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[54] **FINGER OPERATED ELECTRO-OPTICAL LOCK AND METHOD**

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[52] **U.S. Cl.** **70/278;** 70/DIG. 51; 250/221; 317/124; 317/134

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

[58] **Field of Search** ..... 70/278, DIG. 51; 250/209, 250/221; 317/124, 134

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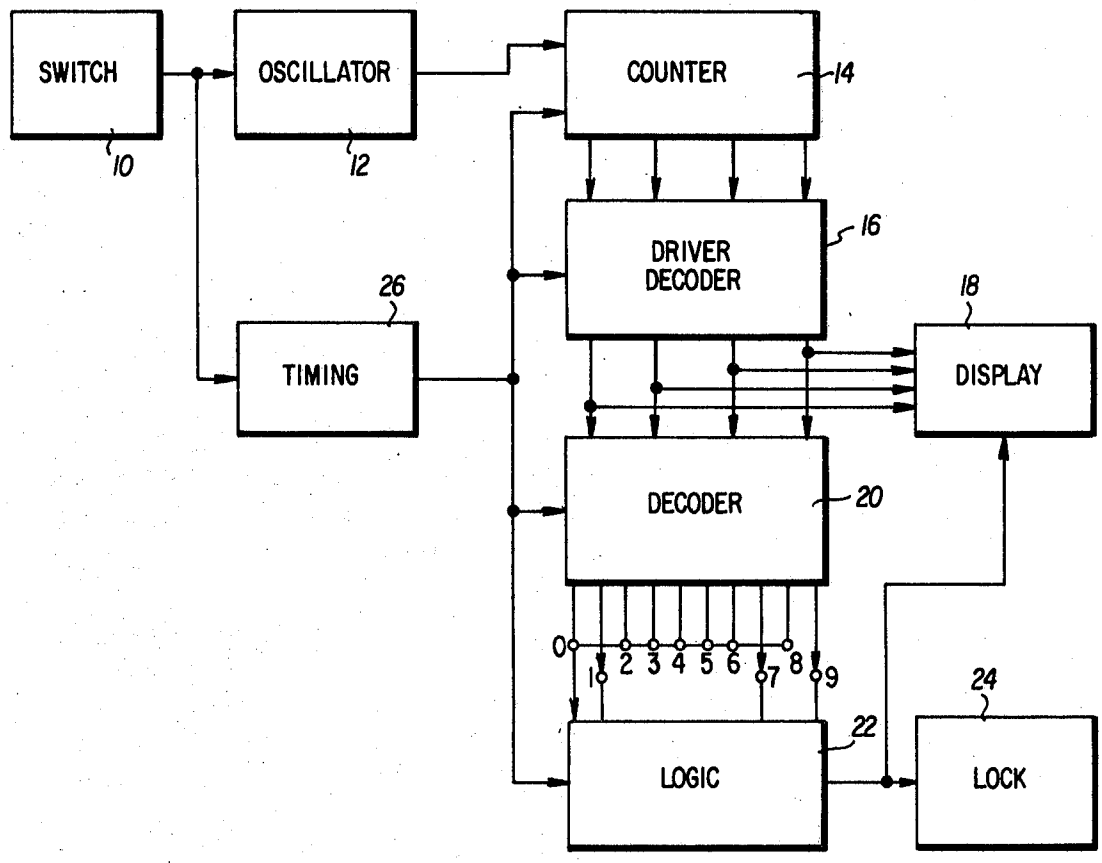
[57] **ABSTRACT**

A finger operated electro-optical lock system in which an optical keyboard having at least one zone indicated thereon is illuminated by ambient energy until touched by a finger of the human hand blocking the radiant energy passing through the zone. A counter is thus enabled to cycle a numeric display. When the first digit of the combination appears in the display, the finger is lifted and reapplied until the second digit of the combination is displayed. The process is repeated until each digit of the combination has been displayed.

