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[54] **ELECTRONIC COMBINATION LOCK AND THEFT PREVENTION DEVICE**
12 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** ..... **307/10 AT**, 180/114
[51] **Int. Cl.** **H02g 3/00**
[50] **Field of Search** ..... 307/10 AT, 10; 180/114

[56] **References Cited**
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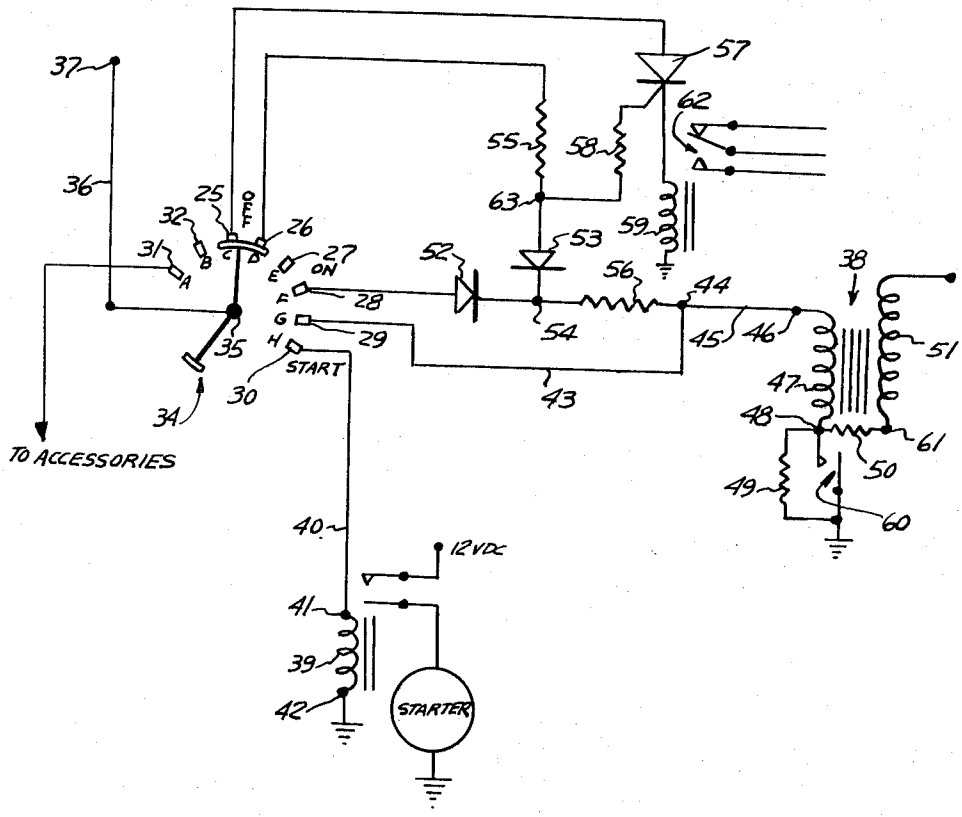
Primary Examiner—Herman J. Hohauser

ABSTRACT: The electronic theft prevention or detection device operates on the principle that the direction of electron flow can be detected and determined to be "correct" or "incorrect." An electrical path connected to the parallel combination of a diode and a relay coil is provided in that portion of an ignition circuit which would normally be "hot wired" by a thief. The jumping or "hot wiring" of the ignition circuit operates the relay coil which can actuate an alarm or means for preventing operation of the engine. If so desired, the conventional ignition key and lock arrangement can be replaced by a novel electronic combination lock, which may also be used for a host of other purposes.



