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Dimitriadis

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[54] **ELECTRONIC LOCKING SYSTEM**

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[21] Appl. No.: **271,251**

[52] **U.S. Cl.** ..... **356/71**, 70/277, 250/219 DQ, 356/165

[51] **Int. Cl.** **G06k 9/08**, E05b 47/00

[58] **Field of Search** ..... 356/71, 165; 250/219 DQ; 70/277, 278, 280

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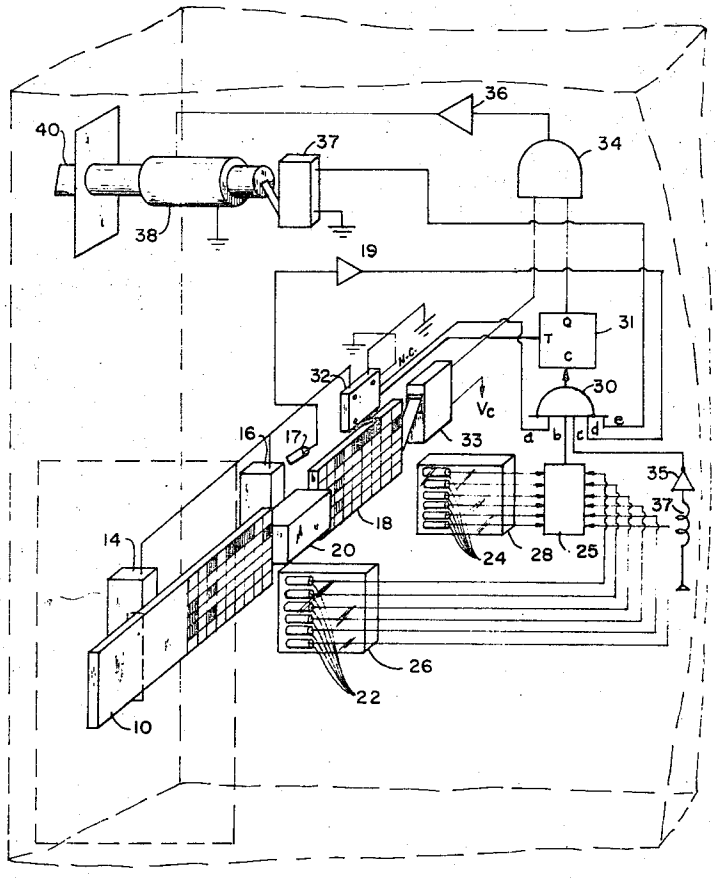
Assistant Examiner—V. P. McGraw
Attorney, Agent, or Firm—Alfred E. Miller

[57] **ABSTRACT**

An opto-electronic locking system for an entry door which is provided with an optically encoded key. The key is decoded internally by a sensing device which translates the light code detected into electrical levels which are compared with a stored code. If the code on the key corresponds to the stored code, then the circuit activates an electromechanical mechanism which in turn opens the lock. If the code on the key is not correct, then the electrical circuit activates an alarm or a security system or both.