10 Claims, 4 Drawing Figures



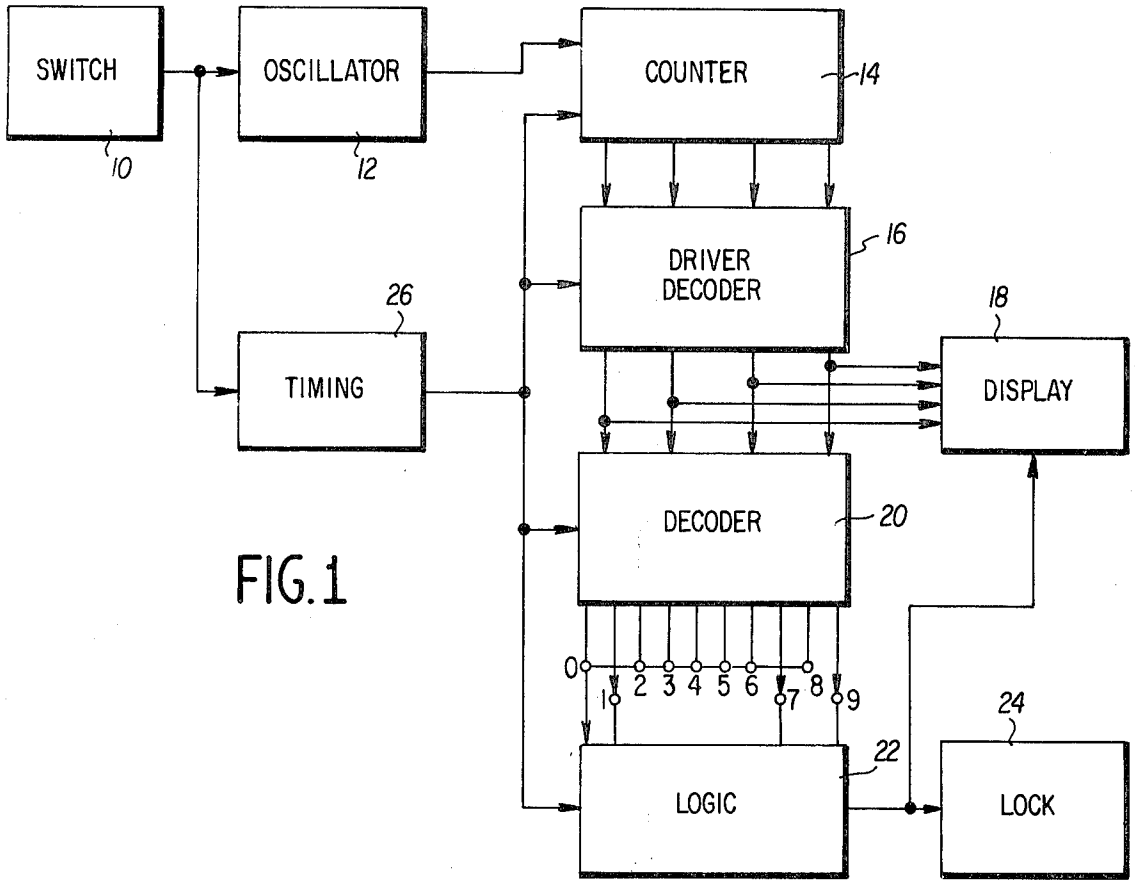


FIG. 1

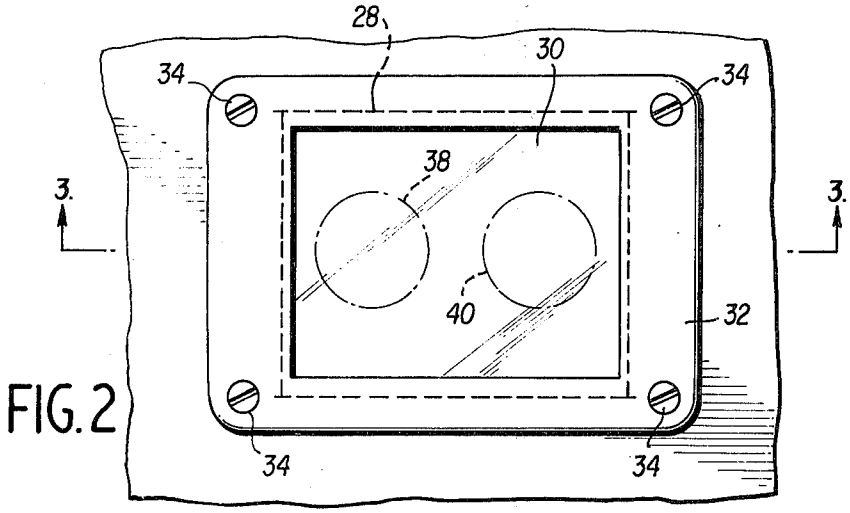


FIG. 2

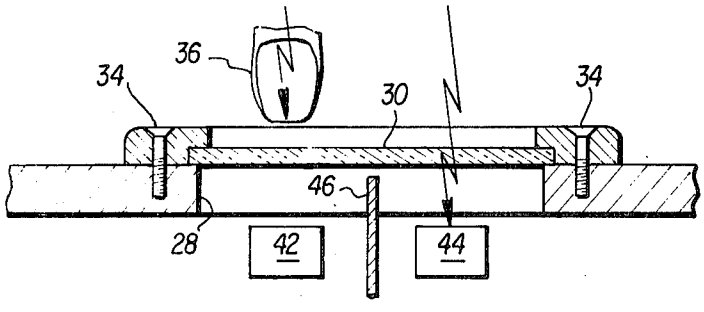


FIG. 3

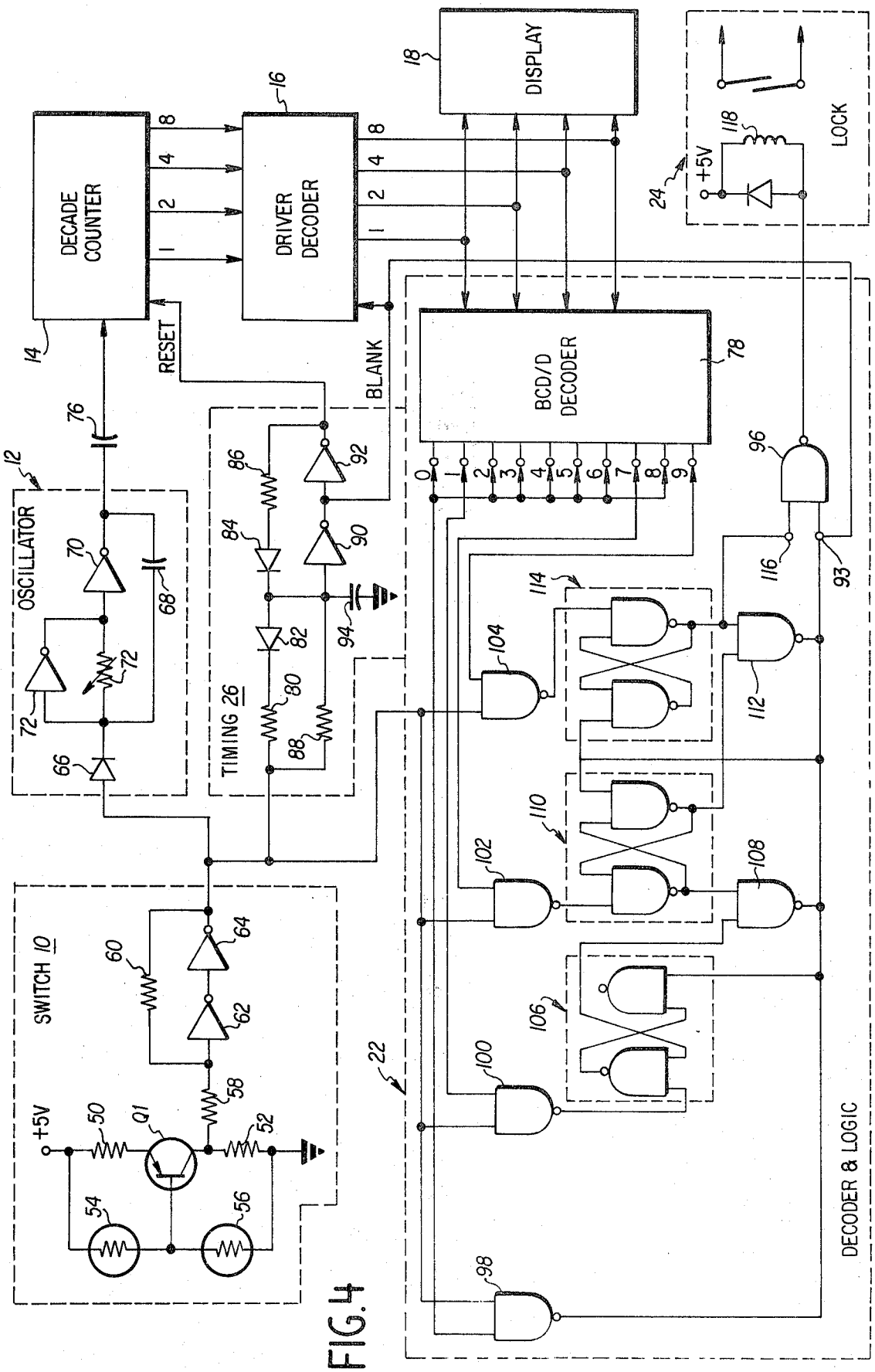

DECADE COUNTER
DRIVER DECODER
DISPLAY
LOCK
+5V
RESET
BLANK
BCD/D DECODER
OSCILLATOR
TIMING 26
SWITCH 10
DECODER & LOGIC
14
16
18
22
24
12
78
76
68
66
70
72
80
82
84
86
88
90
92
94
96
93
116
114
112
110
108
106
104
102
100
98
64
62
60
58
50
52
54
56
Q1
0
1
2
3
4
5
6
7
8
9
118

FIG. 4

FINGER OPERATED ELECTRO-OPTICAL LOCK AND METHOD

BACKGROUND OF THE INVENTION

The present invention relates to an optical keying system and more particularly to an electro-optical system for operating a locking mechanism from a point externally of a building to which entry is desired.

Electronic combination locking systems in which a series of switches are set in a predetermined combination in order to release a locking mechanism are well known. The combination indicating devices for these sytstems are generally mechanically actuated switches which are subject to mechanical wear. Moreover, many of the electronic locking systems operate on the principle of selecting a predetermined combination by simultaneously positioning switches corresponding to the predetermined combination. These systems have the disadvantage that the requirement of simultaneous actuation or setting of the switches to the predetermined combination may offer an observer a view of the combination before it is possible to move the switches away from their combination indicating positions.

