

[54] ENGINE STARTER CONTROL SYSTEM

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

[58] Field of Search..... **123/179 B, 179 BG, 198 D, 123/198 DC; 290/37 R, 38**

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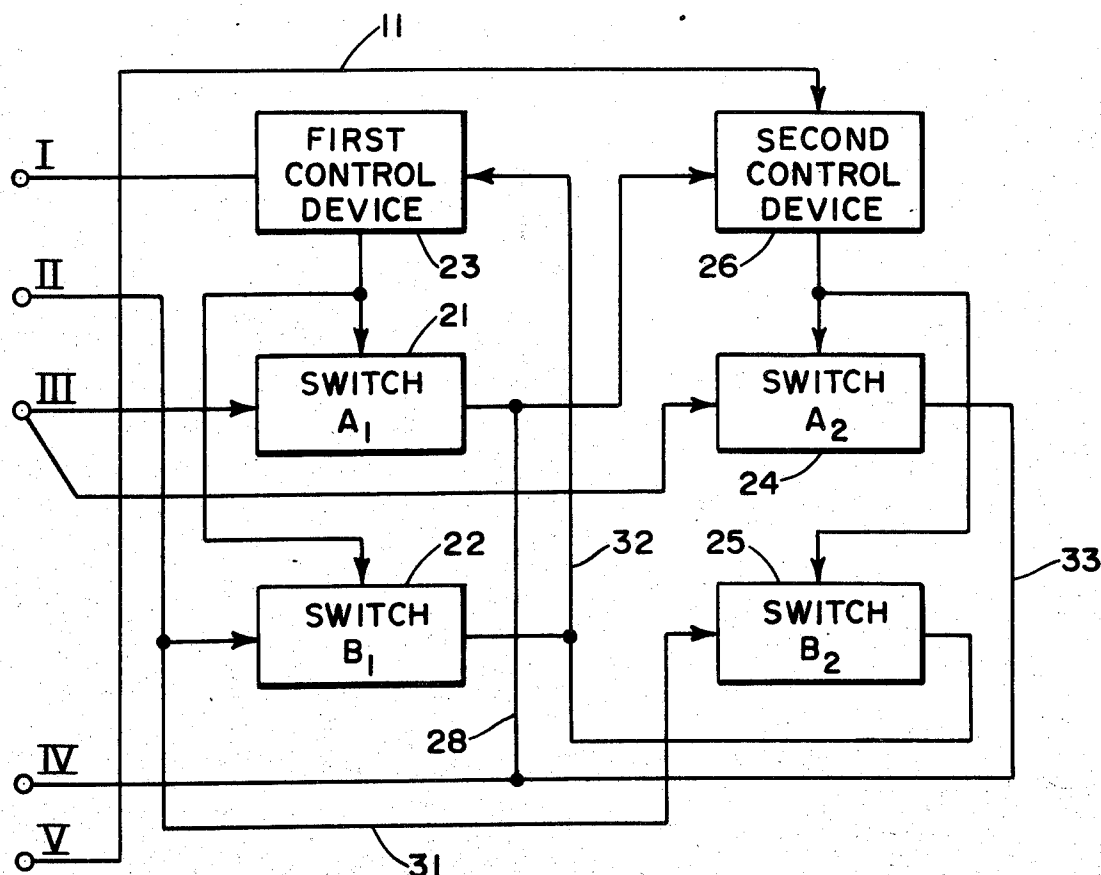
Attorney, Agent, or Firm—Robert T. Dunn

[57]

ABSTRACT

An electrical starting system for an internal combustion engine feeds electric power from the ignition switch to the engine starter motor solenoid. When the ignition switch is switched from the ignition position to the ignition-start position and if the engine does not start, the starter motor can not be energized again until the ignition switch is returned to the "off" position. If the engine starts the starter is automatically disconnected. The system includes two separate pairs of ganged switches, each pair of responsive to a different control such that one switch in each pair upon switching from one state to another holds its associated control to maintain that state and a change of state of each control is initiated by one of the switches associated with the other control.