9 Claims, 3 Drawing Figures



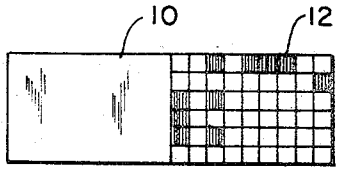

10
12

FIG. 1

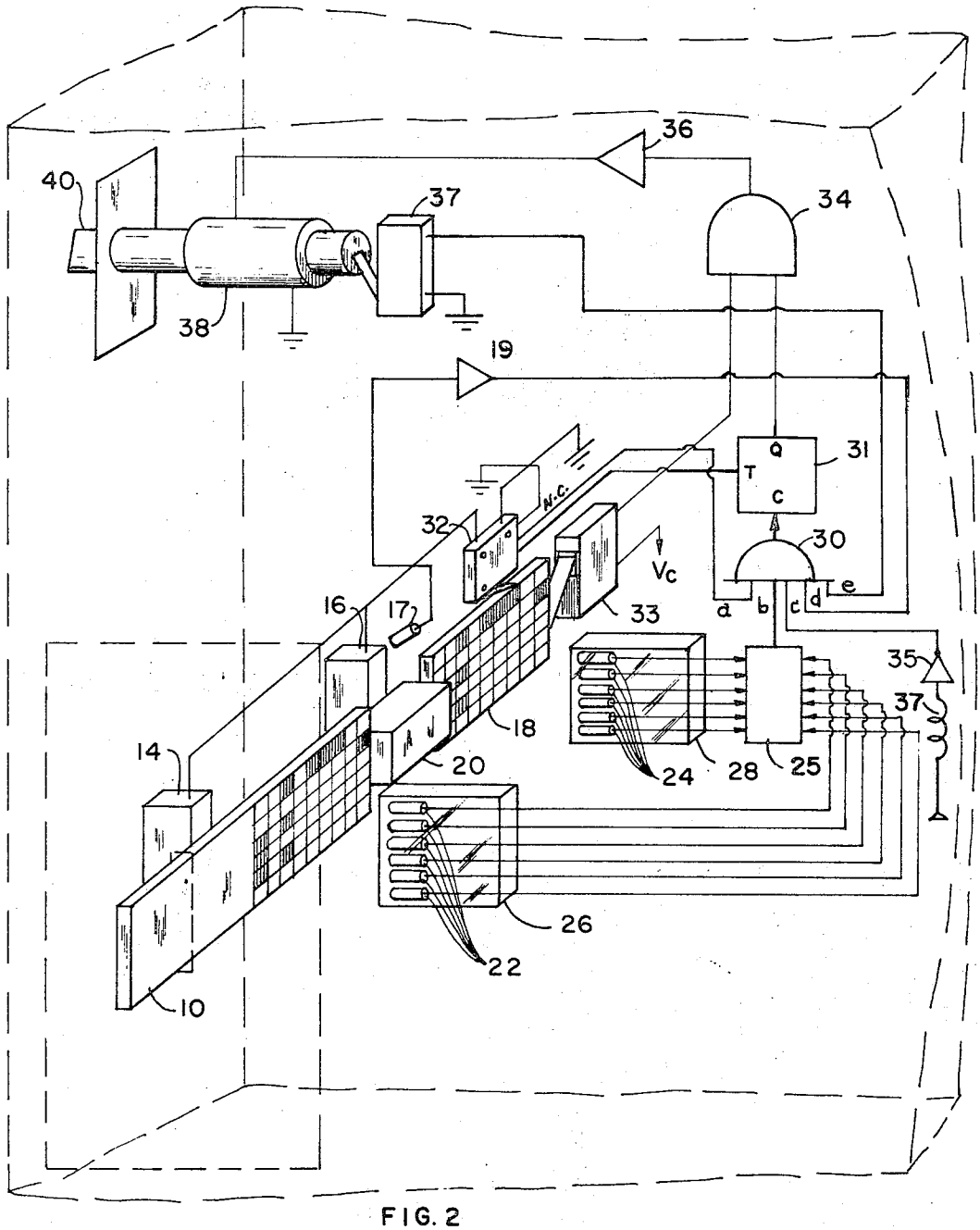

36
40
37
34
38
19
Q
T
C
31
N.C.
32
30
Vc
16
17
33
a
b
c
d
e
35
37
18
14
20
24
28
25
26
22
10

