

[54] **STARTER LOCK-OUT CIRCUIT**

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[51] Int. Cl. **F02n 11/08**

[58] Field of Search **290/37, 38, 36; 123/179 B**

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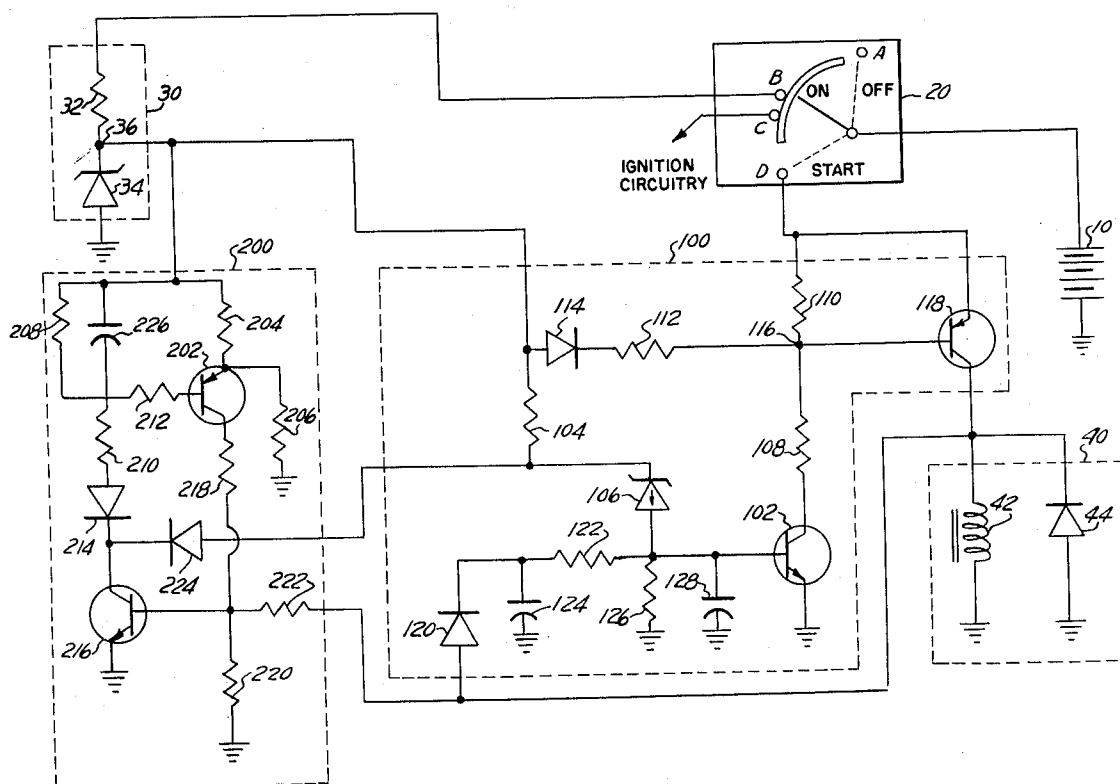
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[57] **ABSTRACT**

An electrical starting system for an internal combustion engine that includes solid-state control devices that are responsive to a first start attempt to prevent the re-energization of the electromechanical cranking system until a manually operated ignition switch is moved to the off position for a predetermined period of time. The starting system further includes a delay circuit to prevent premature starter lock-out due to momentary loss of electrical power due to switch bounce.

