

[54] SAFETY LOCK WITH PROVISION FOR
KEY USER IDENTIFICATION

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[51] Int. Cl. H04g 3/00

[58] Field of Search 340/164 R, 149 A, 149 R

[56] References Cited

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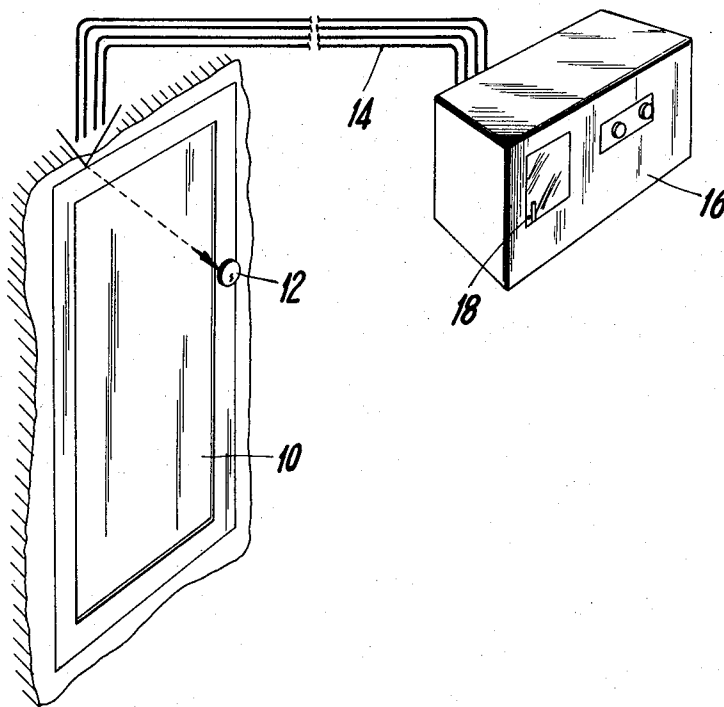
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[57] ABSTRACT

A lock includes a device capable of producing distinctly different electrical signals in response to the key employed to operate the lock. The keys capable of operating the lock are substantially identical in all details except for the depth of one signature notch. The output signal produced by the device is in turn proportional to the depth of the signature notch of the operating key. In the embodiment shown, the signal producing device includes a magnetic member movable within the lock by an extent corresponding to the depth of the signature notch, and a fixed transducing element capable of producing an output signal proportional to the relative position of the movable magnetic member. Also disclosed is a system employing the lock to prevent access of certain individuals into the protected premises only at certain times of the day.