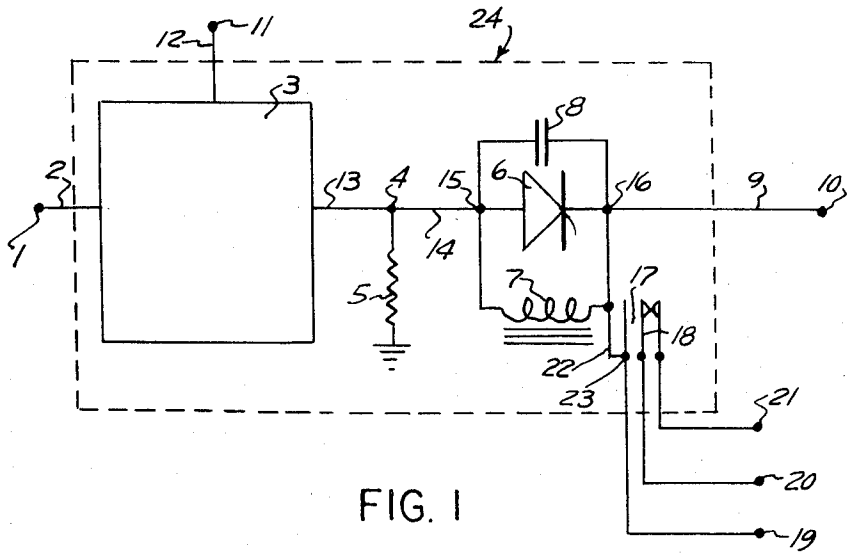


FIG. 1

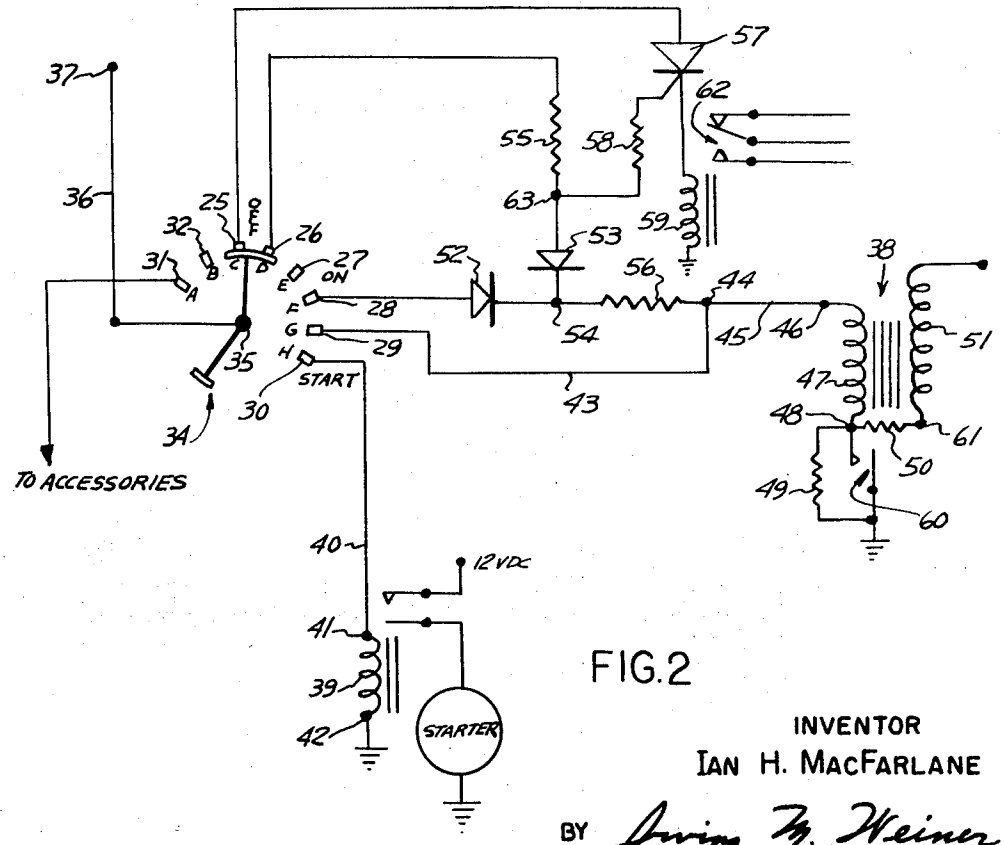


FIG. 2

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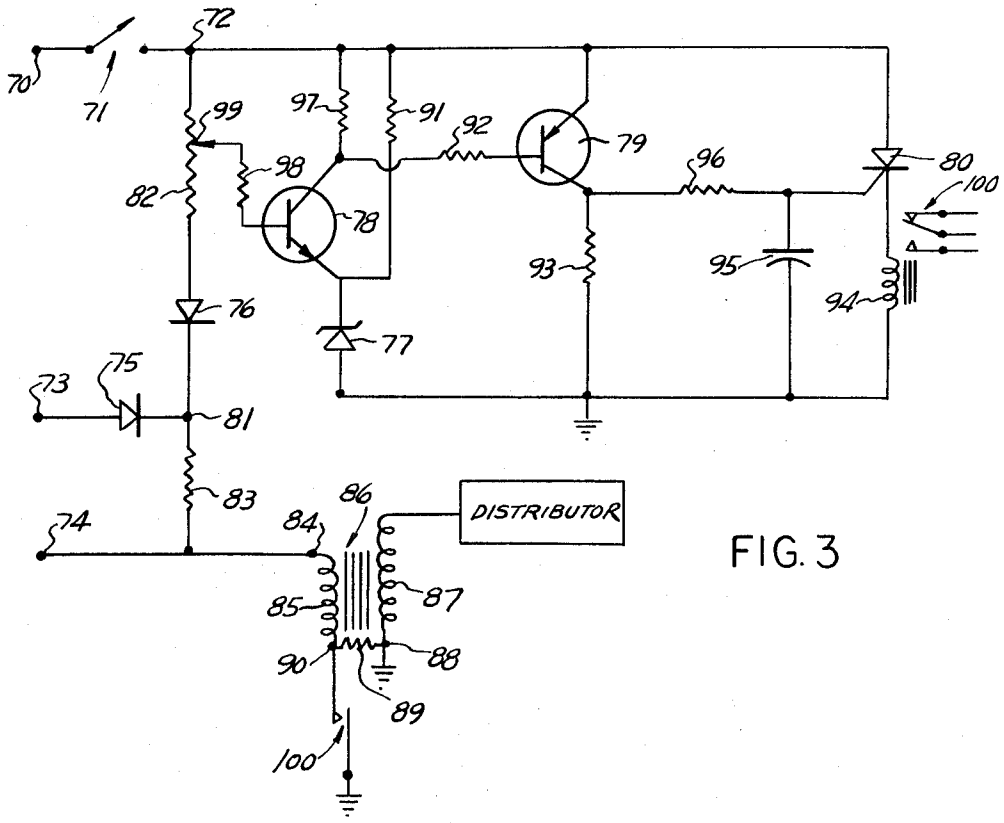

