control system 44 (see FIG. 2) flows from terminal G1 through diode D12, and through silicon controlled rectifier SCR1. This current flows through diode D16 into the field relay unit, and through the voltage regulator 18 to the alternator field coil at terminal 334 and thence to ground. This operation assumes that SCR1 immediately conducts due to current flow through resistor R16, the gate-to-cathode circuit of SCR1, either through the path described immediately preceding, or through capacitor C4 and diode D14 to ground. When capacitor C4 is discharged, SCR1 normally fires immediately causing immediate closure of the starter control relay K2 in the starter control circuit 200.

As noted above, however, it is common for the engine to run momentarily and then die back. Should this die back occur, the battery voltage plus V1 coupled in by the field relay KF having been activated, charges capacitor C4 through resistor R19 and diode D14. When the field relay KF deenergizes, capacitor C4 discharges through resistor R17 and resistor R18, thereby acting as a voltage divider, and preventing a reverse voltage across the cathode-to-gate junction exceeding the maximum allowed value. At the same time current is flowing in a forward direction through resistor R16, branching to resistor R18 and diode D14 to ground, together with flow through resistor R17 and diode D16, the generation circuit, to ground. When the forward current through resistor R17 exceeds the reverse current through resistor R17, a voltage builds up from the gate-to-cathode of SCR1 until such time as it triggers on, thereby enabling the cranking cycle to repeat. The network comprised of resistor R19 and diode D16 is for the purpose of slightly retarding the charging of capacitor C4 when the field relay KF closes in order to maintain a field current flow while the field relay KF becomes firmly activated. In some cases, the field relay KF contacts will bounce. If the capacitor C4 were charged nearly instantaneously upon a short duration closing of the field relay contacts, followed by the field relay contacts opening due to bounce of the contacts, the time delay would take over, and could cause reengagement of the starter control circuit, and, in some cases, could prevent the generation circuit from coupling in. Diode D15 is primarily a clamping diode to provide a suppression path for the inductive discharges of the field coil in the alternator when the field relay KF opens. Diode D12 is primarily an isolation diode for preventing feedback of the in-car circuits to the starter control circuit 200 and the circuit coupled to the SOL terminal in the control system 44. In a similar manner, diode D13 provides isolation of the starter control circuit 200 through the in-car charge indicator circuit through either the ignition or accessory circuit to ground. The charge indicator circuit (not shown) normally provides the injection into the alternator field during normal use of the car to build up the alternator voltage that couples in the field relay KF.

FIG. 3B illustrates an alternative embodiment of a time delay device 24 that can be utilized with any sensing switch that results in the circuit being closed during the cranking operation and becoming opened when the engine is self-running. In this embodiment, the time delay device 24 is comprised of a silicon controlled rectifier SCR2, diode D17, capacitor C5, and resistors R20, R21, R22, and R23. In this circuit arrangement, the G1 terminal is coupled to common point 340, with the SCR conductive path being coupled between common points 340 and 342. Resistor R20 is coupled between common point 340 and common point 344, with the gate terminal of SCR2 also being coupled to common point 344. In this regard, it can be seen that resistor R20 corresponds to resistor R16 in FIG. 3A. Wire 346 couples between common points 344 and 348, with resistor R21 being coupled between common points 342 and 348. Similarly, it can be seen that resistor R21 functions in a manner similar to that of resistor R17 in FIG. 3A Resistor R22 is coupled between common terminals 348 and 350, with diode D17 being coupled between common point 350 and ground. Again, it can be seen that resistor R22 is similar in function to resistor R18, and diode D17 is similar in function to diode D14 as described in FIG. 3A. Capacitor C5 is coupled between common point 350 and common point 352, with wire 354 being coupled through vacuum switch 356 to lead 358, and thence to ground. The vacuum switch 356, or any other equivalent switching device, is such that it is normally closed, and opens the path to ground upon the engine rising in vacuum, or rising to some other sensed condition. In comparing the configuration of FIG. 3B to FIG. 3A, it can be seen that the isolation and controlled feedback elements are not required, such as diodes D12, D13 and D16, and resistor R19. In FIG. 3B, resistor R23 provides the charging path for capacitor C5 through diode D17 to ground, and resistor R23 must be of a high enough resistive value to prevent relay K2 in the starter control circuit 200 from being activated when the sensing switch 356 closes after engine die back. The time delay again results from the discharge of capacitor C5 as it controls the conduction of SCR2.