14 Claims, 6 Drawing Figures



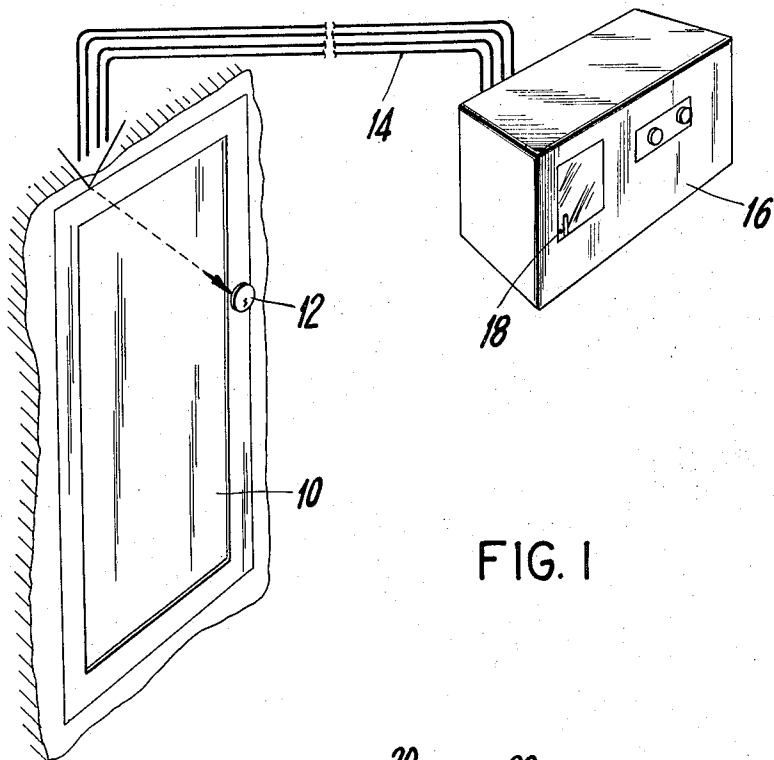


FIG. 1

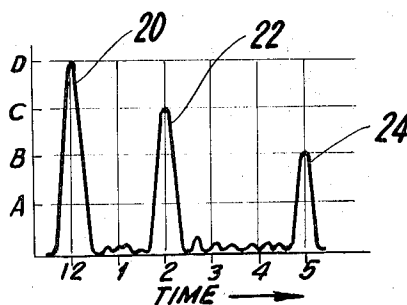


FIG. 2

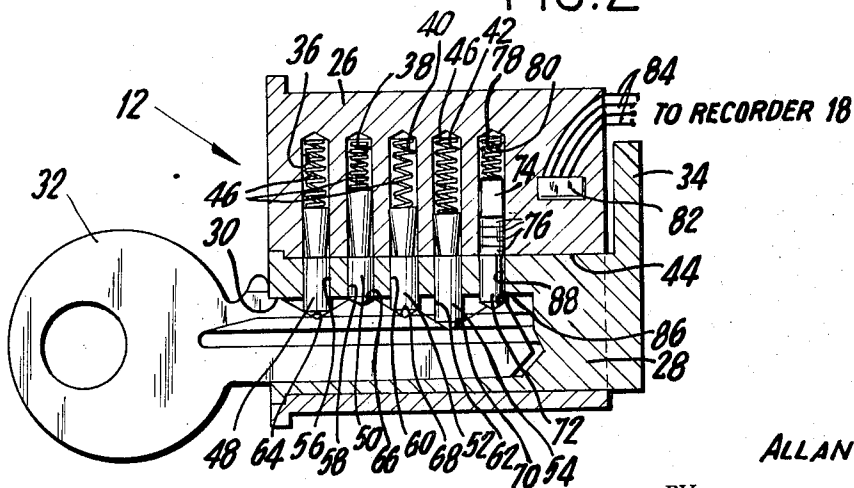


FIG. 3

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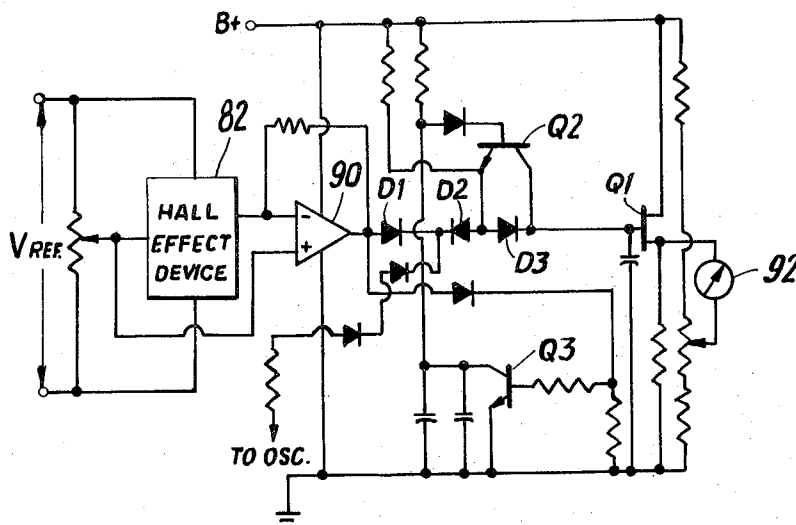