The use of electromagnetic and optical scanners to read a card or other "key" inserted into a slot is generally known and may be found, for example, in the operation of parking lot closures. All systems of this type suffer from the disadvantage that the slot into which the key must be placed may be obstructed by leaves, twigs, dirt and the like by children and by vandals. In addition, the "combination" of such systems have not been readily modifiable.

It is accordingly an object of the present invention to obtain the deficiency of these known systems and to provide a novel and improved electro-optical locking system and method in which a single optical key is actuated for predetermined periods of time for operating a locking mechanism.

It is another object of this invention to provide a novel system and method in which the "combination" of the mechanism may be easily and quickly manually modified.

It is yet another object of the invention to provide a novel circuit and method for evaluating a predetermined sequence of optically controlled time intervals.

It is yet another object of the present invention to provide a novel system and method for operating a lock in which all of the operable parts thereof are located internally of the structure into which entry is desired.

It is still another object of the present invention to provide a novel optical keyboard actuated by the presence of the human finger at a preselected zone on the board for predetermined time intervals.

These and many other objects and advantages of the present invention will be readily apparent to one skilled in the art to which the invention pertains from the claims and from the perusal of the following detailed description in connection with the appended drawings.

THE DRAWINGS

FIG. 1 is a functional block diagram of the system of the present invention;

FIG. 2 is a pictorial view in elevation of the optical keyboard of the system of FIG. 1;

FIG. 3 is a section taken through the optical keyboard of FIG. 2; and,

FIG. 4 is a schematic circuit diagram of the logic circuit of FIG. 1.

THE DETAILED DESCRIPTION

With reference now to FIG. 1 where the system of the present invention is displayed in block diagram form, a switch **10** is manually operated to enable or to unblock an oscillator **12** which in turn applies pulses to a counter **14**. The number of pulses applied to the counter may be decoded in a decoder **16** and displayed in a display **18**.

The switch **10** may be of any suitable conventional type but desirably is of the type hereinafter illustrated and described in detail. The oscillator **12** may be of the type illustrated in the circuit of FIG. **4** but may also comprise any suitable conventional pulse generating circuit. It is desirable, but not necessary, that the pulses provided by the oscillator **12** be of a uniform pulse repetition rate. The counter **14** which receives the pulses from the oscillator **12** may be of any suitable conventional type such as a ring counter to continually increment in response to pulse application. Thus, the operation of the switch **10** enables the oscillator **12** to cycle the counter **14** and to increment the digit displayed by the display **18**.