FIG. 3

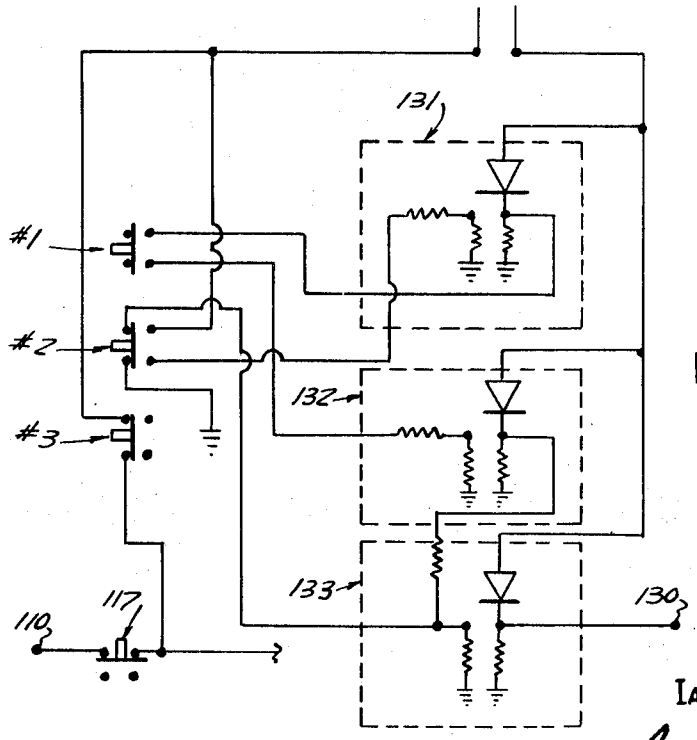

FIG. 5

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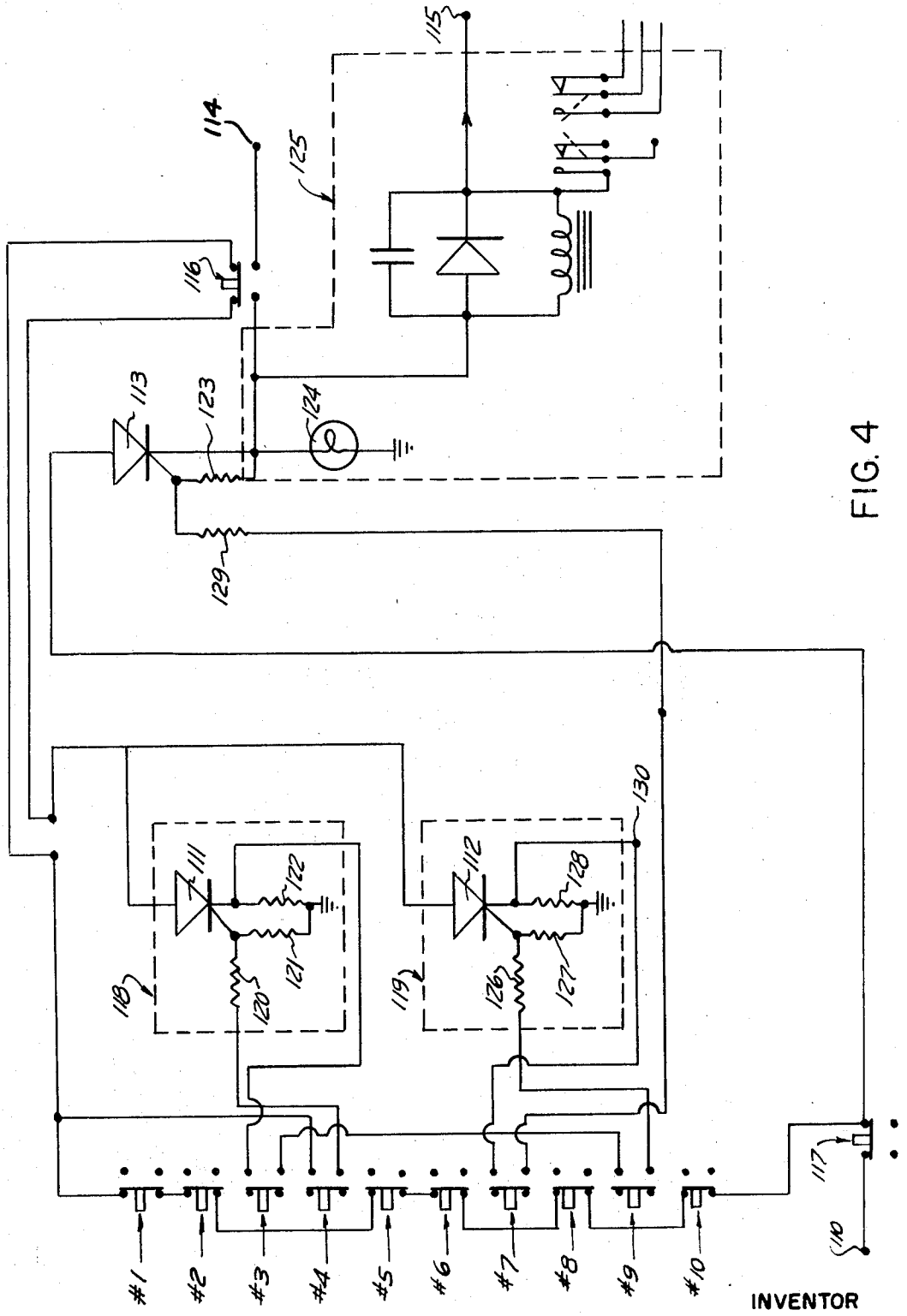

FIG. 4

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ELECTRONIC COMBINATION LOCK AND THEFT PREVENTION DEVICE

The present invention relates to an electronic theft prevention or detection device, and also relates to an electronic combination lock which may be used in conjunction with the mentioned theft prevention or detection device or used in other environments or applications. In particular, the invention can be utilized to control, detect or prevent the starting of any engine or other apparatus which requires a source of electrical power.

The inventive electronic sequential combination lock can be utilized to provide sequential operation in a momentary contact push button-operated locking control for direct current electrical apparatus, and can be adapted to control alternating current apparatus to regulate, control, detect or prevent the action of various solids, fluids, or other substances.

One of the many possible embodiments of the invention relates to the minimizing or completely eliminating the very serious and increasing problem of theft of motor vehicles. The problem of stolen motor vehicles has become very widespread throughout the world. For example, during 1968, one out of every 108 automobiles registered in the United States was stolen. This resulted in a loss of approximately $270,000,000, which in turn will be added to motorists' insurance premiums. The theft of late-model automobiles has become such a big business that many of the 300 car gangs identified by the Federal Bureau of Investigation and the National Automobile Theft Bureau work through regional distributors. One source reports that an average of 2,365 automobiles are stolen every day.

Some professional car thieves even provide the purchaser of the stolen vehicle with "warranties" to resteal the car if it turns out to have major defects, so that a dissatisfied purchaser can collect the retail value from his insurer. A great many of the vehicles which were stolen are stolen using the "hot wiring" or jumping of the ignition technique. The automatic electronic theft prevention or detection device portion of the present invention will eliminate this aspect of the problem. On the other hand, some highly organized and professional thieves utilize key-making machinery which is concealed in a mobile panel truck. This aspect of the problem can be eliminated or solved by the electronic combination lock device portion of the present invention.

SUMMARY OF THE INVENTION

The present invention provides an apparatus or device for use in conjunction with a starting device for starting first means, such as an engine, which requires electricity for operation. The apparatus includes second means, such as a relay coil, having electrical inductance electrically connected between the starting device and the first means. The apparatus also includes third means, such as a diode, electrically connected in parallel with the second means. The third means has a substantially low impedance with respect to a flow of electrons in a predetermined direction and has a substantially low admittance with respect to a flow of electrons in a direction which is opposite to the mentioned predetermined direction. Fourth means, such as a resistor, provides an electrical path between the second means and a reference potential. There is also included fifth means, such as relay contacts functionally connected to an alarm device or an engine enabling device, operative in response to a flow of electrons through the second means to prevent operation of the first means or to activate warning means.

The present invention also provides an electronic combination lock which requires a source of electrical power and a plurality of switching elements, such as push button switches, having a first plurality of terminals and a second plurality of terminals. The first means may be provided for electrically connecting the source of electrical power through at least one of the first (or second) plurality of terminals of the switching

elements. The electronic combination lock also includes a first electronic control device, such as a silicon-controlled rectifier, having a first terminal, a second terminal and a third terminal. Second means electrically connects the first terminal of the electronic control device to the source of electrical power and to one of the second (or first) plurality of terminals associated with the first predetermined one of the switching elements. A first impedance is connected between the third terminal of the first electronic control device and another terminal of the second (or first) plurality of terminals associated with the first predetermined switching element. A second impedance is electrically connected between the third terminal of the first electronic control device and a reference potential, such as ground potential. A third impedance is connected between the second terminal of the first electronic control device and the reference potential. A second electronic control device, such as a silicon control rectifier, is provided having a first terminal, a second terminal and a third terminal. Third means electrically connects the source of electrical power to the first terminal on the second electronic control device. Fourth means, which may include another electronic control device, electrically connects the second terminal of the first electronic control device to the third terminal of the second electronic control device. A fourth impedance may be electrically connected between the second and third terminals of the second electronic control device. Fifth means, such as an indicator lamp or a resistor, electrically connects the second terminal of the second electronic control device to the reference potential. A utilization device, which may include the parallel combination of a diode and a relay coil, may be electrically connected to the second terminal of the second electronic control device. The first electronic control device will be placed in a conductive condition only when the first predetermined switching element is actuated. The second electronic control device will be placed in a conductive condition only if one of the plurality of switching elements is actuated after or simultaneously with a predetermined one of said switching elements. Electrical power will be supplied to the utilization device only when the second electronic control device is in a conductive condition.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates the circuitry of a first embodiment of the present invention which can be employed as a theft prevention or detection device.

FIG. 2 illustrates a second embodiment of the present invention showing the circuitry in an ignition protection embodiment.

