

[54] **VEHICLE ELECTRICAL COMBINATION LOCK**

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[58] Field of Search **340/63, 64; 307/10 AT; 317/134; 200/42, 43, 44, 45; 180/114**

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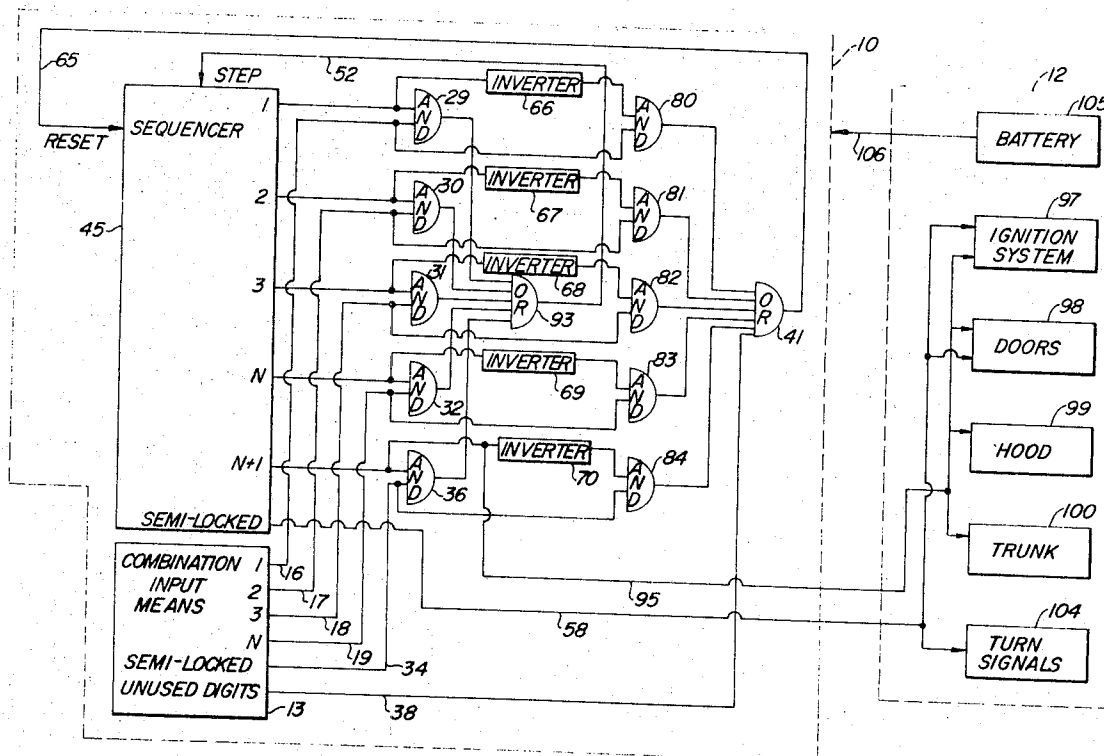
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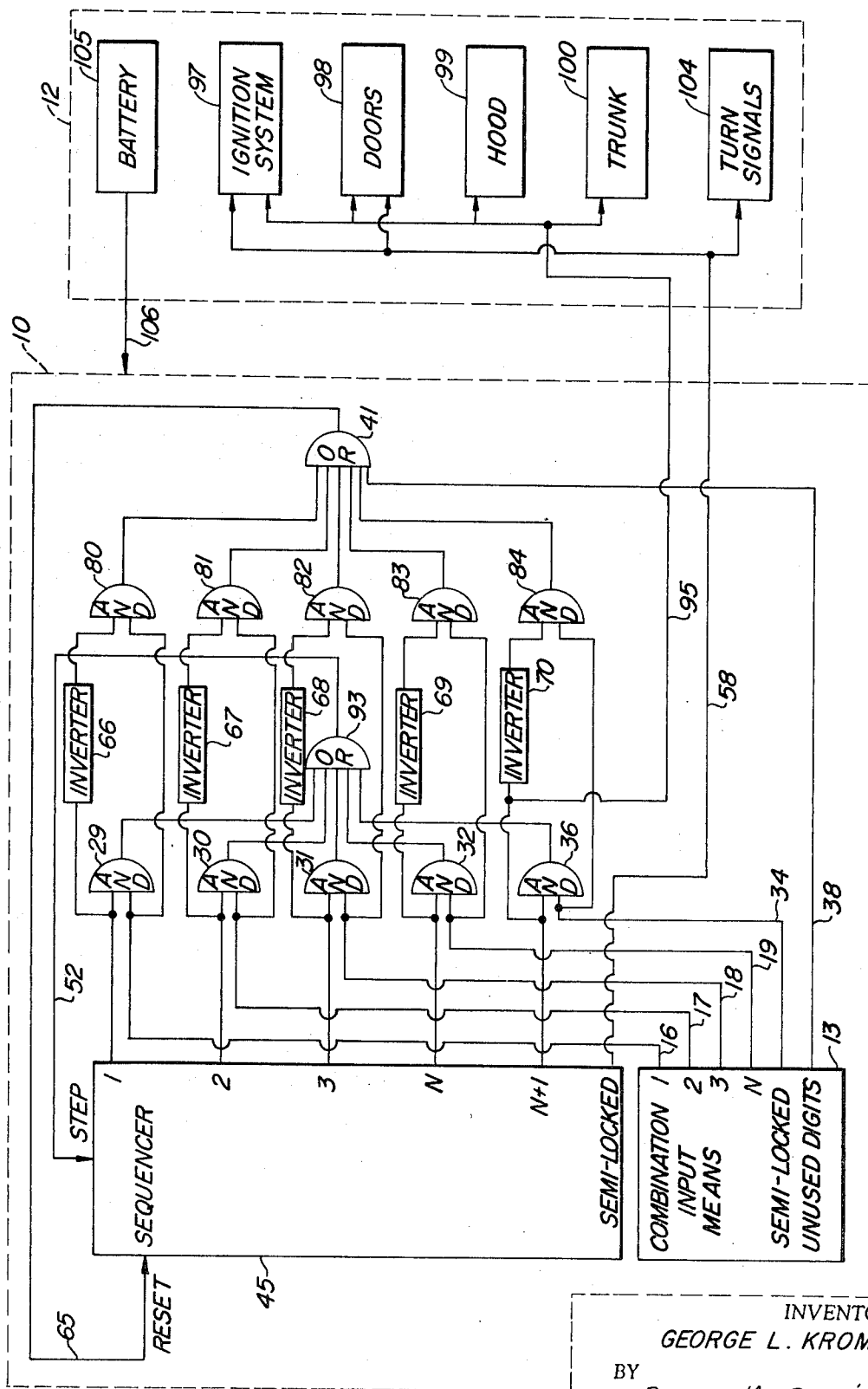
[57] **ABSTRACT**