The safety switch 26 must be such that it will provide a direct grounding path for the holding circuit 74 (see FIG. 2) when the transmission is in neutral or park. The operation must be such that this grounding path is totally interrupted or blocked whenever the vehicle transmission is in an operating gear such as reverse and drive, for preventing theft of the vehicle. The switching arrangement illustrated in FIG. 1 is schematic and represents a wide variety of safety switches. It has been determined that direct electrical coupling to a mechanical switch will operate for many applications, and especially for those devices utilizing a clutch. Most vehicles utilizing automatic transmissions have a neutral switch for purposes of preventing cranking of the engine while the transmission is in one of the drive selections. Often connection can be made to this switch for controlling automatic starting.

In FIG. 4 there is shown the schematic diagram of an electronic safety switch circuit that has been found to be advantageous for use under those conditions where there is no feedback path in the in-car circuits. In this schematic diagram, the safety switch circuit is shown enclosed within dashed block 26, and includes elements such as a transistor Q6, diodes D17 and D18, and resistors R24 and R25. The S terminal from the holding circuit 74 (see FIG. 2) is coupled to common junction point 400, and the ST terminal is coupled to common junction 402. Diode D17 is coupled between junction points 400 and 402. The collector of transistor Q6 is coupled to junction point 400, and the emitter terminal is coupled to junction point 404, with junction point 404 also being coupled to ground. The base of transistor Q6 is coupled to common point 406. Resistor R24 is coupled between common points 406 and 408, with wire 410 coupling points 404 and 408 together. Resistor R25 is coupled between common points 406 and 412, with diode D18 coupled between common points 408 and 412. A portion of the key switch 414 is shown coupled by wire 416 to common point 418. Wire 420 couples common point 402 to common point 418. Wire 422 is coupled to one side of the neutral switch 424, with the other side of the neutral switch coupled by wire 426 to common point 428. Wire 430 couples common point 428 to the starter 16, and wire 432 couples common point 412 to common point 428.

In this circuit arrangement, diode D17 provides a grounding path from terminal S through the neutral switch 424 through the starter circuit 16 to ground. When the neutral switch 424 is opened, the S path to ground therethrough is interrupted providing there is no auxiliary path through the starter control circuit 200 or through the key switch 414. When the control system 44 is set for operation, and the neutral switch 424 is closed, and the starter control circuit 200 is energized, current flow through diode D17 is blocked. However, a portion of the starter current will flow to the divider network comprised of resistors R24 and R25 and will bias transistor Q6 to a level such that it will conduct. The conduction of transistor Q6 results in essentially grounding the S terminal. Diode D17 prevents starter control current from flowing through the collector circuit of transistor Q6. Diode D18 is a voltage clamp to ground, and provides a bypass path for preventing inductive discharge of the starter circuit from flowing in reverse through transistor Q6 and diode D17.

It was mentioned in the discussion of FIG. 1 that a device such as the magnetic switch 60 is utilized to sense when the engine is self-running. Various methods for sensing and detecting that the engine is self-running can be utilized. One of these methods involves sensing the output of the alternator, and deactivating the cranking control when the output from the alternator reaches a predetermined level. Such a system has the disadvantage that the engine cranking may be disengaged before the engine is truly self-running in the instance where the associated alternator has an exceptionally high output. On the other hand, for those situations where the alternator does not have the level of output expected, sensing of the output thereof would tend to have the control system attempting to hold the starter engaged even after the engine has started.

The use of the magnetic switch 60 in sensing the current flow to the starter overcomes these problems. Referring briefly to FIG. 1, it will be recalled that the magnetic switch 60 is basically a reed switch that is inserted in series with the electromagnetic field surrounding the cable leading from the battery to the starter 16 when current is provided to the starter for activating its operation. The operation of the magnetic switch 60 is such that upon energizing the starter 16 the electromagnetic field is formed, and causes the magnetic switch 60 to be closed, thereby providing a path from the G2 terminal to ground. When the starter current drops to a predetermined level, there is insufficient field to hold the magnetic switch closed and it is caused to open. The reduction in current to the starter results when there is reduced load upon the starter due to the self-running of the engine. It will be recalled from the consideration of FIG. 2 that when the G2 terminal is opened, that is the path to ground is interrupted, the starter relay K2 is deenergized and the starter control is deactivated. It is of course clear that the magnetic switch 60 requires other means, as controlled by the control device 44, for initially engaging the starter since the magnetic switch requires the electromagnetic field to be present to cause it to close. It will be recalled from above, that the time delay circuit 24 initially provides a path to ground, thereby permitting the starter control relay K2 to be activated initially. These circuits provide means for opening the path to ground based either on alternator output, or engine vacuum level. With the G1 terminal opened, the control of the disabling of the starter control circuit 200 then rests on the availability of a grounding path from the G2 terminal.