FIG. 3 illustrates the third embodiment of the present invention showing the circuitry in an ignition protection environment.

FIG. 4 illustrates a fourth embodiment of the present invention showing the components of an electronic combination lock.

FIG. 5 illustrates a fifth embodiment of the present invention which shows a modification of the preliminary modules of the FIG. 4 embodiment wherein the modification permits an individual digit of the combination to be repeated.

DETAILED DESCRIPTION OF SOME PREFERRED EMBODIMENTS OF THE INVENTION

With reference to FIG. 1, there is shown a theft prevention or detection apparatus or device for use in conjunction with a starting device for starting first means, such as a vehicle engine, which requires electricity for operation. Terminal 1 may be connected to the positive terminal of a source of electricity, such as an automobile battery. A conductor 2 connects the terminal 1 to a starting device 3, such as a conventional automobile ignition key switch or other locking device.

A conductor 12 connects the starting device to a terminal 11 which may be, for example, electrically connected to the starter solenoid of an automobile. An electrical conductor 13

connects the starting device 3 to a terminal 4. A conductor 14 electrically connects the terminal 4 to a terminal 15.

Second means, such as a relay coil 7, which includes electrical inductance is connected to terminal 15 and to a terminal 16. Third means, such as a diode 6, is also electrically connected between terminals 15 and 16 in parallel with the relay coil 7. A conductor 9 connects the terminal 16 to a terminal 10 which may be conducted to the distributor coil of the automobile engine.

Fourth means, such as a resistor 5, is connected between terminal 4 and a reference potential, such as ground potential.

Fifth means, such as relay contacts 17 and 18 associated with the relay coil 7 and in conjunction with a suitable alarm device (not shown) or a suitable disabling device (not shown), is operative in response to a flow of electrons through the relay coil 7 to prevent operation of the engine or to activate the alarm device. The normally open relay contacts 17 may be connected to terminals 19 and 20, and the normally closed relay contacts 18 may be electrically connected to the terminals 20 and 21.

The apparatus or device illustrated in FIG. 1 operates on the principle that the direction of the flow of electrons can be differentiated and determined to be "correct" or "incorrect." In the correct condition, where electrical power is supplied to the coil of an internal combustion engine through the ignition key switch 3, the electron flow will be from terminal 10 to terminal 1. In that situation, the diode 6 offers virtually no resistance to the flow of electrons, and consequently virtually no voltage will be developed across the relay coil 7.

In the incorrect condition, such as when an attempt is made to jump or "hot wire" the engine, for example, by placing a jumper wire directly from the positive terminal 1 from the battery to terminal 10 of the distributor coil, the diode 6 will block virtually all current flow with a very high resistance, thereby developing a voltage across relay coil 7 which is sufficient to trip the relay. In that situation, the electron flow that transpires is from ground potential through the resistor 5, the relay coil 7 to terminal 10. With the actuation of the relay, a normally open set of contacts 17 or a normally closed set of contacts 18 will be operated, or a combination of them operated, to actuate any alarm or disabling device, such as a siren, bell, horn, locking solenoid for the brakes, steering gear, etc., which may be connected to the terminals 19, 20 or 21.

The embodiment illustrated in FIG. 1 operates automatically and does not have to be set or engaged by the operator or driver in any way after installation. Once installed, it operates whenever needed and does not interfere with the normal operation of the vehicle in any manner.

The relay can be of the mechanical latching type; or can be wired with a conductor 22 connecting terminal 16 to a terminal 23 to be electrically self-latching as shown in FIG. 1. If the electrical self-latching arrangement is desired, terminal 20 may be connected to the positive terminal of the battery.

If desired, all components within the dashed line 24 shown in FIG. 1 may be constructed within a sturdy integral housing.

If desired, a capacitor 8 may be connected to terminals 15 and 16 in parallel with diode 6, but the capacitor 8 is not vital to successful operation of the apparatus.

The following sets forth exemplary values of the various components for automotive use. Diode 6 may be a 1 N3889 diode or an equivalent. The relay, comprising coil 7 and contacts 17 and 18, may be a GA11D or equivalent. The resistor 5 may be a 100-ohm resistor, or an indicator lamp such as a GE 1488 or equivalent. The capacitor 8 may be a 0.5-microfarad capacitor having a 600 direct current working voltage rating. It will be obvious to those skilled in the art that there is a wide range of components which will operate satisfactorily in the disclosed apparatus or device. It will also be obvious to those skilled in the art that the theft prevention or detection device may be used for automotive, marine, or other vehicle engines which require electrical power for operation.

FIG. 2 illustrates an alternative form of an apparatus for use in conjunction with a starting device for starting first means, such as a vehicle engine, which requires electricity for operation. As shown in FIG. 2, there is provided a starting device, such as ignition switch 34, which includes at least a first terminal 25, a second terminal 26, a third terminal 27, a fourth terminal 28, a fifth terminal 29, and a sixth terminal 30. If desired, the ignition switch 34 can also include a seventh terminal 31 which can be used for electrical connection to the automobile accessories, and an eighth terminal 32. The ignition switch 34 also includes a rotary switching element 33 which is capable of electrically connecting or bridging at least two of the various terminals of the ignition switch. The rotary switching element 33 has a center post 35 which may be electrically connected by a conductor 36 to a terminal 37. The terminal 37 may be connected to a source of electrical power, such as the positive terminal of an automobile battery.

First means, such as an automobile engine, is provided which includes a distributor coil 38 and a starter solenoid 39. The sixth terminal 30 of the ignition switch 34 may be electrically connected by a conductor 40 to a first terminal 41 of the starter solenoid 39. Another terminal 42 of the starter solenoid 39 may be connected to a source of reference potential, such as ground potential.

The fifth terminal 29 on the ignition switch 34 may be electrically connected to a terminal 46 of the primary winding of the distributor coil 38 via a conductor 43, a terminal 44 and a conductor 45.

The FIG. 2 embodiment also includes a first diode 52 and a second diode 53 whose cathodes are electrically connected together at a terminal 54. The fourth terminal 28 of the ignition switch 34 is electrically connected to the anode of the first diode 52. A first impedance, such as a resistor 55, is electrically connected between the second terminal 26 of the ignition switch 34 and the anode of the second diode 53. A second impedance, such as a resistor 56, is electrically connected between terminals 44 and 54.

There is also shown an electronic control device, such as a silicon control rectifier 57, whose anode is electrically connected to the first terminal 25 of the ignition switch 34. A relay coil 59 is electrically connected between the cathode of the silicon control rectifier 57 and a reference potential, such as ground potential. Sixth means, such as a resistor 58, may be electrically connected between the anode of the second diode 53 and the gate element of the silicon control rectifier 57.

A third impedance may comprise a resistor 49 which is electrically connected across the breaker points 60 from ground potential to a second terminal 48 of the primary winding 47 of the distributor coil 38. Alternatively, the third impedance element may comprise a resistor 50 which is connected between the terminal 48 of the primary winding 47 to the ground terminal 61 of the secondary winding 51 of the distributor coil 38. It is not necessary to employ both resistors 49 and 50, as either one will suffice.