13 Claims, 6 Drawing Figures



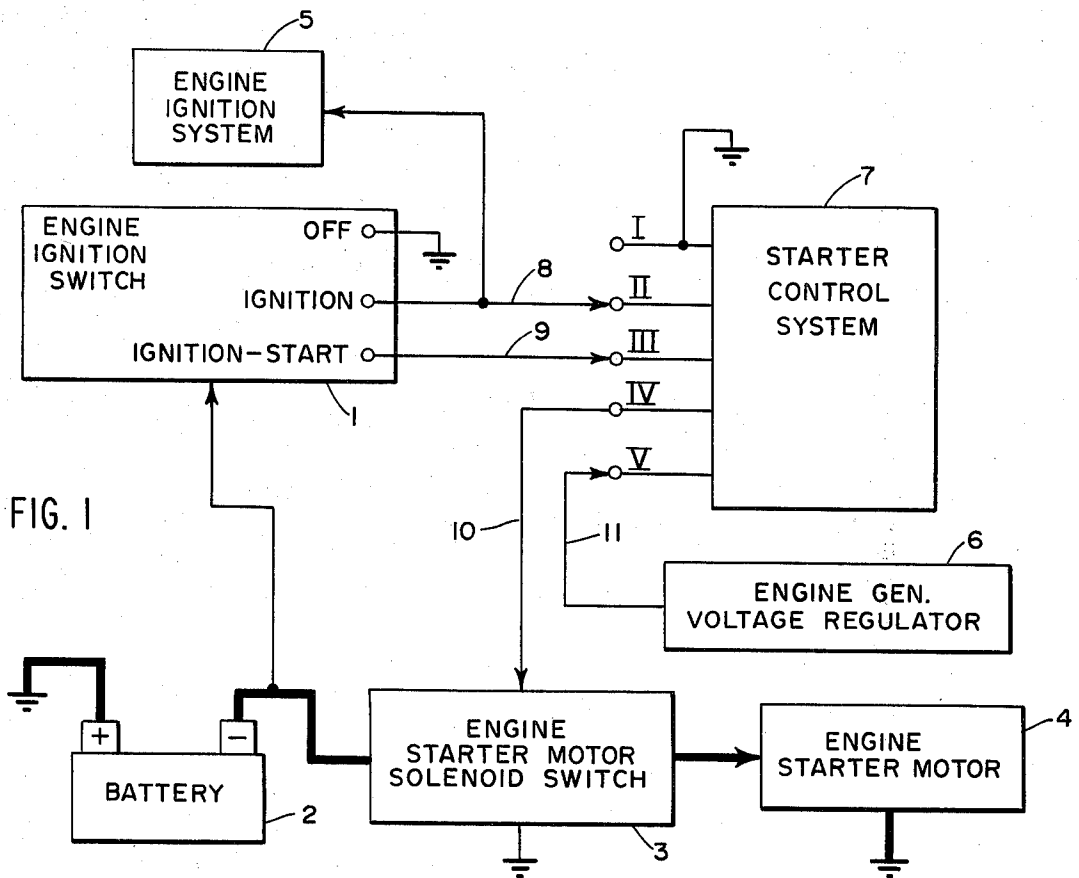
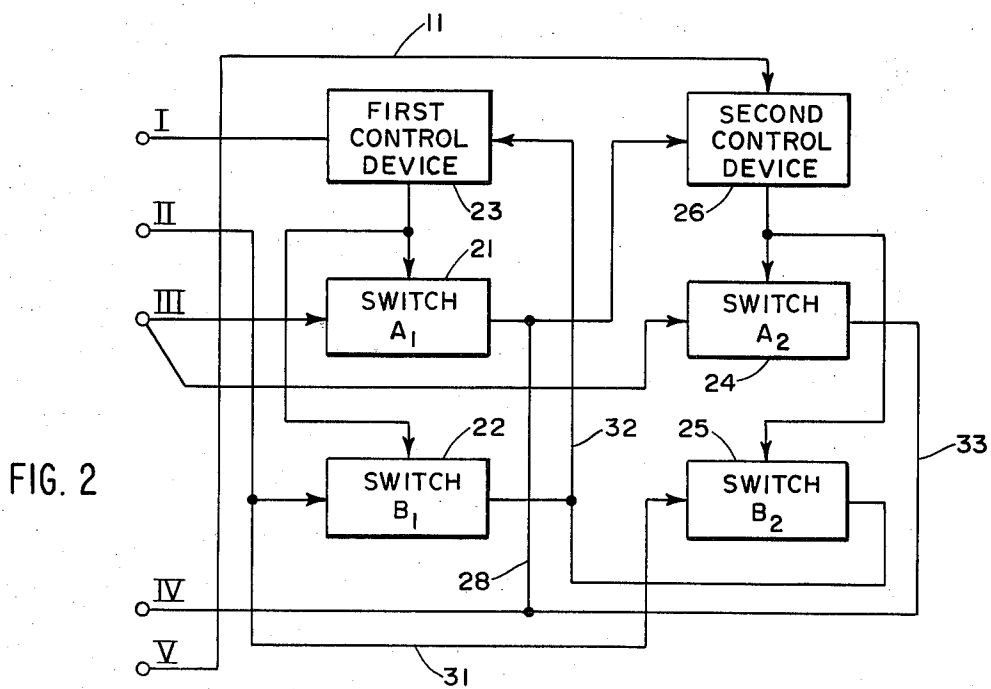


