

[54] **PUSHBUTTON COMBINATION LOCK**

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[51] Int. Cl. **E05b 13/00, E05b 37/16**

[58] Field of Search **70/220, 313; 200/45**

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[57]

ABSTRACT

In a pushbutton combination lock the deflection of a "zero-energy" control element at a prescribed time permits the outer door knob assembly to engage the inner knob assembly thereby to unlatch the door. A logic ladder, activator and a ratcheting arrangement are provided in conjunction with a dual scaffold assembly: (1) an opening scaffold to effect deflection of the control element when particular buttons in a set of pushbuttons are depressed and released in a "walking" manner and in a predetermined sequence or opening combination, but which disables the activator to prevent deflection of the control element at the prescribed time when any deviation from the strict sequence of the opening combination occurs, and (2) a reactivating scaffold to re-enable the activator and thus reactivate the lock when other pushbuttons are depressed and released in another predetermined sequence or reactivating combination.

12 Claims, 28 Drawing Figures

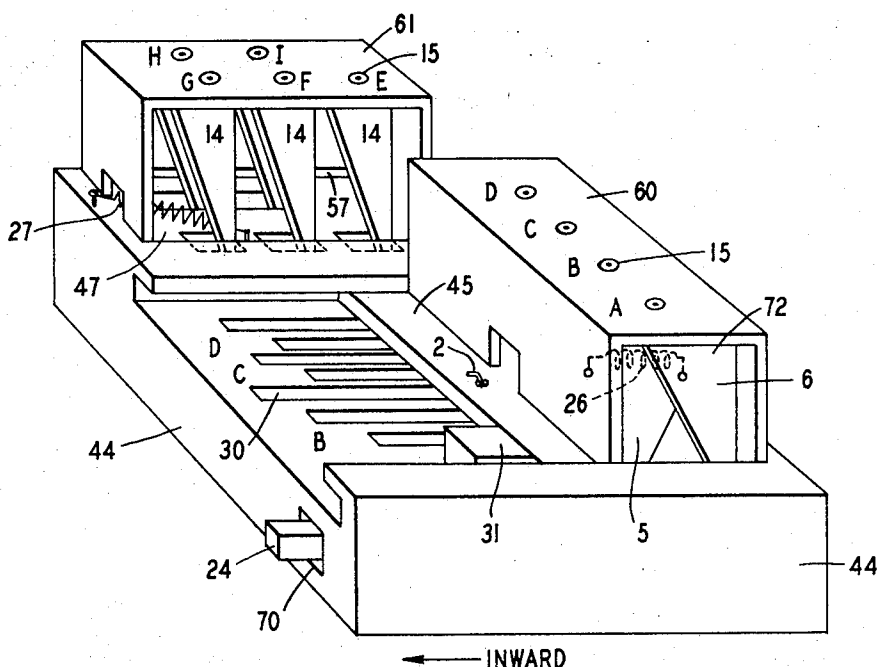


FIG. 1

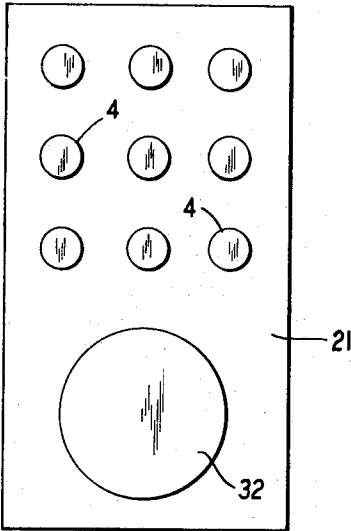


FIG. 3

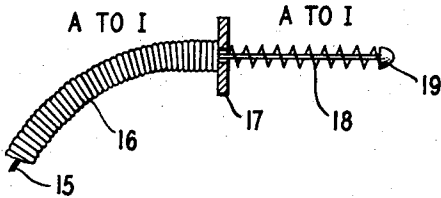


FIG. 4

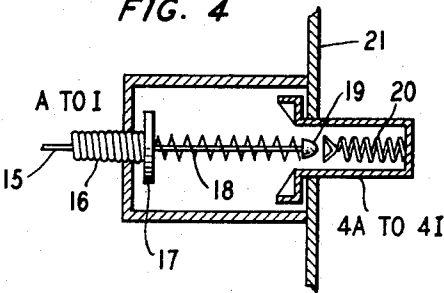
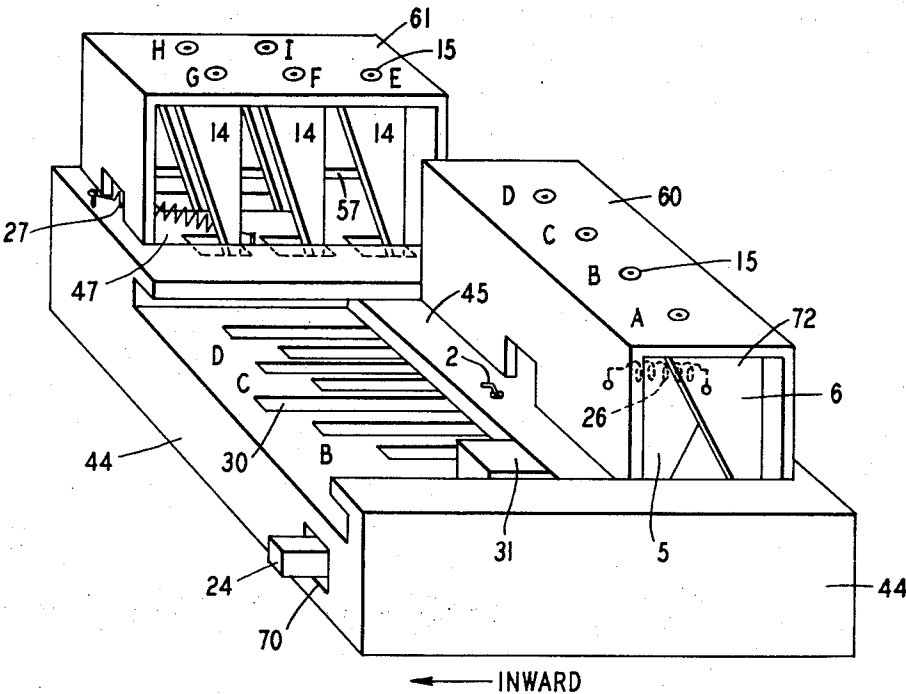