An alternative arrangement is shown in FIG. 5, which is a schematic diagram of an embodiment of an engine self-running detecting circuit utilizing the G1 terminal only. This circuit includes a silicon controlled rectifier SCR3, capacitor C6, Zener diode DZ, diode D19, resistors R26, R27, R28, and R29, and oil switch 500. These elements are used in conjunction with a magnetic switch 60 for controlling the starter 16. Resistor R26 is coupled to junction 502, and is coupled by lead 504 to diode D19, with the other terminal of diode D19 coupled to junction 506. Capacitor C6 is coupled between junctions 506 and 508, with the gate electrode of SCR3 also coupled to junction 508. Resistor R27 is coupled between junctions 508 and 510, with the silicon controlled rectifier SCR3 coupled across junctions 510 and 512. Resistor R29 is coupled between junctions 502 and 512. Junction 506 is coupled to junction 514, and junction 510 is coupled to junction 516. Resistor R28 is coupled between junctions 514 and 516, with junction 516 also being coupled to junction 518. The Zener diode DZ is coupled between junctions 518 and 514, with an oil switch 500 coupled between junction 518 and ground. The oil switch 500 is normally closed, with the circuit path being opened upon a sensed pressure rise. Wire 520 couples junction 512 to the magnetic switch 60.

In operation, then, current will flow initially from the G1 terminal through resistor R29 and silicon controlled rectifier SCR3 to the oil switch 500 and ultimately to ground. This operation will follow when SCR3 is turned on by current flow through resistor R26, diode D19 and the capacitor C6 such that the point 508 is brought to a level to bias the gate-to-cathode circuit of SCR3 to a level that will cause conduction. During this initial triggering of silicon controlled rectifier

SCR3, capacitor C6 charges to a voltage determined by the voltage regulating diode DZ, or its equivalent. The capacitor C6 will maintain this voltage during and after the cranking operation, assuming that the available voltage at the G1 terminal exceeds the regulating voltage provided by the Zener diode DZ. Only after the oil switch **500** opens does the charge on capacitor C6 discharge through resistor R28. Resistor R27 is a stabilizing resistor for the gate-to-cathode circuit of SCR3. Resistor R29 is utilized to assure that some voltage is maintained at terminal G1 when the magnetic switch **60** closes. Once the starter **16** is actuated, the magnetic switch **60** closes, and no current will flow through silicon controlled rectifier SCR3 during cranking. Further, due to the charge established on capacitor C6, no new triggering will take place, thereby completely removing any controlling influence of the oil switch **500** from the circuit.

An essential element of good performance of an automatic engine starting system is the setting and control of the throttle, especially with gasoline-fueled engines. Engines with automatic chokes usually provide the proper choking conditions for starting, providing that the throttle is preset in a position to set the choke. Manually choked carburetors normally require some fuel enrichment to provide good starting, and require some enrichment even when the engine is partially warm. The adjustment of the throttle is becoming evermore important and critical on high performance engines that are becoming evermore popular in use in that one, a great deal of choking is required on such high powered engines; two, a single high position setting of the throttle or a complete closing of the choke will cause an excessively high engine speed, thereby consuming more fuel for warmup than is required for an efficient system; three, a choke that is only allowed to partially close may be sufficient under normal starting conditions, but fail under weather and wind conditions that would tend to remove residual fuel from the manifold; four, the high idle cam in the carburetor may bind with the throttle mechanism causing locking of the throttle position and preventing any further release of the throttle system; and five, an advance speed at turnoff of many high performance engines will result in after-fire, the so-called diesel action, due to a continued inflow of fuel-enriched air that is caused to ignite by the heat of the cylinder head. In view of the foregoing, the straight pull and hold arrangement for advancing the throttle is often insufficient for a smoothly operating automatically starting system.

To overcome these problems, the circuits illustrated schematically in FIGS. 6A and 6B, these circuits being alternative embodiments, provide automatic throttle control.