FIG. 3

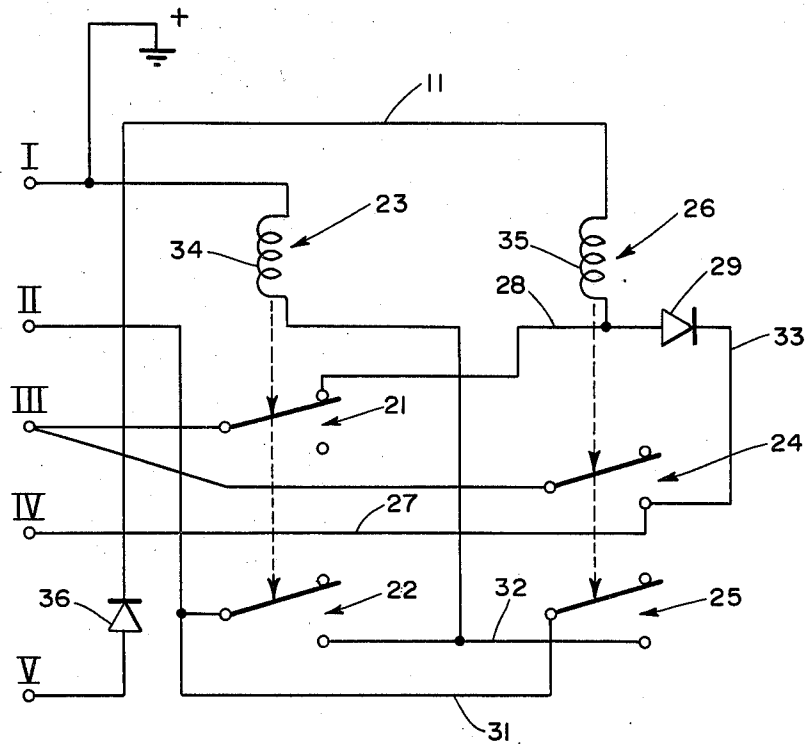


FIG. 4

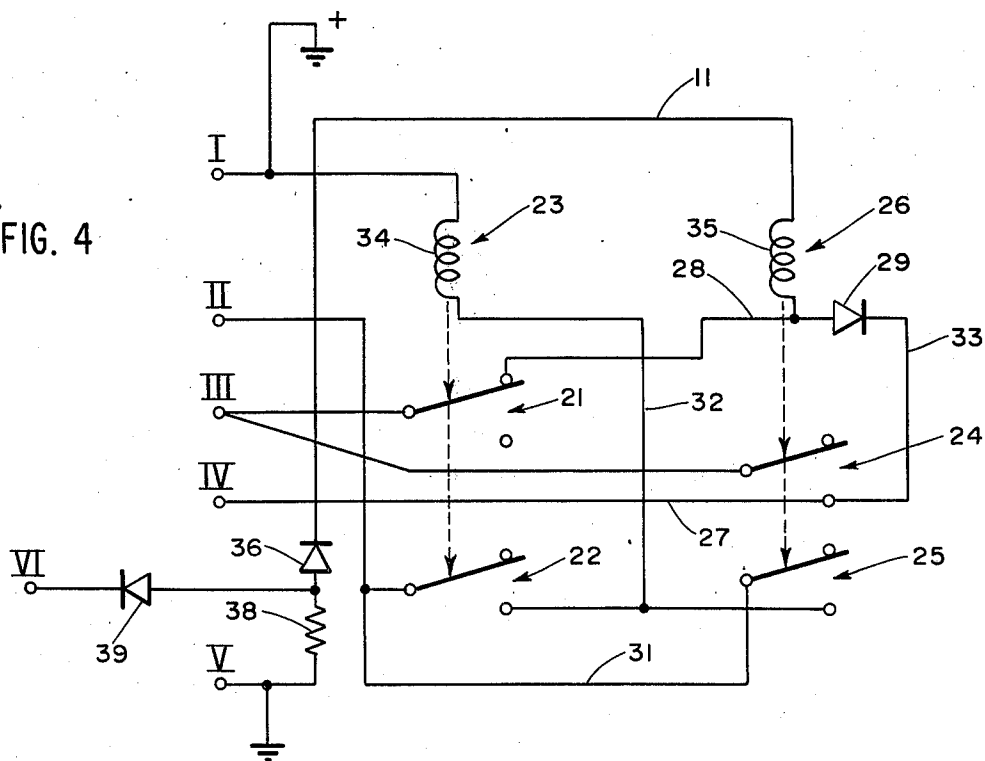


FIG. 5

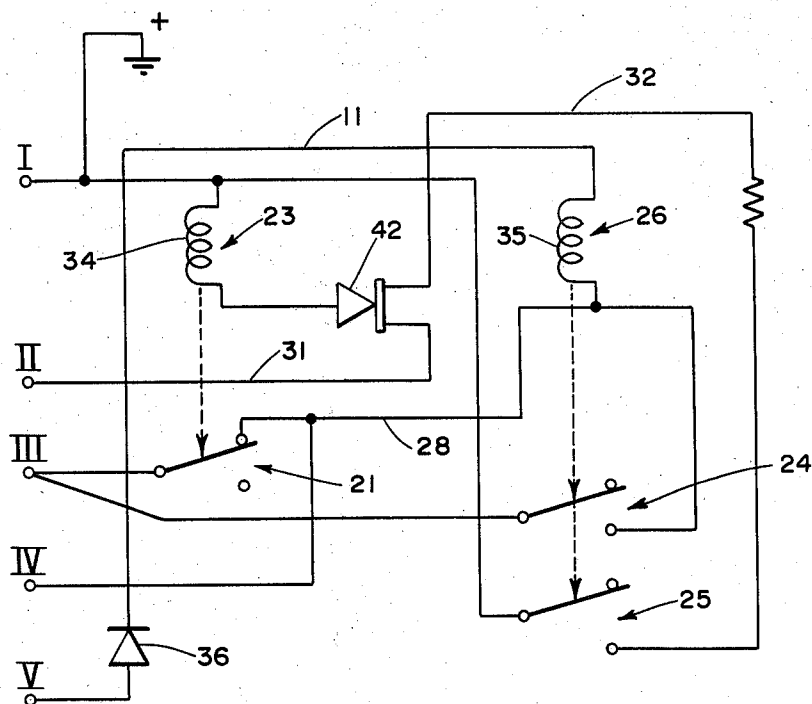
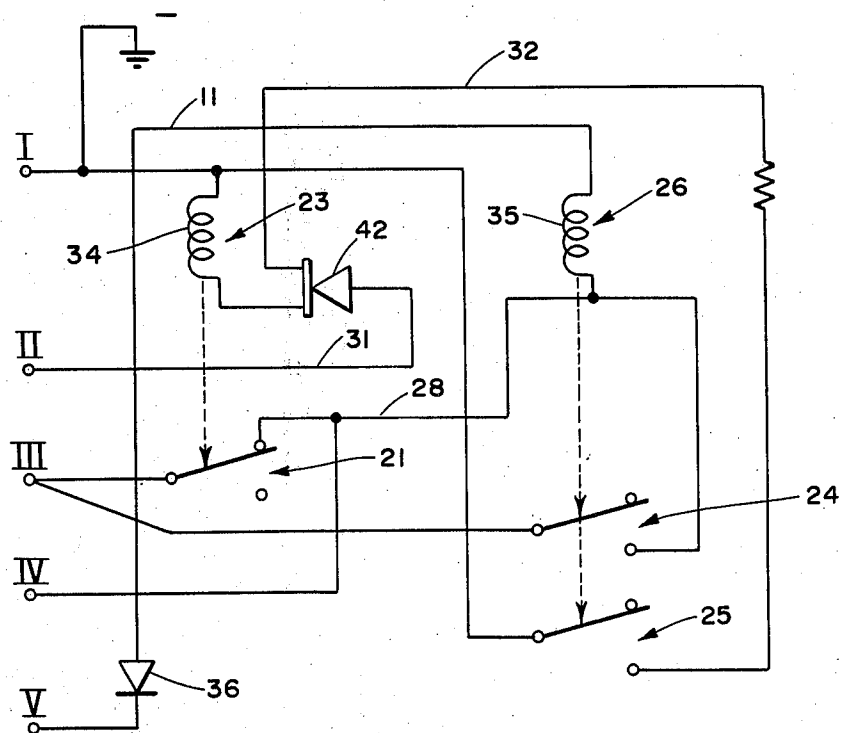


FIG. 6



ENGINE STARTER CONTROL SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to control systems for internal combustion engine starter motors and more particularly, to a circuit between the ignition switch and starter motor solenoid in an automotive vehicle which restricts the sequence for starting the engine to protect the starter motor and the engine.

The electric starting system for an internal combustion engine typically includes a battery which provides DC electric power, a starter motor which mechanically engages a flywheel on the engine, a starter motor solenoid which feeds DC electric power from the battery to the motor, and an ignition switch which connects battery power to the ignition system and connects battery power to the starter solenoid to energize the starter motor. The usual sequence to start such a motor begins with the ignition switch at the off position at which no battery power is connected to the engine ignition system or to the starter solenoid. The operator first switches the ignition switch from the off position to the "ignition" position at which battery power is connected to the engine ignition system. Then the operator turns the ignition switch, usually in the same direction, to the "ignition-start" position and holds the ignition switch in that position until the engine starts. At the ignition-start position of the ignition switch, battery power is still connected to the engine ignition system and in addition, the starter solenoid is energized feeding battery power to the starter motor which immediately drives the engine flywheel. As soon as the engine starts, the operator is supposed to release the ignition switch from the ignition-start position so that the switch returns to the ignition position, which is the normal running position of this switch.