FIG. 4

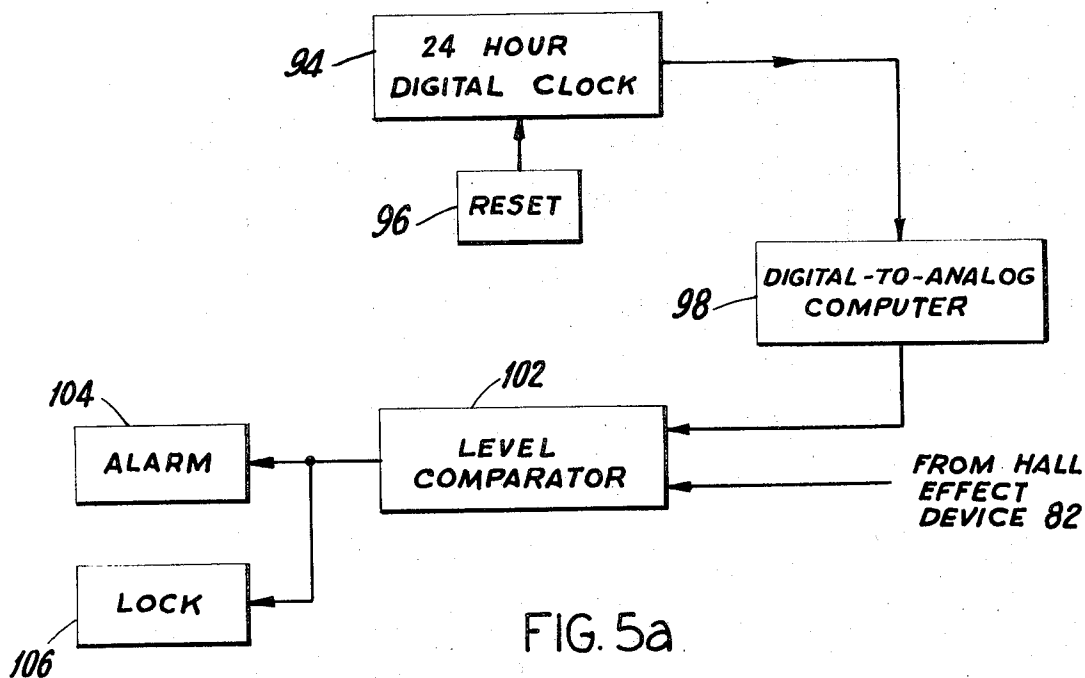


FIG. 5a

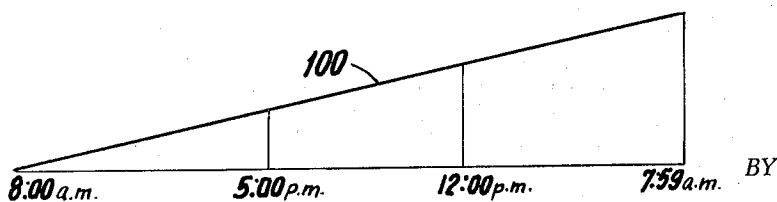


FIG. 5b

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SAFETY LOCK WITH PROVISION FOR KEY USER IDENTIFICATION

The present invention relates generally to security systems and devices, and more particularly to a security system including a lock which is responsive to the key utilized to operate the lock.

In an era in which security problems are causes of great concern in both industrial and residential facilities, many devices and systems have been developed for use in detecting and preventing unwanted intrusions into a protected facility. In one such system, to which the present invention is an improvement, each operation of a lock by the insertion of a key to open a door and thereby gain entrance into the protected facility, is monitored at a remote indicator. The monitoring is achieved on a strip recorder or the like, in which a graphical indication is provided of the opening of the door by the operation of the lock as a function of the time of the day at which access was made. The record produced in this manner is of use in monitoring the activities of those entering the facility and is thus of limited utility in improving the security of the protected facility.

In many facilities, such as stores, factories and offices, keys capable of opening the door to gain entrance are held by several individuals such as officers and certain employees, each of whom may have occasion to enter the locked facility during their normal course of business.