FIG. 2



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FIG. 5

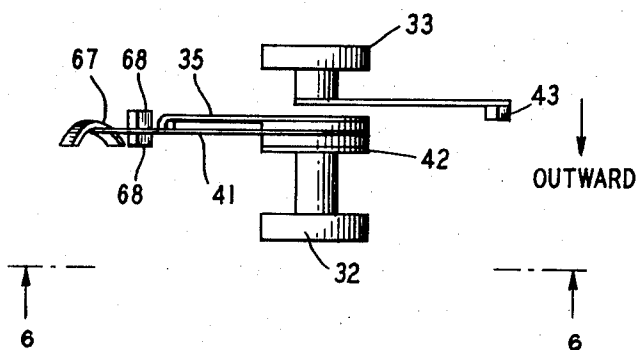


FIG. 7

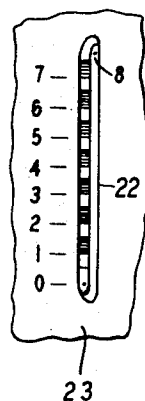


FIG. 8

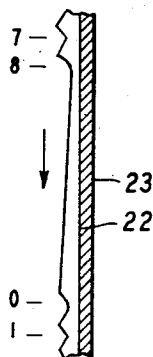


FIG. 6

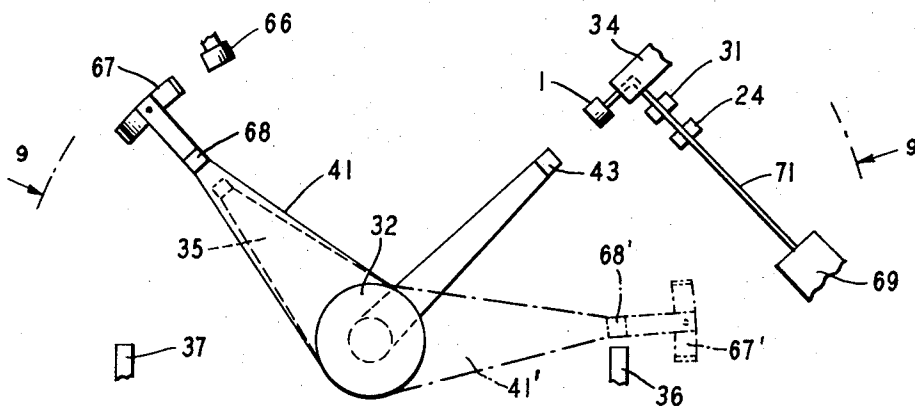
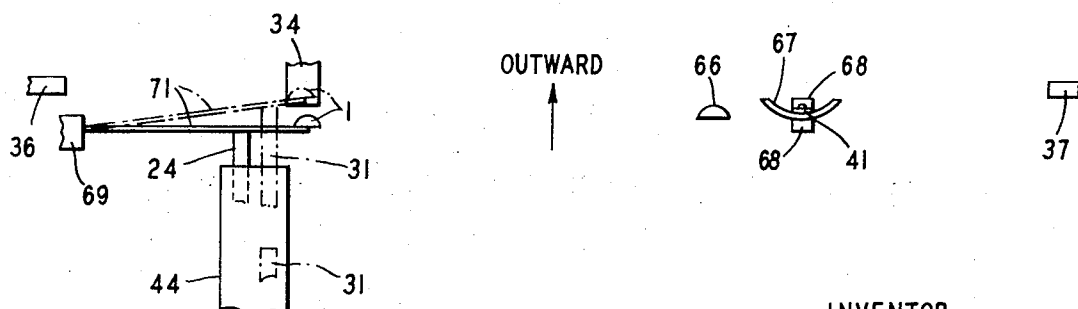


FIG. 9



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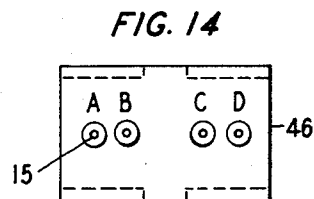
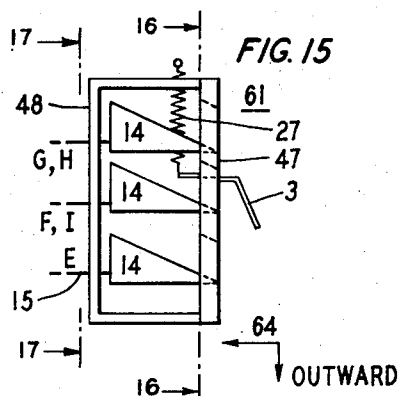
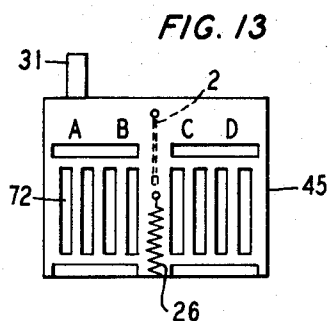
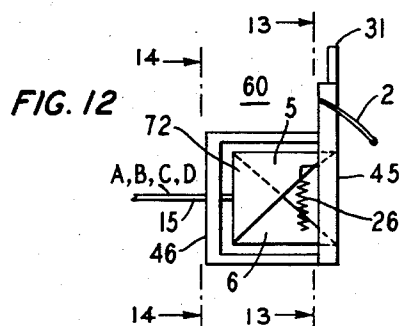
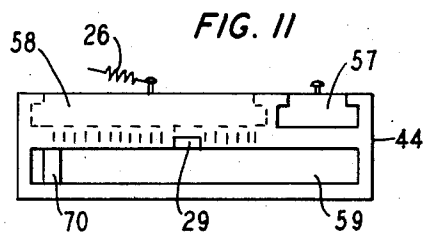
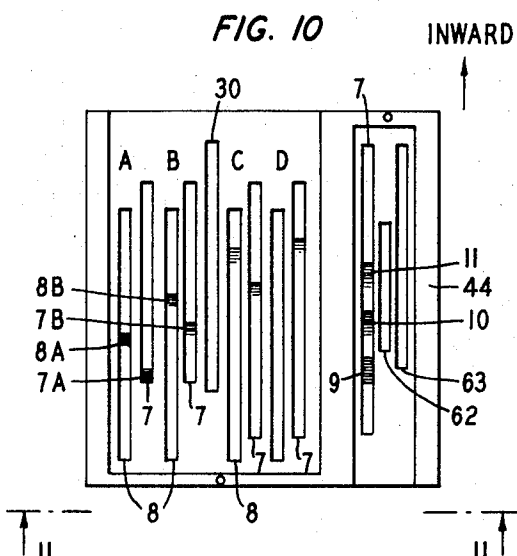