If the operator holds the ignition switch in the ignition-start position after the engine has started and while the starter motor is still engaging the engine flywheel, the engine will then drive the starter motor, overspeeding the starter motor. This may damage or cause excessive wear of the starter motor.

If the starter motor is energized while the engine is turning, the mechanical engagement of the starter motor with the engine flywheel may be severely damaged. This could occur if the operator should inadvertently turn the ignition switch from ignition to ignition start while the engine is running. It also occurs if after attempting to start the motor the operator immediately makes a second attempt to start the motor while the starter motor is still rotating from the previous attempt to start.

Heretofore some efforts have been to provide a system which would prevent energizing the starter motor while the engine was running at a speed greater than cranking speed. Some of these have included a feedback of engine parameters such as oil pressure or engine generator output to operate a switch controlling the start motor solenoid switch. However, generally, these prior systems did not attempt to solve the problems which arise from the operator's immediate attempt to restart the engine after an unsuccessful attempt to start.

SUMMARY OF THE INVENTION

In accordance with embodiments of the present invention a starter control system is provided for use in

conjunction with a typical electric starting system for internal combustion engines such as commonly found in most automotive vehicles. The basic system in these vehicles includes a battery, a starter motor and starter motor solenoid switch, an ignition switch and a voltage regulator. The starter control system of the present invention is electrically between the ignition switch and the starter motor solenoid switch so that the starter motor solenoid and hence the starter motor itself can not be energized except through the starter motor control of the present invention. All other systems of the engine operate independently of the starter motor control system.

In one embodiment of the invention two pairs of switches are provided each pair being slaved to a different control device. Initially when the ignition switch is at the off position, all of the switches are in their zero state and the controls are also in the zero state. When the ignition switch is turned from the off to the ignition position, the engine ignition system of course, is immediately energized directly from the ignition switch, but no change of state occurs with regard to any of the parts in the starter control system. Thereafter, when the ignition switch is switched from the ignition to the ignition-start position, electric power is fed to the starter motor solenoid switch via the ignition switch and one of the switches in the starter control system. Also, within the starter control system, one of the controls changes state and the switches associated therewith also change state causing the other control to also change state and its associated switches to change state. Thereafter, if the engine starts, and the ignition switch is properly returned to the ignition position, one of the controls remains in the one state and the other is switched back to the zero state. The starter control system remains in this condition while the engine is running.

Should the operator inadvertently turn the ignition switch to the ignition-start position while the engine is running, nothing will happen, because the starter motor can not be energized via the starter control system while it is in the condition described. The starter motor can only be energized again by returning the ignition switch to the off position, whereupon all controls and switches in the starter control system return to the zero state, and then commencing the start sequence again.

In one embodiment of the present invention, one or more of the switches in the starter control system are electronic switches such as a silicon controlled rectifier (SCR) which of course has two states of operation which can be designated the zero state and the one state and has but one output line. Since in all embodiments of the present invention, all the switches have but one output line, all the switches could be silicon controlled rectifiers.

It is preferred in all embodiments of the present invention to provide a response to an engine parameter such as oil pressure, generator output or voltage regulator output to stop electrical power to the starter motor once the engine has started as evidenced by one of these parameters.

Accordingly, it is an object of the present invention to provide a system for use in conjunction with the ignition and start system of a conventional automotive engine which prevents reenergization of the starter motor until the engine ignition switch is placed in the off position.

It is another object of the present invention to provide a control system for use in conjunction with a conventional automotive engine whereby damage to the starter motor and damage to the engagement mechanism whereby the starter motor engages the engine which can occur as described above in the Background of the Invention is prevented.

It is another object of the present invention to provide an improved electric start system for cranking a typical motor vehicle engine under control of an ignition switch.

It is another object of the present invention to provide in conjunction with the ignition system and starter motor system of an internal combustion engine, means which prevents the operator from energizing the starter motor until the ignition system for the engine has been de-energized and there energized.

It is a further object of the present invention to provide a system for starting an internal combustion engine and which prevents energizing the engine starter motor except after first turning off the engine ignition.