In the conventional security recorder, the entrance of any individual by the operation of the lock and the time at which such entrance was made are recorded. It is, however, often desirable under certain circumstances to be able to unambiguously identify the individual who opened the door by the operation of the lock at a particular time of the day or night. Thus, when money, merchandise or the like has been stolen from the premises, and the time at which the theft occurred can be determined or accurately approximated, the identity of the last individual to gain entry into the facility prior to the time of the theft would be of considerable value to security officers in making an identification of the thief.

In some facilities it is also sometimes required to restrict access of certain lower-level employees during certain hours of the day. That is, while it may be proper for a certain employee to gain access during a predetermined eight-hour shift, the access of that same employee during another eight-hour period would be unwarranted, and would ordinarily indicate an intention on the part of the employee to perform an improper act.

While the desirability of providing employee access identification as an aid in the protection of property is clear, there has heretofore been no commercially suitable and acceptable device of this type which is reliable and accurate, and yet sufficiently economical to permit its installation and use even by owners of relatively small facilities.

It is an object of the invention to provide a reliable, accurate, and yet low-cost access identification and monitoring system.

It is a further object of the invention to provide an access-indication and monitoring system which can be readily installed into an existing lock system with a minimum modification to that system.

It is another object of the invention to provide an access-indication and monitoring system of the type described, which can be utilized to advantage with a plurality of employees or other similar individuals, without the knowledge of the employees.

It is still a further object of the invention to provide an access-indication and monitoring system of the type described, in which the identification of an entrant is derived from a minor and not readily discernible modification in the key utilized by each possible entrant.

It is yet another object of the invention to provide an access-identification and monitoring system of the type described, in which the entrance of specified key-holders is effectively prevented during predetermined times of the day.

Broadly considered, the access identification system of the invention provides an indication of the time of entrance of an individual into a protected facility, and in addition, unambiguously provides an identification of the individual gaining access by the operation of the lock. In this manner, in the event that an unwarranted act such as the commission of a theft from the facility occurs at a time that can be determined or accurately estimated, the individual who last entered the facility prior to that time can be identified and associated with the commission of the act.

As herein described, the invention includes an otherwise conventional cylinder lock in which an existing bore is modified by the insertion therein of a member that is free to move axially or vertically within the bore with respect to a fixed transducer element positioned adjacent the bore.

Each individual who has permission to gain access into the protected facility by the operation of the lock is provided with a key which is conventionally notched so that when the key is inserted into the lock, the lock cylinder is free to rotate within the lock barrel, to thereby permit the opening of the door as is conventional. The depth of one of the notches in the key (hereinafter called the signature notch) is, however, preset at one of a plurality of specified levels to still permit lock operation, while simultaneously establishing a characteristic axial position of the movable element within the bore when the lock is operated by the particular key. The transducer in response to the thus established axial position of the movable member, produces a signature signal, and thus uniquely identifies the key and the key-operator used to operate the lock.

In the embodiment of the invention herein specifically described, the transducer element is in the form of a semiconductor Hall-effect device capable of producing a voltage output in response to the intensity of a magnetic field intersecting the device. The movable element is made of a magnetic material and its position with respect to the Hall-effect device, as determined by the signature notch depth of the inserted key, establishes the magnetic field that is sensed by the Hall-effect device, which in turn produces a proportional output signal. The output signal produced by the Hall-effect device in this manner accurately reflects the identity of the key used to operate the lock.

That signal produced by the Hall-effect device may, as herein shown, be employed to drive a strip chart recorder so that each time that access is made into the protected premises by the operation of the lock, the recorder stylus produces a visual indication of the access on the moving strip chart at the time at which the ac-

cess is made. Significantly, and unique to this invention, that indication can also be readily associated with the key operator since each visual indication produced by the recorder in response to the signature signal is of a noticeably different magnitude, each magnitude in turn thus identifying one of the key-holders.