FIG. 16

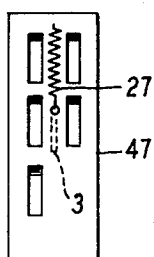


FIG. 17

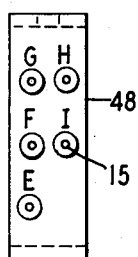


FIG. 18

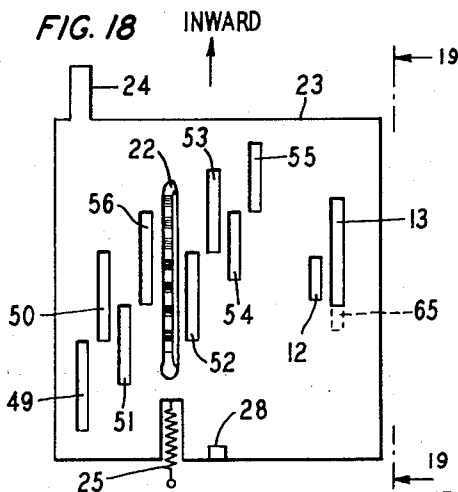
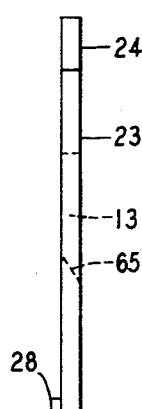


FIG. 19



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FIG. 20D

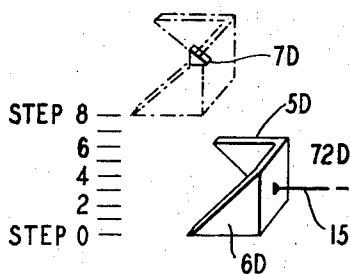


FIG. 20C

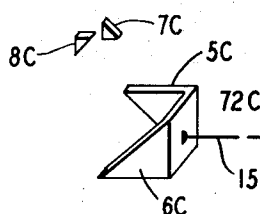


FIG. 20B

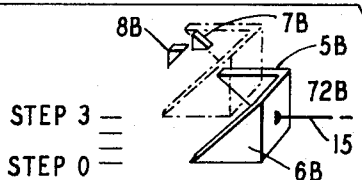


FIG. 20A

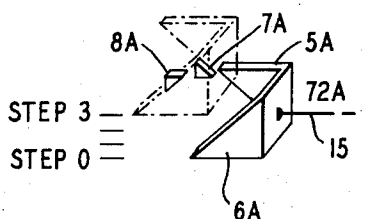
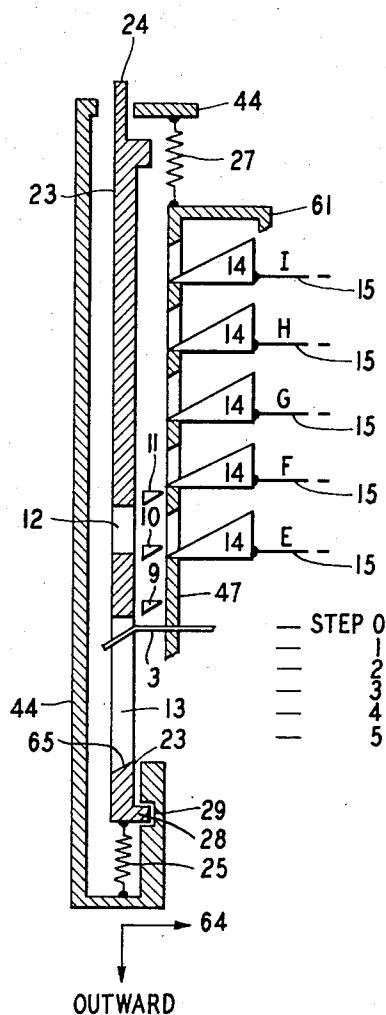


