

[54] **ELECTRONIC COMBINATION LOCK
INCLUDING SEQUENTIAL SIGNAL
GENERATOR AND SIGNAL DISPLAY**

[76] Inventor: **Klaus W. Gartner**, 5711 Ravenspur
Dr., Palos Verdes Peninsula, Calif.
90274

[22] Filed: **June 29, 1972**

[21] Appl. No.: **267,640**

[52] U.S. Cl. **317/134, 70/278, 307/10 AT,
340/147 R**

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

[58] Field of Search **317/134; 70/278;
340/147 MD, 147 K, 147 B, 167 R; 307/10 AT**

[56] **References Cited**

UNITED STATES PATENTS

3,587,051	6/1971	Hovey	317/134
3,718,202	2/1973	Brock	317/134
3,610,943	10/1971	Jones	307/10 AT
3,600,637	8/1971	Bergqvist	317/134
3,411,046	11/1968	Swannick	317/134

Primary Examiner—J. D. Miller

Assistant Examiner—Harry E. Moose, Jr.

Attorney, Agent, or Firm—Miketta, Glenny, Poms &
Smith

[57] **ABSTRACT**

A manually-actuated electronic combination lock is

provided in which the combination code consists of certain preselected digital signals out of a field of many such signals. Circuit means provide for generating a sequence of digital signals constituting the field in response to sustained manual engagement with a push-button switch and a solid state alpha-numeric indicator is connected to display by symbolic representation each of the signals as generated. Selection of the proper combination of signals is provided by manually releasing the switch as each of the proper signals is displayed, whereupon each such selected signal is fed to a decoding circuit. The signals selected in this manner are collected in the decoding circuit, which upon completion of the proper code operates an electromagnet lock or the like. In one embodiment of the invention, the solid state indicator is mounted together with the push-button switch on a portable key member adapted for a detachable connection at a security station, such as a door equipped with an electrically-operated lock. Other disclosed embodiments include, mounting of the solid state indicator and manual push-button within a door handle disposed adjacent to and for operation of an electro-mechanical door lock; and an arrangement of the solid state indicator and push-button in the driver's compartment of a vehicle, preferably and as disclosed with the indicator disposed in a window panel overlying the steering column, for controlled operation of the vehicle ignition and hood locks.

22 Claims, 13 Drawing Figures

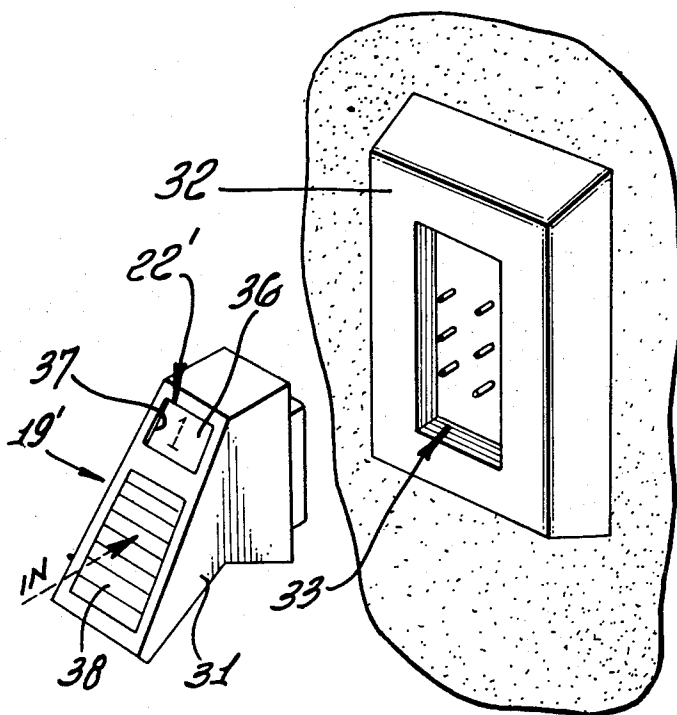


FIG. 1.

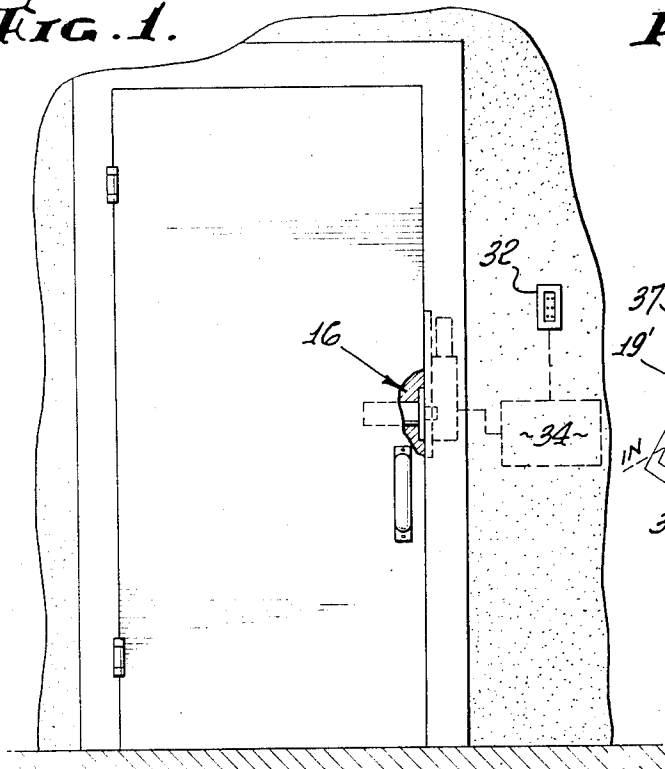


FIG. 2.

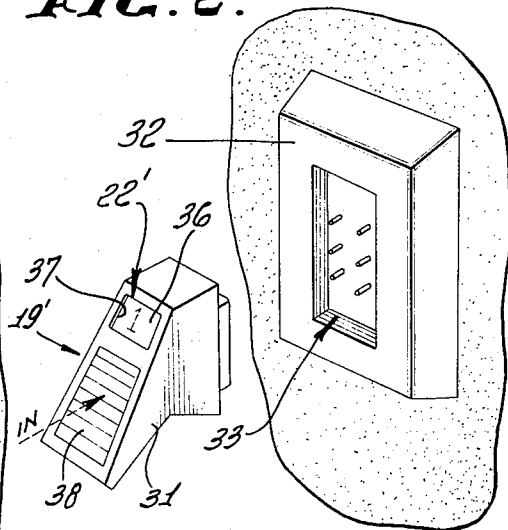


FIG. 3.

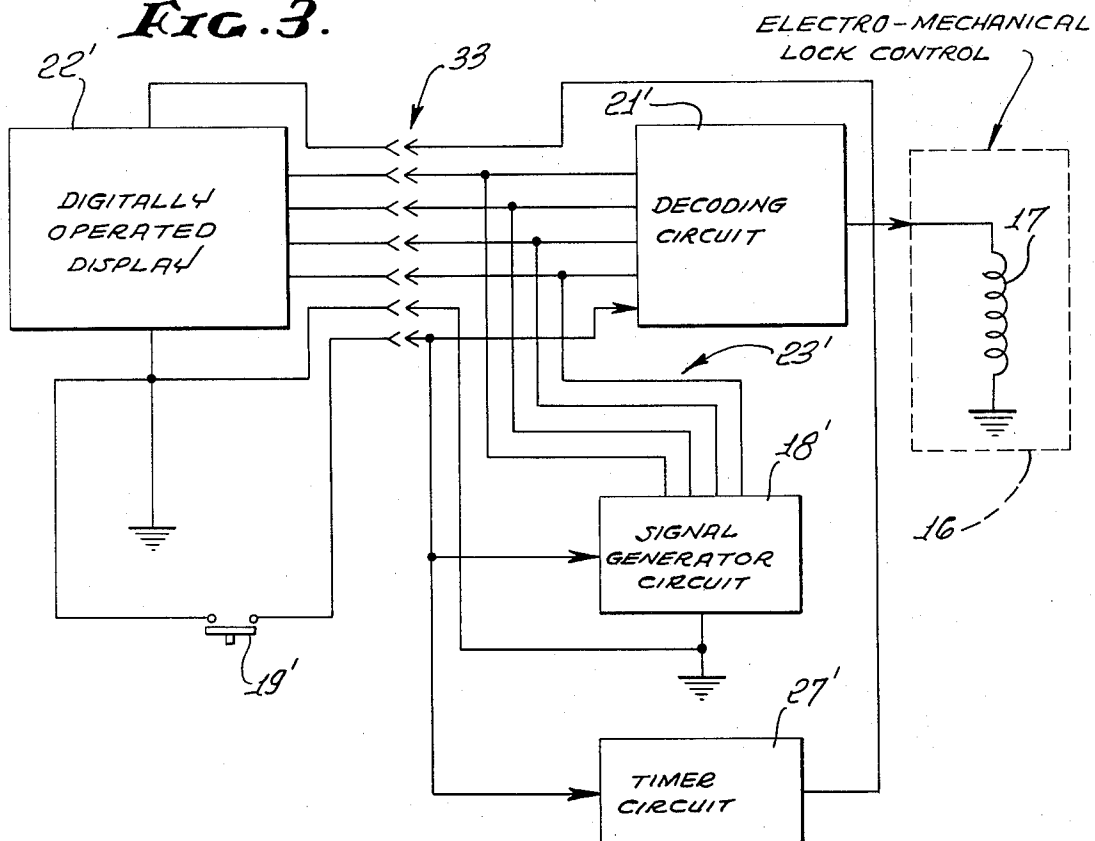


FIG. 4.