The operation of the switch **10** may also enable a timing circuit which resets the counter **14** and enables the driver decoder circuit **16**. In this manner, the operation of the switch **10** may effect the initial reset of the counter **14** and enable the driver decoder circuit **16** so that the number of pulses provided by the oscillator **12** subsequent to the operation of the switch **10** will be indicated to the switch operator at the display **18**. The display **18** will thus continually cycle until the switch **10** is disabled at which time the oscillator **12** will cease to increment the counter **14** and the last pulse digit indication will remain in the display **18**. The timing circuit **26** may be operative after a predetermined time delay such as ten seconds to reset the counter **14** and disable the drive decoder circuit **16** to remove the digit indication from the display **18**.

With continued reference to FIG. **1**, the driver decoder circuit may provide input signals to a decoder circuit **20**. These input signals will, of course, reflect the digit indicated at the display **18**. The decoder **20** may be operative to transform the binary coded decimal contents of the counter **14** to decimal form. The disabling of the switch **10** may, through the timing circuit **26**, effect the reading of the digit stored within the decoder **20** into a logic circuit **22** for evaluation purposes.

The operation of the logic circuit **22** in response to a selected combination is hereinafter discussed in greater detail in connection with FIG. **4**. In the embodiment illustrated, the three digits of the combination are the numerals **1, 7** and **9** and appropriate output terminals from the decoder **20** are connected to the logic circuit **22**. The remaining output terminals **0, 2–6** and **8** are desirably connected together and to the logic circuit **22**. The logic circuit **22** is thus operative to effect resetting of the circuit upon receipt of a single digit signal not in the predetermined combination. In addition, the logic circuit **22** may be operative to reset the circuit in the event that the digit signals are not received in the appropriate predetermined sequence. The sequential receipt of the digits **1, 7** and **9** in the desired order by the logic circuit **22** will effect the operation of the lock

24 for a predetermined time interval as determined by the timing circuit 26 earlier described.

The operation of the embodiment illustrated in the figures will now briefly be announced. The individual desiring access to the interior of an enclosure such as an apartment house or the like will approach the locking mechanism from the exterior of the building and operate the switch 10 by placing a finger over an indicated zone in a plate glass window. The placing of the finger over the appropriate zone will reduce the ambient light at that particular zone which will reset the counter 14 through the timing circuit 26 to enable or unblock the oscillator 12 to continually increment the counter 14 until such time as the finger is removed from the switch.

With the finger against the glass, the counter will continuously cycle the numeral indicated on the display 18 from 0 to 9. The display 18 should be located for ready viewing by the operator so that the operator may remove his finger from the glass when the desired digit is displayed, i.e., the first digit of the combination. Removal of the finger to "freeze" the digit indicated on the display 18 will enable the decoder 20 to provide an output signal on one of the 0 to 9 output terminals.

Should the first decoded digit be 0, 2–6 or 8 for the exemplary 1, 7, 9 combination illustrated, the logic circuit 22 will immediately reset. Should the first decoded digit be the digit 7 or 9, the logic circuit 22 will also reset. Should the first decoded digit be the digit 1, i.e., the first digit of the combination, the logic circuit 22 will internally prepare for receipt of the next digit of the combination, i.e., the digit 7.

If the operator does not again place his finger on the glass to effect operation of the switch 10 within a predetermined time interval, e.g., ten seconds, the timing circuit 26 will reset the logic circuit 22. Should the operator again effect operation of the switch 10, the counter 14 will be reset and again cycle the display 18 until the operator recognizes the second digit of the combination and removes his finger from the glass to "freeze" the display. If the second digit decoded is other than the second digit of the combination, the logic circuit 22 will reset. If, however, the second decoded digit is the second digit of the combination, the logic circuit 22 will be internally enabled to receive the third digit of the combination. The subsequent receipt of the third digit will effect operation of the lock 24 for a predetermined time interval sufficient to permit entrance into the enclosure.

The circuit may be provided with feedback from the locking mechanism to disable the display 18 so that the last digit of the combination cannot be observed by an unauthorized person. Also, the display 18 may be desirably shielded to prevent observation of the display during the operation of the mechanism.