In another embodiment of the invention as herein described, the output signature signal produced in response to the operation of the lock is compared to a signal representing the time of day. When access is made to the premises at a time of day for which the particular key-operator has no access authorization, such as the hours between the normal closing and opening times of the premises, the comparison of the signals causes an alarm to be sounded and, if desired, a supplemental safety lock may be operated to prevent the unauthorized access to the premises.

To the accomplishment of the above and to such further objects as may hereinafter appear, the present invention relates to an access monitoring system, substantially as defined in the appended claims and as described in the following specification taken together with the accompanying drawings in which:

FIG. 1 is a perspective view, somewhat schematic in nature, of a typical installation of the access-indication and monitoring system of the invention;

FIG. 2 is a typical recording produced by the use of the system of FIG. 1, showing the gaining of access into a protected facility by three different individuals during a five-hour period;

FIG. 3 is a vertical cross-sectional view of a cylinder lock modified according to one embodiment of the invention and showing a modified key inserted therein;

FIG. 4 is a schematic diagram of an amplifying and indicating circuit that may be used in the system of the invention shown in FIG. 1;

FIG. 5a is a schematic block diagram of an alternate embodiment of the invention; and

FIG. 5b is a graphical representation of the analog time signal employed in the system of FIG. 5a.

The access monitoring system of the invention provides means for uniquely identifying the operator of a lock to gain access into a protected premises by responding to a slight and practically imperceptible variation in the key used to operate the lock. In a typical installation of the system of the invention shown in FIG. 1, access to the protected premises can be gained only by the opening of a door 10 which is locked by means of a lock 12.

Lock 12 is modified, as described more completely below with reference to FIG. 3, such that when the lock is opened by the insertion of a key, an electrical signal is produced having a specified parameter, e.g., voltage. That signal is coupled over conductors 14 to a remote indicator panel 16. Panel 16, as herein shown, includes a time strip recorder 18 which, as shown more clearly in FIG. 2, provides a running indication as a function of time of the occurrence of access into the premises whenever door 10 is opened by the operation of lock 12.

In accordance with a significant aspect of the invention, the identification of the entrant, that is, the key operator, as well as the time that entrance was effected by the operation of the lock, is provided by recorder 18. As shown in FIG. 2, three incidents of access are recorded by means of spikes 20, 22 and 24 respectively occurring at 12:00, 2:00, and 5:00 p.m. As shown, the

amplitude of the spikes 20-24 are at respectively different levels corresponding to the different individuals who entered the premises at those times by the operation of lock 12, for reasons that are more completely set forth below.

FIG. 3 illustrates a cylinder lock, corresponding to lock 12 of FIG. 1, which has been modified in accordance with the present invention to provide the signature signals that produce the desired recording of FIG. 2 as described above.

As is conventional, lock 12 includes a body or a barrel 26 which is fixedly secured to the door in any known manner. Rotatably mounted within barrel 26 is a cylinder 28 which at one end is coextensive or flush with the end surface of barrel 26 and has an opening 30 for receiving a key 32. The opposite end of cylinder 28 carries a locking bolt 34 which, when the door is locked, is received within a suitable recess provided in the door jamb.

A series of radially extending bores 36-42 are formed within barrel 26 and terminate at their lower end at a shear line 44 defined at the interface between the outer surface of cylinder 28 and the inner surface of the barrel. Disposed within each of bores 36-42 are springs 46 which normally, that is when the lock is in the locked condition, urge a plurality of non-magnetic, e.g., brass, pin tumblers 48-54 of differing lengths and each comprising upper and lower unconnected segments, into radial holes 56-62 formed in cylinder 28 and in respective registration with bores 36-42 formed in the lock cylinder.

Key 32 as is also conventional, includes a shank in which a series of notches 64-70 spaced by intervals equal to the spacing between the cylinder bores are formed at different depths. When the proper key is inserted into the lock cylinder, the lower segments of the pin tumblers are each raised to a level at which their upper surfaces are precisely flush at the shear line at the upper surface of the lock cylinder, to permit the cylinder and thus the bolt to turn when the key is rotated. Of course, if the incorrect key were inserted, at least one of the lower tumbler segments would not be raised to the correct level within the bores so as to prevent rotation of the cylinder within the barrel.