6 Claims, 2 Drawing Figures



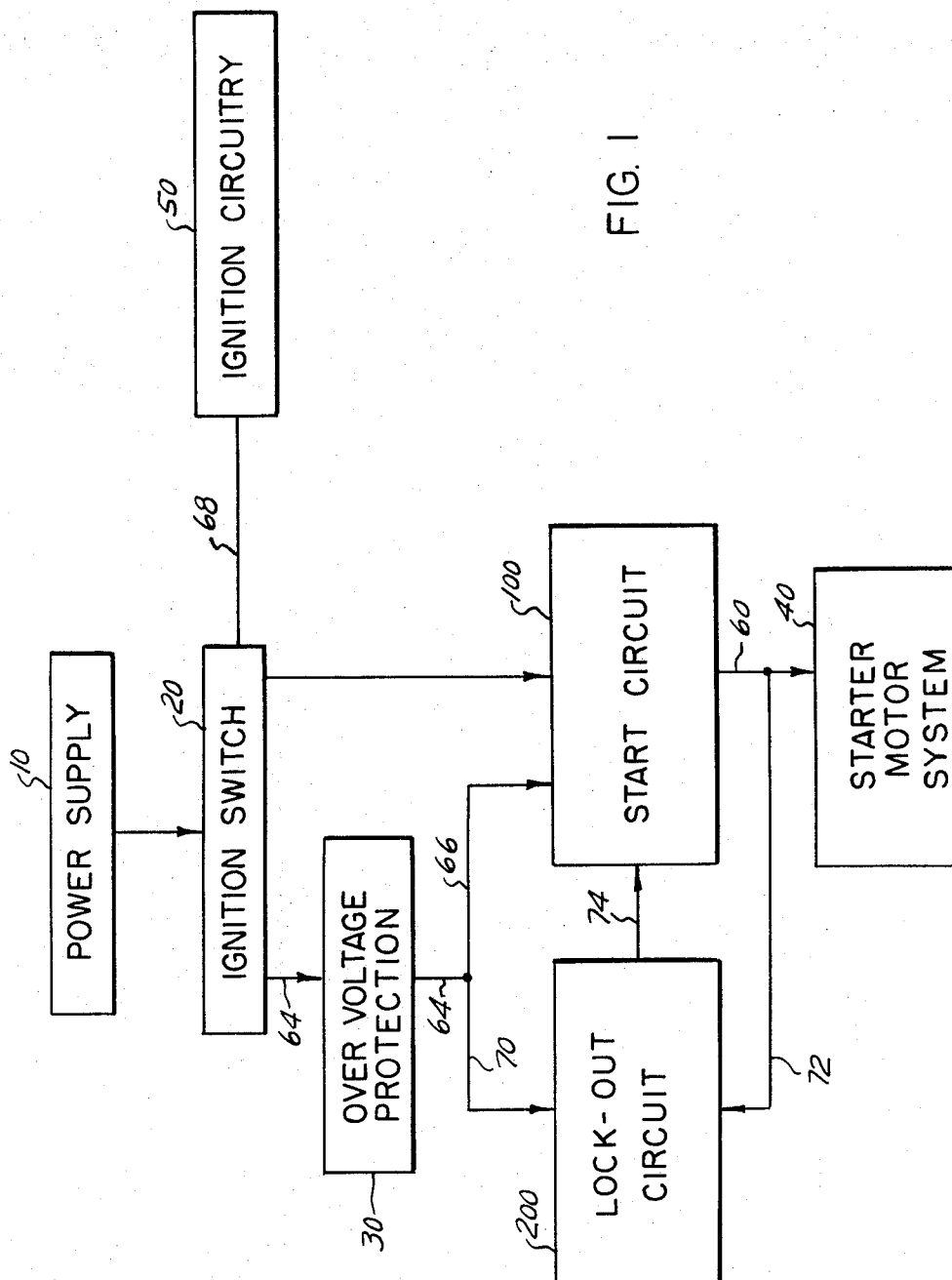


FIG. 1

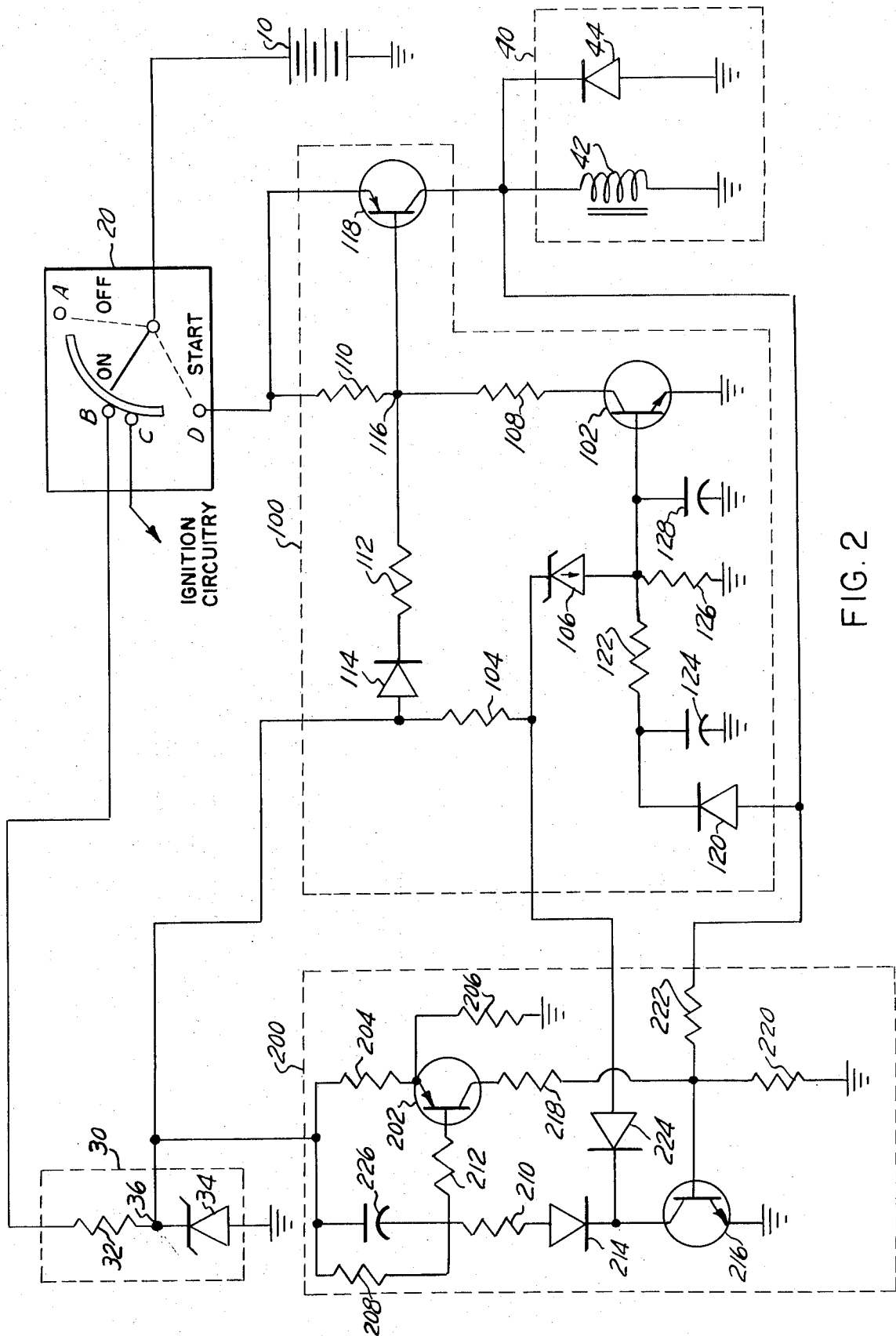


FIG. 2

STARTER LOCK-OUT CIRCUIT**BACKGROUND OF THE INVENTION**

This invention relates to an electric starting system for cranking an internal combustion engine of the type having a battery, a starter motor, a starter solenoid and an ignition switch for connecting the battery to the starter solenoid, which when energized, sequentially couples the starter motor to the engine and connects the battery to the starter motor to crank the engine. In some type of starter systems, it is recognized that the starter motor is coupled to the engine by mechanical means when the starter motor is energized by the battery and starter solenoids are not required. The invention is particularly related to an improved electrical starter lock-out system that prevents the starter motor from being energized when the engine or prime mover is in operation or for a predetermined time after an unsuccessful attempt to start the engine has been made, to allow both the starter motor and the engine to stop. The system further incorporates a delay circuit, which prevents the activation of the lock-out system for a predetermined period of time to accommodate for switch bounce which often occurs when the ignition switch is placed in the start position.

It has been a long standing problem to prevent the coupling of an electrical starter motor to an internal combustion engine when any of the aforementioned occurs so as to protect, the engine, starter motor and/or associated gears from damage. For instance, if the starter motor is operated while the engine is