FIG. 2

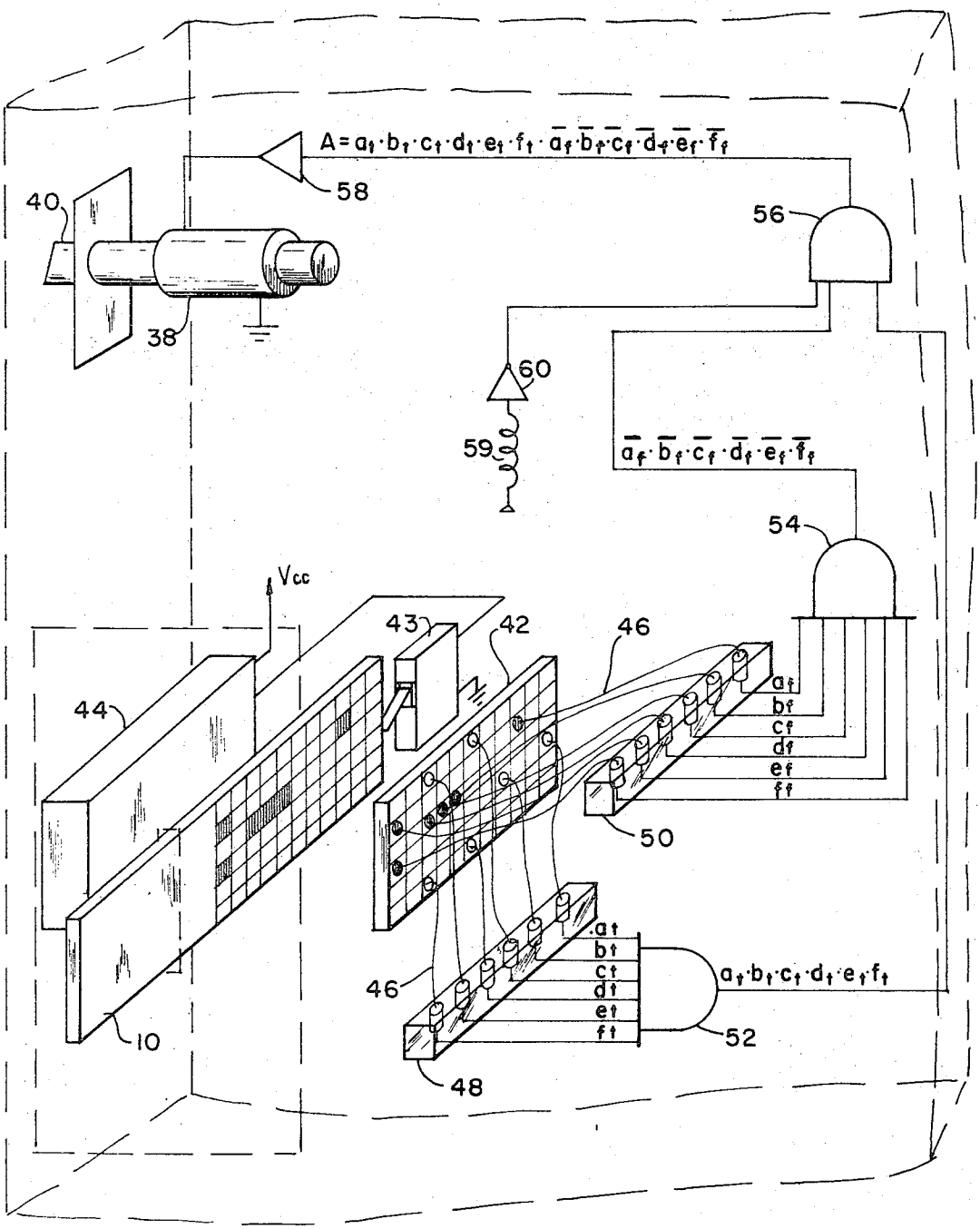

A = $a_f \cdot b_f \cdot c_f \cdot d_f \cdot e_f \cdot f_f \cdot \bar{a}_f \cdot \bar{b}_f \cdot \bar{c}_f \cdot \bar{d}_f \cdot \bar{e}_f \cdot \bar{f}_f$
58
40
56
38
60
59
$\bar{a}_f \cdot \bar{b}_f \cdot \bar{c}_f \cdot \bar{d}_f \cdot \bar{e}_f \cdot \bar{f}_f$
54
Vcc
43
42
46
44
a_f
b_f
c_f
d_f
e_f
f_f
50
46
a_f
b_f
c_f
d_f
e_f
f_f
$a_f \cdot b_f \cdot c_f \cdot d_f \cdot e_f \cdot f_f$
52
10
48