What has thus far been described with respect to the cylinder lock of FIG. 3 is conventional. In accord with the present invention, the two-segment pin tumbler provided in the inboard bores 36-42 is replaced in the outboard bore 80 by a lower non-magnetic segment 72, an upper magnetic segment 74, and a series of substantially identical non-magnetic spacers 76, here shown as four in number, arranged within a registering bore 80 and a cylinder opening 88. A spring 78 positioned in the upper section of bore 80 urges against the upper surface of magnetic segment 74 to normally position the segments 72 and 74 and intermediate spacers 76 in a normal or fixed position.

A transducer here shown as a Hall-effect device 82 is inserted into a recess formed in barrel 26 at a position adjacent bore 80 and magnetic segment 74. A plurality of conductors 84 (corresponding to conductors 14 in FIG. 1) are coupled to and extend from device 82 through a suitable opening formed in the body of the lock. Key 32 is also provided at its outer end with a signature notch 86 which when the key is fully inserted into cylinder 28 to operate the lock, receives the lower, tapered end of segment 72. The depth of notches

64-70 for each of the keys assigned to all employees or other individuals to operate lock 12 are substantially the same, but the depth of the signature notch 86 is different for each employee by amounts that are substantially equal to integral multiples of the heights of spacers 76 for reasons to be described below.

In the operation of the lock of FIG. 3, for each of the keys inserted into cylinder 28 to operate the lock, magnetic segment 74 is raised by the key to a unique relative position with respect to the Hall-effect device in response to the depth of the signature notch in the key. The relative positions of the magnetic segment 74 with respect to Hall-effect device 82 resulting from the use of differently notched keys in the lock, in turn, causes device 82 to produce a different output voltage for each key. As described above, these output signals identify in an unambiguous manner the operator of each of the keys.

The provision of spacers 76 interposed between segments 72 and 74 permits the operation of the lock, that is, the rotation of the cylinder within the barrel, for any of the proper keys that differ only in the depth of their signature notch 86. The upper surface of segment 72 is positioned flush with the shear line 44 when the key having the shallowest signature notch is inserted. For keys having increasingly deeper signature notches, one or more of spacers 76 are received within the cylinder opening 88. Since, as noted above, the height of each spacer 76 equals the incremental difference in notch depths for the different keys, the upper surface of the uppermost spacer 76 within the cylinder opening 88 will be flush with the shear line, thus permitting the rotation of the lock cylinder for each of the keys. All spacers 76 raised above the uppermost spacer in cylinder opening 88 by the insertion of a key are positioned in the lower end of bore 80 and serve to support magnetic segment 74 at its signature level with respect to Hall-effect device 82 with the results described above.

In one embodiment of the invention, the height of each spacer 76 and the corresponding incremental difference in the depth of the signature notch in the keys was 0.020 inch, which was found suitable for use with four different keys. This incremental difference in the depth of the signature notch was found to be capable of producing noticeably different output signals from Hall-effect device 82, but were indiscernible to the casual observer, and would probably not be noticed by the employee whose access is being monitored in the manner described above.

FIG. 4 illustrates a typical amplifier and control circuit that may be employed to convert the output signal of Hall-effect device 82 into the visual indication shown in FIG. 2. Since the circuit is largely conventional, it is only briefly described herein. The output of device 82 is applied to one input of a differential amplifier 90 the other input of which receives a reference voltage. The output amplifier 90 is coupled through a series of oppositely poled diodes D1, D2, and D3 to the gate of an FET Q1, which in turn is normally maintained in the non-conducting state by the operation of switching transistors Q2 and Q3. The printer indicator indicated at 92 is coupled to the output of FET Q1. In operation, when the lock is operated by one of the proper keys, Hall-effect device 82 produces a signature output signal which is amplified in amplifier 90 and applied to the gate of FET Q1 to cause the latter to be conductive. The resulting output of FET Q1, which is

proportional to the Hall-effect device output signal, drives recorder 92 to provide the recording shown in FIG. 2.