FIG. 6A is a circuit that utilizes a pulser **600**, a relay K3 and its associated contacts K3-1 and K3-2, and resistor R30, as shown enclosed within dashed block **34** for representing the throttle control circuit. The solenoid **36** has a holding coil **602**, and a heavy pull coil **604**. The SOL terminal is coupled by wire **606** to common terminal **608**, with wire **610** coupling common terminal **608** to the holding coil **602**. The pulser **600** is coupled between the ST terminal and common terminal **612**, with resistor R30 being coupled across common terminals **612** and **614**. The coil of relay K3 is also coupled across common terminals **612** and **614**, with terminal **614** being coupled to ground. Wire **616** couples the normally open contact K3-2 to common terminal **608**, and wire **618** couples the wiper terminal K3-1 to the heavy pull coil **604**. The solenoid **36** is constructed with a movable sleeve **620** and a lower portion **622**. A spring **624** holds tension on the lower portion **622** tending to urge the plunger **626** upward.

The excitation of the holding coil **602** provided by the activation of the SOL terminal will result in the plunger **626** being forced downwardly against spring **624** a predetermined amount. As the starter is activated, power will be provided to the ST terminal resulting in periodic bursts of voltage through the pulser **600**. This voltage applied at the terminal **612** will cause the activation of relay K3 causing contact K3-1 to be made with terminal K3-2. This contact will apply power to coil **604** and will cause an added magnetic effect on the plunger **626** tending to provide a heavy pull thereon. The pulser **600** will remain on for a predetermined amount of time, at which time it will switch off thereby opening the contact K3-1 due to the deenergization of relay K3. This will remove the heavy pull and the spring **624** will urge the plunger **626** upwardly. The pulser **600** will continue to cycle on and off as long as power is applied to the ST terminal. By utilizing a limited travel of the solenoid, during high excitation, the operation will be to pump the carburetor with the carburetor's acceleration pump due to the repeated activation of coil **604**. The ratio of pull provided by coil **604** to that provided by coil **602** is relatively large. The function of coil **602** is to hold the solenoid in such a position that a desired idling speed is achieved. This type of configuration is particularly suited for engines that utilize a hand choking system. Of course, once power is removed from the ST terminal only the holding coil **602** will be activated, thereby providing the idle speed.

In FIG. 6B there is shown an alternative embodiment of a throttle control circuit **34**, with this circuit utilizing a circuit breaker **630** and variable resistors R31 and R32. The SOL terminal is coupled to common terminal **632**, with circuit breaker **630** coupled across common terminal **632** and **634**. Variable resistor R31 is coupled between these same common terminals, and variable resistor R32 is coupled between common terminal **634** and ground. Lead **636** couples common terminal **634** to the coil **638** of solenoid **36'**. In this embodiment, the solenoid **36'** has the plunger **640** cooperating at one end with a restraining resilient snubber **642**. This resilient snubber **642** can be constructed of rubber, or the like.

The application of voltage to the SOL terminal results in full voltage being applied through the circuit breaker **630** directly to the coil **638**, thereby causing full retraction of plunger **640** against the snubber **642**. The circuit breaker **630** is of a type that remains closed for only a predetermined amount of time. The closure of circuit breaker **630** followed by its opening is cyclical, with the circuit breaker again closing after a second predetermined time. When the circuit breaker **630** opens, the current to the coil **638** is reduced, due to the current having to flow through variable resistor R31. This reduced current flow reduces the holding effect on the plunger **640**, with the snubber acting to tend to force the plunger **640** outwardly to a slightly lower speed position. The cyclical closing of circuit breaker **630** tends to allow release of the high idle cam. Resistor R31 is of a type that is variable in its resistance dependent upon a heating change caused due to current flowing through it, and is of the type that will tend to increase its resistance with self-induced heating. Resistor R32 is also of the type that varies its resistance due to heating resulting from current running through it, but is of the type that tends to decrease its resistance due to the self-induced heating. The increase of resistance of resistor R31 at the time that the circuit breaker **630** is opened, will result in even less current being provided to coil **638** and will allow the engine idle speed to be slowed even more.

From the foregoing, it can be seen that an improved control system for automatically controlling the starting and stopping of an engine as determined by sensed exterior conditions, has been described. Additionally, circuits for enhancing the starting and idling of the engine for warmup have also been described and that time delay device has been provided for preventing starter damage due to recranking at a period too soon following the die back of an engine, and sensing circuits for disabling the control system when the engine is determined to be self-running. Further, circuits have been shown for automatically controlling throttle settings during the starting and idling periods, and an electronic safety switch has been described for assuring that the entire control system will be deactivated should the in-car selector be shifted out of the neutral or park positions.