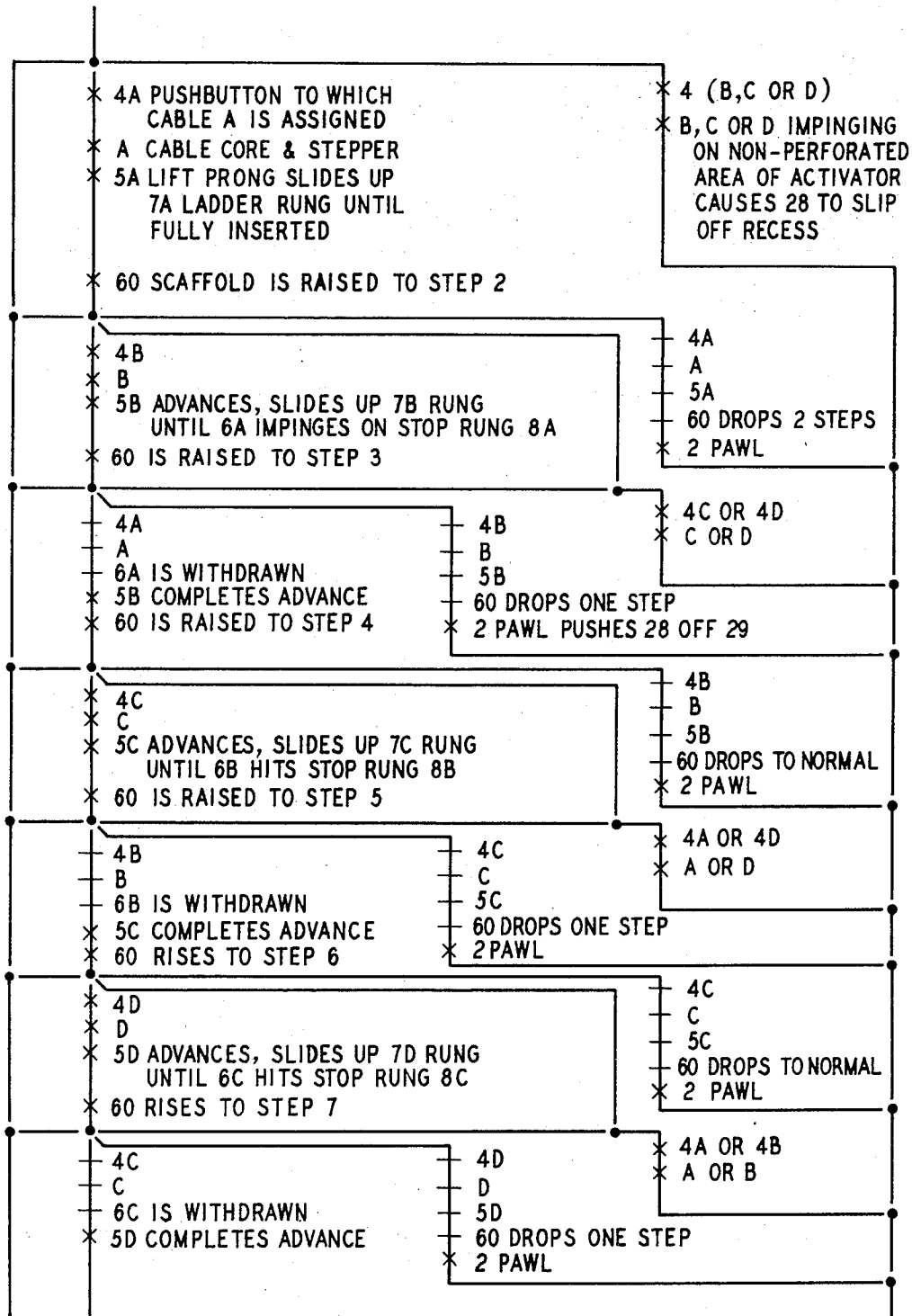
FIG. 21



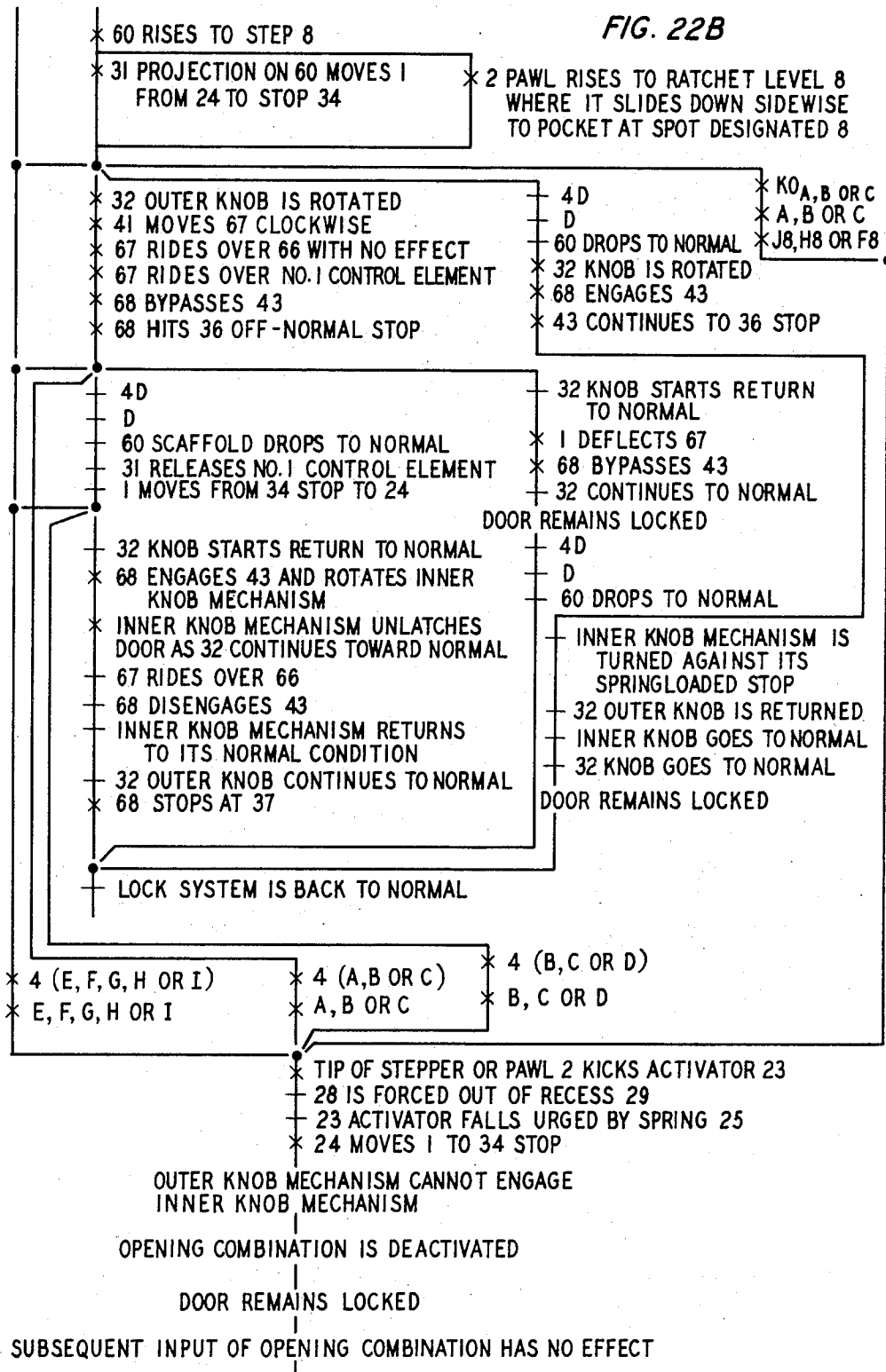
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FIG. 22A