The apparatus or ignition protection system depicted in FIG. 2 is designed to detect or prevent any attempt to hot wire the electrical system of any electrical or internal combustion engine, and to detect the removal of the ignition wire and an attempt to circumvent an alarm system prior to hot wiring the system. The presentation of the battery voltage at terminal 25, as well as any interruption of the voltage divider network consisting of resistor 55, resistor 56, the distributor coil primary winding 47, and resistor 49 (or resistor 50), will actuate any alarm and/or disabling device (not shown) which may be operatively connected to the relay contacts 62 associated with the relay coil 59.

Electrical power is applied to the FIG. 2 embodiment by means of special connections within the ignition key switch 34 so that power is applied only when the key is in the off position. The logic of the ignition switch is all explained below.

When the rotary switching element 33 bridges the terminals 31 and 32, this will be deemed as accessories only position. When the rotary switching element 33 bridges terminals 25 and 26, this will be deemed an alarm engaged position. When the rotary switching element 33 bridges the terminals 27 and

28, this will be deemed an "on" position. When the rotary switching element 33 bridges the terminals 28 and 29 during a momentary contact, this will be deemed an interim shorting position. When the rotary switching element 33 bridges the terminals 29 and 30, this will be deemed the start momentary contact position.

When the engine is on or operating, the apparatus according to the present invention is in an off condition. The operator or driver need not remember to consciously do some special act to engage the alarm or disabling device.

The battery voltage applied to the above-mentioned voltage divider network which provides a very low voltage reference potential at terminal 63, which is shown as being interposed between resistor 55 and the anode of the second diode 53.

In the event that either a jumper wire is employed to provide a battery voltage at terminal 46 or if the ignition wire is removed at terminal 66 or at terminal 56 to interrupt the circuit, then the reference voltage at terminal 63 will rise to approximately the positive battery voltage. This last mentioned voltage or potential will act on the gate element of the silicon control rectifier 57 through the resistor 58, which may be deemed a limiting resistor, to turn on the rectifier 57 which in turn will actuate the relay consisting of coil 59 and contact 62 for whatever alarm or disabling device is connected thereto. The silicon control rectifier 57 will then remain on or in a conductive position until the apparatus is reset by means of the ignition key switch 34 being turned to its on position.

It should be noted that this embodiment of the present invention is readily adapted to present day automobiles for the following reasons. The resistor 56 is the normal dropping resistor which is found in all automobiles having a 12-volt system. It should also be noted that resistor 49 or resistor 50 will be out of the circuit when the engine is stopped at a point when the breaker points 60 are closed. The resistor 49 could be added to ignition systems which have not been built with this device. The resistor 50 can readily be a resistor which is built into the molded plastic coil housing for the built-in apparatus according to the present invention. Various integral housings or potted enclosures can of course be employed to house various combinations of the components illustrated in FIG. 2.

Some exemplary component values for the FIG. 2 embodiment are as follows. Resistor 55 may be a 1,200-ohm resistor. Resistor 58 may be a 200-ohm resistor. Resistor 49 or resistor 50 may be a 60-ohm resistor. The silicon control rectifier 57 may be a C106Y1 rectifier. The diodes 52 and 53 may be of the 1N3889 type and 1N4004 type, respectively. The relay consisting of coil 59 and its associated contacts 62 may be any appropriate relay coil operating at 12 volts at direct current.

If desired, a buffer transistor amplifier may be interposed between terminal 63 and the gate element of the rectifier 57 in lieu of the resistor 58.

The diode 52 will be required only if the switch 34 does not separate the accessory circuit from the ignition circuit when it is in the off position.

A third embodiment of the present invention is illustrated in FIG. 3 which also shows an apparatus for use in conjunction with a starting device, such as an automobile ignition switch, for starting first means, such as an automobile engine, which requires electricity for operation. The starting device or ignition switch includes at least a first terminal 70, a second terminal 73, and a third terminal 74. A source of electrical power, such as an automobile battery (not shown), may be connected to the first terminal 70 of the ignition switch. The apparatus also includes a first diode 75, a second diode 76, and a third diode 77. There is also provided two electronic control devices, such as a first transistor 78 and a second transistor 79. Another electronic control device, taking the form of a silicon control rectifier 80, is also provided in the apparatus.

The second terminal 73 of the ignition switch is electrically connected to the anode of the diode 75, and the cathode of the diode 75 is electrically connected to the cathode of the diode 76 via a common terminal 81. A first impedance element, such as a resistor 82, is connected between the first terminal 70 (which is connected to the positive terminal of the automobile battery) and the anode of the second diode 76.

A second impedance element, such as a resistor 83, is electrically connected between the terminal 81 and the third terminal 74 of the ignition switch. The third terminal 74 of the ignition switch may be considered the engine starting position of the ignition switch. The terminal 74 may be electrically connected to a first terminal 84 of a primary winding 85 of a distributor coil 86 of the engine. A secondary winding 87 of the distributor coil 86 may have one of its terminals, such as 88, electrically connected to a reference potential, such as ground potential. A third impedance element, such as resistor 89, may be connected between a second terminal 90 of the primary winding 85 and terminal 88 of the secondary winding 87.

A fourth impedance, such as a resistor 91, may be connected between terminal 72 and the collector of the first transistor 78. A fifth impedance, such as a resistor 92, may be electrically connected between the collector of the transistor 78 and the base of the second transistor 79.

A sixth impedance, such as a resistor 93, may be electrically connected between the collector of transistor 79 and ground potential.

The anode of the silicon control rectifier 80 may be electrically connected to terminal 72. A relay coil 94 may have one of its terminals connected to the cathode of the silicon control rectifier 80 and have its other terminal connected to ground potential. The capacitor may be connected between the gate of the silicon control rectifier 80 and ground potential.

A seventh impedance, such as a resistor 96, may be connected between the gate of the silicon control rectifier 80 and the collector of the second transistor 79.

An eighth impedance, such as a resistor 97, may be electrically connected between terminal 72 and the collector of the first transistor 78. The cathode of the third diode 77 may be electrically connected to the emitter of the first transistor 77, and the anode of diode 77 may be electrically connected to ground potential.

A ninth impedance, such as a resistor 98, may have one of its terminals connected to the base of transistor 78 and the other of its terminals, designated 99, movably slidable along the resistor 82.

Fifth means, comprising the relay coil 94, its associated contacts 100, and any alarm and/or disabling device operatively connected to contacts 100, are provided to operate in response to a flow of electrons through the relay coil 94 to prevent operation of the engine and to activate the mentioned alarm device or other warning means.