running, elements of the starter assembly, and particularly the gears may be damaged. Further, even if the engine is not operating and the electrical motor is not coupled to the engine, damage could result to the starter motor, engines and/or gears if an attempt is made to restart the starter (and engage gears) while the motor is still rotating from a previous start attempt.

Up to the present time, starter system designs were directed at preventing the operation of the starter system while the engine was operating or for a predetermined time after an unsuccessful start attempt was made. The former is evidenced by prior art reliance upon control signals associated with the engine, i.e., oil pressure, generator or alternator output and/or engine rotation. More recently, attention has been directed to the latter restart problem as is evidenced by some of the more recent prior art (U.S. Pat. Nos. 3,543,039 and 3,629,598) which show delay circuits which prohibit energizing the starter for a predeterminable time after an unsuccessful start attempt. These systems, however, are subject to premature starter lock-out due to switch bounce of conventional ignition switches. Switch bounce is a momentary breaking of the electrical contact in the ignition switch as the switch wiper moves from its point of initial contact with the stationary terminal to its final resting place, and often is of sufficient duration to appear to the lockout circuit as a termination of the start cycle. Switch bounce is an intermittent phenomenon, depending on the design of the switch, the age of the switch, and the operator, however, its occurrence is sufficiently frequent to be a nuisance.

SUMMARY OF THE INVENTION

The disclosed starter lock-out system is an electronic circuit used in combination with the manually operated ignition switch for preventing the energizing of the

electrical starter system for an internal combustion engine under all undesirable conditions, especially under restart after an unsuccessful start attempt. Further, the system is insensitive to momentary loss of electrical power due to switch bounce during actuation of the ignition switch, which in the prior art systems often resulted in premature starter lock-out.

The electrical starter lock-out system is characterized by the fact that it remembers a successful attempt to start the engine and prevents re-energizing of the starter system until the engine has been stopped by turning the ignition switch to the off position; that it remembers a prior unsuccessful starting attempt and prevents the re-energizing of the starter system until the ignition switch is moved to the off position for a predetermined time; and that it is insensitive to a momentary loss of electrical power due to switch bounce during actuation of the ignition switch.

The starter lock-out circuit consists of a pair of interconnected electronic latches which are responsive to each other and the position of the ignition switch. The first electronic latch responds to the unlatched condition of the second electronic latch and the placing of the ignition switch in the START position and latches in a conductive state supplying electrical current to the electromechanical cranking system of the engine until the ignition switch is removed from the START position. The second electronic latch responds to the conduction of the first electronic latch, and latches in a conductive state which prevents a subsequent reoccurrence of the conductive state of the first electronic latch until the ignition switch is returned to the OFF position. The first electronic latch further includes a momentary hold system which holds the first electronic latch in the conductive state due to a momentary loss of conductance due to switch bounce occasioned by placing the ignition switch to the START position. The second electronic latch has a comparable hold circuit which holds the second electronic latch in the conductive state for a predetermined time after the ignition switch is placed in the OFF position.

The electrical starting system comprises the following elements: (1) a storage battery providing the required electrical power, (2) a manually operated ignition switch having an OFF, ON, and START position, (3) a starter motor including means for engaging the starter motor with the engine, (4) a first electronic latch supplying battery power to the starter motor, and (5) a second electronic latch controlling the conductance of the first electronic latch.

The starter lock-out system is designed to operate independent of engine sensors or signal inputs from the engine, the alternator, or any other engine driven source of electrical power. Therefore, the inventive starter lock-out system can be retrofitted into existing or new internal combustion engine systems without modification of existing hardware or the installation of additional sensors.

Accordingly, it is an object of this invention to provide an electrical starter lock-out system for internal combustion engines to prevent actuation of the starter motor when the engine is running.

Another objective is to provide a starter lock-out system which prevents the actuation of the starter motor for a predetermined time after an unsuccessful start attempt.

It is another objective of the invention to provide a system which prevents the re-energizing of the starter motor until the ignition switch is placed in the OFF position of a predetermined period of time.

It is still another objective of the invention to provide a starter lock-out system which prevents premature starter lock-out due to switch bounce during actuation of the ignition switch to the START position.

Finally, it is an object of this invention to provide a starter lock-out system, which can be retrofitted into new and existing internal combustion engine systems without modification of existing hardware or the addition of new engine sensors.

The above and other objectives and features of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawings and claims which form a part of the specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a preferred embodiment of the control system for an internal combustion engine electrical starting system.

FIG. 2 is a schematic diagram of a preferred embodiment of the control circuitry for an internal combustion engine electric starting system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawing, FIG. 1 illustrates a block diagram for an internal combustion engine starting system which utilizes the principles of the invention. A power supply 10 supplies electrical power to the starter motor system 40, the ignition circuitry 50, to the start circuit 100 and lock-out circuit 200 through an ignition switch 20. An over-voltage protection circuit 30 is interposed between the ignition switch 20 and the starter circuit 100 and the lock-out circuit 200 to protect these circuits from any high voltage pulses which may occur across the power supply 10. The start circuit 100 supplies electrical current to the starter motor system 40 by means of lead 60 when electrical power is simultaneously applied to the start circuit 100 from the ignition switch 20 by means of lead 62 and leads 64 and 66, after having passed through the over-voltage protection circuit 30. The start circuit 100 is operative to continue to supply electrical current to the starter motor system as long as ignition switch 20 provides uninterrupted battery power to the start circuit 100 by means of lead 62. Battery power is also applied to the ignition circuit 50 from the ignition switch 20 by means of lead 68.

The lock-out circuit 200 receives battery power from the ignition switch 20 by means of leads 64 and 70 through the over-voltage protection circuit 30. Conduction of the start circuit 100 supplies current to the starter motor system 40 and also communicates a signal to the lock-out circuit 200 by means of lead 72. The lock-out circuit 200 upon receipt of a signal that current has been supplied to the starter motor system, generates a lock-out signal communicated to the start circuit 100 by means of lead 74, which prevents the start circuit 100 from resupplying electrical current to the starter motor system after the battery power on lead 62 has been removed from the start circuit by switch 20. The lock-out circuit 200 is operative to continue to generate the lock-out signal after the first receipt of a

signal on lead 72, indicative that current has been supplied to the starter motor system, until battery power to the lock-out circuit on lead 70 has been removed by the ignition switch 20. Removal of battery power from the lock-out circuit 200 terminates the lock-out signal on lead 74 and both the start circuit and lock-out circuit return to their initial state, after a predetermined period of time.

It is to be noted that the start circuit 100 and the lock-out circuit 200 do not require signals from external sensors or the engine driven source of electrical power in order to prevent current from being resupplied to the starter motor system, after either a successful or unsuccessful start attempt. Therefore, the starter lock-out system of this invention can be retrofitted into new and existing internal combustion engine systems without modification of existing hardware or the addition of new sensors.

Referring now to the drawing, FIG. 2 is a schematic of a preferred embodiment of the starter lock-out system. The system is powered by the electrical system of the internal combustion engine illustrated as a battery 10 having one terminal connected to a common connector illustrated as a ground terminal. The other terminal of the battery is connected to an ignition switch illustrated as a 3 position 4 contact mechanical switch 20. The three positions of switch 20 are the OFF position in which electrical power from battery 10 is connected to contact A only, which serves no function in relation to the inventive starter lock-out system; the ON position in which the electrical power is supplied to contacts B and C as illustrated in FIG. 2, and the START position in which the electrical power is supplied to contacts B, C, and D. Contact C provides power to the internal combustion engine's ignition circuitry as noted. Contact B is connected to an over-voltage protection circuit 30 consisting of resistance 32 and Zener diode 34 serially connected to ground protecting the starter lock-out circuit from high voltage pulses which occur in the electrical system of the engine. Under normal operating conditions, the voltage drop across resistance 32 is negligible and the voltage across Zener diode 34 is too low to initiate conduction. The starter circuit indicated by the dashed line 100 and the starter lock-out circuit indicated by the dashed line 200 derive electrical power from the battery 10 through contact B of the switch 20 and from the junction 36 between resistance 32 and the Zener diode 34. Electrical power from battery 10 is also supplied to the starter circuit 100 from contact D of switch 20.

Referring to starter circuit 100 electrical power from junction 36 is communicated to the base of transistor 102 through resistance 104 and zener diode 106. The emitter of transistor 102 is connected to ground while the collector of transistor 102 is connected to contact D of switch 20 through resistance 108 and 110 and to junction 36 through resistances 108 and 112 and diode 114. The junction 116 of resistances 108, 110 and 112 is connected to the base of transistor 118. The emitter of transistor 118 is connected to contact D of switch 20 and the collector of transistor 118 is connected to the starter system of the internal combustion engine illustrated as a coil 42. The coil 42 may be the starter relay as used in earlier starter motor systems or the starter solenoid as used in many of the more contemporary systems. The collector of transistor 118 is also connected to the base of transistor 102 through diode 120

and resistance 122. Capacitance 124 connected between the junction of diode 120 and resistance 122 and ground and resistance 126 connected between the opposite end of resistance 122 and ground, in combination with resistance 122, forms an RC delay network maintaining a positive potential at the base of transistor 102 for a predetermined period of time after transistor 118 ceases to provide electrical power to coil 42 normally caused by the removal of battery power from contact D of switch 20. The RC delay network of capacitance 124 and resistance 122 including the base to emitter resistance of transistor 102 renders the starter circuit insensitive to momentary loss of conductance by transistor 118 due to switch bounce and is one of the key features of this system. Capacitance 128 connected between the base of transistor 102 and ground functions, in combination with capacitance 124 and resistance 122 as a π type surge filter to prevent the short electrical pulse transmitted by junction capacitance of transistor 118 in the OFF or "nonconducting state" when battery power is applied to the emitter of transistor 118 from contact D of switch 20, from actuating or turning ON transistor 102.