LOCK IS NORMAL ACTIVATED



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FIG. 22C

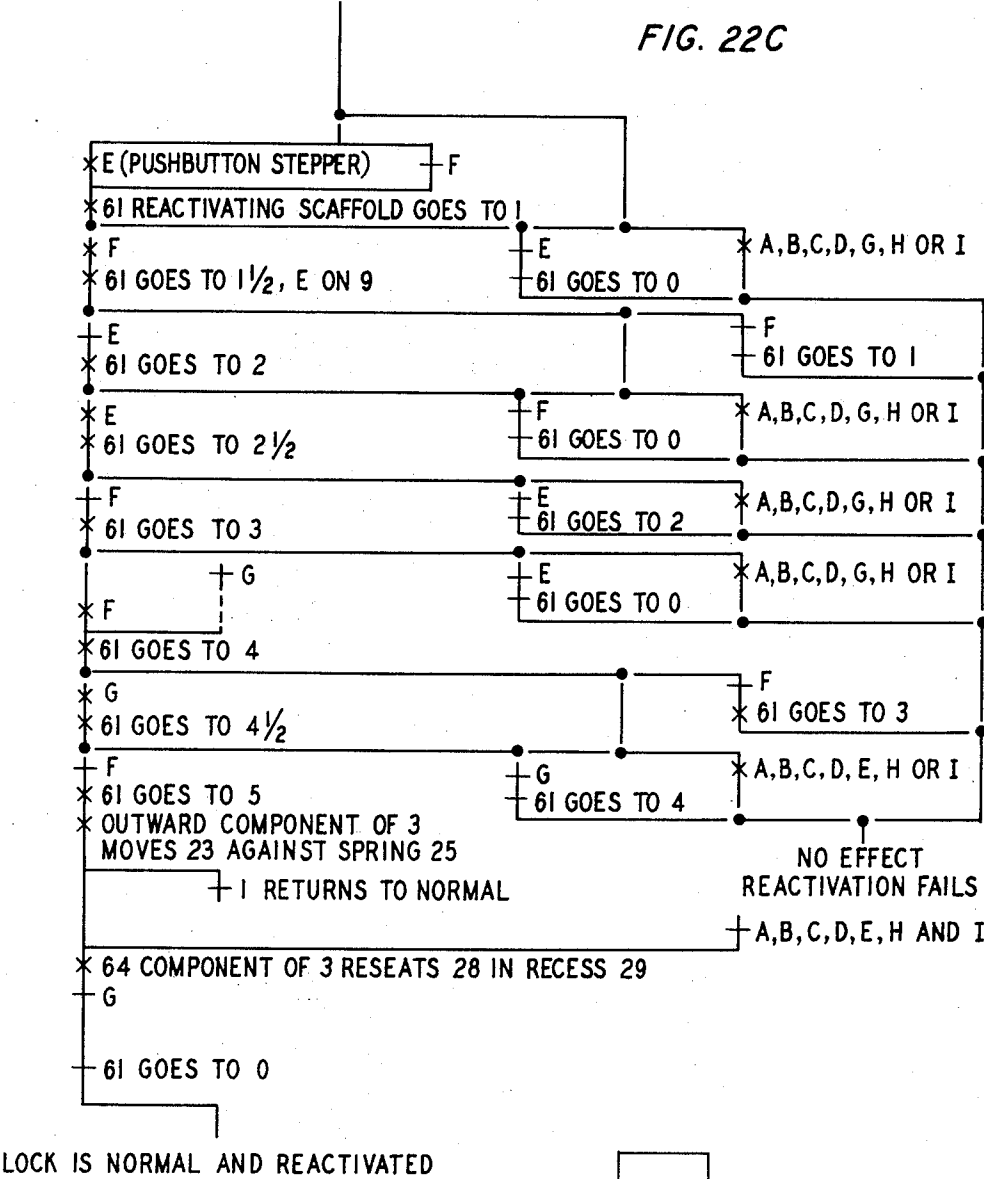


FIG. 22D

FIG. 22A
FIG. 22B
FIG. 22C

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PUSHBUTTON COMBINATION LOCK**BACKGROUND OF THE INVENTION**

This invention relates to mechanical locks and, more particularly, to pushbutton combination locks.

The most widespread type of lock in use today is without doubt the key-operated lock due to its simplicity and attendant low cost even though such locks generally provide inadequate security against unauthorized entry, e.g., entry by means of a lost or stolen key or by those with the dubious distinction of being highly skilled in the art of picking locks.

While combination locks for obvious reasons provide more security than key operated locks, even combination locks (e.g., the rotary type) utilize sufficient energy, usually mechanical, that they inherently provide a "feel" which assists would-be lock picks. To increase the security of such locks often requires prohibitive costs. Moreover, it is difficult, if not impossible, to alter the combination of a conventional lock which often renders the lock useless if the combination is known by unauthorized personnel.

It is, therefore, one object of my invention to provide a combination lock with improved security.

It is another object of my invention to provide such a lock which utilizes a relatively simple opening combination.

It is another object of my invention to provide a combination lock having an opening combination and a reactivating combination either of which can be readily changed to a different combination without the use of tools.

It is still another object of my invention to provide a memory of an unsuccessful attempt at "breaking" the combination.

It is yet another object of my invention to provide for deactivation of my pushbutton combination lock when any deviation from the opening combination or proper manipulation of the pushbuttons occurs.

It is one more object of my invention to provide a pushbutton combination lock which can be readily used in the dark or by the blind.

It is a further object of my invention to require a more complicated combination than the opening combination to reactive my pushbutton combination lock after it has been deactivated.

SUMMARY OF THE INVENTION

These and other objects are accomplished in accordance with an illustrative embodiment of my invention, a pushbutton combination lock in which the deflection of a "zero-energy" control element at a prescribed time permits the outer door knob assembly to engage the inner knob assembly thereby to unlatch the door. A logic ladder, activator and a ratcheting arrangement are provided in conjunction with a dual scaffold assembly: (1) an opening scaffold to effect deflection of the control element when the pushbuttons are depressed and released in a predetermined opening sequence and in a "walking" manner, but which disables the activator to prevent deflection of the control element at the prescribed time when any other sequence is followed or when "non-walking" manipulation of the buttons is employed, and (2) a reactivating scaffold to enable the activator and reactivate the lock when the pushbuttons are depressed in a reactivating

sequence and in a prescribed "walking-rocking" manner.

The scaffolds typically comprise a plurality of steppers each of which is cable-coupled to a separate pushbutton. Each stepper in the opening scaffold comprises a pair of connected wedge-shaped (e.g., right triangular) prongs, one having its hypotenuse upwardly directed and the other having its hypotenuse downwardly directed. In the reactivating scaffold, on the other hand, the steppers typically employ only single prongs.