The third embodiment of the invention illustrated in FIG. 3 is designed to detect and actuate a relay, consisting of coil 94 and contacts 100, or any other sensing device whenever a hot wire jumper is employed by a would-be thief to start a vehicle engine, or whenever the ignition wire is removed prior to the hot wiring attempt to start, or in the event that these detections of an unauthorized start of the vehicle are circumvented, any starting of the vehicle engine while the apparatus is operative or engaged. From the foregoing, it can be appreciated that the inventive apparatus will minimize if not completely eliminate the theft of vehicles employing engines requiring electricity.

In the third embodiment of the invention, the conventional automotive ignition system, consisting of an ignition switch, the dropping resistor 83, the distributor coil 86, and breaker points 101, is first altered by the addition of the diode 75 which isolates the automobile accessories from the remainder of the system. Essentially, the inventive apparatus is connected to the system at terminal 81 which can be located in an area which is quite inaccessible to thieves, such as within a potted enclosure with diode 75 and various other components of the novel apparatus.

If desired, a switch 71 may be provided as a separate switch, or part of the ignition switch which is closed when the ignition

switch is in the off position. The optional switch **71** may provide electrical power from the battery to the apparatus, as well as a reference voltage to terminal **72** of a voltage divider network consisting of potentiometer or resistor **82**, the diode **76**, the dropping resistor **83**, the primary winding **85** of the distributor coil, and the resistor **89** (unless of course the breaker points **101** are closed when the vehicle engine stops, whereby resistor **89** will be out of the circuit, shorted by the breaker points **101**).

The sliding terminal **99** is adjusted to provide a reference voltage at terminal **99** which is slightly more negative than the voltage at the emitter of transistor **78**, thereby biasing the transistor **78** to an off or nonconductive condition. The resistor **98** limits the base current of transistor **78** to within the rated limits when transistor **89** is conducting. The diode **77** cooperates with the resistor **91** to provide a stable reference for the emitter of transistor **78**. The transistor **78** will be turned on if the voltage at terminal **99** rises due to a hot wire or jumper being applied at terminal **84**, or the voltage at terminal **72** rising due to the alternator being engaged by the starting motor.

When transistor **78** fires or changes to a conductive position, the voltage change at the collector of transistor **78** fires or turns on the transistor **79**. The transistor **79** acts through resistor **96** to fire or turn the silicon control rectifier **80**, thereby actuating an alarm and/or relay which engages the actual alarms or disabling devices. The capacitor **95** provides a slight time delay for the rectifier **80** in order to prevent a false alarm when the apparatus is initially switched on.

The diode **75** blocks current flow through the accessories to cut off the voltage divider network. The diode **76** blocks current flow when the apparatus is off and the engine is on in order to protect the apparatus and particularly transistor **78** from damage.

The resistor **89** should be added to the conventional ignition circuit across the breaker points **101** to provide a complete circuit to ground potential to accommodate the situation which occurs when the engine stops and the breaker points **101** are open. The resistor **89** would be shorted out by the breaker points when the engine stops with the breaker points **101** closed.

The third embodiment of the present invention is thus seen to be voltage level sensitive, as well as sensitive to other major changes, such as a jumper wire from the battery to terminal **84**, or the breaking of the integrity of the automotive ignition system.

With reference to FIG. **4**, there is shown a fourth embodiment of the present invention in the form of a novel electronic combination lock. This electronic combination lock utilizes the self-latching characteristics of the thyristor family of semiconductors, and the embodiment illustrated in FIG. **4** employs silicon controlled rectifiers **111**, **112** and **113**, in a form suitable for the control or protection of an automotive or marine electrical system.

FIG. **4** depicts a three-stage electronic sequential combination lock which is shown wired for the combination 4–39–7. The designation **39** indicates that the No. **3** pushbutton and the No. **9** pushbutton must be depressed simultaneously, and this is identical to the designation **93**.

A positive voltage is applied at terminal **110** from a source of electrical power, such as an automobile battery (not shown). For the wired combination 4–39–7, when the switching element or pushbutton No. **4** is depressed, then the silicon control rectifier **111** will be turned on and will maintain conduction even after pushbutton No. **4** returns to its normal or home position as illustrated in FIG. **4**.

The silicon control rectifier **111** then provides a positive voltage at its cathode, which is then used, by depressing pushbutton No. **3** and pushbutton No. **9** simultaneously, to provide a turn on voltage to the gate of a silicon control rectifier **112**. The silicon control rectifier **112** then maintains its conduction which provides a voltage at its cathode which enables a silicon control rectifier **113** to be turned on when a pushbutton No. **7** is depressed.

The silicon control rectifier **113** must have a capacity which is capable of passing sufficient electrical current to operate a load device which may be electrically connected to a terminal **114** and/or a terminal **115**. For example, the terminal **114** may be electrically connected to the starter solenoid of an automobile, and the terminal **115** may be connected to the engine and accessories of an automobile. When a switch, such as a switch **116**, is depressed, for example, to actuate the starter solenoid of an automobile, then the preliminary stages of the electronic sequential combination lock are turned off in order to minimize the current drain and prolong the life of the components.

If an incorrect pushbutton switch is depressed during the sequential combination attempt, then the preliminary stages of the electronic combination lock are turned off by depriving them of electrical current, and the combination must be started again. If desired, there may be provided an "off" switch, such as a switch **117**, which turns off the device when it is depressed at any time. The switch **117** may also serve to automatically reset the combination.

The portions of the embodiment illustrated in FIG. **4** within the phantom lines indicated by the reference numerals **118** and **119** may be considered as integer modules. One module must be used for each individual number of the combination. A multiple digit number in the combination, such as 39, or 321, etc., would be considered or counted as an individual number in the combination. The size of the combination and its complexity can be expanded or contracted by adding or deleting, respectively, integer module stages.

With respect to the module **118**, the silicon control rectifier **111** may be considered to be an electronic control device or may be considered to be a device which is controlled. In any event, the silicon control rectifier **111** is turned on by the application of an appropriate voltage at its gate when there is also an appropriate voltage applied to its anode. A first impedance, such as a resistor **120**, serves to limit the gate current to within rated levels for the silicon control rectifier **111**. A second impedance, such as a resistor **121**, serves as the second leg of a voltage divider network in order to develop sufficient voltage to turn on the silicon control rectifier **111**. A third impedance, such as a resistor **122**, limits the "on" state current to within rated levels, and typically allows only sufficient current to maintain a latched state in the on condition.

The module **119** may be an exact duplicate of the module **118**.

The plurality of switching elements, such as pushbuttons No. **1** through No. **10**, are wired in FIG. **4** in such a way as to provide normally open contacts for each module as desired, and normally closed contacts for the disengaged circuit for incorrect numbers. Of course, this wiring arrangement may be reversed, with respect to the normally open and normally closed contacts, and such a reversed wiring arrangement is illustrated in FIG. **5**.