It being understood that various modifications in arrangement, circuit component selection, circuit usage, and the like, will become apparent to those skilled in the art upon consideration of the description and drawings, without departing from the spirit and scope of the invention, what is intended to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. An automatic engine starter and temperature control system for use with an internal combustion engine having an electrical system including a battery, a voltage regulator, a coil, and a distributor, a starter coupled to the battery for cranking the engine, and a throttle linkage for controlling the speed of the engine, and gear selection apparatus, the combination including:

temperature condition sensing means for providing a first conductive path to a reference voltage in response to first sensed temperature conditions and opening said first conductive path in response to second sensed temperature conditions;

safety switch means for sensing the state of the gear selection apparatus and providing a second conductive path to a reference voltage in response to said gear selection apparatus being in first selection positions and opening said second conductive path in response to said gear selection apparatus being in second selection positions;

engine self-running sensing means for sensing when the engine is self-running and including signaling means for providing self-running indicating signals when the engine is self-running;

throttle control means for coupling to the throttle linkage for altering the position of the linkage in response to received throttle control signals;

time delay circuit means for sensing when the engine has started momentarily and has failed to remain self-running, said time delay circuit means including electronic delay control means for preventing attempting to automatically restart the engine for a predetermined period of time sufficient to allow the engine to slow substantially to a stop;

temperature conditioning means for conditioning temperature in a predetermined manner, said temperature conditioning means including activating means for receiving temperature conditioning means activating signals for causing activation of said temperature conditioning means in response thereto; and

automatic control system means for coupling to the starter and the coil, and coupled to said temperature condition sensing means, said safety switch means, said engine self-running sensing means, said throttle control means, said time delay circuit means, and said temperature conditioning means for automatically activating the starter for starting the engine when said first and second conductive paths are closed and in the absence of said self-running indicating signals, said automatic control system means including electronic crank period timer means for deactivating said control system means in the event said self-running indicating signal is not received within a predetermined period, and further including temperature conditioning means signaling means for providing said temperature conditioning means activating signals after said first conductive path is opened and said self-running indicating signal is received, and the opening of said first or second conductive paths while the engine is running causing the engine to be shut off.

2. The combination as in claim 1 wherein said automatic control system means includes electronic holding circuit means coupled to said safety switch means for providing standby power while said second conductive path is closed, said electronic holding circuit means including first switching means for setting said electronic holding circuit means to provide said standby power; first coupling means for coupling said electronic holding circuit means to said electronic crank period timer means; master circuit means including second switching means coupled to said holding circuit means, said second switching means including terminal means for providing starter signals and means for applying said throttle control signals to said throttle control means and ignition signals to said coil, said master circuit means including second coupling means coupled to said temperature condition sensing means for providing said starter signals, said throttle control signals, and said ignition signals when said first conductive path is closed; starter circuit means, including third switching means coupled to said terminal means, and including starter output means coupled to the starter for applying power thereto in response to said starter signals, and input means coupled to said self-running sensing means for interrupting said power to the starter for permitting the engine to idle in response to said self-running indicating signals; and control means coupled to said starter circuit means, said master circuit means and said electronic crank period timer means for providing said temperature conditioning means activating signals after the engine has started.

3. The combination as in claim 2 wherein said electronic holding circuit means includes voltage charge retaining means for maintaining said electronic holding circuit means in an operative condition to provide said standby power during periods of voltage fluctuation occurring during the time said starter circuit means is applying said power to the starter.

4. The combination as in claim 3 wherein said electronic crank period timer means includes further voltage charge retaining means for charging during the time the engine is being cranked, and transistor switching means coupled to said electronic holding circuit means and to said further voltage charge retaining means for switching said electronic holding circuit means off when said further voltage charge retaining means achieves a predetermined voltage level without said starter circuit means having received said self-running indicating signal.

5. The combination as in claim 4 wherein said time delay means includes switchable means for providing a controlled conductive path to a reference voltage, said controlled conductive path including normally closed sensing means for sensing when the engine has initially started and opening said controlled conductive path in response thereto; said switchable means including gate control means for controlling conduction through said switchable means; capacitor means coupled to said gate control means for storing a predetermined voltage level while said controlled conductive path is closed and preventing said switchable means from again conducting until said predetermined voltage level has been substantially discharged therefrom.