The physical relationship of the switch 10 may be as illustrated in FIGS. 2 and 3. With reference now to FIGS. 2 and 3, an opening 28 may be provided from the inside of an external wall and the opening covered by a one-quarter inch thick sheet 30 of plate glass or other radiant energy transparent material having the desired structural characteristics. Any suitable conventional means such as a metallic plate 32 and a plurality of threaded fasteners 34 may be utilized to mount the sheet 30 over the opening 28. Thus, a convenient window is provided against which the finger of the operator's hand may be positioned.

As indicated in FIGS. 2 and 3, two zones 38 and 40 may be provided in the window by the positioning of detectors 42 and 44. As indicated schematically in FIG. 3, a suitable shield or baffle 46 may be provided to optically isolate the detectors 42 and 44 from radiation passing through all but the particular zone 38 or 40 with which it is associated. Thus, the presence of a finger 36 at one of the zones in the window will optically block the radiant energy normally incident thereon and provide an output signal from the switch as will be subsequently explained in greater detail in connection with the circuit of FIG. 4.

With reference now to FIG. 4, the switch 10 of FIG. 1 may include a PNP transistor Q1 connected between a 5-volt source of positive potential and ground potential by an emitter resistor 50 and a collector resistor 52. The bias for the base electrode for the transistor Q1 may be provided by any suitable conventional radiant energy responsive devices 54 and 56 located respectively in the base-to-emitter and base-to-collector circuits of the transistor Q1. The output signal from the transistor Q1 may be taken from the collector electrode thereof and passed through a resistor 58 and the parallel combination of a resistor 60 with a pair of serially connected converters 62 and 64 as the output signal from the switch 10.

The output signal from the switch 10 may be, as shown in FIG. 1, applied to an oscillator circuit 12, a timing circuit 26 and a logic circuit 22. The oscillator circuit 12 may comprise a diode 66 in series with a parallel circuit in which a capacitor 68 is provided in one branch thereof and in which the other branch thereof includes an inverter 70 in series with the parallel combination of an inverter 72 and a variable resistor 74. The output signal from the oscillator circuit 12 may be passed through a capacitor 76 to the input terminal of a suitable conventional decade counter 14. The decade counter 14 may be provided with parallel output terminals representing the binary digits 1, 2, 4 and 8 and these output terminals may be connected to input terminals of a driver decoder circuit 20 which, when enabled, may apply binary coded signals to a suitable conventional display circuit 18 such as an alphanumeric electronic tube. The output signals from the driver decoder circuit 20 may also be applied to the input terminals of a binary coded decimal to decimal decoder 78 of the logic circuit 22.

With continued reference to FIG. 4, the output signal from the switch 10 may also be provided to the timing circuit 22 which may include the series connection of a resistor 80, diodes 82 and 84 and a resistor 86 and the series connection of a resistor 88 and a pair of inverters 90 and 92 in parallel therewith. The interconnection of the diodes 82 and 84 may be directly connected to the interconnection of the resistor 88 and the inverter 90 and isolated from ground potential by way of a capacitor 94. The output signal from the inverter 92 may be used as the RESET signal applied to the decade counter 14 and the output signal from the diode 90 may be utilized as the BLANK signal for application to the driver decoder circuit 20 and one input terminal 94 of a NAND gate 96.

The logic circuit 22 of FIG. 4 may include a plurality of NAND gates 98, 100, 102 and 104, each connected to receive on one input terminal thereof the output signal from the switch circuit 10. Each of the NAND gates 100, 102 and 104 receives an input signal from a prede-

termined one of the decimal output terminals of the binary coded decimal to decimal decoder **78**. In the preferred embodiment illustrated, the combination is a 3-digit combination with the "**1**" output terminal of the decoder **78** connected to the other input terminal of the NAND gate **100**, the "**7**" output terminal connected to the other input terminal of the NAND gate **102** and with the "**9**" output terminal connected to the other input terminal of the NAND gate **104**.

Any suitable conventional means may be used to effect the selected connection of NAND gate **100, 102** and **104** to the selected output terminals of the decoder **78** to thereby establish the desired combination. Similarly, the connection of each of the noncombination digit output terminals of the decoder **78** to the NAND gate **98** may be effected by any suitable conventional means.