The logic ladder comprises a planar member or plate having a plurality of elongated parallel apertures therein and a plurality of wedge-shaped rungs disposed in selected ones of the apertures. Depression of a pushbutton causes a double prong stepper of the opening scaffold to translate up a rung and into a pair of corresponding apertures.

The activator similarly comprises a plate having elongated pairs of apertures in registry with those of the ladder, and adapted to receive the double prong steppers. Certain other apertures are adapted to receive the single prong steppers of the reactivating scaffold. In addition, the activator includes a ratchet "coupled" to the opening scaffold by a pawl. For reasons to be subsequently discussed, the activator is releasably supported by a recess (or other appropriate means) within the ladder and is released to disable the lock when a deviation occurs from either the predetermined opening sequence or from the "walking" manner of depressing and releasing the pushbuttons. In either case, the activator is pushed from its supporting recess causing a projection thereon to prematurely deflect the control element, thereby deactivating the entire lock and preventing entry until the lock is reactivated and proper operative steps for opening the door are taken.

Briefly, therefore, the activator is disabled in the former case (improper pushbutton sequence) by the force of the dual pronged steppers of the opening scaffold which, when moved out of sequence, strike unperforated portions of the activator. In the latter case ("non-walking" depression), the premature release of a properly depressed pushbutton, causes the pawl, which urges against the ratchet located in the activator, to push the latter off its supporting recess. Once disabled, the activator is reset in its supporting recess by depressing the pushbuttons corresponding to the reactivating scaffold in another prescribed (reactivating) sequence and in a "walking-rocking" manner. Of course, to a would-be lock combination breaker, the pushbuttons for opening and reactivation are indistinguishable.

Thus, when the pushbuttons are properly operated, in the appropriate sequence and in a "walking" manner, the double pronged steppers of the opening scaffold sequentially protrude through the ladder and the activator, and under the upward force of the ladder rungs, cause the opening scaffold to rise until a projection thereon deflects the zero-energy control element at the appropriate time to permit unlatching of the door.

In summary, my invention includes one or more of the following features:

1. an exemplary low probability of $9^{-16} \cdot 10^{-2}$ of breaking both the opening and reactivating combinations;

2. virtually "zero-energy" control of the unlocking function;

3. a very small, light, compact mechanical logic system with virtually no detectable "feel";

4. memory of an unsuccessful attempt at "breaking" the lock combination;

5. enhanced security by requiring overlapping or "walking" operation of the opening pushbuttons;

6. a novel ratcheting arrangement which disables the lock when the pushbuttons are released in other than the prescribed opening sequence;

7. enhanced security by providing for a combination to open the lock which is different from that required to reactivate the lock after an improper attempt at opening;

8. enhanced security provided by a difference in the general pattern of pushbutton manipulation between the opening ("walking") and reactivating ("walking-rocking") combinations.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects of the invention, together with its various features and advantages, can be easily understood from the following more detailed discussion, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic outer view of a lock showing a door knob and illustratively nine pushbuttons;

FIG. 2 is an isometric view of the logic package showing the logic ladder and dual scaffolds in accordance with an illustrative embodiment of my invention;

FIG. 3 shows an illustrative control cable for interconnecting the pushbuttons and scaffolds;

FIG. 4 is a sectional view of an illustrative pushbutton;

FIG. 5 is a top view of the outer and inner knob assemblies;

FIG. 6 is an (inward) front view taken along line 6—6 in FIG. 5;

FIG. 7 shows the ratchet area of the activator of FIG. 18;

FIG. 8 shows a straightened out profile view of the ratchet of FIG. 7;

FIG. 9 is a top view of the knob assemblies taken along line 9—9 of FIG. 6;

FIG. 10 is a plan view of the logic ladder of FIG. 2 with the scaffolds removed;

FIG. 11 is an end view taken along line 11—11 of FIG. 10;

FIG. 12 is a side view of the opening scaffold 60 of FIG. 2;

FIG. 13 is a plan view of the base plate of the opening scaffold taken along line 13—13 of FIG. 12;

FIG. 14 is a top view of the opening scaffold taken along line 14—14 of FIG. 12;

FIG. 15 is a side view of the reactivating scaffold 61 of FIG. 2;

FIG. 16 is a plan view of the base plate of the reactivating scaffold taken along line 16—16 of FIG. 15;

FIG. 17 is a top view of the reactivating scaffold taken along line 17—17 of FIG. 15;

FIG. 18 is a plan view of the activator in accordance with an illustrative embodiment of my invention;

FIG. 19 is a side view taken along line 19—19 in FIG. 18;

FIGS. 20A—20D are an exploded view of the steppers of the opening scaffold and the rungs of the logic ladder in accordance with an illustrative embodiment of my invention;

FIG. 21 is a fragmentary rearrangement in side view of the ladder, activator and reactivating scaffold in accordance with an illustrative embodiment of my invention;

FIGS. 22A—22C are sequence charts indicating the operation in detail of an illustrative embodiment of my invention; and

FIG. 22D shows how FIGS. 22A—22C should be arranged.

DETAILED DESCRIPTION

Turning now to FIG. 1, there is shown in accordance with an illustrative embodiment of my invention the outer view of a combination lock having an outer door knob 32 and nine pushbuttons designated 4 which are used to write in appropriate combinations. The rectangular pattern of pushbuttons facilitates button identification in the dark or by the blind. It has a further advantage in that a seemingly different set of combinations may be issued for each of a number of authorized personnel. For example, each person is given a different numbering pattern as a base for his combination. Two sets — one through nine or zero through eight — may each be arranged left to right from top to bottom, or top to bottom from left to right, or bottom to top from left to right, or peripheral-wise ending or starting with the center.

FIG. 2 shows the complete logic package comprising logic ladder 44, opening scaffold 60, reactivating scaffold 61 and a projecting member 24 of activator 23 (FIG. 18). Each of the nine pushbuttons 4 of FIG. 1 is connected to a corresponding point (A—I) on the opening and reactivating scaffolds by means of a flexible control cable shown in FIG. 3. These cables are similar to those in common use on bicycles. The sheath 16 is fixed at one end to the outer surface of the scaffold and at the other end to winged ring 17. The push-pull core 15 is connected to a two-pronged stepper 72A—72D of scaffold 60 or a single-pronged stepper 14E—14I of scaffold 61. Thus, tip 19 is directly connected to the stepper. Spring 18 urges the stepper to its withdrawn position and the pushbutton to normal. FIG. 4 is a sectional view through such a pushbutton showing the plug end of the cable in place. The winged ring 17 is arranged, by means not shown, to be inserted at the inner end of the pushbutton socket and locked in place by a twist. Spring 20 is a permanent part of the pushbutton and is stiffer than spring 18 as will be explained later. This pluggable feature of the control cables is the means by which the combinations are changed without the use of tools.