6. The combination as in claim 5 wherein said safety switch means includes switchable transistor circuit means coupled to said electronic holding circuit means for providing said second conductive path to a reference voltage for said electronic holding circuit means while said switchable transistor means is conductive and for opening said second conductive path when said switchable transistor means is nonconductive for disabling said electronic holding circuit means; conductor means for coupling said switchable transistor circuit means to the gear selection apparatus, said switchable transistor circuit means maintained conductive while the gear selection apparatus is in said first selection positions and switched nonconductive when the gear selection apparatus is in said second selection positions; and said switchable transistor circuit means including isolation means for preventing the inadvertent resetting of said electronic holding circuit means once said switchable transistor circuit means has been rendered nonconductive.

7. The combination as in claim 6 wherein said engine self-running sensing means includes magnetic switch means coupled to the starter for sensing starter current through coupling to the electromagnetic field generated by said current, said magnetic switch means responsive to a predetermined level of said electromagnetic field for holding said magnetic switch means closed for completing a conductive path to a reference voltage, said magnetic switch means including means spring-biased to open in the absence of said predetermined level of electromagnetic field, the opening of said magnetic switch

means opening said conductive path for providing said self-running indicating signals.

8. The combination as in claim 4 wherein said throttle control means includes solenoid means having at least one coil means and plunger means coupled to said coil means, said plunger means for coupling to the throttle linkage; and current flow interrupter means coupled between said master circuit means and said coil means, said current flow interrupter means providing intermittent pulses of current to said coil means in response to received throttle control signals for moving said plunger means and the throttle linkage.

9. The combination as in claim 8 wherein said solenoid means further includes holding coil means coupled to said plunger means and connected to said master circuit means for receiving said throttle control signals and applying holding force on said plunger means, said solenoid means including spring means for urging said plunger means in a direction opposite that urged by current flow in said coil means and said holding coil means.

10. The combination as in claim 8 wherein said solenoid means includes resilient means in cooperation with the end of said plunger means for urging said plunger means in a direction opposite that urged by current applied to said coil means.

11. For use in an engine starting and temperature control system, automatic control apparatus comprising:

electronic holding circuit means for providing standby power, said electronic holding circuit means including first terminal means for receiving safety disabling signals for disabling said electronic holding circuit, said electronic holding circuit means further including first switching means for setting said electronic holding circuit means to provide said standby power;

master circuit means, including second switching means coupled to said electronic holding circuit means, said master circuit means including temperature condition terminal means for receiving indications of activating temperature conditions for activating said master circuit means, said master circuit means including output terminal means for providing throttle control signals, ignition control signals, and starter activation signals in response to said activating temperature conditions, and for removing said throttle signals and said ignition control signals in the absence of said activating temperature conditions; and

starter circuit means, including third switching means coupled to said output terminal means for receiving said starter activation signals, and including starter output signal means for coupling power to the starter in response to said starter activation signals, and self-running input terminal means for receiving signals indicative that the engine is self-running, said third switching means arranged for terminating the delivery of said power at said starter output signal means for allowing the engine to idle.

12. The apparatus as in claim 11 wherein said electronic holding circuit means includes voltage charge retaining means for maintaining said electronic holding circuit means in an operative condition to provide said standby power during periods of voltage fluctuation occurring during the time said starter circuit means is applying said power to the starter.

13. The apparatus as in claim 11 and further including electronic crank period timer means coupled to said electronic holding circuit means and said starter circuit means for deactivating said electronic holding circuit means in the event the signal indicative that the engine is self-running is not received within a predetermined time period.

14. The apparatus as in claim 13 wherein said electronic crank period timer means includes further voltage charge retaining means for charging during the time the engine is being cranked, and transistor switching means coupled to said electronic holding circuit means and to said further voltage charge retaining means for switching said electronic holding circuit means off when said further voltage charge retaining means achieves a predetermined voltage level without said starter circuit means having received said signal indicative that the engine is self-running.

15. The apparatus as in claim 13 and further including temperature conditioner control means coupled to said master circuit means, said starter circuit means, and said electronic crank period timer means for providing temperature conditioner activating signals after the engine has started.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,569,724 **Dated** March 9, 1971

Inventor(s) ANDREW KUEHN, III

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 49 "spaced" should be --space--.

Column 4, line 29 "thermal" should be --terminal

Signed and sealed this 15th day of June 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents