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Hughes

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[54] **ELECTRICAL COMBINATION LOCK**

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[51] **Int. Cl.**..... **E05b 49/00**

[58] **Field of Search**..... 317/134; 70/271, 70/273, 278, DIG. 81; 200/43, 45

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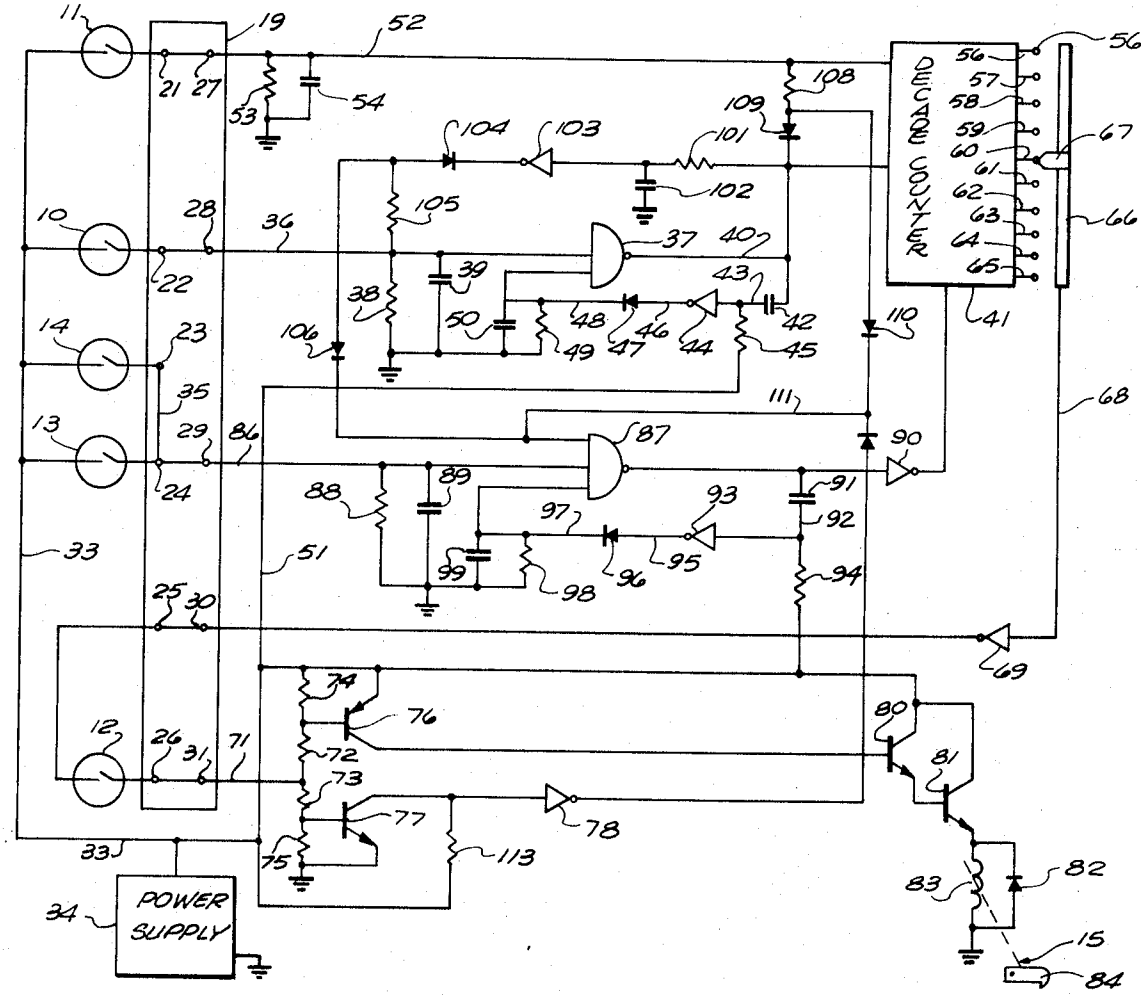
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Assistant Examiner—Harry E. Moose, Jr.
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[57] **ABSTRACT**

An electrical combination lock includes a hidden magnetic reed array, a pulse counter coupled by digital circuitry to the reed array, and an electrically controllable lock coupled to the counter. If predetermined reeds of the array are operated with a magnet in a predetermined sequence within a predetermined time, the counter provides a signal which causes the lock to open. If the reeds are operated in any other order, such operation disables the counter for a predetermined unit of time during which the lock cannot be opened. Thus, knowledge of the location of the magnetic reeds and the sequential operation of particular magnetic reeds within a predetermined time are required in order to open the lock.

10 Claims, 3 Drawing Figures



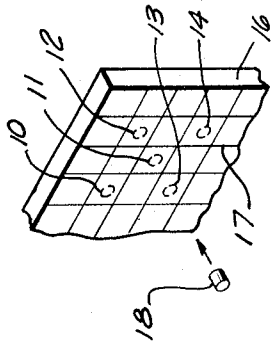


FIG. 2

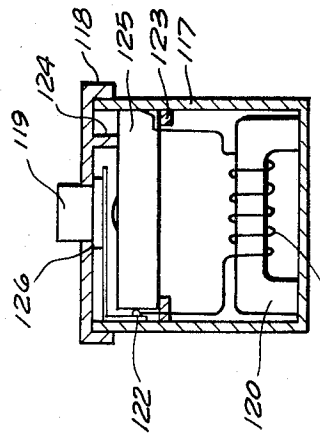


FIG. 3

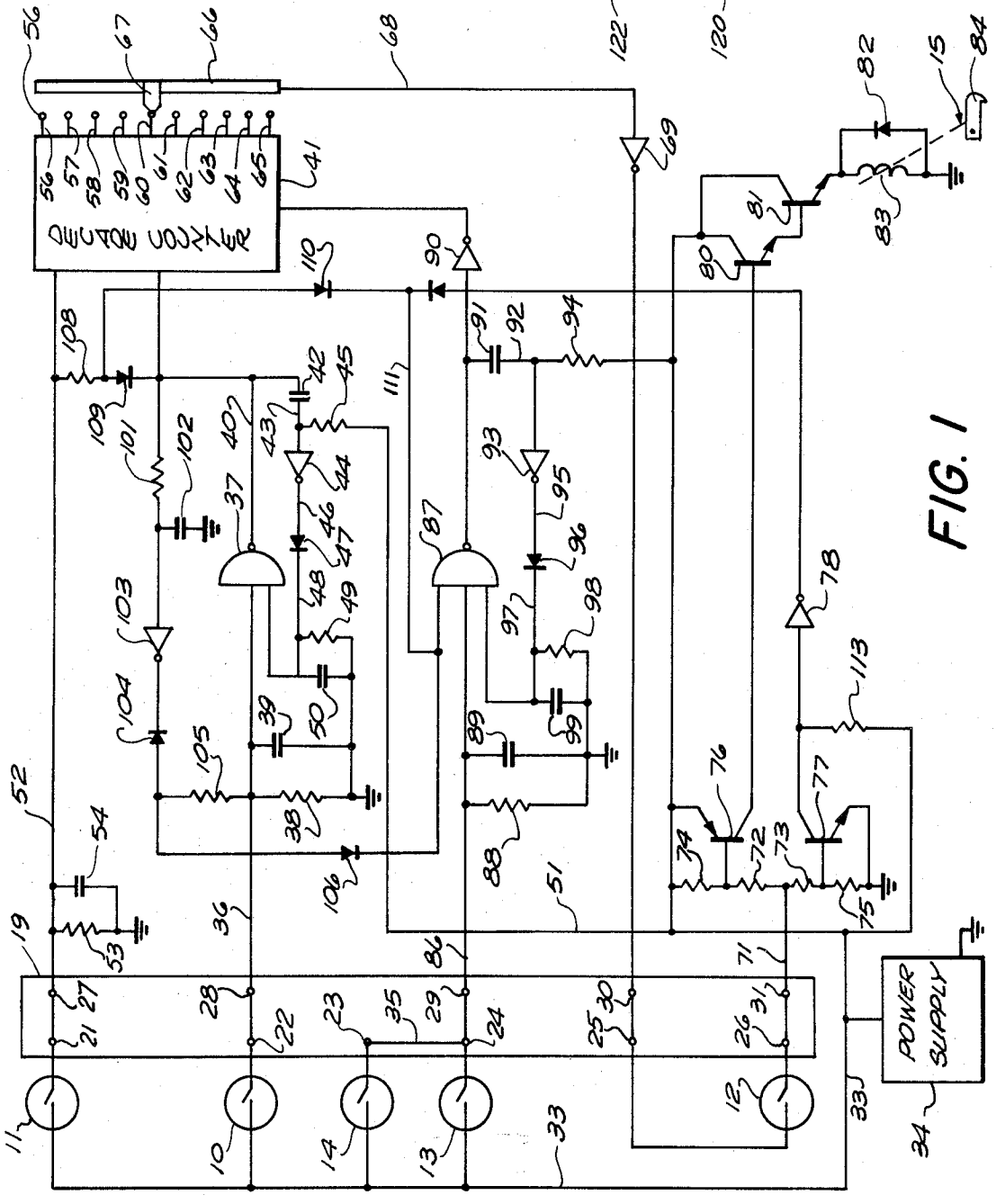


FIG. 1

ELECTRICAL COMBINATION LOCK

This invention relates to electrical combination locks and in particular to an electrical combination lock wherein particular switches of an array must be sequentially operated within a predetermined time interval in order to open the lock.

It is an object of the present invention to provide an electrical combination lock which cannot be opened for a predetermined period of time after an incorrect code has been applied, thereby hindering the use of experimentation to open the lock.

It is another object of the present invention to provide an electrical combination lock wherein the code for opening the lock is readily changeable.

It is still another object of the present invention to provide an electrical combination lock which is magnetically actuated, thereby enabling concealment of the lock from unauthorized users.

The above objects are met, according to the invention, by an electrical combination lock having (a) a pulse counter; (b) a plurality of switch means; (c) an electrically controllable lock; (d) means for permitting said lock to be opened only when said counter receives a predetermined number of pulses; and (e) means responsive to operation of said switch means in a predetermined sequence for enabling said counter to receive pulses for only a predetermined time period, for providing pulses to said counter, and for opening said lock.

Additional objects and features of this invention will become apparent by reference to the following description in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic diagram of an electrical combination lock according to the present invention;

FIG. 2 is a perspective view of a wall of an enclosure having an array of magnetically-operable switches within it, the location of said switches being conveyed to authorized users of the lock by a design on the outer face of the wall, and a magnet in the process of being brought to the design to operate one of the switches; and

FIG. 3 is a cross-sectional view of a portable electromagnet for use in opening the electrical combination lock.

An electrical combination lock according to the invention is schematically illustrated in FIG. 1. In general, the electrical combination lock includes five magnetic reed switches 14–14 which, when operated, activate logic circuits, and a solenoid actuated lock 15 coupled to the logic circuits. Only the movable latch portion 84 of the lock is illustrated. It is to be understood, however, that the latch engages a fixed keeper when the lock is closed and is moved out of engagement with the keeper when the lock is opened. The lock can only be opened if switches 10–12 are operated in a predetermined sequence within a predetermined period of time.

Referring to FIG. 2, to prevent unauthorized users of the combination lock from tampering with its switches 10–14, the switches are fixed in an array to, for example, the hidden face of a non-magnetic wall 16 of an enclosure. The face of the wall 16 is decorated with a design 17, in this example a grid pattern, whose features are used to indicate the location of the switches 10-14 to authorized users. Thus, an authorized user can operate any particular switch with magnetic means 18 whereas an unauthorized user will be burdened with the task of first locating the switches 10-14.

The magnetic means 18 may either be a permanent magnet which is strong enough to close a magnetic reed switch when the magnet is brought into close proximity with such a switch, or an electromagnet, such as is more fully described below.

The logic functions used for opening the lock 15 may be provided using standard components. For example, the logic functions required by the invention may be provided by using, in conjunction with other standard elements, the following solid state logic components: one RCA CD4017lA decade counter; one RCA CD4000A NOR gate pair; and one RCA CD4009A six inverter package. In this example of the invention, the foregoing logic components are operated with a 10 volt power supply 34 (FIG. 1) to provide a low level voltage of approximately zero volts and a high level voltage of approximately 10 volts, said voltages, respectively, corresponding to the well-known 0 and 1 binary states.

More specifically, as shown in FIG. 1, the electrical combination lock includes a combination plug 19 having terminals 21–31. Although the plug 19 is not a necessary part of the invention, the plug is used so as to enable the combination of the lock to be changed by merely changing the connections at the plug 19. For one of a number of possible connections, switch 10 is connected at one end to terminal 22 and at the other end, via wire 33, to the power supply 34. Switch 11 is connected at one end to terminal 21 and at the other end, via wire 33, to the power supply 34. Switch 13 is connected at one end to terminal 24 and at the other end, via wire 33, to the power supply 34. Switch 14 is connected at one end, via wire 33, to the power supply 34, and at the other end to terminal 23 and to terminal 24 via jumper 35. Switch 12 is connected at one end to terminal 25 and at the other end to terminal 26. In the plug 19, each pair of terminals 21 and 27, 22 and 28, 24 and 29, 25 and 30, and 26 and 31, are connected to each other. Thus, terminals 27–31 are available to couple the switches 10-14 to the logic circuits.

The logic circuitry and how it operates to open the lock 15 will now be described. A wire 36 connects terminal 28 to an input of a NOR gate 37, to a grounded resistor 38, and to a grounded capacitor 39. The output terminal of the NOR gate 37 is connected by wire 40 to the "reset" terminal of a decade counter 41 and to one end of a DC blocking capacitor 42. The other end of the capacitor 42 is connected by wire 43 to an inverter 44, and to a resistor 45 which couples, via wire 51, the power supply 34 to the inverter 44 and the capacitor 42. The output terminal of the inverter 44 is connected by wire 46 to the anode of a diode 47. The cathode of the diode 47 is connected by wire 48 to an input of the NOR gate 37, to one end of a grounded resistor 49, and to one end of a grounded capacitor 50.

As a result, when the switch 10 is closed momentarily, a positive pulse is applied to the NOR gate 37. If the pulse width exceeds a predetermined value which is determined by the component values of resistor 38 and capacitor 39, the leading edge of the pulse produced by the closing of switch 10 causes the output voltage of the NOR gate 37 to drop to its low voltage state and the output voltage of the inverter 44 to rise to its high voltage state. The low level voltage from the NOR gate 37 enables the decade counter 41, and the high level voltage from the inverter 44 causes the ca-

pacitor 50 to charge to a positive voltage which exceeds the threshhold level of the NOR gate 37. The trailing edge of the pulse does not cause the output of the NOR gate 37 to rise to its high voltage state because of the positive voltage on the capacitor 50. However, with time, the capacitor 42 charges and the output voltage of the inverter 44 drops, thereby back-biasing the diode 47. The back-biased diode 47 causes the capacitor 50 to discharge through resistor 49, and when the voltage across the capacitor 50 falls below the threshhold level of the NOR gate 37, the output voltage of the NOR gate 37 rises to its high voltage state. The high voltage state of the output of the NOR gate 37 disables the decade counter 41. Thus, the closure of the switch 10 for a brief period of time enables the decade counter 41 for a period of time determined by the component values of resistors 49, 45 and capacitors 42, 50. Typically, the decade counter 41 is enabled for ten seconds.

Switch 11 is connected by wire 52 to the "clock" input of the decade counter 41, to a grounded resistor 53, and to a grounded capacitor 54. Thus, each time the switch 11 is closed momentarily, a pulse is applied to the counter 41. If the pulse width exceeds a predetermined value which is determined by the component values of resistor 53 and capacitor 54, and the counter 41 is enabled, as described above, the counter will count the pulse produced each time that the switch 11 is closed.

Each of the output terminals (not shown) of the decade counter 41 is connected to one of the terminals 56–65 of a slide switch 66, and the wiper arm 67 of the slide switch 66 is adjustable to engage any one of the terminals 56–65. Each of the terminals 56-65 provides a high level output voltage only when a predetermined number of pulses have been applied to the enabled decade counter 41. For example, terminal 60 only provides a high level voltage when 5 input pulses are applied to the decade counter 41 via line 52. Thus, the output voltage on a wire 68 coupled to the wiper arm 67 is at a high voltage state only when a certain number of pulses have been applied to the counter 41 and the wiper arm 67 is connected to the terminal of the counter whose output voltage is caused to rise by the certain number of pulses. Since the wiper arm 67 may be adjusted to make contact with any one of the terminals 56-65, the use of switch 66 provides another means for changing the combination of the electrical combination lock,

The wire 68 is connected to an inverter 69 whose output is connected to terminal 30. As previously described, terminal 30 is coupled to terminal 31 via switch 12. Terminal 31 is connected by a wire 71 to one end of a resistor 72 and to one end of a resistor 73. The other end of resistor 72 is connected to the base of an NPN transistor 76 and, via resistor 74, to the power supply 34. The other end of resistor 73 is connected to the base of a PNP transistor 77 and, via resistor 75, to ground. The emitter of transistors 77 is grounded and its collector, as more fully discussed below, is connected to an inverter 78, and, via resistor 113, to the power supply 34. The emitter of transistor 76 is connected to the power supply 34 and its collector is connected to the base of transistor 80. The transistor 80 is part of a Darlington circuit wherein the collectors of the transistors 80, 81 are connected to the power supply 34, and the emitter of transistor 81 is connected to the cathode of a grounded snap diode 82, and to a grounded solenoid 83. The solenoid 83 is used to control the latch 84 of the lock 15, and the diode 82 is used to protect the Darlington circuit from current spikes. With the arrangement described, the resistors 72–75 normally bias the transistors 76, 77 below their cut-off voltages. However, if the switch 12 is closed when a predetermined number of pulses is applied to the enabled decade counter 41, the positive voltage on the wire 68 causes the transistors 76, 80 and 81 to conduct, thereby energizing the solenoid 83 which pivots latch 84 and opens the lock. Upon deenergization of solenoid 83, a spring returns latch 84 to its locked position.

From the foregoing, it may be seen that the electrical combination lock can be opened by closing switch 10, closing switch 11 an appropriate number of times which is determined by the setting of the slide switch 66, and by closing switch 12. However, the switches 10–12 must be operated within the predetermined time interval. To prevent unauthorized openings of the lock 15, the electrical combination lock also includes a number of "traps", the circuitry of which is described below.

A wire 86 connects terminal 29 to an input of a NOR gate 87, to a grounded resistor 88, and to a grounded capacitor 89. The output terminal of the NOR gate 87 is connected to one end of a DC blocking capacitor 91, and via inverter 90 to the "clock enable" terminal of the decade counter 41. The other end of the blocking capacitor 91 is connected by wire 92 to an inverter 93, and to a resistor 94 which couples the power supply 34 to the inverter 93 and the capacitor 91. The output terminal of the inverter 93 is connected by wire 95 to the anode of a diode 96. The cathode of the diode 96 is connected by wire 97 to an input of the NOR gate 87, to one end of a grounded resistor 98, and to one end of a grounded capacitor 99. As a result, when either switch 13 or 14 is closed momentarily, a positive pulse is applied to the NOR gate 87. If the pulse width exceeds a predetermined value which is determined by the component values of resistor 88 and capacitor 89, the leading edge of the pulse causes the output voltage of the NOR gate 87 to drop to its low voltage state and the output voltages of inverters 93 and 90 to rise to their high voltage state values. This results in disabling the decade counter 41 and causing the capacitor 99 to charge to a positive voltage which exceeds the threshhold voltage level of the NOR gate 87. The trailing edge of the pulse does not cause the output of the NOR gate 87 to rise because of the positive voltage on the capacitor 99. However, with time, the DC blocking capacitor 91 charges and the output of the inverter drops to its low voltage state value, thereby back-biasing the diode 96. The back-biased diode 96 causes the capacitor 99 to discharge through resistor 98, and when the voltage across the capacitor 99 falls below the threshhold level of the NOR gate 87, the output voltage of the NOR gate 87 rises to its normally high voltage state. The high output voltage level at the output of the NOR gate 87 enables the decade counter 41. Thus, the closure of switch 13 or 14 for a brief period of time disables the decade counter 41 for a period of time determined by the component values of resistors 94, 98 and capacitors 91, 99. During the period of time that the decade counter 41 is disabled, it cannot be reset and, therefore, the lock 15 cannot be opened with the procedure described above. Typically, the decade counter 41 is disabled for 20 seconds.

The provide a "trap" which prevents the opening of the lock **15** unless switches **10, 11,** and **12** are operated a predetermined number of times in the stated order, wire **40** at the output of NOR gate **37** is connected to one end of resistor **101.** The other end of resistor **101** is connected to a grounded capacitor **102,** and to the input of an inverter **103** whose output is connected to the cathode of a diode **104.** The anode of the diode **104** is connected via resistor **105** to wire **36** and to the anode of diode **106.** The cathode of diode **106** is connected to the input of NOR gate **87.** Before switch **10** is closed, to start a sequence for opening the lock **15,** the voltage at the input of the inverter **103** is at a high voltage level, and the voltage at the output of the inverter **103** is at a low voltage level. Thus, when the switch **10** is closed once, the diode **104** is forward biased and the pulse voltage provided by the momentary closure of switch **10** is dropped across resistor **105.** However, the pulse, as previously described, causes the output of the NOR gate **37** to drop, and after a delay provided by resistor **101** and capacitor **102** causes the output of the inverter **103** to rise, thereby back-biasing diode **104.** As a result, if after the delay caused by the resistor **101** and capacitor **102,** but within the time during which the decade counter **41** is enabled, the switch **10** is closed a second time, the resulting pulse is coupled, via resistor **105** and diode **106,** to an input of NOR gate **87.** Thus, the decade counter **41** is disabled for a predetermined period of time, as previously described with respect to a pulse provided by switch **13** or **14.** Accordingly, switch **10** cannot be closed more than once if the lock **15** is to be opened.

Further, wire **52,** connecting switch **11** to decade counter **41,** is connected to one end of a resistor **108,** and the other end of resistor **108** is connected to the anode of diode **109** and the anode of diode **110.** The cathode of diode **109** is connected to wire **40** and the cathode of diode **110** is connected, via wire **111,** to an input of the NOR gate **87.** If the switch **10** has enabled the decade counter **41,** wire **40** is at a low voltage level, and positive pulses on wire **52** cause the forward biased diode **109** to conduct. Accordingly, the pulse voltage is dropped across resistor **108.** However, if the decade counter **41** is not enabled when switch **11** is closed, a high voltage is applied to the cathode of diode **109** by the NOR gate **37** and an input pulse supplied by the switch **11** is coupled via resistor **108,** diode **110,** and wire **111,** to the input of the NOR gate **87,** thereby disabling the decade counter **41,** in the manner described above, for a predetermined period of time.

As previously described, when the decade counter **41** is disabled or the wiper arm **67** of switch **66** is connected to a terminal which is at a low voltage state because an incorrect number of pulses have been applied, a low voltage is present on line **68.** Therefore, if switch **12** is closed, the transistor **77** is caused, via resistor **113,** to conduct. The collector of transistor **77** is connected to the inverter **78** and the output of the inverter **78** is connected to the anode of diode **115.** The cathode of diode **115** is connected, via wire **111,** to an input of the NOR gate **87.** Thus, a premature closure of the switch **12** causes the collector voltage to drop momentarily, and a positive pulse is applied to the NOR gate **87,** thereby disabling the decade counter for a predetermined period of time.

From the foregoing it may be seen that the lock **15** can only be opened if the switch **10** is closed once, if thereafter the switch **11** is closed a predetermined number of times, if the switch **12** is closed after switch **11** has been closed a predetermined number of times, and if switches **10, 11,** and **12** are operated as just described, within a predetermined time interval. Any deviation from the sequence set forth above causes the combination lock to be disabled for a predetermined interval of time during which not even the proper sequence will open the lock.

Since the required closing of the switches **10, 11,** and **12** require that a magnet be brought near the switches a predetermined number of times, it is conceivable that one watching the opening of the lock will detect and count the gross movements of the user's hand and arm in the process of opening the lock, thereby obtaining knowledge of the number of pulses required to open the lock. Accordingly, for additional security, the lock may be opened with a portable electromagnet which can be controlled with the less obvious action of, for example, a finger. Such an electromagnet is disclosed below.

Referring To FIG. **3,** a portable electromagnet includes a non-magnetic circular container **117** having a cover **118** through which an actuator **119** extends. In the bottom of the container **117,** there is fixed a magnetic member **120** about which there is located a spirally wound wire **121.** One end of wire **121** is connected to an L-shaped metallic contact **122** which is fixed to the wall of the container **117,** and the other end of the wire **121** is connected to the top surface of an annular abutment **123** extending from the inside wall of the container **117.** The abutment **123** and an arcuate member **124** extending from the cover into the circular container **117** serve to secure a circular battery **125** in the container, and causes engagement between the case of the battery **125** and wire **121.** A portion of the L-shaped metallic contact **122** extends in cantilever fashion over the terminal of the battery **125** and abuts against the base of the actuator **119,** thereby biasing a flange **126** on the actuator **119** against the bottom of the cover **118.** As a result of this arrangement, when the actuator **119** is depressed, the metal contact engages the terminal of the battery **125** and current flows through the wire **121.** The flow of current through wire **121** causes the magnetic member **120** to provide a magnetic field which is useful for operating the magnetic reed switches. When the actuator **119** is released, the metallic contact **122** springs to its normal position, thereby opening the circuit, returning the actuator to its initial position, and terminating the magnetic field.

With an electromagnet as described, an operator of the electrical combination lock can deceptively approach magnetic switches **10-14** of the array any number of times before actuating the electromagnet with the slight movement of a finger, thereby concealing the number of pulses required to open the lock **15.**

In view of all of the above, it should be noted that the electrical combination lock described as an example features a code which can be changed readily by changing the connections at the plug or by changing the setting of the slide switch **65;** and means for concealing the lock and its code.

It is to be understood that the description herein of a preferred embodiment according to the invention is set forth as an example thereof and is not to be construed or interpreted as a limitation on the claims which follow and define the invention.

What is claimed is:

1. An electrical combination lock, comprising:
a. a pulse counter having a plurality of outputs;
b. a plurality of switch means;
c. an electrically controllable lock;
d. means for permitting said lock to be opened only when said counter receives a predetermined number of pulses, said means including means for open circuiting all but one of the outputs of said pulse counter and for coupling the one output to one of the switch means; and
e. means responsive to operations of said switch means in a predetermined sequence for enabling said counter to receive pulses for only a predetermined time period, for providing pulses to said counter, and for opening said lock.

2. An electrical combination lock as defined in claim 1 wherein the plurality of switch means includes a hidden array of switches, and including means for actuating any of the hidden switches.

3. An electrical combination lock as defined in claim 2 wherein the plurality of hidden switches include at least one magnetic reed switch, and said actuating means includes magnetic means for operating magnetic reed switches.

4. An electrical combination lock as defined in claim 3 wherein said magnetic means include an electromagnet.

5. An electrical combination lock as defined in claim 1 wherein said means (e) includes: means responsive to the operation of one of the switch means for enabling the counter for the predetermined period of time, and means responsive to the operation of another of the switch means for providing the pulses to the counter.

6. An electrical combination lock as defined in claim 1 wherein said means (e) includes: means responsive to the operation of another one of the switch means for providing the pulses to the counter, and means responsive to operation of said one of the switch means for opening the lock when the counter has received the predetermined number of pulses.

7. An electrical combination lock as defined in Claim 1 wherein the plurality of switch means further includes first and second switch means; wherein said means (e) includes: means responsive to the operation of the first switch means for enabling the counter for the predetermined period of time, means responsive to the operation of the second switch means for providing the pulses to the counter, and means responsive to operation of said one of the switch means for opening the lock when the counter has received the predetermined number of pulses.

8. An electrical combination lock as defined in claim 7 further including means for keeping the lock closed unless the first, second, and said one switch means are sequentially operated in a predetermined order within the predetermined time period.

9. An electrical combination lock as defined in claim 8 wherein said means for keeping the lock closed includes means responsive to the operation of any of said plurality of switch means in other than said predetermined sequence, for disabling the counter for a predetermined interval of time.

10. An electrical combination lock as defined in claim 1 including means responsive to non-sequential operation of said switch means for disabling said pulse counter for a predetermined period of time.

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