The above and other objects and features of the present invention are apparent from the following specific description of embodiments of the invention which represent the best known uses and applications of the invention all taken in conjunction with the accompanying drawings and claims which form a part of this specification.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating a typical automotive electric starting system incorporating the present invention;

FIG. 2 is a block diagram illustrating the principal parts of the starter control system of the present invention;

FIG. 3 is a schematic diagram illustrating one embodiment of the starter control system using two pairs of solenoid controlled switches;

FIG. 4 is a schematic showing a modification of the starter control system embodiment in FIG. 3; and

FIGS. 5 and 6 are schematic diagrams of another embodiment of the starter control system using an SCR for some of the switching actions in the system, one schematic showing connections for positive ground and the other for negative ground.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

The block diagram in FIG. 1 shows the essential parts of an electric starting system for cranking and starting an internal combustion engine incorporating the starter control system of the present invention. The total system includes the ignition switch 1, a battery 2 shown with the positive terminal grounded, a solenoid switch 3 for feeding power to the starter motor 4 that cranks the engine, the engine ignition system 5 and the engine voltage regulator 6. The starter control system 7 which is constructed as described herein with reference to numerous embodiments of such a system connects electric power from the ignition switch to the starter solenoid. The five terminals to the starter control system are designated I, II, III, IV and V. The terminal II connects to the ignition line 8 from the ignition switch and the terminal III connects to the ignition-start line 9 from the ignition switch. The output of the starter control system is from terminal IV which feeds line 10 to

the motor start solenoid 3. Another input to the starter control system is at terminal V which receives a signal in line 11 from the engine voltage regulator 6. The remaining terminal of the control system, terminal I connects to ground.

In operation of the system shown in FIG. 1, the function of the starter control system 7 is to feed electric energy via the ignition switch and the starter control system to the engine start solenoid 3 whenever the ignition switch is turned to the ignition-start position which feeds energy into both lines 8 and 9, provided the ignition start switch is turned to the ignition-start position from the off position. In addition, when the ignition switch is in the ignition-start position, the engine start solenoid 3 is energized via the starter control system 7 only for so long as there is not sufficient voltage fed to line 11 from the voltage regulator 6. For example, when the engine starts and the voltage regulator produces a sufficient output in line 11, energization of the solenoid 3 via line 10 ceases even though the proper start sequence has been followed by the operator. A number of different embodiments of the starter control system 7 are shown in FIGS. 2 to 6.

FIG. 2 is a block diagram illustrating the essential features of one embodiment of the starter control system. This consists of switches A₁ and B₁, 21 and 22, both controlled by the first control device 23 and switches A₂ and B₂, 24 and 25, both controlled by the second control device 26. Each switch and each control device has a zero and a one state and the switches are slaved to their associated control device so that when the control device is in the zero state the switch is also in the zero state and when the control device is in the one state the switch is also in the one state. The inner connections between the switches and control devices are as illustrated in FIG. 2. Operation of this system such that when the ignition switch is in the off position (at the I terminal) all the control devices and switches are in the zero state. In this state only switch A₁, 21, is closed.

When the ignition switch is switched to the ignition position, terminal II is energized with battery voltage and so battery voltage is applied to the inputs of switches 22 and 25. However, these switches are in their zero state (open) and so nothing happens in the starter control system.

Thereafter, when the ignition switch is switched from the ignition position to the ignition-start position, both terminals II and III are energized with battery power and since switch 21 is closed, battery power is fed through to line 28, to terminal IV that connects to the starter motor solenoid which in turn feeds power to the engine starter motor. At the same time, line 28 feeds battery power to the second control device 26 causing that device to switch from the zero state to the one state which in turn switches each of the switches 24 and 25 from the zero state to the one state, and so these switches are also closed. When switch 24 closes it feeds battery power from terminal III via line 27 to terminal IV. Also, when switch 25 closes it feeds battery power from terminal II in line 31 to line 32 that energizes the first control device 23 causing that device to switch from the zero state to the one state as soon as device 23 switches to the one state, it switches the switches 21 and 22 to the one state also and so switch 21 opens and switch 22 closes. When switch 21 opens, battery power to line 28 via switch 21 ceases, however, line 28 is still

supplied battery power from the output of switch 24 through line 33 and so the second control device 26 remains in the one state. Meanwhile, line 32 is now also energized by the output of switch 22 and so the first control device 23 also remains in the one state. Thus, we find with the ignition switch in the ignition-start position, both of the control devices and all of the switches in the starter control system are in the one state and the starter motor is energized.

As soon as the engine starts and the voltage regulator 6 produces a sufficient signal in line 11 to the second control device 26, that device switches back to its zero state and so do switches 24 and 25 and so battery power to terminal IV ceases and the starter motor is no longer energized. However, at this point the first control device 23 and switches 21 and 22 remain in the one state and are held there because battery power from terminal II feeds through switch 22 to line 32 and holds the first control device 23 in the one state. Thereafter, should the engine stop, it can not be restrained except by first de-energizing terminal II and this is done, of course, by returning the ignition switch to the off position. The starter motor can not be reenergized because so long as the first control device 23 is in the one state and the second control device 26 is in the zero state, switches 21 and 24 are both open and so no battery power is fed to terminal IV. Terminal IV can not again be energized until the first control device 23 is also returned to its zero state and this can occur only by de-energizing terminal II. Thus, the system outlined in FIG. 2, protects the starter motor and engine from attempts by the operator to energize the starter motor after the engine has started and prevents the operator from reenergizing the starter motor without first returning the ignition switch to the off position.