While the embodiment of the invention shown in FIGS. 1-4 is highly suitable for providing information concerning the identity of the person gaining access to the protected premises by the operation of the lock, it alone is, however, unable to prevent unwarranted access of selected individual key-holders only at certain times of the day. That is, for many facilities, certain employees may be permitted entrance to the premises only at certain times of the day; at all other times such access is unwarranted.

A system for preventing or at least hindering unwarranted entrance of this type is shown in FIG. 5 in which the signature signals may be derived in a manner similar to that described above with reference to FIG. 3. The system of FIG. 5, which may be used in conjunction with the time recorder system of FIG. 1, or independently if desired, includes a 24-hour digital clock 94 which generates periodic digital signals representing the time of day. Counter 94 is reset every 24 hours by a synchronous reset 96 at a predetermined time of the day, such as 8:00 A.M., to a zero count. The output of clock 94 is applied to an analog-to-digital converter 98 which converts the input binary signal to a corresponding analog signal 100, shown in FIG. 5b, which is at zero at the preset time of 8:00 A.M., and rises substantially linearly to its maximum level at 7:59 the next morning.

The keys provided to each employee differing only in the depth of their respective signature notches, reflect the hours of the day that each particular employee is allowed access into the premises. Thus, the lower-level employee may be allowed entry only during normal business hours of 8:00-5:00 P.M., while other employees may be allowed entrance only between the hours of 5:00 P.M., to midnight. For such employees, the depth of the signature notch is selected so that the output of the Hall-effect device developed in response to the notch level, as described above, has a predetermined correspondence to the 24-hour analog signal 100.

The 24-hour analog signal 100 is applied to one input of a level comparator 102 which receives at its other input the amplifier output generated by the Hall-effect device 82 arranged in the lock. When the device signal equals or exceeds the analog time signal indicating that the employee is entering the premises at an unwarranted hour, comparator 102 produces at its output an alarm signal that is applied to an alarm 104 to cause the latter to sound, thereby frightening the intruder away or calling the intrusion to the attention of nearby security officials.

If desired, and as herein shown, the alarm signal may also be applied to an electrically controlled lock 106 which maintains the entrance to the protected premises locked even though the key-operated lock is opened by the intruder. Thus, for example, if an employee who is only authorized to enter the premises between the hours of 8:00 A.M., and 5:00 P.M., attempts to gain access to the premises at 11:00 P.M., the Hall-effect device produces an output which is less than the analog reference signal at that time (but greater than the analog signal at 5:00 P.M.) to cause the operation of the alarm as described above. On weekends and holidays the digital clock 94 and converter 98 may be set to produce a steady signal at all times of the day, so as to produce an alarm signal when an attempt is made at any

time of the day by an employee not having authorization to enter the premises during those days.

The access indication and monitoring system of the invention thus has the capability of clearly providing information of the identity of an individual gaining access into a normally locked premises without the knowledge by the entrant that his access is being monitored. As a result of this ability to identify entrants to the premises at any time of day, increased security of the premises is achieved.

The modification required to be performed on an otherwise conventional lock to incorporate therein the movable member and transducer of the invention, is a relatively simple operation which can be performed at a low cost and in a relatively short period of time. The modification of the otherwise conventional keys assigned to the various individuals to form the signature notches at the desired different depths is also a relatively simple and inexpensive procedure.

While the invention has been herein specifically described with respect to the use of a Hall-effect device and a magnetic member that is axially movable along the lock barrel bore, other elements may be employed such as a movable inductive slug operating in combination with a fixed coil or winding to vary the inductance value of a tuned circuit and thereby vary the frequency of the transducer output signal rather than the voltage level as herein previously described. In addition, the movable member may comprise one plate of a capacitor, the other plate of which is fixedly positioned within the lock barrel adjacent the movable plate. Other arrangements to produce a signal having a parameter responsive to the signature notch level may also be employed in the system of the invention, although the disclosed Hall-effect device is presently preferred as a result of its compactness and reliability.