An electrical combination lock circuit providing out-

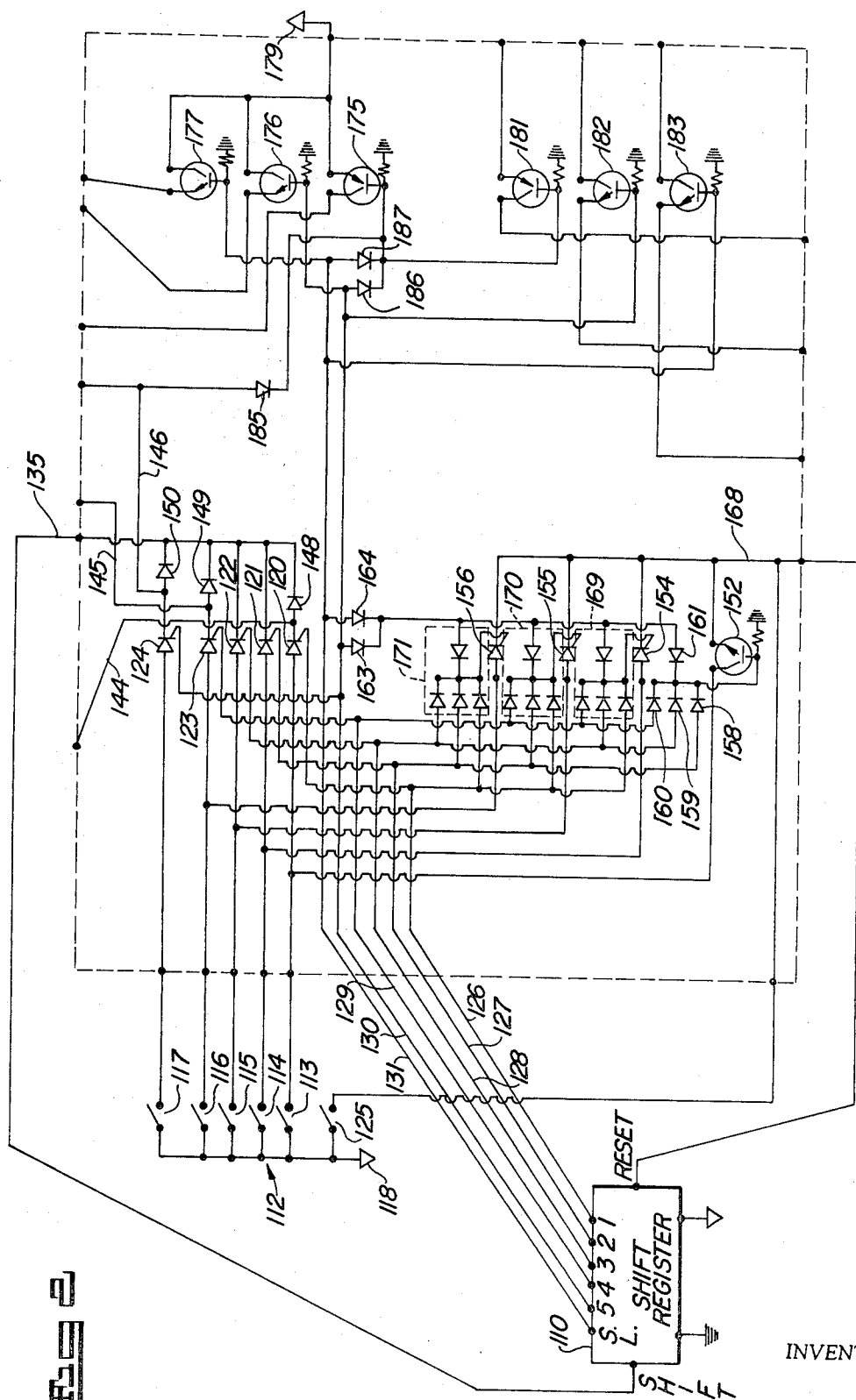
put signals representing locked, unlocked and semi-locked states. An "unlocked" signal is produced by providing input signals in proper sequence representing the unlocking combination. The "semi-locked" signal is produced only by providing an appropriate input signal when the combination lock circuit is in the "unlocked" state. The semi-locked state may be used to allow limited access to the protected area. Provision of an input signal representing a digit that is out of sequence in the combination or that is not in the combination causes the circuit to return to the "locked" state. In each of the locked, unlocked and semi-locked conditions the lock circuit provides a momentary electrical signal, a continuous electrical signal and a contact closure or "continuity" state for use by external locking devices. The electrical combination lock has particular advantage in protecting an automobile. In the semi-locked condition limited use of the automobile is permitted, such as by a parking lot attendant. Multiple sets of combination input means may be employed to provide access to individual areas only such as to the ignition system, trunk or doors of an automobile.

26 Claims, 6 Drawing Figures



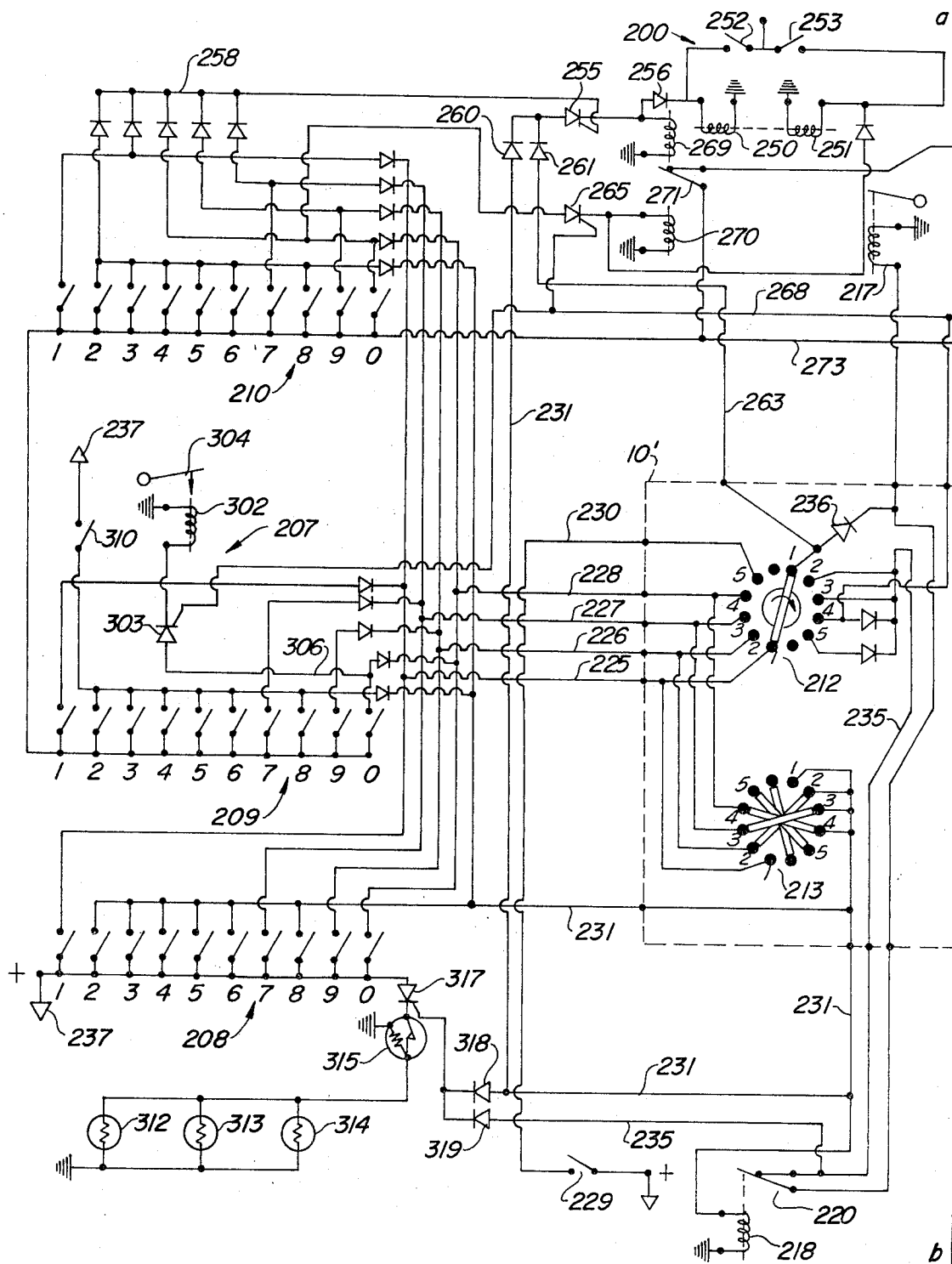


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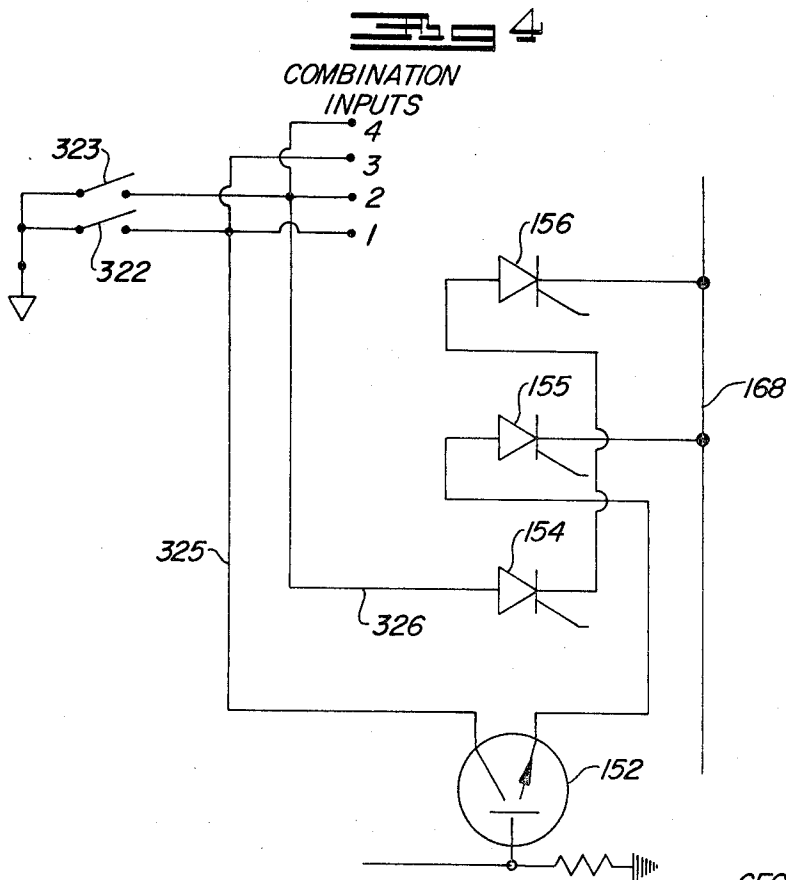
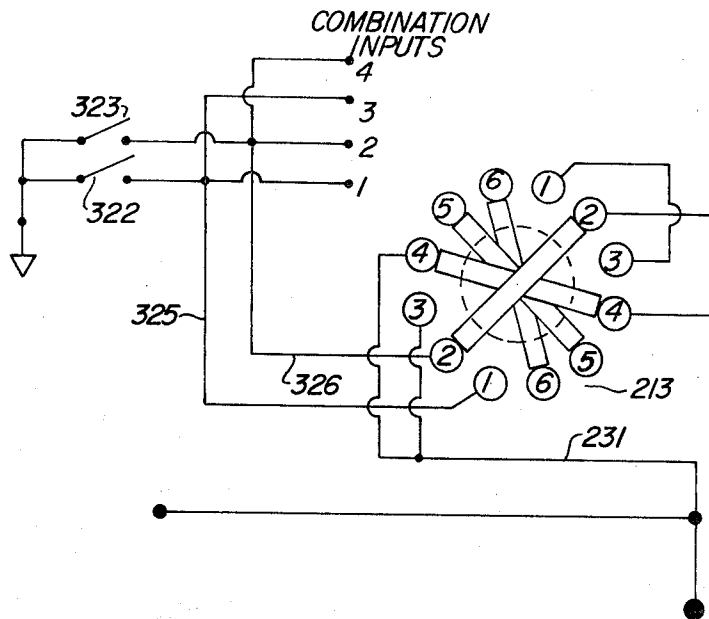
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VEHICLE ELECTRICAL COMBINATION LOCK

BACKGROUND OF THE INVENTION

The present invention relates to locks and more particularly to an improved electrical combination lock.

The necessity for a convenient and reliable locking system for areas that do not require the ultimate in security and the inadequacies of existing locking systems for such purposes are well recognized. Key locks in particular are subject to being defeated in so many ways that they are recognized as being usable only for light security and even then only when properly employed. In addition to the relative ease of defeating the lock itself, other disadvantages with key locks are that keys may be lost or may be left in the lock.

Mechanical combination locks provide much better security but are expensive and inconvenient to use in many applications. Mechanical combination locks, for example, require adequate lighting as well as considerable manipulation to operate the combination.

Another disadvantage with mechanical locks occurs when combinations or keys must be changed. Such changes must usually be made by trained personnel which results in inconvenience and sometimes considerable expense for the owner of the lock.

Finally, a particular drawback with all existing lock systems is that they have only two states, totally locked or totally unlocked. The protected area is, therefore, totally protected or totally unprotected by the lock system. In many applications, it is desirable to permit limited access to the protected area.

SUMMARY OF THE INVENTION

A general object of this invention is to provide a lock that overcomes the inadequacies noted above in prior locks. A more particular object of the invention is to provide an electrical combination lock that is reliable, easily operated and economical.

Another object is to provide an electrical combination lock in which the combination can be easily changed by an untrained person.

Another object of this invention is to provide an electrical combination lock having a semi-locked position to permit authorized but limited use of a protected device or access to a protected area.

Still another object of this invention is to provide an electrical combination lock which can be unlocked, semi-locked or locked from several locations remote from each other and from the lock itself.

Yet another object of the invention is to provide an electrical combination lock employing separate sets of combination input means to control the locking, unlocking and semi-locking of separate protected areas.

Still another object is to provide an electrically operated combination lock that may be produced in either electromechanical or solid state form.

A preferred form of electrical combination lock according to this invention includes means for providing a sequence of combination input signals, and sequencing means for providing a series of signal conditions in predetermined sequence. Means are provided to detect coincidence between predetermined ones of the input signals and predetermined ones of the signal conditions and to advance the sequencing means in response to such coincidence. If such coincidence is detected for a

series of N signal conditions representing the number of digits in the unlocking combination the unlocked output signal is produced. If coincidence is then detected between a predetermined one of the input signals representing the semi-locked input signal and the N+1 condition from the sequencing means a semi-locked output signal is produced.

The locking system of this invention has particular advantage in protecting an automobile in which case the semi-locked output signal may be employed to allow limited use of the automobile to authorized persons with appropriate indication to the public that the use is limited.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the basic lock of this invention connected to protected areas of an automobile and illustrating the general operation of the lock.

FIG. 2 is a schematic diagram of a solid state version of the basic lock of this invention.

FIGS. 3A and 3B make up a schematic diagram of an electro-mechanical version of the complete lock of this invention connected to an automobile to provide complete locking and semi-locking protection thereto, FIG. 3A showing the sequencing and sequence checking stepping switches and the combination input switches, and FIG. 3B showing the stepping switches that provide the continuous current and continuity output signals.

FIG. 4 is a schematic diagram of the sequence checking stepping switch wired for a repeated digits combination.

FIG. 5 is a schematic diagram of the sequence checking circuit in the solid state combination lock for a repeated digits combination.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1 for a general description of the operation of the basic combination lock of this invention, the basic lock circuit 10 is shown connected to an automobile 12 for supplying locked, unlocked and semi-locked output signals thereto. The lock 10 includes combination input means 13 for providing input signals representing the digits of the unlocking combination. The combination input means 13 also provides an input signal to shift the combination lock from the unlocked condition to the semi-locked condition as will be described below. Typically, combination input means 13 will include a set of switches representing the digits 0 through 9 and another switch representing the semi-locked input signal.

The output lines 16, 17, 18 and 19 carry signals representing the first, second, third and Nth digits of the N-digit unlocking combination and are connected respectively to inputs of AND gates 29, 30, 31 and 32. Output line 34 from the combination input means 13 carries an input signal for switching the locking system to the semi-locked from the unlocked condition and is connected to an input of AND gate 36. Output line 38 from the combination input means represents all the digits that are not used in the combination and is connected to an input of OR gate 41 for a purpose to be described below.

A sequencer 45 provides a series of signal conditions in predetermined sequence. In its initial or reset state sequencer 45 provides a signal to an input of AND gate 29. The sequencer 45 provides N+1 signal conditions in sequence as an appropriate number of step input signals are received in line 52. A particular signal condition is transferred in sequence from AND gate 29 to AND gates 30, 31, 32 and 36 and line 58 as the second, third, N N+1 and semi-locked steps in the sequence. Line 58 is connected directly to automobile 12 for reasons that will become apparent below. Sequencer 45 is reset to its initial condition from any step in its sequence when a signal is received in line 65. The sequence of signal conditions from sequencer 45 will be referred to hereinafter as step 1, step 2 and so on while the input signals representing the digits of the unlocking combination will be referred to as input 1, input 2, and so on.

The steps from sequencer 45 are connected to a series of inverters 66, 67, 68, 69 and 70 which have their outputs connected to AND gates 80, 81, 82, 83 and 84. The corresponding inputs from combination input means 13 are also connected to inputs of AND gates 80 to 84. The outputs from AND gates 29 to 32 and 36 are connected to the inputs of an OR gate 93 while the outputs of AND gates 80 to 84 are connected to the inputs of OR gate 41 along with the signal in line 38 representing all unused digits from the combination input means 13. The output signal from OR gate 93 provides the step input signal in line 52 to sequencer 45 while the output from OR gate 41 provides a reset signal in line 65 to sequencer 45.

In operation, combination input signals from combination input means 13 are entered sequentially into the lock circuit beginning with input 1. In AND gate 29, coincidence is checked between input 1 and step 1 from sequencer 45 and, if found, an output signal is passed through OR gate 93 to advance sequencer 45 to step 2. If coincidence is not found by AND gate 29, no such signal is produced and sequencer 45 must not have been positioned at step 1. In that case, coincidence is detected by AND gate 80 between input 1 and the absence of a signal representing step 1 and an output signal from AND gate 80 is passed through OR gate 41 to reset sequencer 45 to step 1. Thereupon, coincidence is detected by AND gate 29 between input 1 and step 1 and a signal is passed through OR gate 93 to advance sequencer 45 to step 2 as described above.

Inputs 2, 3, and so on to input N are entered sequentially into the combination lock system and, in each case, the input is determined to coincide with the corresponding step from sequencer 45 to produce a signal from OR gate 93 that advances sequencer 45 to the next step. If any input is presented out of sequence the appropriate AND gate 81 to 84 will detect it and will pass a signal through OR gate 41 to reset sequencer 45 to step 1. Likewise, if a signal is produced in line 38 representing a digit not used in the combination, a signal will be passed through OR gate 41 to reset sequencer 45 to its initial condition.

Assuming that inputs 1 to N are entered in the proper sequence, sequencer 45, after the entry of input N, will be positioned at step N+1 and an output signal condition from step N+1 is transmitted through line 95 to unlock a protected area such as one or more of the pro-

tected areas of automobile 12. Protected areas of the automobile may include the ignition system 97, doors 98, hood 99, and trunk 100. The unlocked signal may be utilized to unlock these areas in a manner to be described below.

At this point, the lock circuit may be relocked by transmitting to the system an input representing any digit of the combination or representing any unused digit. In either case, a signal will be transmitted through OR gate 41 to reset sequencer 45 and relock the circuit.

Alternatively, the lock system may be switched to the semi-locked condition by providing a semi-locked input signal through line 34 to AND gate 36. In AND gate 36 coincidence is detected between the semi-locked input signal and step N+1 and an output signal will be provided through OR gate 93 to advance sequencer 45 to the semi-locked state. A semi-locked output signal from sequencer 45 is produced in line 58 and transmitted to automobile 12 to allow limited use thereof in a manner to be explained more fully below. In addition to affecting the ignition system and doors, the semi-locked signal may be used to actuate the turn signals 104 of the automobile to provide a prominent visual indication that only limited use of the automobile is authorized.

When the combination lock is used to protect an automobile, the battery 105 thereof is employed to provide operating power as indicated by the line 106.

Referring now to FIG. 2 there is shown a solid state version of the basic combination lock of this invention including a sequencer in the form of a shift register 110 for providing step inputs and a set of combination input switches generally designated 112 for providing combination input signals. The circuit as shown is wired to be unlocked by a four digit combination. Switches 113, 114, 115, 116, and 117 corresponding to inputs 1, 2, 3, and 4 and the semi-locked input signal, respectively, are arranged to selectively connect a voltage source 118 to the anodes of controlled rectifiers 120 to 124. Switch 125 represents all the digits not used in the combination and is wired as described below. Steps 1, 2, 3, 4, and 5 from shift register 110 are connected to the gates of controlled rectifiers 120, 121, 122, 123, and 124, respectively. Controlled rectifiers 120 to 124 act as gating means to detect coincidence between the combination input signals and the corresponding step inputs from shift register 110. The cathodes of controlled rectifiers 120 to 124 are connected together and to line 135 which is connected to the shift input of shift register 110.

For a four digit unlocking combination, shift register 110 has six conditions. In its initial or reset condition a positive voltage appears on line 126 while zero volts appear on lines 127, 128, 129, 130 and 131. As shift input signals are received in line 135 the positive voltage in line 126 is shifted to lines 127, 128 and so on in a manner well known in the art. The shift register is designed so that the shift occurs on the trailing edge of the shift input signal.

Controlled rectifiers 120, 123, and 124 provide momentary output signals in lines 144, 145, and 146 respectively for use by associated circuits as will be explained more fully below. Rectifiers 148, 149 and 150 prevent momentary output signals from occurring in

lines 144, 145 and 146 out of sequence when shift input line 135 is energized by other shift input signals.

Combination input switch 113 is also connected to the collector of a transistor 152 while combination input switches 114, 115, and 116 are connected to the anodes of controlled rectifiers 154, 155 and 156 respectively. The base of transistor 152 is connected to the output of an OR gate including diodes 158, 159, 160 and 161. The inputs to diodes 158, 159 and 160 are step inputs 2, 3 and 4, respectively, while the input to diode 161 is step input 5 through diode 163 or the semi-locked step input through diode 164. Thus, it can be seen that transistor 152 will be rendered conductive if combination input 1 is produced simultaneously with any one of steps 2, 3, 4, 5 or the semi-locked step. The emitter of transistor 152 is connected to line 168 in common with the cathodes of controlled rectifiers 154, 155 and 156. Line 168 is connected to the reset input of shift register 110. combination input switch 125 which represents all of the combination input switches corresponding to unused digits is also connected to line 168 and thereby to the reset input of shift register 110. A signal at the reset input of the shift register causes the shift register to return to its reset or initial condition as is well known in the art.

It will be seen that the gate of controlled rectifier 154 is also connected to an OR gate generally designated 169 having as its inputs step 1, 3, 4, 5, and the semi-locked step so that coincidence between combination input 2 and any step of shift register 110 other than step 2 will fire controlled rectifier 154 and produce a reset input signal in line 168 to shift register 110. In like manner, controlled rectifier 155 will be rendered conductive through OR gate 170 when coincidence is detected between combination input 3 and any step from shift register 110 other than step 3 and will provide a reset signal to shift register 110. Controlled rectifier 156 in the same manner detects coincidence between combination input 4 and, through OR gate 171, any step of shift register 110 other than step 4 and provides a reset signal to shift register 110.

Thus, shift register 110 will be reset to its initial condition if any combination input switch is operated out of sequence or if a switch is operated that represents a digit not used in the unlocking combination.

It will be noted that the combination input switches, which produce input signals only so long as they are depressed, are connected to the anodes rather than the gates of controlled rectifiers 120 to 124 and of controlled rectifiers 154 to 156. These controlled rectifiers will, therefore, produce output signals that are equal in time duration to the length of time the combination input switches are depressed. In brief, the output signals from the controlled rectifiers are momentary. Each of these controlled rectifiers, once rendered conductive, remains conductive as long as the corresponding combination input switch remains depressed even though the step signal at its gate is removed. Transistor 152 is, however, used instead of a controlled rectifier to detect coincidence between combination input 1 and any step of shift register 110 other than 1 because it is desired to return the circuit to its initial condition when combination input 1 switch 113 is depressed as well as to begin the unlocking sequence. Assuming that shift register 110 is at some step other than 1 and it is

desired to enter the unlocking combination, depressing combination input 1 switch 113 will provide a positive voltage at the collector of transistor 152 and render the transistor conductive because there will be a signal at its base representing a step of shift register 110 other than step 1. A reset signal to shift register 110 will be produced and cause the shift register to return to its reset condition. At that point the signal at the base of transistor 152 will be removed and the transistor will cease to conduct. Controlled rectifier 120 will then detect coincidence between combination input 1 and step 1 and provide a shift signal in line 135 to advance shift register 110 in the normal manner. If, however, transistor 152 were replaced by a controlled rectifier removal of the signal at its gate when shift register 110 was reset would not render the controlled rectifier non-conductive, a reset input signal to the shift register would remain and the combination lock would be locked-up.

As noted above the basic combination lock circuit provides output signals indicating its locked, unlocked and semi-locked states in the form of momentary signals, continuous currents and switch closures. The momentary signals are provided from controlled rectifiers 120, 123 and 124 representing the locked, unlocked and semi-locked conditions, respectively. The continuous current outputs for the locked, unlocked semi-locked conditions are provided by transistors 175, 176 and 177, respectively. The collectors of transistors 176 and 177 are connected in common with the emitter of transistor 175 to a positive voltage source 179. These transistors are rendered conductive and supply current from voltage source 179 in a manner that will be described below in connection with the description of operation of the solid state combination lock circuit.

Switch closures or continuity output conditions for the locked, unlocked, and semi-locked conditions are provided by transistors 181, 182, and 183 respectively which are rendered conductive in the lock conditions they represent. The collector and emitter of each transistor is made available to external means for the purpose desired in a particular application. The manner in which the transistors are rendered conductive will be described below in connection with the description of operation of the basic solid state combination lock circuit.

In the following description of operation it will be assumed that the solid state combination lock circuit is initially in the locked condition with shift register 110 positioned at step 2. It will be noted that locked continuous current output transistor 175 is a PNP transistor normally biased into the conductive state by the voltage at its base being less positive than the voltage at its emitter. The transistor remains in that conductive state unless rendered nonconductive by a signal at its base through diode 185, 186 and 187 representing respectively, a momentary semi-locked output signal from controlled rectifier 124, the unlocked step (step 5) and the semi-locked step from shift register 110. Since none of these signals are present in the locked condition transistor 175 is conductive and capable of supplying current to external devices.

Unlocked condition continuous current output transistor 176 is an NPN transistor having its conduc-

tion status controlled by the unlocked step (step 5) signal in line 130 from shift register 110. Semi-locked condition continuous current output transistor 117 is also an NPN transistor and has its conduction status controlled by the semi-locked step signal in line 131 from shift register 110. Both transistors 176 and 177 are nonconductive in the locked condition.

Switch closure or continuity output transistors 181, 182, and 183 representing the locked, unlocked and semi-locked states are of the same type as the corresponding continuous current output transistors and each transistor 181, 182, 183 is biased on or off by the same signal that controls the conduction state of the corresponding continuous current output transistor. Thus, the base of transistor 181 is connected directly to the base of transistor 175, the base of transistor 182 is connected directly to the base of transistor 176 and the base of transistor 183 is connected directly to the base of transistor 177. Thus, in the locked condition, locked condition continuity output transistor 181 is biased on while unlocked condition continuity output transistor 182 and semi-locked condition continuity output transistor 183 are biased off.

With the circuit in the locked condition and shift register 110 at step 2, depressing combination input 1 switch 113 produces a positive voltage at the collector of transistor 152. Transistor 152 is rendered conductive by the collector voltage and the positive voltage at its base through diode 158 representing step 2 from shift register 110. A signal is produced in line 168 to reset the shift register to step 1. At that point transistor 152 will be rendered non-conductive by the removal of the step 2 signal from its base. Controlled rectifier 120 is fired by coincidence between combination input signal 1 and step signal 1 and will produce a shift input signal in line 135 to advance shift register 110 to step 2. Combination input 2 switch 114 is then depressed and controlled rectifier 121 is fired by coincidence between the input 2 signal and the step 2 signal and provides another shift input signal to advance shift register 110 to step 3. Combination input signals 3 and 4 are entered in sequence from switches 115 and 116 in the same manner with the result that shift register 110 is advanced to step 4 and then to step 5 (the unlocked step).