With reference to FIG. **4**, the final stage, such as the silicon control rectifier **113**, is similar to the modules **118** and **119** with the major exception that a fourth impedance, such as a resistor **123**, is electrically connected between the cathode and the gate of the rectifier **113** to prevent a negative voltage from being employed to turn on the device. A fifth means, such as an indicator lamp **124**, may serve as an electrical path for the minimum latching current, as well as an "on" indicator for the complete device. If desired, the indicator lamp **124** may be replaced by a resistor. Also, if desired, the module **125** enclosed in phantom lines in FIG. **4** may be similar to the automatic theft detector apparatus illustrated in FIG. **1**.

The terminology used in some of the appended claims such as a fifth impedance, a sixth impedance, a seventh impedance and an eighth impedance may refer to resistors **126**, **127**, **128** and **129**, respectively, as shown in FIG. **4**. The cathode of the silicon control rectifier has been indicated as a terminal **130** for reasons which will become apparent in the following description of the fifth embodiment of the invention shown in FIG. **5**. The selection of the various components illustrated in FIG. **4** is not critical. An exemplary component selection for

the embodiment shown in FIG. 4 may be as follows. The resistors 120 and 126 may be 500-ohm resistors with a ½-watt rating. The resistors 121 and 127 may be 200-ohm resistors with a ½-watt rating. The resistors 122 and 128 may be 1,000-ohm resistors having a ½-watt rating. The resistor 129 may be a 100-ohm resistor with a 1-watt rating. The resistor 123 may be a 50-ohm resistor with a ½-watt rating. The silicon controlled rectifiers 111 and 112 may be of the C106Y1 type. The silicon control rectifier 113 may be of the 2N682 type. The indicator lamp 124 may be a GE1488 lamp. The various push-button switches No. 1 through No. 10 may be any double-pole double-throw switches which have suitable current capacity. In the off state, the device will draw minimum current typically less than 5 microamperes, and in the on state the device will pass sufficient current with less than 0.6 voltage drop across the silicon control rectifier 113.

A fifth embodiment of the present invention is illustrated in FIG. 5. The FIG. 5 is actually a partial or truncated schematic of the preliminary modules which employ a wiring arrangement that allows an individual number in the combination to be repeated. In particular, the wiring arrangement shown is for the combination 2–1–2. Some of the components illustrated in FIG. 5 which are identical to components shown in FIG. 4, are indicated by like reference numerals. Similarly, the portions of FIG. 5 within the phantom lines indicated by the reference numerals 131, 132, and 133 are the integer modules. The terminal 130 shown in FIG. 5, as with the terminal 130 illustrated in FIG. 4, would lead or be electrically connected to the final number in the combination for the last stage of the electronic combination lock.

It is important to note that the final stage electronic control device, for example, the silicon controlled rectifier 57 in the second embodiment, or the silicon control rectifier 80 in the third embodiment, or the silicon controlled rectifier 113 in the fourth embodiment, need not necessarily be electronically connected to a relay coil or relay device. In other words, it is possible to utilize the inventive concept herein disclosed without the necessity of a relay electrically connected to the final stage electronic device by having the final stage electronic control device directly actuate any desired warning means, disabling device or alarm mechanism.

The electronic sequential combination lock illustrated in FIGS. 4 and 5, and any variations or modifications thereof, can of course be used for many other applications or jobs, such as a door lock, an ignition lock for all types of vehicles, a cryptographic lock for security areas, an ignition lock for marine use, a machinery lock, etc.

It should also be noted that the novel electronic combination lock disclosed herein can be utilized to control a plurality of other devices. For example, one of the novel electronic combination locks can be wired to control thirty other devices.

The electronic combination lock can also be used in other areas, such as mail boxes for apartment houses, and dispensing units. In essence, the invention provides a novel switch which can replace any other switching device now in use.

According to the invention, the matrix selected for the combination lock may permit tens tests of millions of variations in the combination. Also, a time limitation feature can easily be included in the inventive combination lock to require the completion of the combination within a predetermined time interval, e.g., 10 seconds, but this is not mandatory. Moreover, the novel electronic combination lock can be manufactured in the form of a secure potted-type of unit to maintain the integrity of the lock and to minimize the possibility of an individual tracing the wiring in an attempt to learn the combination.

I claim:

1. Apparatus for use in conjunction with a starting device for starting first means which requires electricity for operation, comprising, in combination:

second means including electrical inductance electrically connected between said starting device and said first means;

third means electrically connected in parallel with said second means;

said third means having a substantially low impedance with respect to a flow of electrons in a predetermined direction and having a substantially low admittance with respect to a flow of electrons in a direction which is opposite to said predetermined direction;

fourth means providing an electrical path between said second means and a reference potential; and

fifth means operative in response to a flow of electrons through said second means to prevent operation of said first means or to activate warning means.

2. Apparatus characterized in accordance with claim 1, wherein said first means comprises a vehicle engine including a coil; said starting device has a first terminal electrically connected to a source of electricity, and a second terminal electrically connected to said second means; said second means comprises a relay coil; said third means comprises a diode which is connected between said second terminal of said starting device and said coil of said vehicle engine; and said fourth means comprises a resistor connected between said second terminal of said starting device and ground potential.

3. Apparatus for use in conjunction with a starting device for starting first means which requires electricity for operation, comprising, in combination:

said starting device including at least a first terminal, a second terminal, a third terminal, a fourth terminal, a fifth terminal and a sixth terminal, and a rotary switching element which is capable of bridging at least two of said terminals and having its center post electrically connected to a source of electrical power;

said first means comprising a vehicle engine including a distributor coil and a starter solenoid;

said sixth terminal of said starting device being electrically connected to said starter solenoid;

said fifth terminal of said starting device being electrically connected to said distributor coil;

a first diode;

a second diode;

a relay coil;

a silicon controlled rectifier;

a first impedance element;

a second impedance element;

a third impedance element;

said relay coil being connected between a reference potential and the cathode of said silicon-controlled rectifier;

said first terminal of said starting device being electrically connected to the anode of said silicon-controlled rectifier;

said first and second diodes having their cathodes electrically connected together;

said fourth terminal of said starting device being electrically connected to the anode of said first diode;

said second impedance element being electrically connected between the cathodes of said diodes and the distributor coil;

said first impedance element being connected between said second terminal of said starting device and the anode of said second diode;

sixth means electrically connected between the anode of said second diode and the gate element of said silicon-controlled rectifier;

said third impedance element being connected between a reference potential and the primary winding of said distributor coil;

and fifth means operative in response to a flow of electrons through said relay coil to prevent operation of said first means or to activate warning means.

4. Apparatus characterized in accordance with claim 3, wherein said sixth means includes a resistor electrically connected between the gate element of said silicon-controlled rectifier and the anode of said second diode.

5. Apparatus characterized in accordance with claim 3, wherein said sixth means includes an amplifier electrically

connected between the gate element of said silicon-controlled rectifier and said anode of said second diode.

6. Apparatus characterized in accordance with claim 3, wherein said third impedance element includes a resistor electrically connected between a reference potential and the primary winding of said distributor coil.