FIG. 3 shows an embodiment operating as described above with reference to FIG. 2 including two solenoids 34 and 35 which function as the first and second control devices, respectively and mechanically drive the two position switches 21 to 25. This system includes a diode 29 and a diode 36, oriented as shown when the positive terminal of the battery is grounded. In this case, a diode 29 prevents current flow in line 28 from terminal IV and so the current flow from terminal IV must be through line 27, switch 24 and from switch 24 to terminal III. Thus, substantially the complete starter control system is formed by two pairs of switches controlled by two solenoids. The system in FIG. 3 responds to a signal in terminal V from the engine voltage regulator which is fed to solenoid coil 35 via a diode 36 electrically directed as shown for such a system when the positive terminal of the battery is grounded. In this same system, if the negative terminal of the battery is grounded, then the direction of the diode 36 is reversed.

Another embodiment of the starter control system also using two pairs of switches controlled by two solenoids is illustrated in FIG. 4 and differs slightly from the system in FIG. 2. In this embodiment, in addition, an impedance 38 is provided in series with diode 36. DC output from an alternator feeds through diode 39 making the DC potential on coil 35 zero causing said coil to de-energize so that switches 24 and 25 return to their zero position.

The embodiments illustrated in FIGS. 5 and 6 are identical except that in FIG. 5 the positive terminal of the battery is grounded and in FIG. 6 the negative ter-

minal of the battery is grounded. This system includes an SCR in place of switch 22. Otherwise, the switches and solenoids in the system shown in FIGS. 5 and 6 are the same as shown in FIGS. 2 and 3 and so they have the same reference numbers. The SCR is shown in FIG. 5 (battery positive terminal grounded), is denoted 42. When this SCR draws current to terminal II, solenoid coil 34 is energized. Furthermore, this SCR can not draw current until line 32 is grounded via switch 25 (when switch 25 is closed) to terminal I. Thus, the SCR 42 is effective in the same fashion as switch 22 in FIGS. 2 and 3.

In operation, when the ignition switch 15 switched from the off to the Ignition position, terminal II is energized. At this point in time, switch 21 is closed, switches 24 and 25 are open and neither of the solenoid coils 34 or 35 are energized. Next, when the ignition switch is switched from ignition to ignition-start, terminal III is energized, battery power is fed through switch 21 to terminal IV and current is drawn from terminal V through diode 36, solenoid coil 35, line 28 and switch 21 to terminal III, energizing solenoid 35 which switches switches 24 and 25 from their zero state to their one state and so these switches close. When switch 25 closes, it applies ground from terminal I to line 32 connected to the SCR 42. At the same time, switch 24 which also closes draws current through solenoid 35. When the SCR is grounded as described, it draws current through solenoid 34 from terminal I to terminal II and so the solenoid 34 is energized and it actuates switch 21 opening that switch. When switch 21 opens, it no longer connects terminals III and IV and no longer draws current through solenoid 35, however, switch 24 continues to draw current through solenoid 35 until the engine starts and produces a sufficient signal at terminal V to stop current flow through diode 35 to solenoid 35 and so this solenoid is de-energized and the switches 24 and 25 return to their open position and battery power is no longer fed from terminal III through switch 24 to terminal IV and so the engine start motor is de-energized. However, the SCR 42 continues to conduct even though it is not grounded through line 32, and so long as it conducts, it draws current through solenoid 34 which holds switch 21 open. Thus, with switch 21 open and switch 24 open, there can be no voltage applied to terminal IV from terminal III. When this condition occurs, the ignition switch must be returned to the off position removing battery voltage from terminal II so that the SCR ceases to conduct, solenoid 34 is de-energized and switch 21 closes. Thus, it is seen, that the circuit in FIG. 5 stops electric power to the engine start motor as soon as the engine starts and exceeds the cranking speed and the circuit also prevents reenergizing the starter motor following an attempt to start the engine except by first returning the ignition switch to the off position.

A very similar system in FIG. 5 is shown in FIG. 6, the only difference being that the negative terminal of the battery is connected to ground and so the direction of the diode 36 is reversed and the direction of the SCR 42 is reversed.