When combination input 4 switch 116 is depressed a momentary unlocked signal is provided in line 145 from controlled rectifier 123 for use by external apparatus. It should be noted that depressing any of the combination input switches 113 to 116 out of sequence or depressing a switch representing a digit not used in the combination would have produced a reset signal in line 168 to reset shift register 110 to step 1. Thus, shift register 110 can be advanced to the unlocked step by entering only the combination digits in proper sequence.

With the circuit in the unlocked condition the step 5 signal from shift register 110 renders transistors 176 and 182 conductive to provide the continuous current and continuity outputs for the unlocked condition. The step 5 signal in line 130 also turns off transistors 175 and 181 terminating the continuous current and continuity outputs for the locked condition. The continuous current and continuity outputs provided by transistors 176 and 182 may be used by external ap-

paratus to unlock a protected area such as the ignition of an automobile as will be described below.

With the circuit in the unlocked condition it may either be relocked or advanced to the semi-locked condition. Relocking is accomplished by depressing any combination input switch other than semi-locked input switch 117. Depressing any combination input switch will produce a reset signal in line 168 to reset shift register 110 to its initial condition and relock the circuit.

The combination lock circuit is switched to the semi-locked condition by depressing semi-locked input switch 117 which tires controlled rectifier 124 and provides a shift input signal in line 135 to advance shift register 110 to the semi-locked step. A momentary semi-locked output signal is produced in line 146 and coupled through rectifier 185 to the base of continuous current output locked condition transistor 175 to prevent its becoming conductive momentarily during the transition of shift register 110 from step 5 to the semi-locked step and, perhaps, affecting external apparatus. The momentary semi-locked output signal may also be used by external apparatus as desired.

With the combination lock circuit in the semi-locked condition a semi-locked state signal in line 131 turns on the continuous current output transistor 177 and the continuity output transistor 183 for the semi-locked condition and, through diode 187, provides a signal to the bases of locked condition transistors 175 and 181 to maintain them nonconductive. Unlocked condition transistors 176 and 182 are rendered nonconductive by the removal of the unlocked step 5 signal in line 130. The continuous current and the continuity condition provided by transistors 177 and 183, respectively, for the semi-locked condition may be used by external apparatus to allow limited access to a locked area or limited usage of a locked device, an example of which will be given below.

With the combination lock circuit in the semi-locked condition it is possible to transfer it only to the locked condition. This may be accomplished by depressing any combination input switch. Any switch depressed except the semi-locked input switch 117 will produce a signal in line 168 to reset shift register 110 to its initial condition and relock the combination lock circuit.

Referring now to FIGS. 3A and 3B there is shown an electro-mechanical version of the combination lock circuit of this invention as installed in an automobile to provide complete protection therefor. FIG. 3A is the left half and FIG. 3B is the right half of a schematic diagram of the complete lock circuit. The protected automobile is provided with electrical switch circuits which employ the locked, unlocked, and semi-locked output signals from the basic lock circuit to provide various degrees of protection to the automobile. The switch circuits include a door lock switch circuit generally indicated at 200 (FIG. 3A), an alarm switch circuit generally indicated at 202 which includes mechanically actuated switches for the doors, hood and trunk of the automobile, an ignition enabling switch circuit associated with the ignition system and generally indicated at 203, a hood latch solenoid generally indicated at 205, a turn signal switch circuit indicated generally at 206 for providing a visual indication to the public that authorized use of the protected automobile is limited, and a trunk lock switch circuit

207. The operation of the switch circuits will be described below.

The electrical combination lock circuit for automobiles includes at least one and preferably 3 sets of combination input switches (FIG. 3A), one set generally indicated at 208 for controlling at least the ignition of the automobile, another set 209 for allowing at least access to the trunk and a third set 210 for allowing basic control of the automobile along with control of the doors. Each set of switches 208, 209, 210 is connected to provide combination input signals to the basic combination lock circuit 10' so that the circuit can be unlocked or semi-locked. In this respect the switches are connected in parallel. The trunk combination input switches 209 and the door combination input switches 210, in addition to providing combination input signals to the basic combination lock circuit, also unlock the trunk and doors respectively as will be described below.

The ignition combination input switches 208 are preferably mounted on a panel on the dash board of the automobile. The trunk combination input switches 209 are preferably mounted on a panel on the trunk and the door combination input switches are mounted on a panel on a door of the automobile. Inserting the unlocking combination from the ignition combination input switches unlocks the ignition and the hood but does not unlock the trunk and does not change the door lock switch circuit from its previous condition, either locked or unlocked. Insertion of the unlocking combination from the trunk combination input switches unlocks the ignition, hood and trunk but does not change the status of the door lock switch circuit. Insertion of the unlocking combination from the door combination input switches unlocks the ignition, hood and doors but does not affect the trunk lock switch circuit. Thus, access can be gained to particular areas of the automobile without rendering it completely unlocked.

In the semi-locked condition the door and trunk combination input switches are inoperative, the hood and trunk remain locked and the alarm switch circuit will be energized if either the hood or trunk should be forced open. Also, with the conventional ignition switch of the automobile closed the turn signals of the automobile are caused to blink on and off to provide an indication that only limited use of the automobile is authorized.

In the electro-mechanical version of the basic combination lock circuit 10' sequencing, sequence checking, continuous current in the unlocked and semi-locked output conditions and continuity (switch closure) in the unlocked and semi-locked conditions are provided by a series of stepping switches. The sequencing stepping switch is shown at 212 and the sequence-checking stepping switch at 213 in FIG. 3A. The continuous current stepping switch is shown at 215 and the continuity stepping switch at 216 in FIG. 3B. Stepping switches 212, 215 and 216 are wired to transfer a signal from one contact of the stepping switch to another to thereby provide a path for the particular signal only when the stepping switch is in the particular position connecting the two terminals. Sequence-checking stepping switch 213 is wired so that an open circuit exists between predetermined input and

output contacts of the stepping switch when it is in a predetermined position. In that predetermined position a signal at any other input contact will be transferred to an output contact. In effect, stepping switches 212, 215 and 216 produce an output signal when coincidence is detected between a particular input signal and a particular position of the stepping switch while sequence checking stepping switch 213 detects coincidence between a particular input signal and a particular position of the stepping switch and provides no output signal if the position and the signal coincide.

The stepping switches 212, 213, 215 and 216 have an initial or reset condition identified as step 1 and are connected so that they will advance to subsequent steps and return to the reset step together. The stepping switches are advanced by energizing a stepping coil 217 which magnetically attracts a stepping armature and tensions an actuating spring. When the current to the stepping coil is interrupted the stepping armature is snapped back into its original position by the actuating spring. A pawl on the stepping armature engages a ratchet gear and advances the gear incrementally. The stepping switches are connected to move with the gear and are thereby advanced to the next step. As the ratchet gear is stepped it tensions a ratchet return spring. The ratchet gear is held in each position by a dog which engages the ratchet gear after each stroke to prevent the gear and switches from returning to reset position. The stepping switches are reset by energizing a reset coil 218 to magnetically attract a reset armature causing the release of the dog holding the ratchet gear and causing the tensioning spring to return the ratchet gear and the switches to their initial or reset position.

An interrupter switch 220 actuated by reset coil 218 is provided to prevent stepping coil 217 from being energized during the reset operation. This is necessary because sequencing stepping switch 212 passes through several steps on its way to the reset step, one of which might be connected to the combination input signal causing the reset and, if so, would connect that signal to the stepping coil and interfere with the reset operation. Interrupter switch 220 prevents such a situation from occurring. As will be explained more fully below, interrupter switch 220 does not prevent stepping coil 217 from being energized in the first step position which is at the end of the reset cycle. This is necessary so that depressing of any combination input switch 1 will return the sequencing stepping switch to its initial condition and then advance it to the next step as explained above in connection with the description of FIG. 2.

The basic electro-mechanical combination lock circuit 10' is completely analogous to the solid state version described above. In the example illustrated the unlocking combination is 1970 and combination input switches representing those digits in each of the sets of combination input switches are connected in parallel and to the combination input terminals of the basic combination lock circuit 10' through lines 225, 226, 227 and 228. The semi-lock input switch 229 is preferably located with the ignition combination input switch 208 on the dashboard of the automobile and is connected through line 230 to the semi-lock input terminal lock 10'. The switches representing all the unused digits in the sets are connected together and to reset line 231. Sequencing stepping switch 212 and

stepping switches 213, 215 and 216 are shown in their first step or reset positions. Lines 225 and 228 are connected to the first, second, third and fourth step inputs, respectively, of sequencing stepping switch 212. Output steps 2, 3, 4 and 5 of the stepping switch are connected together to line 235 and energize stepping coil 217 through interrupter switch 220 when coincidence is found between a particular combination input signal and the position of sequencing stepping switch 212. Output step 1 of stepping switch 212 is connected directly to stepping coil 217 through diode 236 and not through interrupter switch 220 for reasons given above. Output step 1 is also connected to the door lock switch circuit 200 for purposes to be described below.