Furthermore, security arrangements employing the basic principles of the invention other than those specifically described herein may also be employed, such as the use of two signature notches on each key, or the use by each employee of two keys each having a different signature notch depth, with suitable level detection and logic circuitry being provided to ensure that only authorized personnel are allowed access into the protected premises.

Thus, while only several embodiments of the invention have been herein specifically described, it will be apparent that many modifications may be made therein, all without departing from the spirit and scope of the invention.

I claim:

1. Security apparatus comprising:

a lock;

a plurality of keys;

electrical identification signal generating means including a tumbler-like element movable by different ones of said keys to at least two positions in addition to an initial position normally occupied by said element before a key is inserted into said lock; one of said keys being formed with a pre-set key characteristic operable to move said element to a first of said at least two positions in response to normal operation of said key within said lock; another of said keys being formed with a pre-set key characteristic operable to move said element to another of said at least two positions in response to normal operation of said other key within said lock;

each of said keys being formed to both operate said lock and to move said element to one of said at least two positions in response to the normal operation of said key within said lock; and

said signal generating means being operable to generate a first analog signal when said element is moved to said first position and operable to generate a second, different analog signal when said element is moved to said other position.

2. The apparatus of claim 1, in which said analog signal comprises electrical voltage.

3. The apparatus of claim 2, in which said signal generating means further comprises a fixed element, said movable element being movable with respect to said fixed element in response to each said preset key characteristic.

4. The apparatus of claim 2, in which said movable member is magnetic, and said fixed member includes means responsive to the magnetic field intensity produced thereat by said movable magnetic member for generating said identification signal.

5. The apparatus of claim 4, in which said key includes a shank having a plurality of axially spaced notches formed therein, said preset key characteristic being defined by the depth of a selected one of said notches.

6. The apparatus of claim 5, in which said locking means includes a barrel, a cylinder mounted for rotation in said barrel and including an axial recess for receiving the key, said barrel and cylinder including a plurality of radially arranged bores and openings in respective registration with one another, one of said openings being adapted for registration with said one of said notches, said movable magnetic member being received in the one of said bores in registration with said one of said openings.

7. The apparatus of claim 6, further comprising a non-magnetic member received in said one of said openings, and a plurality of non-magnetic spacing elements received in said one of said bores and said one of said openings and interposed between said non-magnetic member and said movable magnetic member.

8. The apparatus of claim 7, wherein the depth of one of said notches in each of said keys (differing) differs from key to key by predetermined substantially equal incremental amounts, said spacing elements each having a substantially equal dimension that is equal to said incremental amount to insure normal operation of said locking means by any of said keys.

9. The apparatus of claim 8, in which said fixed element is a Hall-effect device.

10. The apparatus of claim 8, further comprising resilient means disposed in said one of said bores for biasing said movable element in a rest position with respect to said fixed element prior to the insertion of the key into said locking means.

11. The apparatus of claim 2, in which each said key includes a shank having a plurality of axially spaced notches formed therein, said preset key characteristic being defined by the depth of a selected one of said notches.

12. The apparatus of claim 11, wherein the depths of said one of said notches differs from key to key by substantially equal increments, said locking means further comprising a plurality of spacer means operatively communicating with said one of said notches when any of said keys is inserted into said locking means, to

thereby permit the operation of said locking means by any of the keys.

13. In combination with the apparatus of claim 1, means producing a timing signal representative of the time of day, and means coupled to said identification signal producing means and said timing signal producing means for comparing said timing signal and said identification signal and for producing an alarm signal whenever the latter bears a predetermined relation to

the former.

14. The combination of claim 13, in which said timing signal producing means comprises a source of digital signals indicating in binary form the time of day, means for resetting said digital signal source at a preset time of the day, and means coupled to said digital signal source for correcting said binary signal into a corresponding analog time signal.

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