7. Apparatus characterized in accordance with claim 3, wherein said third impedance element includes a resistor having one terminal connected to the primary winding of said distributor coil and having another terminal connected to the grounded terminal of the secondary winding of said distributor coil.

8. Apparatus for use in conjunction with a starting device for starting first means which requires electricity for operation, comprising, in combination:

said starting device including at least a first terminal, a second terminal and a third terminal;

a source of electrical power which is connected to said first terminal of said starting device;

a first diode, a second diode, and a third diode;

a first transistor and a second transistor, each of said transistors having a first terminal, a second terminal and a third terminal l;

said first means comprising a vehicle engine including a distributor coil;

a silicon controlled rectifier having a cathode element, an anode element, and a gate element;

said second terminal of said starting device being electrically connected to the anode of said first diode;

said first diode having its cathode electrically connected to the cathode of said second diode;

a first impedance element connected between said first terminal of said starting device and the anode of said second diode;

a second impedance element electrically connected from the cathodes of said first and second diode to said third terminal of said starting device;

said third terminal of said starting device being electrically connected to a first terminal of a primary winding of said distributor coil;

the secondary winding of said distributor coil having one of its terminals electrically connected to a reference potential;

a third impedance element connected between a second terminal of said primary winding of said distributor coil and said one terminal of said secondary winding of said distributor coil;

a fourth impedance electrically connected between said first terminal of said starting device and said third terminal of said first transistor;

a fifth impedance electrically connected between said first terminal of said first transistor and said second terminal of said second transistor;

a sixth impedance connected between said third terminal of said second transistor and said reference potential;

said anode element of said silicon-controlled rectifier being electrically connected to said first terminal of said starting device;

means connecting said cathode element of said silicon-controlled rectifier to said reference potential;

a capacitor connected between said gate element of said silicon-controlled rectifier and said reference potential;

a seventh impedance connected between said gate element of said silicon-controlled rectifier and said third terminal of said second transistor;

an eighth impedance connected between said first terminal of said starting device and said first terminal of said first transistor;

said third diode having its cathode electrically connected to said third terminal of said first transistor and having its anode electrically connected to said reference potential;

a ninth impedance having one of its terminals connected to said second terminal of said first transistor and having the other of its terminals movably slidable along said first impedance; and

fifth means operative to a conductive condition of said silicon-controlled rectifier to prevent operation of said first means or to activate warning means.

9. An electronic combination lock comprising, in combination:

a source of electrical power;

a plurality of switching elements having a first plurality of terminals and a second plurality of terminals;

first means for electrically connecting said source of electrical power to at least one of said first plurality of terminals of said switching elements;

a first electronic control device having a first terminal, a second terminal and a third terminal;

second means electrically connecting said first terminal of said electronic control device to said source of electrical power and to one of said second plurality of terminals associated with a first predetermined one of said switching elements;

a first impedance connected between said third terminal of said first electronic control device and another terminal of said second plurality of terminals associated with said first predetermined switching element;

a second impedance electrically connected between said third terminal of said first electronic control device and a reference potential;

a third impedance connected between said second terminal of said first electronic control device and said reference potential;

a second electronic control device having a first terminal, a second terminal and a third terminal;

third means electrically connecting said source of electrical power to said first terminal of said second electronic control device;

fourth means electrically connecting said second terminal of said first electronic control device to said third terminal of said second electronic control device;

a fourth impedance electrically connected between said second terminal of said second electronic control device and said third terminal of said second electronic device;

a fifth means electrically connecting said second terminal of said second electronic control device to said reference potential;

a utilization device electrically connected to said second terminal of said second electronic control device;

and whereby said first electronic control device will be placed into a conductive condition only when said first predetermined switching element is actuated, and whereby said second electronic control device will be placed into a conductive condition only if one of said plurality of switching elements is actuated after or simultaneously with first predetermined one of said switching elements, and whereby electrical power will be supplied to said utilization device only when said second electronic control device is in a conductive condition.

10. An electronic combination lock characterized in accordance with claim 9, wherein said utilization device comprises a starting device for starting sixth means which requires electricity for operation, and including:

seventh means having electrical inductance electrically connected between said starting device and said sixth means;

eighth means electrically connected in parallel with said seventh means;

said eighth means having a substantially low impedance with respect to a flow of electrons in a predetermined direction and having a substantially low admittance with respect to a flow of electrons in a direction which is opposite to said predetermined direction;

and ninth means operative in response to a flow of electrons through said seventh means to prevent operation of said sixth means or to activate warning means.

11. An electronic combination lock characterized in accordance with claim 9, wherein said fourth means includes:

a third electronic control device having a first terminal, a second terminal, and a third terminal;

said second means electrically connecting said first terminal of said third electronic control device to said source of electrical power and to at least one of said first or second plurality of terminals of said switching elements;

a fifth impedance electrically connected between said third terminal of said third electronic control device and one of said second plurality of terminals associated with a second predetermined one of said switching elements;

sixth means electrically connected to another one of said second plurality of terminals associated with said second predetermined switching element to said second terminal of said first electronic control device;

sixth impedance electrically connected between said third terminal of said third electronic control device and said reference potential;

a seventh impedance electrically connected between said second terminal of said third electronic control device of said third electronic control device and said reference potential;

a first electrical conductor connected between said second terminal of said third electronic control device and one of said second plurality of terminals associated with a third predetermined one of said switching elements;

and an eighth impedance electrically connected between said third terminal of said second electronic control device and another terminal of said second plurality of terminals associated with said third predetermined one of said switching elements.

12. An electronic combination lock characterized in accordance with claim **9**, wherein said fourth means includes:

a third electronic control device having a first terminal, a second terminal, and a third terminal:

a fourth electronic control device having a first terminal, a second terminal, and a third terminal;

said second terminal of said first electronic control device being electrically connected to one of said second plurality of terminals associated with one of said switching elements;

an impedance electrically connected between said third terminal of said third electronic control device and one of said second plurality of terminals associated with said one switching element;

an impedance electrically connected between said third terminal of said third electronic control device and said reference potential;

an impedance electrically connected between said second terminal of said third electronic control device and said reference potential;

an impedance electrically connected between said second terminal of said third electronic control device and said third terminal of said fourth electronic control device;

an impedance electrically connected between said second terminal of said fourth electronic control device and said reference potential;

an impedance electrically connected between said third terminal of said fourth electronic control device and said reference potential;

said third terminal of said fourth electronic control device being electrically connected to one of said first plurality of terminals associated with said first predetermined switching element;

another one of said first plurality of terminals associated with said first predetermined switching element being electrically connected to said reference potential;

said second terminal of said fourth electronic control device being electrically connected to one of said second plurality of terminals associated with a second predetermined switching element;

an impedance electrically connected between said third terminal of said second electronic control device and another of said second plurality of terminals associated with said second predetermined switching element;

and wherein said first terminal of said first electronic control device, said first terminal of said second electronic control device, said first terminal of said third electronic control device, and said first terminal of said fourth electronic control device are all electrically connectable to said source of electrical power.

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