Lines 225 to 228 from the combination input switches are also connected to step input contacts 1, 2, 3 and 4 of sequence checking stepping switch 213. The output steps of stepping switch 213 are connected together and to line 231 to provide reset signals to the reset coil 218. The operation of sequence checking stepping switch 213 is such that no reset signal will be produced if combination input signals appear only when the stepping switch is in the proper position to interrupt them. If a combination input signal is produced other than when the sequence checking stepping switch is at the corresponding step, a reset signal will be produced.

The continuous current stepping switch 215 (FIG. 3B) has its step input terminals connected to a source of voltage 237 such as the battery of the automobile through line 238 and has its step output terminals 1 to 4 connected together to provide a continuous output current through line 240 when the stepping switch is at steps 1, 2, 3 or 4. Step output 5 (the unlocked step) of stepping switch 215 is connected to line 241 and provides a continuous current to ignition lock switch circuit 203 in the unlocked state. The semi-locked step output is connected to line 243 to provide continuous current for the alarm circuit 202 in the semi-locked state of the lock circuit.

The continuity or contact closure stepping switch 216 does not employ step inputs or step outputs 1 to 4 but has its step 5 (unlocked step) input connected through a hood latch switch 245 to the battery 237 of the automobile and has its unlocked step output terminal connected through line 246 to the hood latch solenoid 205. The semi-locked step input of continuity stepping switch 214 is likewise connected to the battery 237 of the automobile through the conventional automobile ignition switch 248. The semi-locked step output is connected by way of line 249 to the turn signal switch circuit 206 which causes the turn signals to blink when the ignition switch 248 is closed and the lock circuit is in the semi-locked state.

The operation of the basic lock circuit with stepping switches is completely analogous to the operation of the solid state version described above. When the combination input signals are provided in the proper sequence they are passed through sequencing stepping switch 212 and cause the stepping switch to advance to the next step. Operation continues in this manner until the unlocked step is reached or until a switch representing a digit not used in the combination is depressed or a combination input switch is depressed out of sequence which causes the stepping switches to

return to their reset condition. From the unlocked condition the lock circuit can be stepped to the semi-locked condition by operating the semi-lock switch 229 or can be relocked by operating any other switch in any of the sets. The various switch circuits for the automobile that utilize the outputs of the basic lock circuit are described below.

The door lock switch circuit 200 includes an electrically operated door latch having a locking coil 250 and an unlocking coil 251. Coils 250 and 251 when momentarily energized transfer the latch to its locked and unlocked position respectively. Manual switches 252 and 253 allow the locking and unlocking coils, respectively, to be energized from inside the automobile to lock and unlock the doors at any time.

Locking coil 250 is energized from the combination lock circuit by a signal from controlled rectifier 255 through rectifier 256. The gate of controlled rectifier 255 is connected to an OR gate generally designated 258 having as its inputs all of the door combination input switches 210. Thus, the gate of controlled rectifier 255 is energized only by a signal from the door combination input. The anode of controlled rectifier 255 is connected to the output of an OR gate including diodes 260 and 261 which are connected respectively to reset line 231 and to line 263 which carries a momentary step 1 output signal at the appropriate time.

Unlocking coil 251 is energized by controlled rectifier 265 which has its anode connected to the door combination input switch representing the last digit in the combination, which in this example is the digit 0. The gate of controlled rectifier 265 is connected to line 268 which carries a momentary unlocked output signal at the appropriate time.

Controlled rectifiers 255 and 265 also control a door alarm enabling relay having coils 269 and 270 and contacts 271. Energization of coil 269 by controlled rectifier 255 closes contacts 271 while energization of coil 270 through controlled rectifier 265 opens 271. Contacts 271 when in the closed position allow current from line 273, which carries continuous current in the locked condition of the lock circuit, to flow to alarm switch circuit 202 to provide an audible alarm under conditions to be described below. Line 273 is also connected to the input sides of door and trunk combination input switches 210 and 209 and provides a current path to those switches under conditions to be described below. It will be appreciated from the foregoing description that the doors of the automobile can be locked or unlocked with the combination lock circuit only from the door combination input switches.

Referring now to the alarm circuit 202 (FIG. 3B) an audible alarm means 275 is energized through a delay relay 276 when contacts 277 are closed connecting the alarm to a supply of voltage such as battery 237. Contacts 277 are switched to their closed position by momentarily energizing coil 278 and are switched to their open position by momentarily energizing coil 279. Coil 278 is connected to the output side of a set of door switches 280, a hood switch 283 and a trunk switch 284 which are closed when the respective door, hood or trunk of the automobile is open. Current to the door switches 280 is supplied from contacts 271 of the door alarm enabling relay while current for the hood and trunk switches 283 and 284, respectively, is supplied

either from line 240 in the locked state of the lock circuit or from line 243 in the semi-locked state of the circuit.

A line 286 connects the common side of the door, hood and trunk switches directly to audible alarm means 275. If any of the door, hood or trunk switches is closed when a current is being supplied thereto audible means 275 is energized directly through line 286 and remains energized as long as the door, hood or trunk remains open. The door, hood and trunk switches also provide a path for current to energize coil 278 which closes contacts 277 to provide voltage to the audible alarm means 275 through delay relay 276. After a delay, preferably of about 20 seconds, caused by delay relay 276 audible alarm means 275 will be energized through contacts 277 even if the door, hood or trunk has been closed. A dashboard warning light 287 is also lighted when contacts 277 are closed. The delay in energizing the audible alarm means allows the automobile owner to shut off the alarm system if he should accidentally trigger it. This can be done only by entering the proper unlocking combination.

When alarm means 275 is energized through contacts 277 it operates for a maximum of 3 minutes after which a delay relay 289 operates and connects the voltage input to alarm means 275 to coil 279 which opens contacts 277 and shuts off the alarm. This operates as a battery saving feature in cases where the alarm has been triggered by a potential thief who has been frightened away by the alarm. Coil 279 of the alarm latching relay is also energized through diode 290 from line 268 which carries the momentary unlocked signal.

Referring now to the ignition lock switch circuit 203 it will be seen that a controlled rectifier 293 has its gate connected to be energized through the conventional starter switch 294 of the automobile, has its cathode connected to the conventional ignition coil of the automobile and has its anode connected to line 241 which carries continuous current in the unlocked condition of the basic lock circuit. A PNP transistor 295 has its emitter connected to the anode of controlled rectifier 293, its base connected to the cathode of controlled rectifier 293 and its collector connected through diode 296 to line 273 which is connected to the input sides of the door and trunk combination input switches. Controlled rectifier 293 locks the ignition of the automobile unless the basic lock circuit is in the unlocked state. Continuous current is supplied to line 273 through PNP transistor 295 in the unlocked condition of the lock circuit unless the automobile engine is running. In that case, PNP transistor 295 is biased off by current from controlled rectifier 293 flowing through base resistor 297. This is a safety feature which prevents operation of the combination lock from the trunk or door combination input switches while the automobile is running.

The turn signal switch circuit 206 is energized through continuity stepping switch 216 in the semi-locked condition of the lock circuit as noted above. Current from the battery 237 of the automobile through ignition switch 248 when it is closed energizes controlled rectifiers 299 and 300 through line 249 and also energizes the ignition coil in the automobile through rectifier 301. Pulsating current from the turn signal blinker flows through controlled rectifiers 299

and 300 causing all the turn signals to blink on and off. These blinking lights notify the general public that limited use of the car is authorized.

The trunk lock switch circuit (FIG. 3A) includes a trunk unlocking solenoid 302 which is supplied with current through controlled rectifier 303 and operates a trunk latch 304. The gate of controlled rectifier 303 is connected to line 268 which carries the momentary unlock signal at appropriate times while the anode of the controlled rectifier is connected through line 306 to the trunk combination input switch representing the last digit in the unlocking combination, which in this example is the digit 0. The trunk unlocking solenoid 302 is therefore operative to unlock and open the trunk only when the unlocking combination has been entered from the trunk combination input switches. The trunk latch 304 is returned to its original locking position at the end of the momentary unlocking signal so that the trunk will be automatically relocked when it is closed. A relock switch 310 is closed momentarily when the trunk is closed and provides a signal from battery 237 to reset line 231 to energize reset coil 218 and return the lock circuit to its reset condition.