Referring to the lock-out circuit 200 electrical power from junction 36 is communicated to the emitter of transistor 202 from the junction of voltage divider network formed by the serially connected resistance 204 and 206 connecting junction to ground. Serial resistances 208 and 210 form a second voltage divider network to supply electrical power to the base of transistor 202 through resistance 212 connecting the junction of resistances 208 and 210 to the base of transistor 202. The terminal end of the series resistances 208 and 210 are connected to ground through diode 214 and transistor 216. The collector of transistor 202 is connected to the base of transistor 216 through resistance 218 and to ground through the series combination of resistances 218 and 220. Further, the base of transistor 216 is connected to the collector of transistor 118 in starter circuit 100 by resistance 222. The collector of transistor 216 is also connected to the junction of resistance 104 and zener diode 106 in the starter circuit 100 by means of diode 224. Capacitance 226 is connected in parallel with resistance 208 to form in combination with resistances 204, 208 and 212 and the emitter to base resistance of transistor 202 an RC network maintaining transistor 202 in its ON or conductive state for a predetermined time after electrical power has been terminated at junction 36 by turning switch 20 to the OFF position.

Diode 44 in the starter motor system 40 is connected in parallel with the coil 42 to dissipate the inductive spike of the coil when the coil is de-energized.

OPERATION

Referring to FIG. 2, the starter lock-out circuit operates as follows.

Mechanical Switch Moved to ON Position

Placing the mechanical switch 20 in the ON position applies battery power to contact B which is connected to junction 36 in the overvoltage protective circuit 30. Current flows from junction 36 through resistance 104 and diode 106 establishing a base to emitter current in diode 102 sufficient to turn transistor 102 partially ON. Current also flows from junction 36 through diode 114 and resistances 112 and 108 providing a collector cur-

rent for transistor 102. In the absence of power applied to contact D of switch 20, transistor 118 cannot conduct electrical current to the base of transistor 216. With transistor 216 in its blocked or OFF state, the potential applied to the base of transistor 202 through resistances 208 and 212 is higher than the potential communicated to the emitter of transistor 202 by the voltage divider consisting of resistance 204 and 206, thereby blocking the conductance of transistor 202 and preventing capacitance 226 from charging.

Mechanical Switch Moved to START Position

Moving the mechanical switch 20 to the START position maintains the application of battery power to contact B and applies battery power to contact D. The battery power applied to the emitter of transistor 118 from contact D causes transistor 118 to conduct and supply battery power to the coil 42 which is operative to apply electrical power to the starter motor system of the engine and supplies electrical current to the base of transistor 102 through diode 120 and resistance 122, and current to the base of transistor 216 in the lock-out circuit 200 through resistance 222.

Referring to the starter circuit 100, the current flowing through diode 120 charges capacitance 124 and supplies through resistance 122 base current to transistor 102 sufficient to turn it fully ON providing a high conductance path for the emitter to base current of transistor 118 through resistance 108. This combination effectively forms an electronic latch which is a distinctive feature of this invention, and holds transistor 118 in the conductive state dependent only upon the continued application of battery power to contact D. Capacitance 124, resistance 122 and the base to emitter resistance of transistor 102 form an RC time delay network which continues to provide base current to transistor 102 in event of a momentary break in the application of battery power to contact D and transistor 118 which would ordinarily unlatch this circuit as will be discussed hereafter. The value of the capacitance 124 and resistance 122 are selected so that a base current to transistor 102 sufficient to hold transistor 102 in the conductive or ON state is maintained for a period of approximately 10 ms after power to contact D is terminated. Therefore, momentary loss of power due to switch bounce of ignition switch 20 will not unlatch the starter circuit and result in premature starter lock-out.