FIG. 3

ELECTRONIC LOCKING SYSTEM

The present invention relates to an electronic locking system that can be easily installed in an entry door and that achieves a security level not possible in traditional mechanical or electromechanical locking systems.

It is a well known fact that mechanical locks, such as the pin tumbler lock, deadbolt, and side-bar lock, have security disadvantages in that these locks can be opened by unauthorized persons who have some expertise in this field. It should also be noted that burglars are becoming more and more sophisticated in their techniques of securing entry through locked doors. In order to overcome the drawbacks of mechanical locks, several electro-mechanical locks have been proposed. However, these locks, too, are not considered to completely solve the security problem.

It is therefore an object of the present invention to provide an electronic locking system for doors which includes an opto-electronic device which decodes an optically encoded key.

A further object of the present invention is to provide an opto-electronic locking device which utilizes a serial decoding method.

Another object of the present invention is to provide an electronic locking system which has an easy interface with a security system.

Another object of the present invention is to provide an opto-electronic locking device which makes use of a parallel decoding method.

An object of the present invention is to provide an electronic locking system which has a pick proof opto-electronic operation.

Another object of the present invention is to provide an electronic locking system which is provided with corresponding matrix codes on the key and the hidden interior duplicate in the door so that when the correct key is inserted in the electronic locking system, a solenoid is activated which in turn opens the lock.

A further object of the present invention is to provide an electronic locking system in which the codes can be changed easily and inexpensively.

Another object of the present invention is to provide an electronic lock in which the insertion of the wrong key or tampering with the lock can be easily detected, and either an audible or silent alarm activated.

The invention will now be more fully described with reference to the accompanying drawings wherein:

FIG. 1 is a front elevational view of a key having a matrix code thereon which has been constructed in accordance with the teachings of the present invention.

FIG. 2 is a perspective diagrammatic view of the electronic locking system having a serial decoding arrangement, and

FIG. 3 is a perspective diagrammatic view of an alternate embodiment of the present invention in which the electronic locking system is shown provided with a parallel decoding arrangement.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The electronic locking system of the present invention utilizes a key **10** which is a simple flat support having a prearranged matrix code **12**, as seen in FIG. **1**. The key has a suitable optical filter coating on the matrix which prevents direct readout of the prearranged code by any person intending to copy the code. The key **10**, as seen in FIG. **2**, is inserted, for example in a

door D in which light sources **14** and **16** are shown that illuminate the key **10**. The latter is responsive to light, and according to the prearranged code, segments thereof are either transparent or non-transparent to light thereby forming a predetermined pattern.

Spaced from the key **10** is a duplicate coded flat plate **18** which is separated from the key **10** by a separator **20** that serves two functions, i.e., to transmit the linear motion of the key **10** to the duplicate plate **18** and to function as a mechanical barrier between the external and internal sections of the lock. Thus, both the key **10** and the duplicate plate **18** simultaneously move across two appropriately spaced sensors **26** and **28**. The duplicate plate **18** is spring biased to normally return the plate **18** to its forward position after it has been pushed rearwardly or into the interior of the door. It will be noted that each of the sensors **26** and **28** is provided with a column of light detectors **22** and **24** which is equal in number to the number of rows in the matrix code on both the key **10** and the duplicate plate **18**. Although six detectors are shown in each of the sensors **26** and **28**, any suitable number of detectors may be chosen.