A convenience feature which is helpful when inserting the unlocking combination at night in unlighted areas is a series of lights 312, 313, and 314 associated with the trunk, door, and ignition combination input switches, respectively. The lights are energized through a slow-release relay 315 and a controlled rectifier 317. The anode of controlled rectifier 317 is connected directly to the battery 237 of the automobile while its gate is connected to be energized through diode 318 by a reset signal in line 231 or through diode 319 by a signal in line 235 that advances the stepping switches. The lights 312, 313, and 314 are thus turned on for a period, preferably about 30 seconds, determined by the release time of slow-release relay 315 each time a reset or step signal is generated. Thus, ample time is allowed for insertion of the combination from any one of the three combination input switch sets after which the lights are automatically extinguished.

Typical operation of the entire automobile locking system will now be described assuming that the circuit is initially in the locked condition and all areas of the automobile are locked. In the locked condition line 240 and continuous current stepping switch 215 (FIG. 3B) provide a path for current from battery 237 to the alarm switch circuit 202 to enable hood switch 283 and trunk switch 284, so that if either trunk or hood is opened by force or otherwise while the circuit is in the locked condition an audible alarm will be given as described above. Line 240 is also connected to line 273 through diode 321 to connect the input side of the door combination input switches 210 and the trunk combination input switches 209 to continuous current stepping switch 215. Line 273 (FIG. 3A) also provides a path for current to contacts 271 of the door alarm enabling relay which is connected to door switches 280 in the alarm switch circuit 202 (FIG. 3B). An audible alarm will be produced in the manner described above if any of the doors of the automobile are opened by force or otherwise when the door lock switch circuit 200 is in the locked condition.

Thus, in this condition, every area of the automobile is locked including the doors, ignition, hood and trunk

and the alarm switch circuit 202 is enabled to provide an alarm in the manner described above if a door or the hood or trunk is opened.

Depending now on the degree of access desired to the automobile the unlocking combination must be inserted from the appropriate set of combination input switches. If access to the trunk is desired the combination must be inserted from the trunk combination input switches 209. As the combination is entered the lock circuit advances in steps to the unlocked state as described above. When the unlocked condition is reached the trunk unlocking solenoid 302 is energized in the manner described above and the trunk of the automobile opens providing access thereto. The hood of the automobile is also unlocked by continuity stepping switch 216 and may be opened by actuating hood latch switch 245 to energize hood latch solenoid 205. The ignition of the automobile is also unlocked in a manner to be described below. The doors of the automobile, however, were not unlocked because the locking combination did not originate from the door combination input switches and, therefore, the momentary unlocked signal in line 268 was blocked by controlled rectifier 265 in the door lock switch circuit. The circuit is relocked when the trunk is closed, momentarily operating relock switch 310.

Entering the unlocking combination from the ignition combination input switches 208 provides access to the same areas as provided by entering the combination from the trunk combination input switches except that the trunk is not unlocked.

The operation of the basic combination lock circuit, i.e., advancing in steps to the unlocked step, when the unlocking combination is entered from the door combination input switches is the same as described above. In addition to operation of the basic lock circuit the door lock switch circuit is operated as described below.

When combination input 1 (in this example, the digit 1) is inserted from the door combination input switches a signal is supplied to the gate of controlled rectifier 255 in the door lock switch circuit 200 through either rectifier 260 from the reset line 231 or through rectifier 261 from line 263 carrying the momentary first step output from sequencing stepping switch 212. This momentary first step output is required to lock the doors if the circuit is in the locked position and the first combination input switch is the one selected at random to lock the doors. Since the door combination input switches 210 are being used to insert the unlocking combination, controlled rectifier 255 will be rendered conductive and pass current to locking coil 250 to lock the doors and to coil 269 to close contacts 271 and enable the door switches 280 in the alarm switch circuit 202 (FIG. 3B). When the last digit of the combination is entered a momentary unlocked signal appears in line 268 and at the gate of controlled rectifier 265. Controlled rectifier 265 is rendered conductive and energizes unlocking coil 251 to unlock the doors and coil 270 to open contacts 271 of the door alarm enabling relay and disable the alarm switch circuit 202 for the doors.

A continuous current unlocked signal appears in line 241 (FIG. 3B) from continuous current stepping switch 215 and at the anode of controlled rectifier 293 and to the emitter of transistor 295 in the ignition lock switch

circuit 203. Transistor 295 is biased into conduction until the starter switch 294 of the automobile is closed and, until then, provides current through rectifier 296 to line 273 to energize input sides of the trunk and door combination input switches. Controlled rectifier 293 will be triggered into conduction when the starter switch 294 of the automobile is closed and will pass current to the ignition coil to allow the automobile to be started in the normal manner. Conduction by controlled rectifier 293 will turn off PNP transistor 295 and interrupt current in line 273 so that the door and trunk combination input switches 210 and 209 will be inoperable. This is a safety feature which prevents any alteration of the circuit condition by switches external to the automobile when it is running. The hood of the automobile may also be opened by operating hood latch switch 245 to energize hood latch solenoid 205 through a path provided by continuity stepping switch 216.

At this point the doors, hood and ignition of the automobile are unlocked. The alarm switch circuit 202 is inoperative since there is no path provided for current flow thereto. The ignition and hood alone may be relocked and the alarm made operative for the hood and trunk by depressing any of the ignition or trunk combination input switches. Every area of the automobile may be relocked, including the doors, by operating any door combination input switch.

From the unlocked condition described above the lock circuit may be switched to the semi-locked condition by actuating semi-locked switch 229 (FIG. 3A) which advances stepping switches 212, 213, 215 and 216 to their semi-locked positions. In the semi-locked condition a continuous current is provided from continuous current stepping switch 215 (FIG. 3B) through line 243 to hood and trunk switches 283 and 284 in the alarm switch circuit 202. The alarm will then sound if the hood or trunk of the automobile is opened. No path is provided for current to line 273 to the inputs of the door or trunk combination input switches. Accordingly, those switches are inoperable in the semi-locked condition of the lock circuit. A path is provided through continuity stepping switch 216 and line 249 to allow operation of the ignition system of the automobile by closing ignition switch 248 which completes a current path through rectifier 301 to the ignition coil of the automobile. When the ignition switch 248 is closed intermittent signals from the turn signal blinker to the anodes of controlled rectifiers 299 and 300, which have their gates energized from line 249, cause the turn signals to blink on and off regularly indicating to any observer that the automobile is in authorized use for limited purposes. The hood and the trunk of the automobile remain locked.

An example of the authorized but limited use for which the semi-locked condition is intended is use by a parking attendant to whom the automobile has been surrendered for parking. Limited use of the automobile for parking and for moving about the parking area when necessary is available but with the lights flashing and with no access provided to the trunk or hood of the automobile. Thus, a thief cannot disable the lock circuit itself which is preferably beneath the hood, nor can a thief drive the automobile any appreciable distance to a safe spot without attracting a great deal of attention

because of the blinking lights. A parking attendant can be instructed to relock the automobile by depressing any ignition combination input switch when he has moved the automobile for the last time. This will lock all areas of the automobile except the doors which can then be locked by operating any door combination input switch.

It will be apparent to those skilled in the art that the combinations of the electrical combination lock of this invention can be easily changed by connecting different combination input switches from the various sets to the combination input 1, 2, 3 and 4 terminals of the basic combination lock circuit. All switches representing digits not used in the new combination are connected together and to the reset line for the reasons described above. It will also be apparent that combinations having other than four digits may be used.

In some cases it may be desired to provide a repeat combination, for example a four digit combination consisting of two digits followed by the same two digits in the same order. This may be accomplished by a small amount of rewiring of the sequence-checking circuits as shown in FIGS. 4 and 5. FIG. 4 shows the sequence-checking stepping switch 213 and FIG. 5 shows the principal components of the sequence-checking or reset circuit of the solid state version of the electrical combination lock circuit. In both FIGS. 4 and 5 combination input switch 322 representing the first and third digits of the combination is wired both to combination input 1 and combination input 3 of the basic lock circuit while switch 323 representing the second and fourth digit in the combination is wired to both combination input 2 and combination input 4 of the basic lock circuit.

In FIG. 4 line 325 represents the first and third digits of the combination and is wired to step input 1 of the sequence checking stepping switch 213. Line 326 representing the second and fourth digits of the combination is wired to step input 2 of stepping switch 213. Step outputs 1 and 3 of stepping switch 213 are connected together and step outputs 2 and 4 are likewise connected together. Step inputs 3 and 4 are connected together with reset line 231. The stepping switch itself is arranged so that two open circuits spaced from each other by one step are provided at each position of the stepping switch. The effect of this wiring is that no reset signal is produced at either the first or third step position of the stepping switch when combination input 1 or combination input 3, which are the same digit, is present. Likewise, no reset signal is produced when the stepping switch is in the second or fourth step position and the switch representing the second and fourth digits of the combination is operated. Except for this difference, operation proceeds in the normal manner and operation of a combination input switch out of order, such as by depressing the same combination input switch twice in succession, or operation of a switch representing a digit not used in the combination will produce a reset signal and relock the circuit.