The output signal from the NAND gate **100** may be applied to a timing circuit **106** to enable a NAND gate **108** for a predetermined time interval. Similarly, the output signal from the NAND gate **102** may be applied to the timing circuit **110** to enable a NAND gate **112** and the output signal from the NAND gate **104** applied through a timing circuit **114** to provide a signal at the other input terminal **116** of the NAND gate **96**. The output signal from the NAND gate **96** may be connected to the relay coil **118** of a switch within the lock **24**.

In operation, the placing of a finger to block the ambient light to the detector **42** of FIG. **3** may effect the unbalancing of the bias of the transistor Q1 to drive the transistor into cutoff. The output signal from the collector electrode of the transistor Q1 will assume a low signal level and the circuit including the invertors **62** and **64** operate as a Schmitt trigger to remove the normally high signal level signal from the oscillator **12**, the timing circuit **26** and the decoder and logic circuit **22**.

Removal of the signal from the timing circuit **26** will effect the generation of the RESET signal applied to the decade counter **14** to effect the resetting thereof and will also remove the normally high signal level BLANK signal from the driver decoder **16** so that the decoder **16** will be operative to drive the display **18** to visually indicate the digit in the counter **14**. Removal of the BLANK signal will also enable the NAND gate **96** of the decoder and logic circuit **22**.

The removal of the input signal from the oscillator **12** will effect the application of periodic pulses to the decade counter **14** through the capacitor **76**. The incrementing of the decade counter **14** will provide the signals necessary to operate the display **18** through the driver decoder **16**.

When the finger is removed from the position illustrated in FIG. **3**, the transistor Q1 again saturates to disable the oscillator **12**. Because of the time constants of the resistor **88** and capacitor **94**, the resetting and blanking functions do not recur for a predetermined time interval, e.g., 10 seconds. If the switch **10** is again activated within this predetermined time interval, the oscillator **12** again increments the counter **14** to cycle the display **18** until such time as the finger of the operator is again removed to disable the switch **10**. This process is repeated until the operator sequentially "freezes" by the removal of his finger at an appropriate time, each digit of the combination on the display **18**.

The removal of the finger to "freeze" the digit displayed enables each of the NAND gates **98, 100, 102** and **104** of the decoder and logic circuit **22**. Should the decoder **78** provide a low signal level signal on any of the output terminals **0 2–6** or **8**, the NAND gate **98** will be disabled to disable the NAND gate **96** and thus the operation of the lock **24**. Should the decoder **78** provide the NAND gate **100** with an appropriate low signal level signal during this time, the NAND gate **100** will enable the NAND gate **108** so that the NAND gate **96** will remain in an enabled condition. Should the decoder **78** provide a "**7**" output signal during this first sampling of the decoder **78**, the NAND gate **102** will inhibit the NAND gate **108** and thus the NAND gate **96** and the operation of the lock **24**. Similarly, the presence of a "**9**" output signal from the decoder **78** during this first sampling interval will inhibit the NAND gate **96** through the operation of the NAND gate **104**.

At the time of the next sampling interval, e.g., when the finger is again removed to "freeze" the second digit of the combination in the display **18**, the NAND gate **102** will operate to enable the NAND gate **112** and maintain the NAND gate **96** in an enabled condition. The subsequent receipt of a "**9**" signal from the decoder **78** by the NAND gate **104** will effect the operation of the NAND gate **96** to operate the relay **118** associated with the lock **24**.

ADVANTAGES AND SCOPE OF THE INVENTION

Many of the advantages of the present invention will be readily apparent from the foregoing description of a preferred embodiment. For example, the optical keyboard of the present invention utilizes ambient radiation easily blocked by the human finger.

Another of the major advantages of the present system is that observation of the time intervals in which the finger is placed in proximity to the zone of the keyboard is easily hindered to protect the combination of the lock. Further, the difficulty in measuring time intervals is advantageous. The display of but a single digit at one time and an automatic reset feature precludes any residual indication of the combination as may exist where the combination is set by a plurality of switches or the like.

Because of the resetting of the logic circuit upon the detection of a single out-of-sequence time interval, security is assured. It will be further appreciated that the combination cannot be detected by a sense of feel or mechanical noise since no mechanical combination locking or unlocking apparatus is utilized.

Moreover, the ease with which the combination may be changed facilitates revision of the security measures and thus reduces the likelihood of compromise. Since the device is finger operated, there are no keys to be lost or stolen.

Another of the major advantages of the present invention is the complete lack of moving parts in the operation of the system. The use of plate glass provides the desired structural strength and obviates the necessity for an opening which may be obstructed by children or vandals.

The present invention may thus be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not as restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of

equivalancy of the claims are therefore intended to be embraced therein.

What is claimed is:

1. A lock system for an enclosure entrance comprising:
- manually operable electro-optical switch means internal of the enclosure;
- pulse means responsive to said switch means for providing a series of pulses at a predetermined repetition rate;
- display means for providing a visual indicia internal of the enclosure related to the number of pulses provided by said pulse means, said display means being positioned for viewing by the operator of said switch means external of the enclosure so that the operation of said switch means may be selectively terminated to effect the display of predetermined visual indicia by said display means to the operator external of the enclosure;
- lock means; and,
- circuit means internal of the enclosure and responsive to the effecting of the display of predetermined visual indicia by said pulse means for effecting the operation of said lock means.

2. The system of claim 1 wherein said manually operable switch means includes:
- a sheet of radiant energy pervious material;
- a pair of detectors on the side of said sheet internal of the enclosure, each of said pair of detectors being responsive to ambient radiant energy passing through a predetermined zone on said sheet from the other side thereof; and,
- circuit means responsive to an imbalance in the ambient radiant energy detected by said pair of detectors for effecting the operation of said switch means.

3. The system of claim 2 wherein said circuit means includes means for inhibiting the operation of said lock means in the event that the visual indicia display effected by said pulse means is other than predetermined indicia.

4. The system of claim 1 wherein said circuit means includes means for inhibiting the operation of said lock means in the event that the visual indicia display effected by said pulse means is other than predetermined indicia.

5. An electro-optical locking system for an enclosure entrance comprising:
- a sheet of radiant energy pervious material carried by the enclosure and providing structural integrity for the enclosure;
- a pair of detectors on the side of said sheet internal of the enclosure, each of said pair of detectors being responsive to radiant energy passed through a predetermined zone on said sheet;
- a lock; and,
- means internal of the enclosure responsive to a predetermined sequence of the durations of a plurality of time intervals each related to an imbalance in the radiant energy detected by said pair of detectors for effecting the operation of said lock, said lock operating means including:
  - switch means for establishing a desired sequence of time interval duration,
  - counter means advanced in response to each imbalance in the radiant energy detected by said pair of detectors to a value related to the duration of the imbalance, and
  - circuit means for effecting the operation of said lock for a predetermined time interval in response to the sequential advancement of said counter means to each of a predetermined plurality of values, said circuit means being reset in response to the termination of advance at a value other than said predetermined plurality of values and in response to the termination of advance at one of said predetermined plurality of values in other than a predetermined sequence.

6. A system for operating the lock of an enclosure entrance comprising:
- a sheet of radiation transparent material carried by the enclosure and providing structural integrity for the enclosure;
- a plurality of radiation responsive elements on the side of said sheet internal of the enclosure, each of said elements being associated with a predetermined zone of said sheet;
- switch means on the side of said sheet internal of the enclosure operable in response to a modification of the radiation of said elements from the side of said sheet external of said enclosure;
- display means;
- means responsive to the duration of the operation of said switch means for modifying the indicia displayed by said display means and for providing a unique signal related to the duration of the operation of said switch means responsively to the termination of the operation of said switch means; and,
- means for evaluating said unique signal and for effecting the operation of the enclosure lock in response to a favorable evaluation.

7. The system of claim 6 wherein said switch means is operable from a position external of the enclosure by the positioning of the finger of a human hand in a predetermined position on said sheet of radiation transparent material.

8. The system of claim 7 wherein said lock operating means includes:
- switch means for establishing a desired sequence unique signal provision.

9. The system of claim 8 wherein said sheet of material is glass having a thickness of at least about one-quarter inch.

10. A method for operating the locking device of the entrance to an enclosure without compromising the integrity of the enclosure comprising the steps of:
- a. sequentially modifying for a plurality of time intervals the passage of radiant energy from a source external of the enclosure through a predetermined zone of a sheet of structural material optically transparent to the radiant energy;
- b. detecting internally of the enclosure the duration of each of the time intervals during which the passage of radiant energy is modified;
- c. evaluating the sequence of time interval duration detection with respect to a predetermined sequence; and,
- d. operating the locking device responsively to the evaluation of the time interval duration sequence evaluation.

* * * * *