The detectors **22** and **24** are of the opto-electronic type in that they translate light levels into electrical signals. Although photo-transistors are contemplated for use in the present system, other suitable detectors may be used, such as photo-voltaic cells or photo resistors.

Both the key **10** and the duplicate plate **18** are illuminated by the light sources **14** and **16** that are located adjacent thereto and light transmission by transparency is the mode utilized. HOwever, it should be understood that the reflective mode of light transmission may be employed within the principles of the present invention. It should be noted that the light sources **14** and **16** are activated only by the contacts a and b of micro switch **32**. Thus, the light sources are only activated during operation of the lock which significantly increases the life of the light sources. It should be apparent from FIG. **2** that as the key **10** is inserted and moves linearly across the sensor **26**, the plate **18** moves simultaneously across the sensor **28**. The outputs of the detectors **22** and **24** are fed into a comparator **25**. The comparator **25** is an electronic logic device which compares each corresponding bit of the output of the detector **22** from the key **10** and the output of the detector **24** from the duplicate plate **18**. The output of the comparator **25** is a logical true when the corresponding inputs from the key **10** and the duplicate plate **18** have identical logical values, that is, both have the same pattern on the matrix code. On the other hand, the output of the comparator **25** becomes a logical false when the corresponding inputs from the key **10** and the duplicate plate **18** are not identical. Thereafter, the output of the comparator **25** is fed into the AND gate **30**. There are four other auxiliary inputs into the AND gate **30** which clear the flip flop **31** under certain conditions. First auxiliary conditional input into the AND gate **30** is from the light source **16** through the detector **17** and the amplifier **19** into the d input of the AND gate **30**. The purpose of this input is to prevent false comparison of the key **10** and the duplicate plate **18** due to light source failure. If no light ie present at the source **16**, then the output of amplifier **19** will be logical false which will clear the flip flop. The second auxiliary conditional input is from the antenna **37** and inverter amplifier **35** into the input *c* of the gate **30**. The purpose

of this circuit is to prevent false true setting of the flip flop 31 due to electrical noise. The inputs a and e into the clear AND gate 30 are used to reset the flip flop 31 after the lock has operated. The flip flop is initially set at a logical true by means of a micro switch 32 and the duplicate plate 18 operates the micro switch 32 at the beginning of the insertion of the key 10 into the lock assembly in the door D. The output of the flip flop 31 is fed into the AND circuit 34. The second input into the AND circuit 34 is from the micro switch 33. The micro switch 33 is operated by the duplicate plate 18 and its output becomes a logical true following the full insertion of the key 10 into the lock. Accordingly, the two inputs into the AND circuit 34 will be logical true only when the key 10 has the same pattern as the duplicate plate 18 and the key 10 has been fully inserted, and the auxiliary conditions of the light sources being on, and the non-presence of electrical noise. It should also be noted that during insertion, if any code of the key 10 does not match the duplicate plate 18, the output of the comparator 25 becomes a logical false, which will clear the flip flop 31.

The output of the AND circuit 34 is thereafter fed into a driver circuit 36 which in turn activates a solenoid 38. The latter opens a lock 40 when activated. It should be noted that the solenoid 38 will only become operative when the two inputs into the AND circuit 34 are logical true which occurs only when two basic conditions are met, i.e., the key 10 and the duplicate plate 18 have the same pattern and the key 10 has been fully inserted in the lock so that a complete optical reading can be achieved. In addition to the two basic conditions, there are two other auxiliary conditions which have to be met for the lock to operate, i.e., the light source 16 must be operative during insertion of the key 10 and the inverter amplifier 35 must not sense electrical noise. It should be clear that the auxiliary conditions to be met by the present invention eliminates erroneous operation of the lock due to false comparison of the matrix codes of the key 10 and the duplicate plate 18 because of light source failure, and also false operation of the lock due to the pickup by the system of certain electrical noise. In case either of these conditions is not met, the flip flop 31 is cleared through either amplifier 19 or amplifier 35 and the AND gate 30. When the flip flop 31 clears, the lock will not operate. The arrangement shown in FIG. 2 is a serial decoding electronic lock and must be put in the reset condition after each unlocking operation. In this regard, the reset condition for the sequential logic of the serial decoding lock is achieved by two operations as follows: The first one being the operation of the solenoid 38 after the proper key is inserted, which activates the micro switch 37. The micro switch 37, when activated, grounds the e input of the AND gate 30 which in turn clears the flip flop 31. The second operation is due to the duplicate 18 being spring returned to its original place when the key is taken out. The micro switch 32 will be deactivated when the duplicate 18 is at its initial position. The contact N. C. on the micro switch 32 will then put a ground clear signal into the a input of the AND gate 30 which in turn clears the flip flop 31. This second clear signal is used as a continuous reset condition until the key is inserted again. The first reset signal from the solenoid 38 through the micro switch 37 will be momentary during opening of the lock.

FIG. 3 illustrates another arrangement of the present invention in which a parallel decoding system is shown. In the arrangement, the entire pattern of the matrix code on the key 10 is processed simultaneously, and not sequentially as the system shown in FIG. 1, by a sensor block 42. In this construction, the key 10 is shown illuminated by a light source 44. The light source 44 is activated by the micro switch 43 when the key 10 is inserted. The source 44 therefore is only on during operation of the lock which significantly increases the life rating of light source 44. The sensor block 42 is further shown being provided with a plurality of light guides 46 for each code area on the key 10. For reasons of clarity, only a part of the light guides 46 are illustrated. The light guides 46 are fed into two separate detector banks 48 and 50, the former being a logical true detector bank and the latter being a logical false detector bank. All the light guides 46 opposite transparent coded areas of the key 10 are fed into the logical true detector bank 48 while all of the light guides 46 opposite non-transparent coded areas of the key 10 are fed into the logical false detector bank 50. Both of the aforesaid detector banks 48 and 50 are composed of light detectors which translate light levels into electrical signals. The output of the logical true bank 48 is thereafter fed into the AND circuit 52 while the output of the logical false bank 50 is fed into the logical NOR circuit 54. Subsequently, the output of the logical AND circuit 52 and the output of the logical NOR circuit is fed into the logical AND circuit 56. The logical expression for the output of the AND circuit 56 is as follows:

$$(a_t \cdot b_t \cdot c_t \cdot d_t)\ (\bar{a}_f \cdot \bar{b}_f \cdot \bar{c}_f \cdot \bar{d}_f) = A$$

where a_t, b_t, c_t, d_t are derived from logical true areas of the key 10 and a_f, b_f, c_f, d_f are derived from logical false areas of the key 10.

If the key 10 produces any logical false signal which is fed to the logical true detector bank 48 from the signals a_t, b_t, c_t, d_t, e_t, and f_t, A becomes a logical false. Similarly, if any of the logical false signals a_f, b_f, c_f, d_f, e_f, and f_f derived from the key 10 are logical true, then A again becomes logical false. Therefore, it should be understood that when a key 10 with a different pattern from the original key is inserted in the locking system, then either some of the logical true inputs into bank 48 will not be logical true and/or some of the logical false signals will not be logical false. In that condition, and in accordance with the logical expression for the output of the AND circuit 56, said output will be logical false. In any event, the output of the AND circuit is fed into the driver circuit 58 which drives the solenoid 38. Consequently, when the solenoid 38 is driven, the lock 40 is activated to unlock the door. It should be apparent that the lock 40 will only operate when the inputs into the AND circuit 56 are logical true, and this occurs only when the key with the correct pattern is inserted into the locking system. In addition to the basic condition of the key 10 having the correct pattern code, there is an additional auxiliary condition of not having false activation by electrical noise. This condition is satisfied by the antenna 59 and the inverter amplifier 60. The amplifier 59's output is logical false when electrical noise is present; this output is fed into the AND gate 56, which eliminates false operation of the lock due to electrical noise.