Referring to lock-out circuit 200, current supplied to the base of transistor 216 through resistance 222 when transistor 118 in the starter circuit 100 is conducting turns transistor 216 ON. Conduction of transistor 216 effectively grounds by means of diode 224 the junction between resistance 104 and diode 106 of the starter circuit 100 making the latching circuit of circuit 100 completely dependent upon the continued application of battery power to contact D. Conductance of transistor 216 and diode 214 also effectively grounds the associated end of resistance 210 permitting emitter to base current to flow through transistor 202 causing transistor 202 to go into its conductance or ON state. Collector current flowing through transistor 202 is supplied to the base of transistor 216 through resistance 218 effectively latching both transistors 202 and 216 in their conductive state independent of the current supplied to the base of transistor 216 from transistor 118 in the starter circuit 100. Because the conductance of transistor 216 effectively interrupts the base current to tran-

sistor 102 in the starter circuit from junction 36, the latching of transistors 202 and 216 effectively locks-out the re-energizing of starter circuit 100 after it has been unlatched by the termination of battery power to contact D for a period of time exceeding the time constant of the RC delay network in base of transistor 102 as discussed above. Transistors 202 and 216 remain in their latched condition as long as battery power is applied to junction 36 through contact B of the ignition switch 20. Conductance of transistor 216 and the forward biasing of diode 214 also provides a current path for the voltage divider network consisting of resistance 208, paralleled by the resistances 204 and 212 and including the emitter to base current of transistor 202, and in series with resistance 210, to ground. Current flowing through the voltage divider network, causes a potential difference to be established across capacitance 226 causing it to charge to a potential equal to the potential drop across the parallel resistance 208. The latching feature of the lock-out circuit differentiates the system of this invention from the prior art because the latching in the lock-out state is independent of external engine sensors or signals from the engine driven electrical power supplies.

Return of Manual Switch to ON Position

The return of the manual switch to the ON position after either a successful or unsuccessful start attempt removes battery power from contact D causing transistor 118 to be turned OFF. After the predetermined time period, established by capacitance 124 and resistance 122, current flow to the base of transistor 102 is terminated turning transistor 102 OFF effectively opening the current path connected to the base of transistor 118. The termination of base current flow in both transistors 102 and 118 unlatches the electronic latch of the starter circuit 100 and the starter circuit remains insensitive to the reapplication of battery power to transistor 118 through contact D as long as transistor 216 in lock-out circuit 200 remains latched in its conductive state effectively grounding the junction between resistance 104 and diode 106 preventing base current from flowing to transistor 102 from junction 36. The turning off of transistor 118 also terminates current flow to the base of transistor 216 from the collector of transistor 118, however, current flow through transistor 202 continues to supply base current to transistor 216 maintaining the lock-out circuit 200 in the latched state with transistor 216 conducting and capacitance 226 fully charged. The lock-out circuit 200 remains in this latched state as long as battery power is supplied to contact B of the ignition switch 20.

Manual Switch Returned to START Position

Return of the manual ignition switch 20 to the START position reapplies battery power to contact D and the emitter of transistor 118. Because transistor 102 is OFF or in its nonconducting state forming a high impedance to the flow of base current in transistor 118, transistor 118 will remain in its OFF state preventing the application of power to relay 42. Due to the junction capacitance of transistor 118, the application of power to transistor 118 will produce a small current pulse at the collector of transistor 118, capable of turning transistor 102 on. However, the π filter consisting of capacitances 124 and 128 and resistor 122 is sufficient to buffer this current pulse before it reaches the

base of transistor 102. Therefore, transistor 102 remains in its OFF state and the starter circuit remains unlatched. The lock-out circuit 200 is not affected by turning the ignition switch 20 to the START position and remains in its latched state preventing the starter circuit 100 from supplying battery power to the coil 42.

Mechanical Switch Turned to the OFF Position

Placing the mechanical ignition switch to the OFF position removes battery power from the start circuit 100 and the lock-out circuit 200. Referring to the lock-out circuit 200, removal of battery power causes capacitor 226 to start to discharge through resistance 208 and resistances 204 and 212 including the emitter to base resistance of transistor 202. This forward biases transistor 202 until the charge on capacitance 226 decays to a potential insufficient to keep transistor 202 in its forward biased state, and provides that if power is reapplied to the lock-out circuit 200 while transistor 202 is forward biased, base current to transistor 216 will be resumed keeping the lock-out circuit in its latched state. When transistor 202 ceases to be forward biased, lock-out circuit 200 resets to its initial unlatched state. The capacitance 226 and the resistances 204, 208 and 212 are selected to maintain the lock-out circuit in its latched state for a period of approximately 2 seconds or longer.