The various embodiments of the present invention described herein provide a starter control system in circuit between the engine ignition switch and starter motor solenoid switch. Some of the embodiments described herein include conventional solenoid actuated ganged switches and the last embodiment includes an

SCR functioning as a switch. Clearly, all these switches and the solenoid controls could be solid state devices or more particularly, binary circuits functioning generally as described herein with respect to FIG. 2. Clearly, these and other components could be substituted for the components described without departing from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In an engine start system for starting an engine and energizing the ignition thereof, said system including a starter motor, a source of electrical energy, an electrically controlled start motor switch, having an electrical input control, said switch electrically connecting the source to the motor and an ignition switch electrically connecting the source to the starter motor switch input control and to the engine ignition, said ignition switch having OFF, IGNITION and IGNITION-START positions producing in the latter two positions an ignition output signal and an ignition-start output signal, respectively, means for controlling the sequence of energization of the starter motor comprising,
 - electrical switches A₁, B₁, A₂ and B₂ each having an electrical signal input and output and a control input and each capable of being in a conducting or a non-conducting state between the signal input and output thereof,
 - first electrically energized control means for switches A₁ and B₁ having an electrical input and having an output and capable of being in one or the other of two electrical states represented by the output thereof,
 - second electrically energized control means for switches A₂ and B₂ having an electrical input and having an output and capable of being in one or the other of two electrical states represented by the output thereof,
 - first means coupling the output of the first control means to the control inputs of switches A₁ and B₁
 - second means coupling the output of the second control means to the control inputs of switches A₂ and B₂,
 - the said ignition output signal being coupled to the signal inputs of switches B₁ and B₂
 - the ignition-start output signal being coupled to the signal inputs of switches A₁ and A₂,
 - means connecting the outputs of switches B₁ and B₂ to the first control means input and
 - means connecting the outputs of switches A₁ and A₂ to the second control means input and to the starter motor electrical input control,
 whereby the starter motor switch cannot be energized to electrically connect the source to the starter motor following switching the ignition switch from the IGNITION-START position to the IGNITION position, except by first switching the ignition switch to the OFF position.
2. An engine start system as in claim 1 wherein, the first control means and switches A₁ and B₁ are provided by a solenoid relay having two switches driven by the solenoid.
3. An engine start system as in claim 2 wherein, the second control means and switches A₂ and B₂ are provided by a solenoid relay having two switches wherein the solenoid drives both switches.
4. An engine start system as in claim 1 wherein, one

or more of the switches is a semi-conductor device.

5. An engine start system as in claim 1 wherein, the electrical state of the second electrically energized control means is changed from one state to another state by the output of switch A₁ and thereafter compelled to remain in said other state by the output of switch A₂ when the ignition switch is in the IGNITION-START position,
- the electrical state of the first electrically energized control means is changed from one state to another state by the output of switch B₂ when the ignition switch is in the IGNITION-START position and thereafter compelled to remain in said other state by the output of switch B₁ when the ignition switch is in the IGNITION position,
- electrical energy to the starter motor switch electrical input control is provided through switch A₁ when the ignition switch is in the IGNITION-START position and the first control means is not in said other state,
- electrical energy to the starter motor switch electrical input control is provided through switch A₂ when the ignition switch is in the IGNITION-START position and the second control means is in said other state, and
- switch B₂ holds the first control means when the ignition switch is in the IGNITION position.
6. An engine start system as in claim 1 wherein, the first and second electrically energized control means and the switches A₁, B₁, A₂ and B₂ each has two states, a zero state and a one state and all switches and the first and second control means are energized by the source through the ignition switch and are in the zero state when the ignition switch is in the OFF position.
7. An engine start system as in claim 6 wherein, a signal is produced by the engine representative of the engine speed and said engine speed signal is applied to the input of the second control means changing the state thereof.
8. An engine start system as in claim 6 wherein, the zero state of the first and second control means occurs when they are not electrically energized.
9. An engine start system as in claim 8 wherein, the starter motor switch is initially energized while the first and second control means are in the zero state.
10. An engine start system as in claim 9 wherein, a signal is produced by the engine representative of the engine speed and said engine speed signal is applied to the input of the second control means compelling said last mentioned means to remain in the zero state.
11. An engine start system as in claim 10 wherein, the engine speed signal from the engine is initiated from an engine generator driven by the engine.
12. An engine start system as in claim 10 wherein, the engine speed signal from the engine is applied through a diode.
13. An engine start system as in claim 12 wherein, the outputs of switches A₁ and A₂ are connected by a diode, whereby electrical energy to the starter motor switch cannot be provided through a switch A₁ and can be provided through switch A₂.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,885,543 Dated May 27, 1975

Inventor(s) Mark Swartz

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 19, after "which" insert -- time --;

Column 1, line 23, after "which" insert -- time --;

Column 1, lines 45 and 46, delete "be severely damaged" and insert -- cause severe damage to the engine flywheel and/or starter motor --.

Column 1, line 52, delete "is" and insert -- and engine flywheel are --.

Column 1, line 53, after "been" insert -- made --.

Column 4, line 59, delete "27" and insert -- 33 --.

Column 5, line 20, delete "restrained" and insert -- restarted --.

Column 5, line 29, delete "be" and insert -- by --.

Signed and Sealed this

ninth Day of December 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE
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