Furthermore, it is to be understood that although in FIG. 2 light detectors 22 and 24 are shown directly op-

posite the light sources 14 and 16 it is within the scope of the present invention to provide suitable optical transmission mediums, such as light guides, for example, fiber optics, lenses, mirrors, and the like that can be utilized to transmit the code information from the key 10, and the duplicate plate 18 to the detectors 22 and 24, respectively. Utilization of such optical components as described above allows the detectors 22 and 24 to be placed at any location desired rather than directly opposite the light sources 14 and 16. It is also to be noted that the power source for the electrical components of the present lock can be any type, such as a line operating source, batteries, or any combination of these which are suitable for my novel locking system.

Although micro switches are illustrated herein, it is to be understood that other types of means may be employed within the scope of the teachings of the present invention, which translate mechanical positional or orientation information into electrical signals, such as magnetic reed switches, opto-electronic switcheS, proximity switches, and any other suitable switching mechanisms.

What is claimed is:

1. An opto-electronic locking arrangement for a closure having a locking bolt comprising an optically encoded key, an identically optically encoded element in said closure and hidden from view, at least one light source for irradiating said key and said element whereby a matrix code is formed having predetermined light levels, a separate light sensor for said key and said element whereby said light levels obtained therefrom are converted to electrical signals, a linearly movable separator positioned between said key and said element whereby when said key is inserted in said closure and moved past one light sensor said separator is engaged and moved which in turn moves said element in a linear direction past the other light sensor, a comparator device for comaring the output of the electric signals from said key to the output of said electric signals from said element, a locking solenoid for said locking bolt, an electronic circuit connecting said comparator device with said locking solenoid including an AND gate whereby when the electric signals derived from said key and said element at said AND gate are identical said locking solenoid is activated to unlock said locking bolt.

2. An opto-electronic locking arrangement as claimed in claim 1 wherein each of said light sensors is provided with a column of light detectors corresponding in numbers to the number of rows in said matrix code on both said key and said element.

3. An opto-electronic locking arrangement as claimed in claim 1 further comprising a flip flop device in said electronic circuit which receives the output of said comparator device, a micro switch for setting said flip flop device at a logical true, and the output of said flip flop device being fed into said AND gate.

4. An opto-electronic locking arrangement for a closure as claimed in claim 1 wherein the movement of said light sensors co-acts simultaneously.

5. An opto-electronic locking arrangement for a closure as claimed in claim 1 wherein said light sensors detect said matrix code in sequential columns.

6. An opto-electronic locking arrangement for a closure as claimed in Claim 1 wherein the logical expression of the output of the AND Circuit is

$$(a_t \cdot b_t \cdot c_t \cdot d_t)\ (\bar{a}_f \cdot \bar{b}_f \cdot \bar{c}_f \cdot \bar{d}_f) = A$$

where a_t, b_t, c_t, d_t are derived from logical true areas of the key and a_f, b_f, c_f, d_f are derived from logical false areas of the key

7. An opto-electronic locking arrangement for a closure as claimed in claim 1 wherein said optically encoded key is provided with an optical filter coating to prevent visual readout of the code.

8. An opto-electronic locking arrangement for a closure as claimed in claim 1 further provided with means for activating said light source only when said key is inserted in said locking arrangement.

9. An opto-electronic locking arrangement for a closure as claimed in claim 3 further provided with a first means which clears the flip flop device if the light source is not operative, and a second means which clears the flip flop device if certain electrical noise is picked up by the locking arrangement.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,797,936 Dated March 19, 1974

Inventor(s) Andre C. Dimitriadis

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

Column 2, line 32 "HOwever" should be --However--.
Column 2, line 63 "ie" should be --is--.
Claim 1, line 15, "comaring" should be --comparing--.

Signed and sealed this 9th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

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* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.