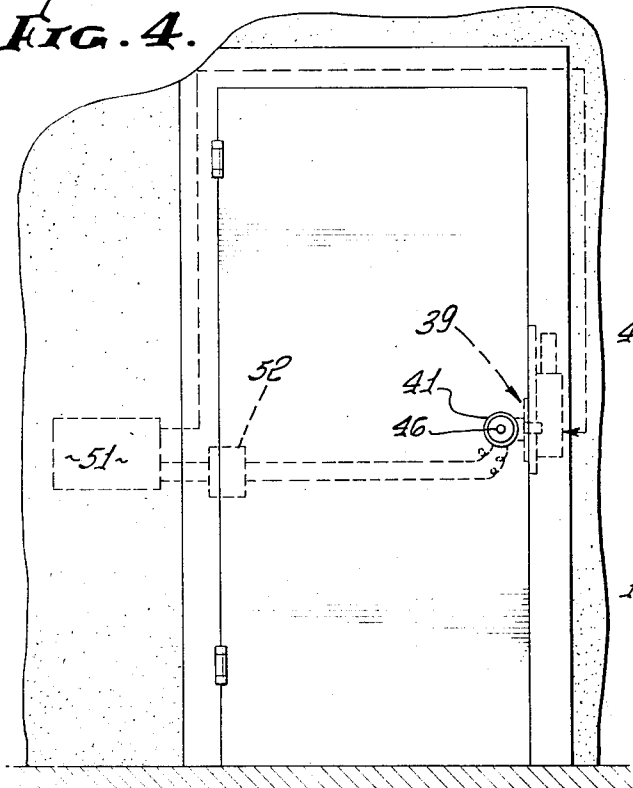


FIG. 5.

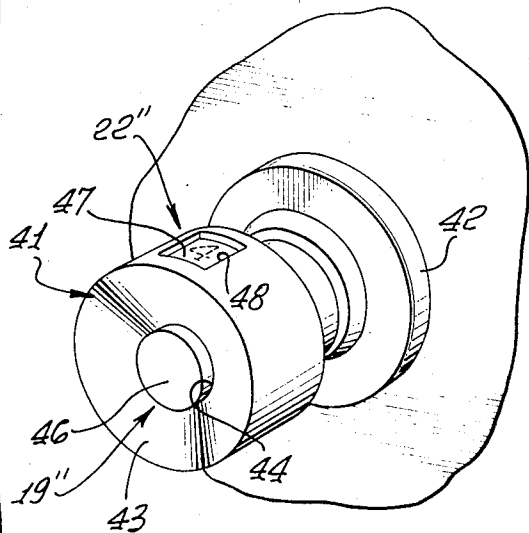


FIG. 6.

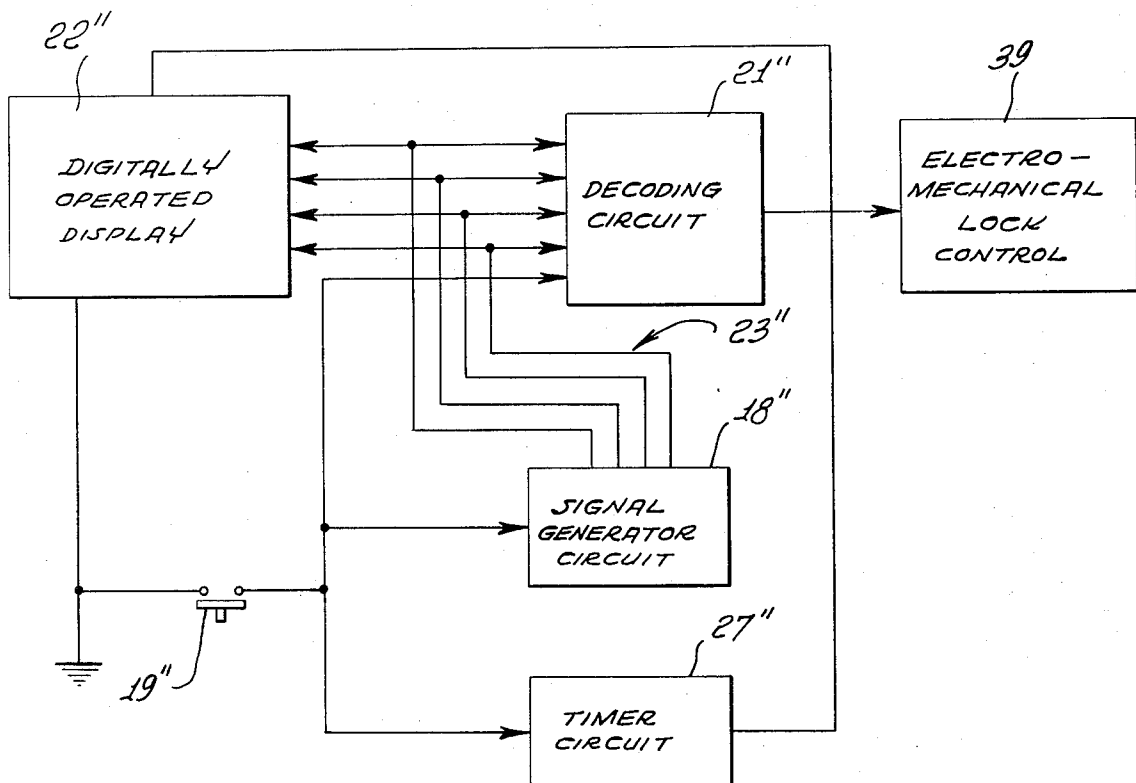


FIG. 7.

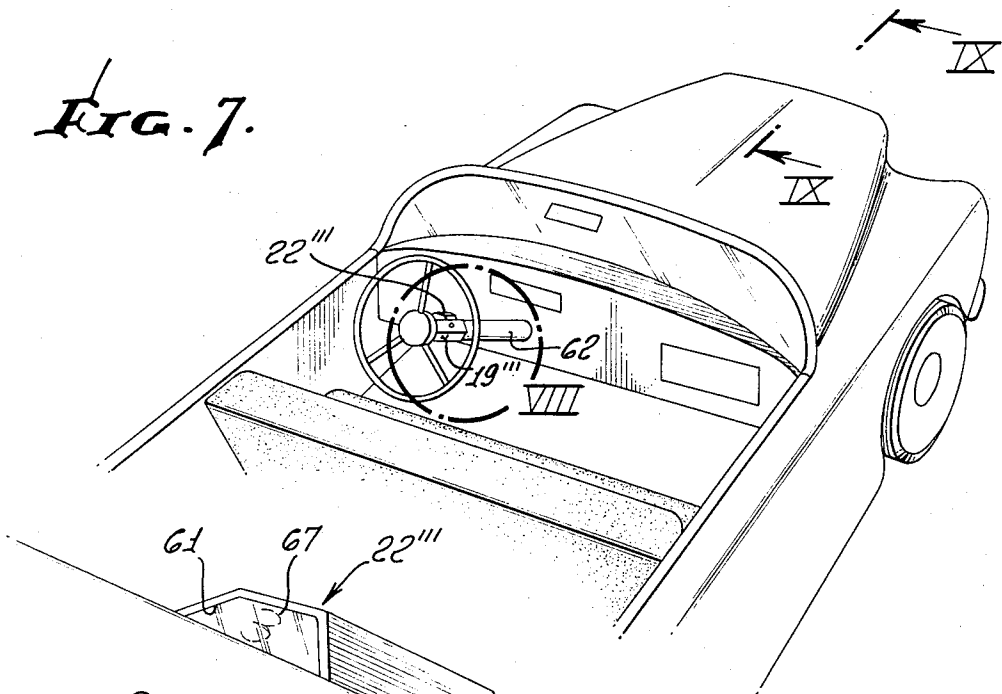
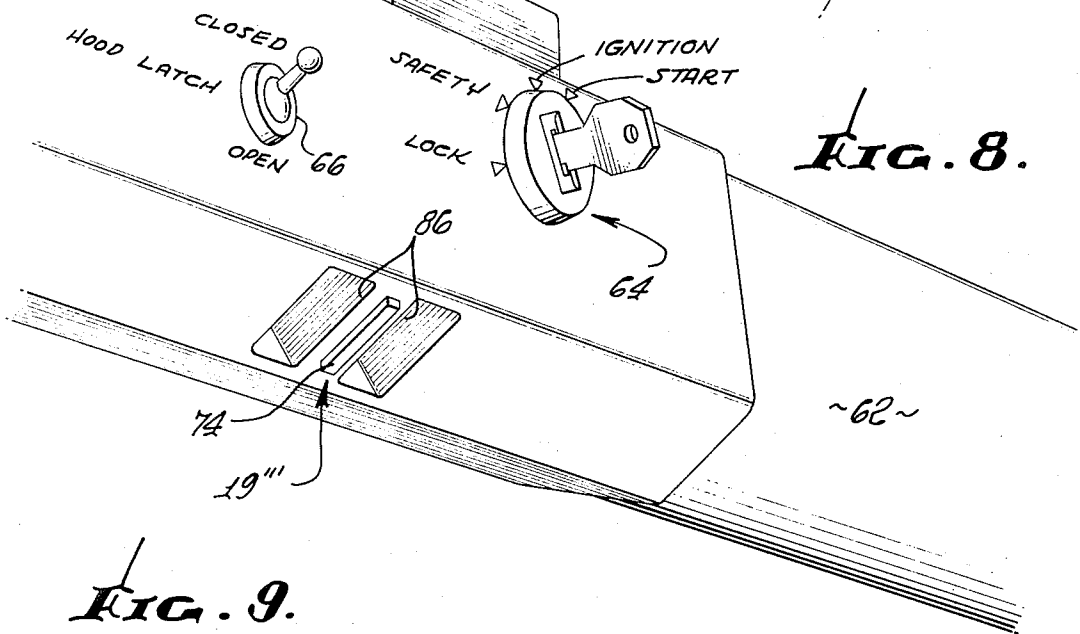


FIG. 9.

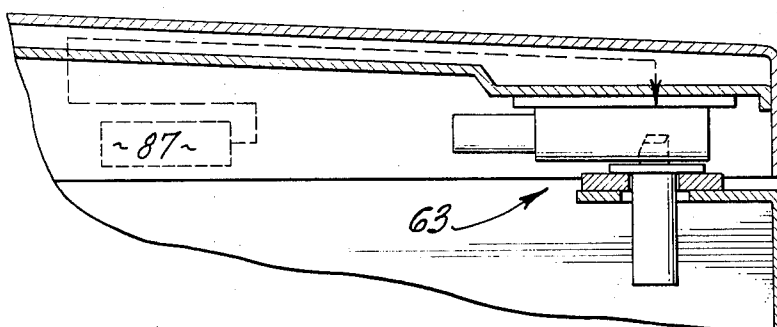
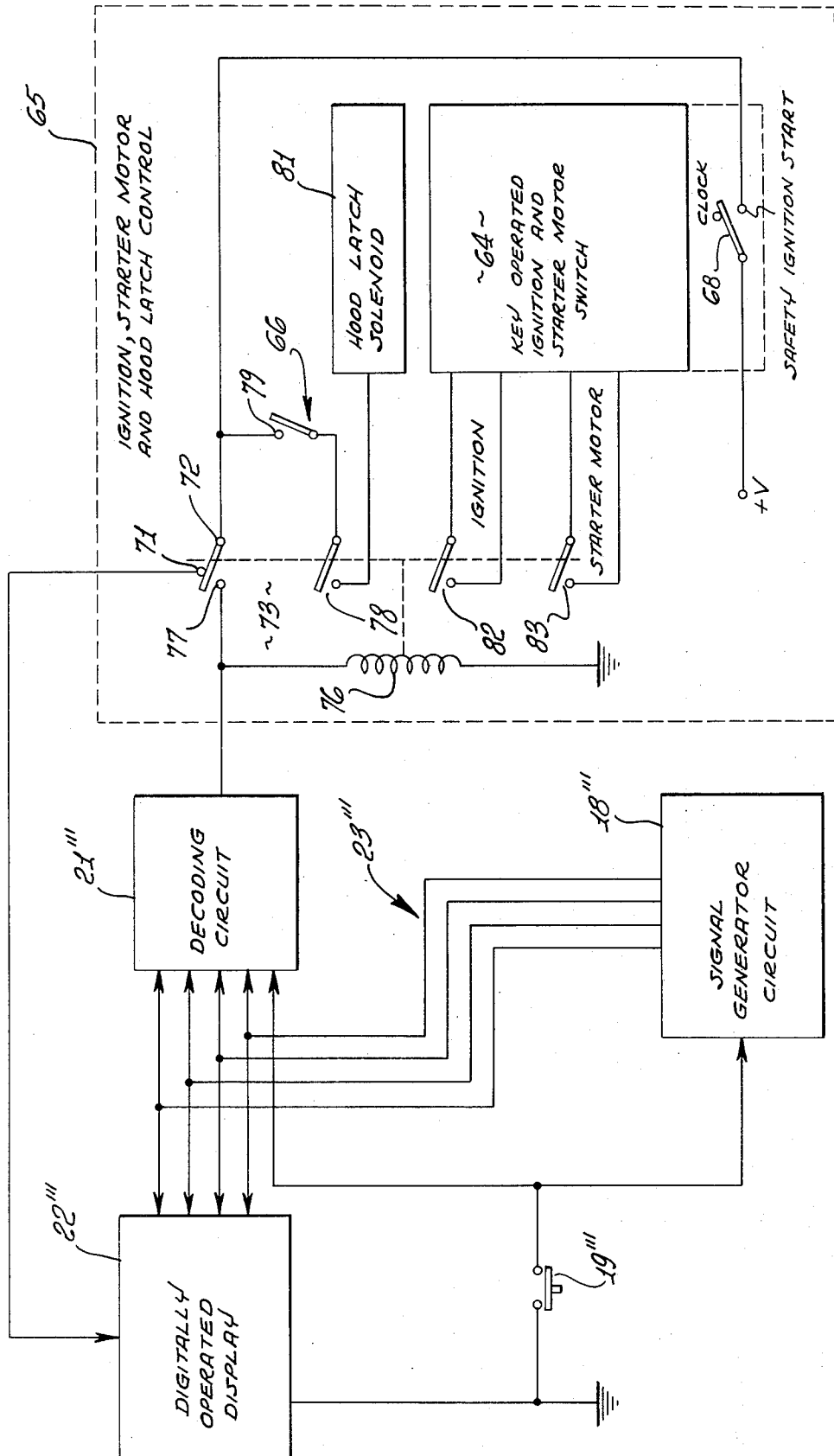


FIG. 10.



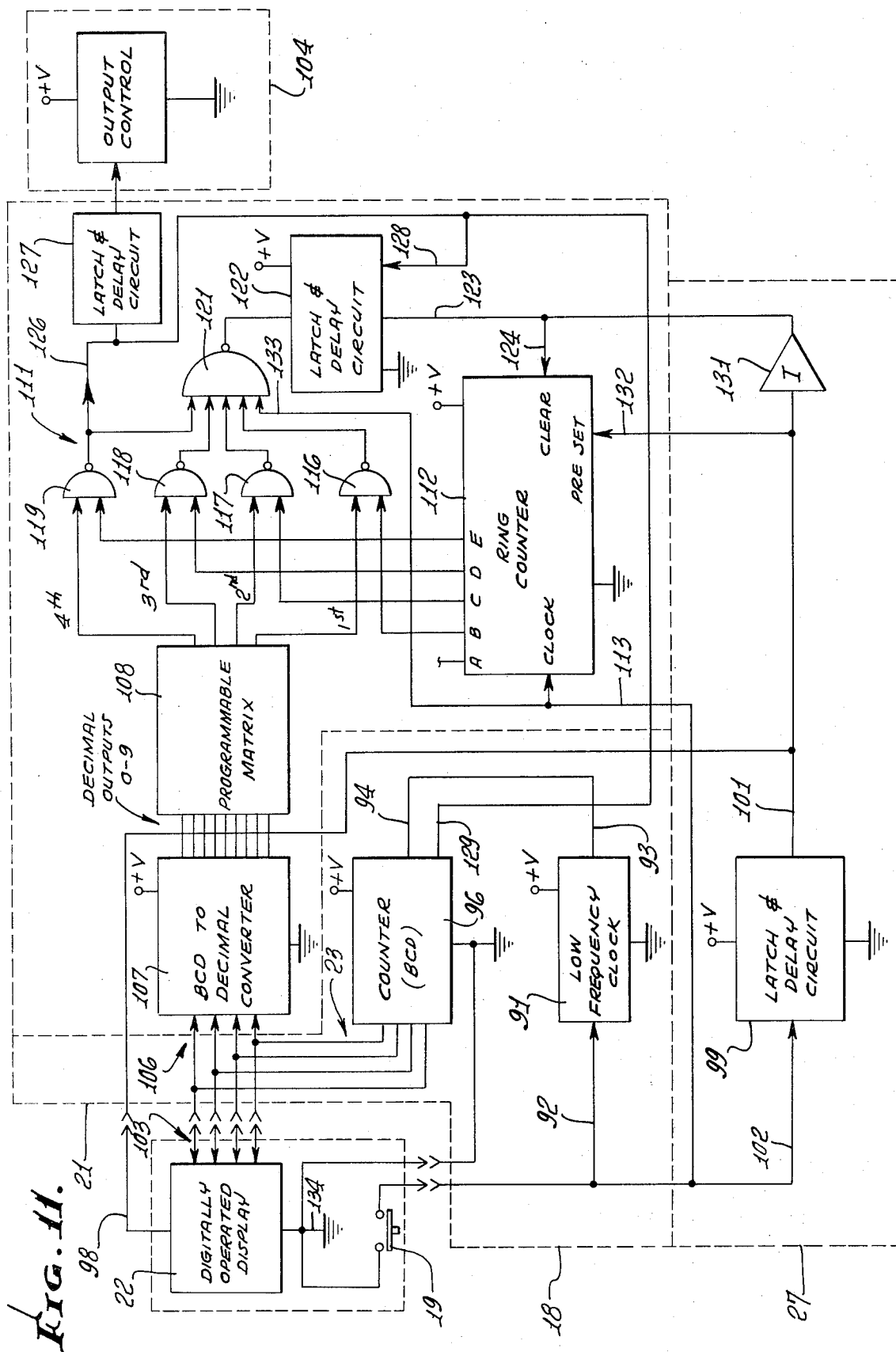


FIG. 13.

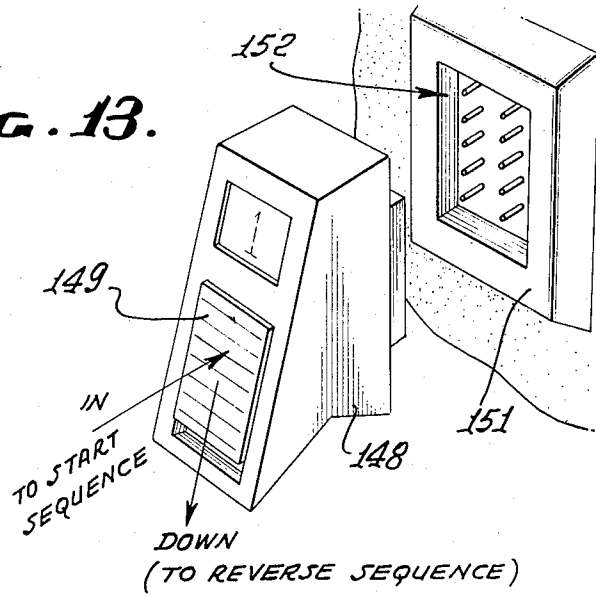
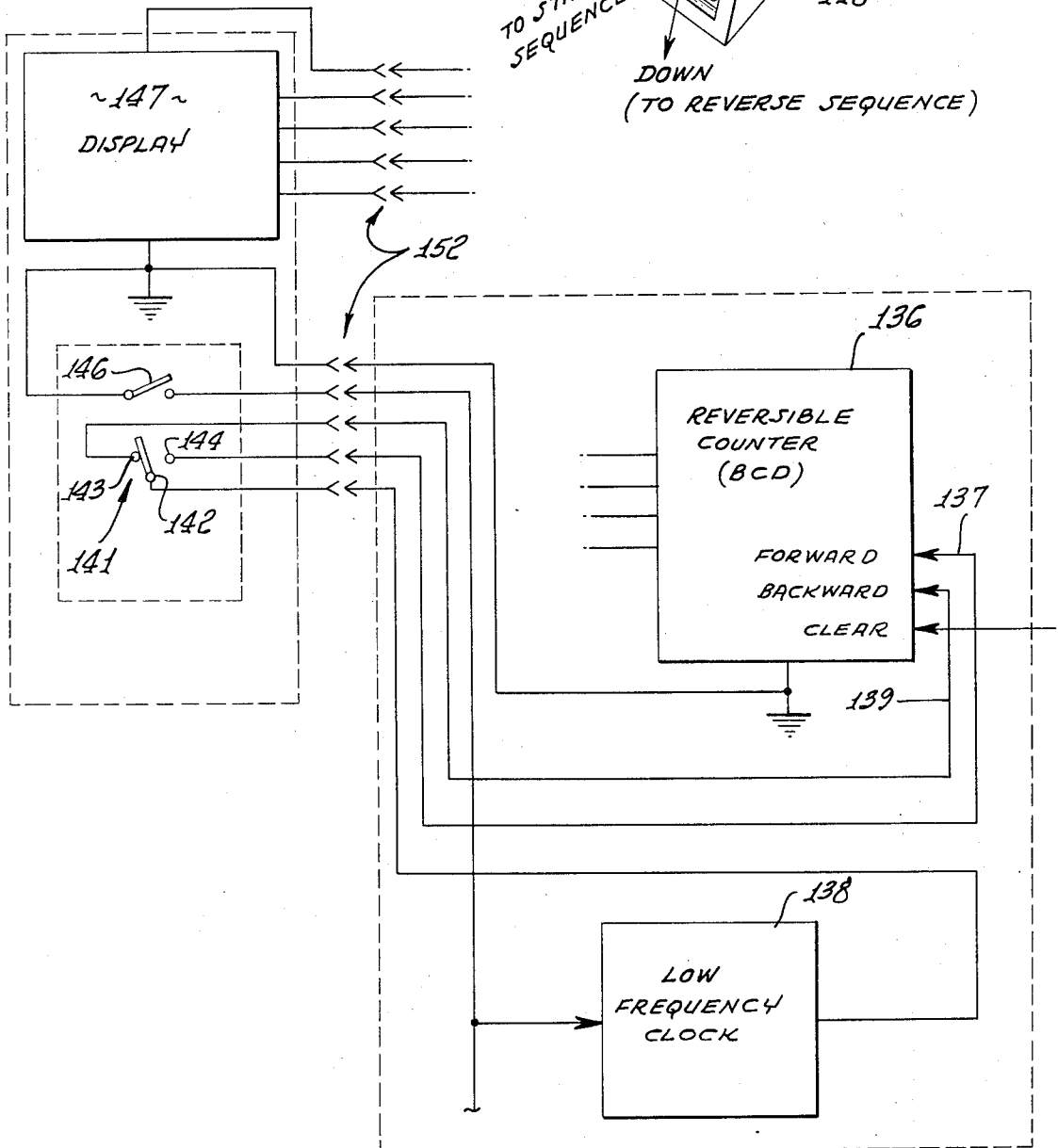


FIG. 12.



ELECTRONIC COMBINATION LOCK INCLUDING SEQUENTIAL SIGNAL GENERATOR AND SIGNAL DISPLAY

BACKGROUND OF THE INVENTION

In general the present invention relates to security control systems and more particularly to electronic combination locks of the type operated by manual control such as by a pushbutton switch.

A variety of manually-actuated electronic combination lock controls have been heretofore devised; however such previous systems are generally cumbersome to operate in that they generally require a large number of switching devices for entry of the combination code. Additionally, the numerous combination or input switches render such prior systems bulky and difficult to package for a convenient mounting in confined areas, and costly because of the cumulative cost of the many switches.

Further still, these available electrical combination locks are inflexible in their installation again because of the manner in which the code or combination is entered into the circuit by a plurality of manual switches. This characteristic of previous controls renders impractical an installation, for example, in which the manually-operated code input means is portable relative to the station at which the control lock or other security control is mounted.

Another shortcoming of available electronic combination locks lies in the installation of the manual control panel so as to be readily accessible by unauthorized persons, thereby increasing the chance of an intruder breaking the combination by trial and error attempts, and increasing the risk of entry by crafty thieves capable of short-circuiting the electrical connections associated with the switches. A protective feature eliminating this risk would provide for removable attachment of the manual code entry means at the secured station to permit portable transportation of such means, as a key, by authorized persons. However, such an arrangement is not practical for existing electronic locks in which entry of the code is by a plurality of manual switch inputs.

BRIEF DESCRIPTION OF THE INVENTION AND ITS OBJECTIVES

It is therefore an object of the present invention to provide a manually-actuated electronic combination lock control of the type involving entry of a sophisticated combination code in which the manually-actuated input means is substantially simplified over previous systems and yet the over-all operation of the lock provides a high degree of security against unauthorized operation.

It is another object of the present invention to provide an electronic combination lock control having an additional element of security, heretofore unavailable in comparable electronic combination locks. In this regard it is an advantage of one embodiment of the present invention that the manually-actuated code entry means is detachable from a security station for portable transportation by authorized persons. In this manner the code entry means is unavailable at the station itself for tampering with by intruders. Operation of the security control thus requires both physical possession of the code entry means and prior knowledge of the combination code itself.

A further advantage of the present invention lies in the simplification of the manual code entry control, which in its most general form consists of a single manually operated push-button switch and a single alpha-numeric display panel presenting a convenient code entry format and yet providing a sufficient number of permutations such that it is virtually impossible to fortuitously or by trial and error to break the combination and operate the lock.

These objects and various advantages of the invention are achieved by a security control system in which a circuit means provides for generating a sequence of electrical signals in response to continuous manual engagement of a switch and for selecting and entering certain of these generated signals into a decoding portion of the circuit for operating the lock. The selection and signal entry is provided by an appropriately timed release of the manually engaged switch. To enable the operator to appropriately time his release of the switch, a solid state digitally controlled alpha-numeric indicator is connected to the circuit to provide a visual display of symbolic representations of the generated signals. The operator, with prior knowledge of the particular symbols corresponding to the successful access code, engages the switch means to initiate the sequential display of each of the generated signals and releases the switch as the first symbol, such as a number, of the code is displayed. Repeated manual actuation and release of the switch provides for entry of all of the symbols or numbers of the coded combination whereupon the circuit issues an output signal for energizing a suitable control means, such as an electromechanical lock or latch.

In one preferred embodiment of the invention, the digitally-operated alph-numeric indicator panel is mounted together with a manually-actuated push-button switch on a portable key member having detachable connection means for engagement with mating connection means fixedly disposed at a security station. The security station may be a door and door jamb assembly provided with a suitable electrically-operated lock as disclosed in the following detailed description of the invention, or a vehicle in which the electronic combination controls the ignition thereof. The portable key means having the display and manual push-button may be transported relative to the station and inserted in the station receptacle for entry of the combination and operation of the lock or vehicle ignition.

In another preferred embodiment of the present invention the solid state indicator panel is mounted for visual display within a window formed in a door handle, especially an annular knob as disclosed herein, with the manual push button mounted in an axial end of the same annular door knob. The knob with display panel and manual push button is thus adapted for attachment to a security door and with suitable connection means extending to the electronic circuit and electrically-operated lock. By this arrangement the door handle knob provides a convenient mounting for the display panel and push button such that all of these components may be installed as a unit on the door and easily connected to and for controlling the electrically-operated lock.

A still further desirable embodiment of the present invention provides for mounting the alpha-numeric display in a panel or window adjacent the upper surface of a steering column in a vehicle and disposition of the

manual switch control on a side or lower surface of the same column to afford both easy vision of the display and convenient manual access to the pushbutton actuator. Additional switch controls, such as a standard key ignition switch and auxiliary hood latch switch are provided in association with the electronic combination control for supplementing the operations thereof. It is observed in this connection that one of the advantages of the vehicular installation of the present invention is that it functions both as an anti-theft device and as an anti-drunk driving control since the operator of the combination lock must have a normal amount of visual-motor coordination to successfully release the push-button switch each time the proper code symbols appear on the steering column display.

While the foregoing provides a brief description of the invention and its objectives, further objects and various advantages of the electronic combination lock according to the present invention will become apparent to those skilled in the art from a consideration of the following detailed description of the exemplary embodiments thereof. Reference will be made to the appended sheets of drawings which are briefly described as follows:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary, side elevation view of a door and door jamb assembly equipped with a security control lock system according to the present invention.

FIG. 2 is an enlarged fragmentary, perspective view of a receptacle including electrical connection means for fixed installation at the security door of FIG. 1 and for detachably receiving a portable key means having mating electrical connections and carrying the alpha-numeric indicator panel and manual push button for entry of the combination code.

FIG. 3 is a generalized block diagram of the electrical circuitry for providing the sequential generation of the electrical signals, the display thereof on the indicator and the selection, entry and decoding of the electrical signals selected by the switch means for operating an electromechanical lock control.

FIG. 4 is a fragmentary, side elevation view of a door jamb and door jamb assembly equipped with an embodiment of the security control system of the present invention in which the display panel and manual switch are mounted within a door knob affixed to the door.

FIG. 5 is an enlarged fragmentary perspective view of the door knob of FIG. 4.

FIG. 6 is a further generalized block diagram of the circuitry, similar to FIG. 3, but in this instance associated with the security control system of FIGS. 4 and 5.

FIG. 7 is a fragmentary, perspective view of a vehicle showing the driver's compartment including a steering column to which the code entry means, namely the push-button actuator and display panel of the present invention are mounted for operation by the driver.

FIG. 8 is an enlarged fragmentary view of FIG. 7 showing the portions circumscribed by circle VII and showing more clearly the display panel, push-button actuator, and auxiliary hood switch and a standard ignition key assembly.

FIG. 9 is a fragmentary, section view taken along the plane IX—IX of FIG. 7 and illustrating an electromechanical latch mechanism for selectively securing the hood of the vehicle.

FIG. 10 is a composite block diagram and schematic drawing of the circuitry associated with the vehicular embodiment of the invention shown in FIG. 7, 8, and 9.

FIG. 11 is a detailed composite block and schematic diagram of the circuitry of the electronic combination lock of the present invention wherein the illustrated circuit is suitable for the circuits generally shown by the block diagrams of FIGS. 3, 6, and 10.

FIG. 12 is a fragmentary block diagram of a preferred alternative embodiment of the circuits of FIGS. 3, 6, 10, and 11, in which an additional manually-operated switch is provided for reversing the sequence of displayed symbols on the alpha-numeric indicator panel, such that an operator may selectively reverse the sequence to reach the next code number of symbol in the shortest amount of time.

FIG. 13 is a perspective view of a portable key means similar to the key of FIG. 2 but in this instance adapted with a manually actuated switch capable of providing the additional control switch of FIG. 12 for reversing the display sequence.

DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to FIGS. 1, 2 and 3, the electronic combination lock of the present invention is adapted for operating an electrically-controlled lock means, or the like such as electromechanical lock control 16 for a striker assembly as illustrated in FIG. 1 mounted in cooperation with a door and door jamb assembly. In this instance, control 16 is of a construction disclosed and claimed in my co-pending U.S. application, Ser. No. 169,750 filed Aug. 6, 1971 for "Lock Construction." Further details of the construction and operation of the lock control shown in FIG. 1 may be obtained by referring to this previously filed application.

For the purpose of describing the present invention, it will be observed that lock control 16 includes an electrically operated component here in the form of a solenoid coil 17, and it will be appreciated that any electrically controlled device serving as a lock or security control may be employed in lieu of lock control 16.

In accordance with the present invention, circuit means are provided, as shown in FIG. 3 including a signal generator circuit 18' for generating a sequence of electrical signals, preferably in a digitally encoded format, in response to continuous manual engagement with a push-button switch 19' of the momentary contact type. Push-button switch 19' is also connected to a decoding circuit 21' including memory means, which is responsive to operation of the switch to select and enter certain of the signals generated by circuit 18' for operating lock control 16. It is necessary in accordance with the invention to select certain predetermined signals and to enter them in a given sequence in order to successfully operate control 16. Such selection is made possible by virtue of a digitally-operated display 22' which receives the generated signals from circuit 18' and develops a visual display by symbolic representation, such as by letters or numbers, of the generated signals. Thus, in response to manual engagement of switch 19', circuit 18' is activated to initiate a sequential generation of individually unique signals, in this instance in the form of digitally encoded signals carried by a set of 4 bit lines 23', which are received and interpreted by display 22' to be presented in the

form of symbolic information meaningful to the operator. For example, numbers 1 through 10 may be generated and displayed corresponding to 10 different signals from generator 18'. Selection of particular ones of these generated signals for application to the decoding circuit 21' is provided by an appropriately-timed release of the manually-engaged switch 19'. In particular this operating characteristic is obtained by a connection of switch 19' not only to circuit 18' but also to decoding circuit 21' as illustrated such that the operator by releasing switch 19' as a number or other symbol of the predetermined combination is displayed, causes the corresponding electrical signal to be fed to decoding circuit 21'. Repeated manual engagement and release of switch 19' permits entry of all of the numbers of symbols comprising the coded combination whereupon circuit 21' responds by issuing a signal to and for operating lock control 16. A timer circuit 27' is provided for responding to an initial operation of switch 19' to provide power to the circuitry enabling operation thereof for a predetermined amount of time. Suitable circuitry for circuits 18', 21', and 27' is illustrated by FIG. 11 in the form of corresponding circuits 18, 21, and 27, operating in conjunction with a corresponding switch 19 and a corresponding display 22, to be described more fully herein.

In the preferred embodiment of the invention illustrated by FIGS. 1 through 3, digitally-operated display 22' and push-button switch 19' are mounted together on a portable key device 31 as shown in FIG. 2 for detachable connection to a receptacle means 32 mounted along with the electromechanical lock at a security station, in this instance the door and door jamb assembly of FIG. 1. Key device 31 and receptacle 32 are formed with mating connection means 33 illustrated schematically in FIG. 3 and shown in FIG. 2 for receptacle 32, for electrically-connecting display 22' and push-button switch 19' to the remainder of the circuit means, including circuits 18', 21', and 27'. With reference to FIG. 1, these latter circuits are in this instance fixedly mounted at 34 in a wall adjacent the door jamb as shown in FIG. 1, and permanently wired to electromechanical lock control 16 and receptacle 32 as shown by the dotted lines for selective connection with the key mounted digitally-operated display and push-button switch. Furthermore, digitally-operated display 22' is preferably provided by a digitally-operated solid state alpha-numeric indicator 36 mounted as shown within a window 37 provided for the purpose in key device 31. A suitable indicator for this purpose is fully described in connection with FIG. 11 herein, and for the present purpose it may be characterized as providing selective individual display of a plurality of symbols, such as letters or numbers, at a single and relatively small window area. In this instance, indicator 36 displays numbers 0 through 9 in response to the output of signal generator circuit 18'. Mounted adjacent window 37, and in this instance immediately therebelow, there is a manually engageable pad 38 spring biased outwardly and depressible inwardly as shown for closing switch 19' which is located within key device 31 by suitable means (not shown).

By this arrangement, key device 31 may be selectively removed from receptacle 32 and transported by an authorized person such that the code entry means, namely switch 19' and display 22', is unavailable at the security station for unauthorized use or tampering. The

person to whom the key has been properly issued thus has available both the physical possession of the means necessary for entering the code and pre-knowledge of the code itself. Unauthorized access requires an intruder to gain control of not only the code, but also the key device.

It is further observed, that in the absence of key device 31 it is virtually impossible to operate lock control 16 by tampering with the exposed contact means of receptacle 32 in view of the arrangement of the connecting contacts between display 22' and decoding circuit 21'. Without the benefit of the displayed symbols, it would be extremely difficult to enter the proper combination of signals in the proper sequence in order to dis-
pose circuit 21' in a condition for operating lock control 16. In this regard, it will be appreciated to those skilled in the art that although connection means 33 is here provided at a location which separates display 22' and switch 19' from the remainder of the circuit, the connection means may alternatively be provided at some other interim location within the circuitry of circuits 18', 21', and 27' and yet still provide the same security feature mentioned above. Such an alteration of the circuit and connection means would provide for the mounting of certain of circuits 18', 21', and 27' within key device 31, an arrangement which is not only possible but practical in view of the modern day miniaturization of electronic circuits. In line with the foregoing discussion, it will be observed however, that the connection means 33 should not preferably be relegated to merely connecting the output of circuit 21' to lock control 16 as such an arrangement would be vulnerable to operation of control 16 by short circuiting the contacts at the exposed receptacle 32.

Electrical power or voltage for operating display 22' is received in this instance via connection 33 from timer circuit 27'. Thus, display 22' and more particularly solid state indicator 36 thereof is inoperative when key device 31 is removed from receptacle 32. As described more fully hereinafter in connection with FIG. 11, indicator 36 of display 22' is not provided with power until key device 31 has been inserted in receptacle 32 at the security station, and switch 19' closed by manual engagement and depression of pad 38. Thereupon, timer circuit 27' is actuated to supply a dc voltage through connection means 33 to and for energizing display 22' where such voltage is maintained for a given amount of time, sufficient to enable an authorized person to enter the proper combination code. During this interval, release of pad 38 to open switch 19' and enter the instantaneously generated signal into decoding signal 21' does not interrupt the voltage supplied to display 22'. This voltage remains available at the display 22' for the duration of the timing cycle provided by circuit 27'.

In another preferred embodiment of the present invention as shown in FIGS. 4 through 6, digitally-operated display 22'' and push-button switch 19'', corresponding to display 22' and switch 19' respectively, are mounted on a door handle 41, preferably of conventional annular shape, as a doorknob, so as not to attract attention. Handle 41 is fixedly mounted to a door equipped as in the case of FIG. 1 with an electromechanical lock control 39 cooperating with the door and a door jamb. In particular, handle 41 is provided with a first axial end 42 fixedly mounted to the door at the usual position for a door knob. The opposite axial end

43 is provided with a centrally-located aperture 44 in which a manually engageable push-button 46 is matingly disposed. Button 46 is connected by suitable means (not shown) to and for operating switch 19'' located within the handle with button 46 being spring bi-ased outwardly such that inward manual depression thereof closes the electrical contacts of the switch.

As in the case of key device 31 of FIG. 2, the digitally-operated display 22'' of FIG. 6 in which provided by a digitally-operated solid state alpha-numeric indicator 47 mounted within a window 48 provided for the purpose at an upper circumferential portion of handle 41 as illustrated by FIG. 5. Indicator 47 exhibits a single relatively small panel area in which symbols, in this instance numbers, are displayed.

In this embodiment the remainder of the circuitry other than display 22'' and switch 19'' is mounted at a location indicated at 51 within a wall adjacent the hinged edge of the door and connection means illustrated by dotted lines are provided between the display 22'', switch 19'', lock control 39 and the circuitry located within the adjacent wall at 51. Suitable means 52, well known to those skilled in the art, are provided for extending the electrical connections between handle 41 and circuit location 51 at the hinged edge of the door.

Operation of the combination lock in this instance is similar to the embodiment described in connection with FIGS. 1 through 3 except the means for entering the code is permanently located at the secured station. An initial manual depression of button 46 closes push-button switch 19'' actuating timer circuit 27'' to apply power to display 22'' and light up indicator 47. Simultaneously, circuit 18'' generates a sequence of individually unique digitally encoded signals over bit lines 23'' which signals are displayed at indicator 47 of display 22'' as a series of sequentially appearing numbers. Timed release of button 46 opens switch 19'' which causes entry of the corresponding electrical signal into decoding circuit 21''. Repeated manipulations of the push-button provide entry of the remaining symbols or signals of the combination code for operating lock control 39 to enable opening of the door. Further particulars regarding circuits 18'', 21'' and 27'' together with switch 19'' and display 22'' are described in connection with a complete circuit diagram shown in FIG. 11 and including corresponding circuits 18, 21, 27 and a corresponding switch 19 and display 22.

Although the embodiment of the invention illustrated in FIG. 4 provides for mounting of the circuitry of FIG. 6 at a wall location 51 adjacent the door and door jamb assembly, it will be appreciated that such circuitry may in the alternative be mounted directly within a hollow portion provided for the purpose within handle 41. In such case, push-button switch 19'', digitally operated display 22'' and the remainder of the circuitry including circuit 18'', 21'', and 27'' may be installed as a unit by merely mounting the door knob to the door assembly and providing a connection to suitable power means and to and for controlling lock control 39.

A still further desirable embodiment of the present invention is illustrated in FIGS. 7 through 10, in which a digitally-operated display 22''', corresponding to displays 22'' and 22'', is mounted in a display window provided for the purpose within the driver's compartment of a vehicle and preferably as shown by FIG. 8 within a display window 61 fixedly mounted on an upper sur-

face of a steering column 62. Along with display 22''', a push-button switch 19''', corresponding to switches 19' and 19'', mounted preferably as shown in FIG. 8 on a lower or side surface of steering column 62. Display 22''' and push-button switch 19''' in this manner provide means accessible within the driver's compartment of the vehicle for operating an electronic combination lock which in this instance controls the automobile ignition and an electrically-operated latch for the car hood, shown as latch 63 in FIG. 9.

With reference to FIGS. 8 and 10, the electronic combination lock in accordance with the present invention functions in cooperation with a key operated ignition switch 64 and an auxiliary hood latch switch 66 to control starting of the car and access to the engine compartment secured by the hood by means of control 65. Entry of the combination code is effected by the driver's selective actuation of push-button switch 19''' in coordination with the numerical sequential display produced by a solid state alpha-numeric indicator 67 mounted within window 61 and providing display 22'''.

Unlike the previous circuits shown in FIGS. 3 and 6, the circuitry as shown in FIG. 10 for this embodiment provides for supplying electrical dc power to digitally-operated display 22''' from a suitable power source voltage + V, for example from the car battery, through the contacts of a switch 68 operated by key switch 64, and through a pair of normally closed contacts 71 and 72 of a relay operated by the output of a decoding circuit 21''', corresponding to circuit 21' and 21''. When the vehicle is parked, key switch 64 is disposed in the locked position and switch 68 is open such that power from source + V is not connected to and for operating display 22'''. When the driver enters the car he turns the key switch 64 clockwise to either "safety" or "ignition" position which causes closure of switch 68 supplying the + V voltage through a pair of normally closed contacts 71 and 72 of a relay 73 to energize display 22'''. The display thereupon lights up. Advancement of the numerical display does not occur until circuit 18''' is actuated by depressing a button 74 which is mechanically connected to operate push-button switch 19''' causing closure thereof, and activation of the signal generator circuit.

With key switch 64 in this condition, the driver enters the combination code in the same manner as described in connection with the previous embodiments. Upon completion of the code, decoding circuit 21''' provides for energization of a coil 76 of relay 73 causing relay contacts 71 and 72 to open, and normally open contacts 72 and 77 to close latching relay 73 in an energized state via supply voltage + V passing through switch 68 and through now closed contacts 72 and 77. Furthermore, a pair of contacts 78 are closed enabling manually selective closure of contacts 79 controlled by auxiliary hood switch 66 on steering column 62 to operate a solenoid 81 of electrically operated hood latch 63. It is observed in this connection, that once the combination lock has been operated by proper entry of the code, relay 73 is immediately energized which would simultaneously operate hood latch solenoid 81 via contacts 78. However, serially inter-connected contacts 79 of the auxiliary hood switch 66 provide an overriding control of the hood latch operation.

Also upon operation of the electronic combination lock, relay 73 closes a pair of contacts 82 in series with

the vehicle ignition and a pair of contacts 83 in series with the vehicle starter motor, enabling operation of these circuits such that when key switch 64 is rotated clockwise into the ignition position and from there to the start position the vehicle may be started in the normal manner. So long as key switch 64 is in the safety, ignition, or start position, relay 73 will remain energized. Thus, the vehicle engine may be turned off by rotating key switch 64 from the ignition to the safety position, thus permitting starting and operation of the vehicle without re-entering the combination code. This allows another person, such as a parking attendant, to operate the vehicle. Once however key switch 64 is turned to its full counter-clockwise position, in this instance corresponding to the lock position as shown in FIG. 8, contacts 68, as shown in FIG. 10 are open, interrupting the supply of voltage to coil 76 of relay 73, de-energizing or unlatching the relay and restoring the circuit to its initial condition for responding to the output of decoding circuit 21''' upon subsequent receipt of the proper combination code.

Adjacent push-button 74 of switch 19''' on steering column 62 are a pair of recesses 86 disposed on opposite sides of the button to provide means for manually locating it. With switch 19''' positioned as shown on steering column 62 along with digitally-operated display 22''', the driver is provided with both easy vision of the display panel and convenient manual access to the push-button control.

It is observed that this embodiment of the invention in addition to serving as an anti-theft device also affords an antidrunk driving safety feature in that a normal amount of visual-motor skill is required to enter the proper combination.

Preferably in accordance with the present invention, signal generator circuit 18''', decoding circuit 21''' and relay 73 are all disposed at a circuit location 87 within the compartment, preferably the engine compartment, secured by latch 63. By virtue of such an arrangement, tampering with the ignition circuitry to "hot-wire" the vehicle is prevented because access to such circuitry is only via the locked hood which can only be opened by proper entry of the combination code. Furthermore, forcing the combination lock by tampering with the circuitry thereof is virtually impossible unless access is gained to the decoding circuit 21''' which, again requires access to the compartment secured by latch 63. Electrically operated latch 63 may be provided by suitable solenoid operated latching or lock means and in this instance is provided by the lock disclosed in my co-pending U.S. application, Ser. No. 169,750 referenced above.

With reference to FIG. 11, the circuit means described above in connection with the various embodiments of the invention as signal generator circuits 18', 18'', and 18''' may be provided as shown in FIG. 11 by a signal generator circuit 18. Circuit 18 here includes a low-frequency clock 91 connected to a suitable supply voltage + V and having a control input 92 extended for connection to ground via the normally opened contacts of push-button switch 19 corresponding to previously described switches 19', 19'', and 19'''. An output 93 of clock 91 issues an extremely low frequency signal, such as one or less cycles per second, suitable for the present purpose, namely, driving the symbolic display. Output 93 of the clock is extended to an advancing clock input 94 of a digital counter 96

which is connected between a supply voltage + V and ground as shown. Counter 96 is of the binary coded decimal BCD type and develops a digital count corresponding to the number of clock pulses received at input 94 from clock 91. The output of counter 96 is in this instance in the form of four digital bit lines, indicated at 23, and corresponding to the above-described bit lines 23', 23'', and 23''', wherein each such line carries a discreet logic level representing a 1 or 0, which taken together represent in binary-coded decimal format the instantaneous count on counter 96. Bit lines 23 are jointly connected to digitally-operated display 22, corresponding to displays 22', 22'', and 22''' discussed above, and to a binary coded decimal (BCD) to decimal converter of decoding circuit 21 which corresponds to circuits 21', 21'' and 21''' previously mentioned.

Digitally-operated display 22 receives the digitally encoded signal from bit lines 23 and when energized by a supply voltage + V over a line 98, provides for translating the digital information on lines 23 into a visual symbolic display, such as decimal numbers from 0 through 9 representing the instantaneous count of counter 96. For the embodiments of the invention shown in FIGS. 1 through 6, display 22 is energized over line 98 by a voltage output from a latch and delay circuit 99 which issues a voltage + V at an output 101 for a predetermined interval of time in response to momentary grounding of a control input 102 via push-button switch 19. Thus when switch 19 is momentarily closed in the first instance, circuit 99 responds by assuming a latched condition, the duration of which is controlled by a delay circuit portion thereof, such that display 22 is powered for a pre-determined interval adequate for an authorized person to enter the proper combination code. In the automobile embodiment of the invention as shown in FIG. 10 digitally operated display 22''' is energized via contacts of a relay 73 as described above rather than by latch and delay circuit 99.

In accordance with the present invention, digitally operated display 22 is preferably provided by a commercially available solid state alpha-numeric indicator. Such indicator includes its own latch memory and binary to decimal matrix decoder and operates by an array or matrix of light-emitting diodes (LED) driven by an LED matrix driver. The LED matrix provides a rectangular display panel having side dimensions of less than an inch and a thickness of approximately 0.1 to 0.2 of an inch and carrying an array of light-emitting diodes which when selectively energized provide for a letter, number or other symbolic display. The present invention employs one such panel for each of displays 22', 22'' and 22'''. Although such indicators are available from a number of sources, one suitable device is marketed by Hewlett-Packard as their 5082-7300 series Solid State Numeric Indicators. Such display panels or indicators each have a voltage supply input to which line 98 is connected, a four line binary-coded decimal input to which bit lines 23 in FIG. 11 are connected and a ground input which as shown in FIG. 11 is connected to ground.

In order to cause display 22 to visually present the various numbers or symbols of the combination code, switch 19 is displaced from its unactuated and open condition, as shown in FIG. 11 to an actuated or closed condition and maintained in such closed condition to

produce the following result. First, circuit 99 as above described energizes display 22 over line 98. Clock 91 and counter 96 also as above described generate a slowly changing binary coded decimal count on bit lines 23 which when applied to the four line BCD input of display 22 at 103 results in a visual and in this instance numeric display of the signals developed by counter 96, sequentially as generated. This operating mode is maintained so long as push-button switch 19 is continuously manually engaged in its actuated state.

The particular combination code is entered into the circuitry and in particular entered into decoding circuit 21 by releasing push-button switch 19 at the instance a symbol to be selected and corresponding to one of the numbers of a predetermined combination code appears on display 22. Preferably and in accordance with the present invention, the combination code consists of a plurality of symbols, in this instance numbers, arranged in a predetermined sequence and entered sequentially into the decoding circuit. For example, the combination code may be set as 8 5 3 2. These numbers must be entered in this sequence into decoding circuit 21 by appropriately timed releases of switch 19. When the final number of code, in this instance number 2, is entered then decoding circuit 21 functions to energize or otherwise activate an output control 104 representing the various lock or other security controls described above as lock control 16 and 16' and ignition, starter motor, and hood latch control 65.

In particular, push-button switch 19 cooperates with decoding circuit 21 in the following manner. The output bit lines 23 from counter 96 are in addition to being connected to the four line BCD input of display 22 are connected as shown at 106 to a digital converter 107 providing a binary coded decimal to decimal conversion of the information carried by lines 23 as generated. The digitally encoded information at the input to converter 107 is thus translated into a decimal format with outputs 0 through 9 as shown being connected to a programmable matrix 108. Matrix 108 provides a means for selective, semi-permanent connection of a set of four output lines therefrom to particular ones of the decimal outputs 0 through 9 available from converter 107. These four output lines identified as the first, second, third and fourth lines from matrix 108 are energized as the decimal outputs to which these lines have been connected by programming matrix 108 are energized by counter 96 through converter 107. Matrix 108 thereby establishes the certain numbers developed by counter 96 and displayed by display 22, which must be entered in order to operate the decoding circuit. The sequence of such entry is dictated by circuitry including a logic circuit 111 and a ring counter 112 which in turn are connected for control by switch 19 over a line 113.

In particular, ring counter 112 develops a gating signal at each of its outputs, B, C, D, and E in a manner determined by the manual actuation and release of push-button switch 19. These gating signals are extended to one of the inputs of each of a set of four NAND gates 116, 117, 118 and 119 to enable each of these gates to issue an output signal to an error detecting NAND gate 121 only if the operator releases push-button 19 at the proper time to select the proper code number in the predetermined sequence. Failure to enter the proper combination number or entry of the proper number in the wrong sequence results in NAND

gate 121 issuing an output signal to a latch and delay circuit 122 which serves as a time penalty circuit immediately generating a signal at output 123 disabling further functioning of ring counter 112 by clearing the count thereon at a clear input 124. This disabling mode is maintained for a predetermined amount of time provided by the delay portion of latch and delay circuit 122. If on the other hand NAND gate 121 does not detect a false number or a number out of sequence, then each of the combination numbers are entered by sequentially enabling gates 116, 117, 118 and 119 by the first, second, third, and fourth position output lines of matrix 108. Upon reaching the fourth position, corresponding to the last number or symbol in the four digit code, gate 119 is energized and logic circuit 117 develops an output over line 126 providing for operation of output control 104 through a latch and delay circuit 127. Simultaneously, the signal on line 126 is extended to and for disabling circuit 122 during operation of the output control at an inhibit control 128 and to clear counter 96 at clear input 129. In this regard it will be observed that the output at line 126 is only transitory following successful entry of the combination code and latch and delay circuit 127 serves to provide a sustained output to operate control 104 for a time interval determined by the delay portion of circuit 127.

Accordingly, the operation of the circuitry shown in FIG. 7 for entering a code combination 8532, used in the example above, will proceed as follows: An operator initially engages push-button switch 19 energizing display 22, starting clock 91 and simultaneously clearing ring counter 112 by the signal issued at output 101 of circuit 99 via an inverter 131, and presetting counter 112 to the output A position by a preset control 132 extended to output 101 of circuit 99. During continuous manual engagement with switch 19 numbers sequentially appear on display 22. NAND gate 121 serving as an error detector receives at an input 133 a low logic signal by virtue of its connection to ground 134 through the closed contacts of switch 19. This is significant in that NAND gate 121 must have at all times applied to any one of its inputs a low logic signal in order to prevent triggering of the time penalty delay of circuit 122. In the absence of such a low signal the output of gate 121 issues a signal triggering operation of latch and delay circuit 122, thereby disabling further entry of the code for the penalty time.

As the first number of the combination code appears on display 22, in this instance number 8, the operator immediately releases push-button 19. This transition of switch 19 from its actuated state to its unactuated state develops a signal on line 113 which clocks ring counter 112, shifting a high logic level from preset output A to output B. Simultaneously, the 1st line output of matrix 108 corresponding to the first position of the combination code, will go high as matrix 108 has been programmed to connect the decimal line carrying decimal 8 from converter 107 to the 1st output line of the matrix. These two high signals are connected to the input of NAND 116 which responds by issuing a low logic signal to another of the inputs of NAND gate 121, thus preserving the condition mentioned above whereby gate 121 must receive at all times a low signal at one of its inputs.

Having thus released push-button 19 as 8 appeared on display 22, the operator proceeds to enter the second number of the combination, namely, 5. Switch 19

is again engaged and disposed in its actuated state causing the display to sequentially generate signals in response to counter 96. As 5 appears on the display, switch 19 is released and the digital signal corresponding to decimal 5 is applied to converter 107, whereupon the decimal output 5 thereof is directed by matrix 108 to the second output line thereof. Simultaneously the ring counter 112 is stepped over line 113 to the C output which is fed along with the second output line of the matrix 108 to the inputs of NAND gate 117. The resulting output from NAND gate 117 is again a low signal and the output of gate 121 remains unenergized. In a similar manner the third position code number, namely 3 is selected and entered into the decoding circuit and together with the D output of ring counter 112 is connected to NAND gate 118 having the same result discussed above in connection with gates 116 and 117. Finally, the last digit or position of the combination code, namely 2, is entered in a similar manner discussed above and the D output of ring counter 112 and the 4th position output line of matrix 108 combine to drive the output of NAND gate 119 low, with this low signal constituting the energizing signal for operating latch and delay circuit 127 and operating output control 104.

It will be appreciated that if during the entry of the code a mistake is made, then one of NAND gate's 116, 117, 118 or 119 would issue a high logic signal to NAND gate 121, thereby triggering circuit 122 to prevent completion of the code.

In this manner entry of a sophisticated combination code is provided through the use of a single push-button 19 and a single indicator panel forming a part of digitally operated display 22. To provide the sophisticated security feature of a multi-position combination code number, in this instance four positions or digits, it will be appreciated that de-coding circuit 21 includes in the form of logic circuit 111 and ring counter 112 an electrical memory circuit for receiving information concerning the position or digit of the combination being entered at any given time. This memory aspect of logic circuit 111 and ring counter 112 affords a circuit capable of accepting a combination code having multiple digits or positions, wherein this information is entered sequentially via a single manually operated push-button and a single alpha-numeric display indicator.

While a particular arrangement of circuitry is shown in FIG. 11, it will be appreciated that other circuits may be employed to achieve the functions taught by the present invention. It will also be recognized that the circuit of FIG. 11 may include other known security features, such as an error counter for counting the number of mistakes and disabling the circuit operation after receiving a pre-selected number of such mistakes, and means operating an alarm in response to an initial mistake such as detected by NAND gate 121.

With reference to FIGS. 12 and 13, an alternative preferred embodiment of the invention is illustrated in which the circuit of FIG. 11 and the key device of FIG. 2 have been modified to provide for a manually selective reversal of the sequence by which the combination symbols or numbers are displayed. Specifically, a counter 136 similar to counter 96 of FIG. 11 is provided with a reversible feature, wherein a forward input 137 advances the counter in a forward count direction in response to clock pulses received from a low frequency clock source, such as clock 138 corresponding

to clock 91 of FIG. 11. A backward input 139 is also provided and is responsive to the same clock source to count backward. Thus the embodiment of FIG. 12 includes additional manually operated switch 141 having a pair of normally closed contacts 142 and 143 and a pair of normally open contacts 142 and 144. The set of normally closed contacts 142 and 143 of switch 141 are adapted to connect the output of clock 138 to the forward input 137 of counter 136 whereas the normally open contacts 142 and 144 connect the same clock output to the backward input 139 of the reversible counter 136. A manually operated push-button switch 146 corresponding to switch 19 of FIG. 11 activates clock 138 to feed clock pulses to counter 136 with the output thereof being visually registered on display 147, corresponding to display 22 of FIG. 11.

In operation, switch 146 is manually engaged to start the sequential display and switch 141 if unoperated remains in the condition shown in FIG. 12 with the normally closed contacts providing a forward count on counter 136 which for example may appear on the display indicator as 1, 2, 3, 4, etc. . . . On the other hand, if the operator desires to reverse the sequence in order to pick up a number, such as 3 when the display is on 4 or 5, he may reverse the sequence of generation by manually operating switch 141 to close the normally open contacts 142 and 144 applying the clock signal to the backward input 139 of counter 136.

To provide for this manual operation of both switch 146 and reversing switch 141 a key device 148, similar to key device 31 of FIG. 2 is provided having suitable means, which is conventional and thus not shown, for permitting two different modes of manual operation of an engageable pad 149 to afford selective operation of both switches. In this instance, pad 149 may be depressed inwardly as in the case of pad 38 of key device 31 of FIG. 2 to close switch 146 and start the display sequence. Also, pad 149 is provided with a downward movement which is mechanically connected by means not shown to operate switch 141 opening the normally closed contacts 142 and 143 and closing the normally open contacts 142 and 144. The downward movement of pad 149 simultaneously with inward depression thereof, thus results in a continued display sequence, however with sequence reversed.

In addition to this modification, switch 148 must be provided along with a receptacle 151, corresponding to receptacle 32 of FIGS. 1 and 2, with suitable connection means for accommodating the additional electrical circuits, here shown as contacts 152. While the reversal switch feature is illustrated in connection with the embodiment corresponding to the portable key arrangement of FIGS. 1 through 3, it will be appreciated that the circuitry of FIG. 12 including the reversal switch may be adapted to each of the other embodiments of the invention such as those shown in FIGS. 4 through 10.

I claim:

1. An electronic combination lock comprising: electrically operated lock control means, circuit means including manually actuated switch means having an unactuated state and being placed in an actuated state by continuous manual engagement therewith, said circuit means generating a sequence of electrical signals during the actuated state of said switch means and being operable to select predetermined ones of said generated signals

for operating said lock control means in response to transitions of said switch means from its actuated state to its unactuated state, and means for displaying said generated signals, whereby said switch means may be selectively and manually operated between its actuated and unactuated states to achieve the selection of said predetermined signals.

2. The lock of claim 1, wherein said circuit means includes an electrical signal generator for generating said sequence of signals of said switch means being connected to and for operation of said generator.

3. The lock of claim 2, wherein said circuit means further includes a decoding circuit responsive to said predetermined signals to operate said lock control means.

4. The lock of claim 1 wherein said display means is comprised of a digitally operated solid state alphanumeric indicator.

5. The lock of claim 1, said lock control means including an electro-mechanical lock adapted for installation in a door and door jamb assembly, and further comprising, a door handle adapted to be mounted on said door, said display means and said switch means of said circuit means being mounted on said door handle.

6. The lock of claim 5, said handle having an annular shape with one axial end adapted for mounting to said door, said switch means including a push-button switch mounted on the other end of said handle substantially coaxially therewith.

7. The lock of claim 6, said display means comprising, a solid state alpha-numeric indicator disposed in a window provided for the purpose in said handle.

8. The lock of claim 1, said lock control means including an ignition switch for a vehicle and said display means and switch means of said circuit means be adapted for installation in the driver's compartment of such vehicle.

9. The lock of claim 8 further comprising, a vehicle steering column having a display window disposed for observation by a driver, said display means including a solid state alpha-numeric indicator mounted in said column window, and said switch means mounted on said steering column.

10. The lock of claim 9, wherein said window is mounted on an upper surface of said steering column and said switch means is mounted in a side or lower surface of said steering column, and further comprising, manual switch locator means disposed on said steering column immediately adjacent said switch means.

11. The electronic combination lock of claim 1, said circuit means comprising signal generator means having a forward mode and a backward mode generating said sequence of signals in a forward and reverse order respectively, and additional manually actuated switch means selectively disposing said generator means in either its forward or backward mode.

12. A security control system for selectively electrically operating control means adapted for fixed installation at and control of a secured station comprising, electrical circuit means including manually actuated switch means for generating a sequence of electrical signals and for selecting certain of said signals in order to operate said control means, and portable key means for detachable connection at said station and having electrically operated display means for displaying sym-

bolic representations of said generated signals, whereby said certain signals may be selected by selective manual operation of said switch means in accordance with the displayed representations of said generated signals.

13. The control system of claim 12, further defined by a push-button switch providing said manually actuated switch means, said push-button switch mounted on said portable key means and having an unactuated state and being disposed in an actuated state during continuous manual engagement therewith, said circuit means generating said sequence of electrical signals during the actuated state of said push-button switch and said circuit means responsive to a transition of said push-button switch from its actuated state to its unactuated state to select one of the sequentially generated signals, whereby said push-button switch is manually engaged to initiate a sequential display of the generated signals and manually released at the instance of a displayed symbol to select the corresponding electrical signal.

14. The security control system of claim 12 wherein said circuit means comprises signal generator means having a forward mode and a backward mode for generating said sequence of electrical signals in a forward and a reverse order respectively, and additional manually actuated switch means selectively disposed said generator means in either its forward or backward mode.

15. In a security control system having electrically operated lock means, the combination therewith comprising:

circuit means including generator means for automatically generating a sequence of electrical signals and said circuit means further including decoding means responsive to predetermined ones of said sequence of signals for operating said lock means,

electrically-operated display means connected to said generator means for visually displaying symbolic representations of said generated signals, and

manually operated switch means having a plurality of states and capable of being selectively and manually disposed in said various states, said generator means being responsive to one of said states of said switch means to issue said sequence of electrical signals and said decoding means being responsive to another of said states of said switch means to receive the signal issued by said generator means at the instance of any select time, whereby selective manual operation of said switch means between its various states enables an operator to select with the assistance of said display means the predetermined ones of said sequence of signals for successfully operating said lock means.

16. In the control system of claim 15, the combination thereof being further defined by said electrically operated display means comprising a single display panel selectively, sequentially displaying alphanumeric symbols as said representations of said generated electrical signals, and said manually operated switch means comprising a single manually controlled actuator for selectively disposing said switch means in said various states, whereby a compact control device is provided in which a single manual control serves to enter selected alphanumeric symbols as a plurality of

17

the symbols are sequentially visually presented on the single display panel.

17. In the control system of claim 15, said signal generator means of said circuit means having a forward mode and a backward mode generating said sequence of electrical signals in a forward and reverse order respectively, and said generator means being responsive to one or more of said plurality of states of said manually operated switch means for selectively disposing said generator means in either its forward or backward mode.

18. In the control system of claim 15, wherein said electrically operated lock means includes an electromechanical lock adapted for installation in a door and door jamb assembly, the combination further comprising, a door handle adapted to be mounted on said door, said display means and switch means being mounted on said door handle.

19. In the security control system of claim 15, wherein the electrically operated lock means includes a vehicle ignition switch, the combination further comprising, a vehicle steering column fixedly carrying a display window disposed for observation by a driver, said display means mounted in said column window and said switch means mounted on said steering column.

20. In a security control system having electrically operated lock means adapted for fixed installation at a controlled security station, the combination therewith comprising:

circuit means including generator means for generating a sequence of electrical signals and decoding means responsive to predetermined ones of such signals for operating said lock means, electrically-operated display means connected to said generator means for visually displaying symbolic representations of said generated signals, and

manually operated switch means connected to and for operating said generator means for selective generation of said signals and said switch means

18

connected to and for operating said decoding means to select and communicate said predetermined signals thereto for operation of said lock means, and

a portable key means detachably electrically connected to a receptacle means provided at said station, said receptacle means being connected to said circuit means, said display means and said switch means being mounted on and carried by said key means for portable transportation thereof relative to said station.

21. An electronic combination lock comprising: electrically operated lock control means adapted for fixed installation at a controlled security station, circuit means including manually actuated switch means having an unactuated state and being placed in an actuated state by continuous manual engagement therewith, said circuit means generating a sequence of electrical signals during the actuated state of said switch means and being operable to select predetermined ones of said generated signals for operating said lock control means in response to transitions of said switch means for its actuated state to its unactuated state,

means for displaying said generated signals,

portable key means detachably electrically connected at said station for portable transportation relative thereto, said means for displaying said generated signals being carried by said key means for operation of the former when said key means is connected at said station, whereby said key means may be connected at said station and said switch means selectively and manually operated between its actuated and unactuated states to achieve the selection of said predetermined signals.

22. The electronic combination lock of claim 21, wherein said switch means of said circuit means is carried by said key means together with said display means for detachable electrical connection at said station.

* * * * *

45

50

55

60

65