Reapplication of battery power to junction 36 by turning the ignition switch to the ON position prior to the time the lock-out circuit has reset itself to its initial state and with transistor 216 still in a conducting state maintains the lock-out circuit in its latched state, holds the latching circuit of the starter circuit in the unlatched state and recharges capacitance 226 to its maximum value.

In order to restart the engine, the ignition switch must remain in the OFF position for a time equal to or greater than the time required for the engine, the starter motor and/or gears to come to rest from a previous start or unsuccessful start attempt. Once the mechanical ignition switch has been in the OFF position for the proper interval determined by the RC network, the switch 20 can be returned to the START position and the engine cranked once again.

What is claimed is:

1. In combination with an electric starting system for cranking an internal combustion engine of the type having a battery providing electrical power; and electromechanical cranking system including a starter motor and means for engaging the starter motor with the engine; and a mechanical switch disconnecting the battery from circuit relationship with the cranking system in a first position and connecting the battery in circuit relationship with said cranking system providing a current flow in a second position, said cranking system in response to the current flow couples the starter motor to the engine and subsequently applies power to the starter motor, the improvement comprising:

bistable means having solid state components receiving electrical power from said battery independent of said mechanical switch for switching from an initial state to a lock-out signal generating second state in response to a signal indicative of a current flow to the cranking system, said bistable means operative to remain in said second state as long as said electrical power is received and for a predeter-

minable time after the removal of the electrical power from the bistable means; and
 a start control circuit electrically disposed between the mechanical switch and the cranking system for controlling the current flow to the cranking system, said start control circuit having at least one transistor switch, said transistor switch having an initial ON state permitting an initial current flow to said cranking system when said mechanical switch is in said second position and an OFF state inhibiting said current flow, said start control circuit operative to switch said at least one transistor switch to said OFF state in response to said lock-out signal after said initial current flow to the cranking system is terminated.

2. The combination as recited in claim 1 wherein the movement of said mechanical switch to said second position may cause a momentary termination of current flow through said mechanical switch due to switch bounce, said start control circuit further includes means for keeping said at least one transistor switch in said ON state during said momentary termination of current flow due to said switch bounce.

3. The combination as recited in claim 2 wherein said at least one transistor switch is an electronic latch consisting of a first transistor switch in circuit relationship with a second transistor switch wherein said first transistor switch in its ON state places said second transistor switch in its ON state, and the current flow of said second transistor switch in its ON state responding to application of electrical power to said second transistor switch when said mechanical switch is placed in said second position, holds said first transistor switch in its ON state and said electronic latch remaining in said ON state with said first transistor switch and said second transistor switch in their respective ON state until said first transistor switch is switched to its OFF state in response to said lock out signal and the termination of current flow through said second transistor switch and wherein said means for keeping is an RC network providing a current flow to said first transistor switch for a predetermined time after the termination of current flow through said second transistor switch.

4. The combination as recited in claim 3 wherein said bistable means comprises a first transistor switch in circuit relationship with a second transistor switch, wherein said first transistor switch in its ON state places said second transistor switch in its ON state and the

conductance of said second transistor switch in its ON state, responding to said signal indicative of a current flow in said start control circuit, places said first transistor switch in its ON state forming a latched state, and said electronic latch remaining in latched state until said first transistor switch is switched to its OFF state by disconnecting said lock-out circuit from circuit relationship with said battery said second electronic latch further including an RC network providing current flow to said first transistor switch for a predeterminable period of time after said electrical power is removed from said second electronic latch.

5. An electric starting system for cranking the engine of a motor vehicle comprising:

a storage battery for providing electrical power;
 a manually operable switch having an OFF, ON, and START position, in circuit relationship with said battery;

a starter motor including means for engaging said starter motor with said engine;

latch means having solid state control devices connected between said switch and said starter motor having a first state, providing electrical power to said starter motor when said switch is in said START position and operative to switch to a second state terminating electrical power to said motor in response to a lock-out signal and the termination of electrical power to the starter motor; and

lockout means having solid state control means for generating a lockout signal in response to said latch means providing electrical power to said starter motor, said lockout means operative to generate said lockout signal with said switch in said ON and said START position, and a predetermined time after said switch is placed in said OFF position, said lockout signal operative to inhibit said latch means switching from said second state to said first state.

6. The starter system as claimed in claim 5 wherein the movement of said switch to said START position may cause a momentary termination of electrical power to said starter motor by said switch in said START position due to switch bounce, said latch means further includes means for preventing said latch means from switching to said second state for a predetermined period of time after the occurrence of said loss of electrical power.

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