Depression of the pushbuttons in predetermined sequence (i.e., the opening combination) and in a "walking" manner causes member 31 of the logic package of FIG. 2 to deflect a control element and thereby permit the unlatching of a door, the details of which are shown in FIGS. 5, 6 and 9. Thus, in FIG. 5 there is shown a top view of the outer and inner knobs 32 and 33, respectively, and the associated means of interlocking their actions. By means of torque limiter 42 the outer knob 32 rotates arm 41 and hence guide

member 67 and engaging member 68 located thereon. Inner knob 33 is rotated by outer knob 32 when engaging member 68 engages a second engaging member 43 as will be explained later. The means by which the inner knob mechanism withdraws the latch is not shown since conventional arrangements are well known to those skilled in the art. One purpose of torque limiter 42 is to prevent internal damage to the lock by application of a tool to force rotation of the outer knob (e.g., forcible entry by one with larcenous intent).

As shown in FIG. 6, arm 41 is fabricated of thin reed-like material capable of transmitting high rotational torque while maintaining light force in the inward direction against rigid arm 35. In the interest of clarity, arm 41 is not shown in its normal position which is at normal stop 37. A phantom view designated 41' shows arm 41 at the off-normal stop 36 which is reached by bypassing engaging member 43 in a manner to be described later. The inner knob arm is shown in its normal position in radial alignment with the control element 1 whose function will also be described below with reference to FIG. 9.

In FIG. 9, therefore, there is shown a view taken along line 9—9 of FIG. 6. Consequently the curved path traced by guide member 67 appears to be straightened out. This view is intended to show how control element 1 functions to cause interlocking between the outer and inner knob mechanisms. The support for arc-shaped control element 1 is an elbowed reed spring 71 which is normally tensioned against activator projection 24. Opening scaffold projection 31 moves control element 1 from projection 24 to stop 34 when the opening sequence causes the opening scaffold 60 to move from stop 7 to stop 8 as will be described more fully hereinafter.

The outer knob is then rotated causing bow-shaped guide member 67 to advance away from normal stop 37. Guide member 67 rides outwardly over curved deflection member 66 without effect and continues toward off-normal stop 36. Subsequently, guide member 67 encounters control element 1 in its off-normal position against stop 34, and rides outwardly over control element 1 causing engaging member 68 to bypass engaging member 43. The outer knob assembly stops when engaging member 68 reaches off normal stop 36. As will be described later, the opening scaffold 60 recedes withdrawing projection 31, in turn allowing control element 1 to return to its normal position against projection 24. As the outer knob 32 is now returned, guide member 67 clears control element 1 and members 68 and 43 engage one another causing the inner knob assembly to be carried along. By means not shown, but well known in the art, the inner knob mechanism unlatches the door.

As the return of the outer knob continues, guide member 67 again rides over deflection member 66, members 68 and 43 disengage allowing the inner knob assembly to return to its normal position as the outer knob assembly continues to its normal stop 37. From the foregoing description it can be appreciated why control element is referred to as a "zero-energy" control element.

If, however, the outer knob 32 is rotated prematurely without deactivation, member 68 engages member 43

and rotates the inner knob assembly against its spring-loaded normal stop (not shown) until member 43 is stopped at 36. Reversing rotation merely restores the previous condition without effect.

The manner in which the logic package shown in FIG. 2 causes projection 31 on the opening scaffold 60 to deflect the zero-energy control element 1, in addition to deactivation and reactivation procedures, will now be described. The basic components of the logic package include a logic ladder 44 (FIGS. 2, 10, 11), an activator 23 (FIGS. 18, 19), a ratchet arrangement (FIGS. 7, 8, 12, 18), an opening scaffold 60 (FIGS. 2, 12-14, 20) and a reactivating scaffold 61 (FIGS. 2, 15-17, 21).

A plan view of the logic ladder 44 with the scaffolds removed is shown in FIG. 10. The stepper apertures or channels 7, 8 and 63 and the rungs 7A, 8A, 7B etc., as well as rungs 9, 10 and 11, are indicated. The functions of the rungs will be more clearly explained later. Besides the stepper channels there are two other channels with special functions. Channel 30 is provided to permit pawl 2 (FIG. 12) to function with ratchet 22 of activator 23 (FIG. 18). Channel 62 permits reactivating member 3 to function with specially shaped channel 13 of activator 23. As shown in FIG. 11, an end view taken along line 11—11 in FIG. 10, the opening scaffold 60 functions in channel 58, reactivating scaffold 61 functions in channel 57 while activator 23 functions in compartment 59. Recess 29, into which projection 28 fits, supports activator 23 when the latter is in the activated condition. Aperture 70 is provided for projection 24.

A plan view of activator 23 is shown in FIG. 18. In the activated condition projection 28, inserted into recess 29 (see FIG. 21), supports activator 23 against the urging of compressive spring 25 (retained by a clip not shown). Deactivation, as described in greater detail hereinafter with reference to FIG. 22A, results when a force against the nonperforated area (improper depression of a pushbutton), or a force against area 22 (improper release of a pushbutton), causes projection 28 to leave recess 29. Activator 23, urged by compressive spring 25, then moves inwardly and projection 24 extends farther causing control element 1 to move to its off-normal stop 34 as previously described with reference to FIGS. 6 and 9. Apertures 49-56 allow the intrusion of two-pronged steppers 72A-72D (FIG. 12, 20) when the steppers are caused to move in accordance with the opening combination. If the steppers intrude out of sequence, either before or after the proper time, deactivation results. Apertures 12 and 13 will be discussed later with reference to FIG. 21. FIG. 19 is a side view taken along line 19—19 of FIG. 18, chiefly of interest to show the beveled shape of the outward end of channel 13.

The ratchet 22 of activator 23 is shown in greater detail in FIGS. 7 and 8. Pawl 2 shown in FIG. 12 rides up the toothed channel and down the right-hand channel in a complete circuit during a normal opening operation. The step numbers shown indicate the points where the pawl tip rests at the end of each step. Steps 8 and 0 are important in effecting a round trip circuit. These steps will be examined in detail next.