As shown in FIG. 5, the rewiring of the solid state version of the combination lock circuit for operation with a repeat combination as described above is accomplished in an analogous way. Line 325 representing the digit that appears first and third in the combination is connected to the collector of transistor 152 which

has its emitter connected to the anode of controlled rectifier 155. Also, line 326 representing the digit that occupies the second and fourth positions in the combination is connected to the anode of controlled rectifier 154 which has its cathode connected to the anode of controlled rectifier 156. The cathode of controlled rectifier 155 and of controlled rectifier 156 are connected to reset line 168. The effect of this wiring is the same as that described above. At the first and third steps of shift register 110 no current path through both transistor 152 and controlled rectifier 155 is provided for a signal representing the digit that is first and third in the combination. Likewise, at the second and fourth steps of shift register 110 no path is provided through both controlled rectifiers 154 and 156 for a signal representing the digit that is second and fourth in the combination.

While preferred forms of this invention have been specifically disclosed herein it will be apparent to those skilled in the art that changes and improvements can be made in the forms herein specifically disclosed without departing from the spirit and scope of the invention. Accordingly, this invention is not to be limited to the forms herein specifically disclosed nor in any other way inconsistent with the progress in the art promoted by the invention.

What is claimed is:

1. A combination-operated electrical lock system for providing signals to open a lock when signals representing N digits of an N-digit combination are sequentially entered into the system comprising means for providing a sequence of combination input signals, sequencing means for providing a series of signal conditions in predetermined sequence, means responsive to coincidence between predetermined ones of said input signals and predetermined ones of said signal conditions for advancing said sequencing means to an N+1 signal condition providing an unlocking output signal, and means responsive to coincidence between the N+1 signal condition and a predetermined one of said combination input signals for providing a semi-locking output signal.

2. The system as claimed in claim 1 including means responsive to coincidence between said input signals and said signal conditions other than between predetermined ones of said input signals and predetermined ones of said signal conditions for resetting said sequencing means to its initial condition.

3. The system as claimed in claim 1 wherein said unlocking signal includes a momentary electrical signal, a continuous electrical signal and a closed circuit connection.

4. The system as claimed in claim 1 wherein said semi-locking output signal includes a momentary electrical signal, a continuous electrical signal and a closed circuit connection.

5. The system as claimed in claim 1 wherein said sequencing means includes stepping switch means providing a signal path to allow itself to be advanced when predetermined ones of said combination input signals occur in predetermined sequence.

6. The system as claimed in claim 5 wherein said stepping switch means provides a signal path to allow itself to be reset to its initial condition when coincidence is not found between predetermined ones of

said input signals and predetermined ones of said signal conditions.

7. The system as claimed in claim 6 wherein said stepping switch means provides an output unlocking signal when it has been advanced to the N+1 step.

8. The system as claimed in claim 7 wherein said stepping switch means provides an output semi-locking signal when it has been advanced to the N+2 step.

9. The system as claimed in claim 1 wherein said sequencing means includes a shift register for producing a series of signals in predetermined sequence, and wherein each of said coincidence responsive means includes gating means for detecting coincidence between predetermined ones of said combination input signals and predetermined ones of said signal conditions.

10. A combination-operated electrical lock system for opening a lock on an automobile when signals representing N digits of an N-digit combination are sequentially entered into the system comprising means for providing a sequence of combination input signals, sequencing means for providing a series of signal conditions in predetermined sequence, means responsive to coincidence between predetermined ones of said input signals and predetermined ones of said signal conditions for advancing said sequencing means for a series of N input signals to an N+1 signal condition providing an unlocking signal, means responsive to coincidence between the N+1 signal condition and a predetermined one of said combination input signals for providing a semi-locking signal, said automobile lock including ignition lock means for maintaining the ignition of said automobile normally locked, said ignition lock means being responsive to said unlocking signal or to said semi-locking signal for unlocking said ignition.

11. The system as claimed in claim 10 including hood lock switch means associated with the hood of said automobile for maintaining said hood normally locked, said hood lock switch means being responsive to said unlocking signal for enabling said hood to be opened.

12. The system as claimed in claim 10 including means responsive to coincidence between said input signals and said signal conditions other than between predetermined ones of said input signals and predetermined ones of said signal conditions for resetting said sequencing means to its initial condition.

13. The system as claimed in claim 10 wherein said means for providing combination input signals includes separate sets of combination switches for the doors, for the ignition and for the trunk of said automobile.

14. The system as claimed in claim 13 including a trunk lock switch circuit for maintaining the trunk of said automobile normally locked, said trunk lock switch circuit being responsive to said unlocking signal to unlock said trunk only when said combination input signals are provided from said set of trunk combination switches.

15. The system as claimed in claim 13 including a door lock switch circuit associated with said automobile and operative to lock the doors of said automobile only in response to signals initiated from said door combination switches.

16. The system as claimed in claim 15 wherein said doors are locked in response to coincidence between the combination input signal representing the first digit of the unlocking combination and the first of said signal conditions.

17. The system as claimed in claim 15 wherein the doors of said automobile are locked in response to a lack of coincidence between one of said input signals and a corresponding one of said signal conditions.

18. The system as claimed in claim 15 including a plurality of door switches opening and closing with the closing and opening of the doors of said automobile, and an alarm switch circuit responsive to the locked condition of said door lock switch circuit for providing an audible alarm when one of said door switches is closed.

19. The system as claimed in claim 15 wherein said door lock switch circuit is responsive to said unlocking signal to unlock said doors only when said combination input signals are provided from said door combination switches.

20. The system as claimed in claim 13 including means responsive to said unlocking signal for rendering said set of door combination switches and said set of trunk combination switches inoperative to provide combination input signals when the motor of said automobile is running.

21. The system as claimed in claim 13 including means responsive to said semi-locking signal for rendering said set of door combination switches and said set of trunk combination switches inoperative to provide combination input signals.

22. The system as claimed in claim 10 including means responsive to said semi-locking signal for energizing the turn signals of said automobile when the normal ignition switch of said automobile is closed.

23. The system as claimed in claim 10 including a hood switch and a trunk switch opening and closing with the closing and opening of said hood and said trunk, and an alarm switch circuit responsive to the absence of said unlocking signal and to the closing of either of said hood or trunk switches for providing an audible alarm.

24. The system as claimed in claim 23 wherein said alarm switch circuit is responsive to said semi-locking signal and to the closing of either of said hood or trunk switches for providing an audible alarm.

25. A combination-operated electrical lock system for opening a lock on an automobile when signals representing N digits of an N digit combination are sequentially entered into the system comprising switch means for providing a sequence of combination input signals, sequencing means for providing a series of signal conditions in predetermined sequence, first gate means responsive to coincidence between predetermined ones of said input signals and predetermined ones of said signal conditions for advancing said sequencing means, second gate means responsive to coincidence between said input signals and said signal conditions other than between predetermined ones of said input signals and predetermined ones of said signal conditions for resetting said sequencing means to its initial condition, said sequencing means being advanced to an N+1 signal condition providing an unlocking signal, third gate means responsive to coincidence between said N+1 signal condition and a predetermined one of said combination input signals for advancing said sequencing means to an N+2 signal condition providing a semi-locking signal, said automobile lock including ignition lock means and hood lock switch means for maintaining the ignition and the hood

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of said automobile normally locked, said ignition lock means being responsive to said unlocking signal or to said semi-locking signal for unlocking said ignition, and said hood lock switch means being responsive to said unlocking signal for enabling said hood to be opened. 5

26. A combination-operated electrical lock system for opening a lock on an automobile when signals representing N digits of an N-digit combination are sequentially entered into the system comprising switch means for providing a sequence of combination input signals, 10

stepping switch means having:

a first set of contacts providing a signal path to allow itself to be advanced when predetermined ones of said combination input signals occur in predetermined sequence, 15

a second set of contacts providing a signal path to allow itself to be reset to its initial condition when combination input signals occur other than in predetermined sequence, and 20

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a third set of contacts providing an output unlocking signal when said stepping switch means is advanced to an N+1 step, and providing a semi-locking output signal when said stepping switch is advanced to an N+2 signal condition in response to coincidence between said N+1 signal condition and a predetermined one of said combination input signals,

said automobile lock including ignition lock means and hood lock switch means for maintaining the ignition and the hood of said automobile normally locked,

said ignition lock means being responsive to said unlocking signal or to said semi-locking signal for unlocking said ignition, and

said hood lock switch means being responsive to said unlocking signal for enabling said hood to be opened.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,710,316 Dated January 9, 1973

Inventor(s) George L. Kromer

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

Change the city of patentee's residence from "Hickley", Ohio to --Hinckley,-- Ohio

Column 3, line 9, insert a comma between "N" and "N+1"

Column 8, line 12, change "tires" to --fires--

Column 10, line 66, before "lock" insert --of--

Column 11, line 2, change "and" to --to--

Column 13, line 7, after "audible" insert --alarm--

line 29, change "saying" to --saving--

Column 15, line 21, change "locking" to --unlocking--

Column 16, line 60, change "packing" to --parking--

Signed and sealed this 29th day of May 1973.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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