FIG. 8 is a straightened-out profile view of the contours which the pawl tip follows. To insure a complete

circuit the pawl tip swings to the opposite channel at each end. From the crest between steps 7 and 8 the tip path drops down sidewise to the deep spot indicated as step 8. When the pawl drops down the right-hand channel the tip is leading. The outward component of the tip force against the activator should be less than that required to push the activator off the supporting recess 29. To this end the channel becomes gradually more shallow until it crests near the bottom. Below this crest the tip path drops down sidewise to the deep spot indicated as step 0. This ratcheting arrangement detects premature release of a pushbutton used in the opening combination (i.e., non-walking operation).

The opening scaffold, as shown in FIGS. 2 and 12 comprises a plurality of two-pronged steppers 72A-72D which are shown in greater detail in the exploded view of FIGS. 20A to 20D along with their associated ladder rungs 7A, 8A, 7B, etc. While the opening steppers are shown in FIG. 20 with vertical separation for clarity, the spatial relationship between each stepper and the associated rungs is retained. The phantom views of the steppers show how the transition from step 2 to 3 is controlled. Subsequent odd-numbered steps are reached in similar manner. When stepper 72A advances, prong 5A slides through aperture 73A in base plate 45 (FIG. 13) and similarly when stepper 72 advances, prong 5B slides up rung 7B lifting the scaffold as well as stepper 72 whose 6A prong is stopped by rung 8A at step 3 as indicated. When stepper 72A recedes, the scaffold rises to step 4 as stepper 72B continues to advance as urged by spring 20 (FIG. 4) in the associated pushbutton. The phantom in FIG. 20D shows stepper 72D fully advanced and supporting the scaffold at step 8 on rung 7D. In this position projection 31 on base plate 45 (FIG. 13) deflects control element 1 (FIG. 9) permitting the door to be unlatched. Note that during the above-described operative steps, the opening scaffold is being urged back to normal by a spring 26 (FIGS. 2, 11, 13) which is connected between ladder 44 and base plate 45.

As mentioned previously, when deactivation occurs, activator 23 is forced out of recess 29.

Deactivation as a result of the operation of the ratcheting arrangement occurs as follows, reference being made to FIG. 22A:

1. depressing the 4A pushbutton causes the 5A lift prong to slide up the 7A ladder rung until fully inserted; scaffold 60 is thus raised to step 2;

2. if now the 4A pushbutton is released, scaffold 60 drops two steps and pawl 2 pushes activator 23 out of supporting recess 29 deactivating the lock;

3. if instead of (2) above with pushbutton 4A still depressed, the 4B pushbutton is also depressed, the 5B lift prong advances up the 7B rung until prong 6A impinges on step rung 8A causing scaffold 60 to be raised to step 3;

4. if now the 4B pushbutton is released, scaffold 60 drops one step and pawl 2 pushes projection 28 out of recess 29 deactivating the lock;

5. if instead of (4) above, with pushbutton 4B still depressed, pushbutton 4A is released, prong 6A withdraws, lift prong 5B completes its advance and scaffold 60 is raised to step 4;

6. if now pushbutton 4B is released, scaffold 60 drops to normal and pawl 2 pushes activator 23 out of recess 29 deactivating the lock;

7. if instead of (6) above, with pushbutton 4B still depressed, pushbutton 4C is also depressed, then prong 5C advances up rung 7C until prong 6B hits stop rung 8B; scaffold 60 is thus raised to step 5;

8. if now pushbutton 4C is released, scaffold 60 drops one step and pawl 2 pushes activator 23 out of recess 29 deactivating the lock;

9. if instead of (8) above, with pushbutton 4C still depressed, pushbutton 4B is released, then prong 6B is withdrawn, prong 5C completes its advance and scaffold 60 is raised to step 6;

10. if now pushbutton 4C is released, scaffold 60 drops to normal and pawl 2 pushes activator 23 out of recess 29 deactivating the lock;

11. if instead of (10) above, with pushbutton 4C still depressed, pushbutton 4D is also depressed, then prong 5D advances up rung 7D until prong 6C hits stop rung 8C; scaffold 60 is thus raised to step 7;

12. if now pushbutton 4D is released, scaffold 60 drops one step and pawl 2 pushes activator 23 out of recess 29 deactivating the lock;

13. if instead of (12) above, with pushbutton 4D still depressed, pushbutton 4C is released, then prong 6C is withdrawn and prong 5D completes its advance, scaffold 60 is thus raised to step 8, projection 31 on scaffold 60 moves control element 1 from projection 24 to stop 34, and pawl 2 rises to ratchet level 8 where it slides down sidewise to point designated 8;

14. further operation relates to the door knob mechanism and is described in FIG. 22B.

Before the opening combination can be again effective to unlatch the door, the activator must be reset in recess 29. Reactivating scaffold 61 shown in FIGS. 2 and 15 serves this purpose. In addition, FIG. 21 shows a fragmentary rearrangement of the reactivating scaffold, associated ladder rungs and activator features. For the purposes of clarity single-prong steppers 14H and 14I are shown in the same alignment with single-prong steppers 14E, 14F and 14G, instead of the actual parallel alignment. Activator 23 is also shown in modified form (but the illustrated functions are unchanged) and in the activated condition. When deactivated with projection 28 out of recess 29, activator 23 is pushed by spring 25 inwardly one step.

Reactivation, as described also in FIG. 22C, is effected as follows: stepper 14E is advanced, sliding on rung 10 of ladder 44 and forcing scaffold 61 outwardly if stepper 14F is normal. At step 1 stepper 14F is advanced and moves scaffold 61 an additional one-half step where progress is blocked by stepper 14E on rung 9. Stepper 14E then recedes allowing stepper 14F to continue to advance and move scaffold 61 to step 2. Stepper 14E again advances and now bears on the inclined side of rung 9 moving scaffold 61 to step 2½ where stepper 14F is stopped by rung 10. Stepper 14F recedes allowing stepper 14E to advance again and move scaffold 61 to step 3. Stepper 14F again advances moving scaffold 61 to step 4. Stepper 14G then advances moving scaffold 61 to step 4½ where scaffold 61 is blocked by stepper 14F on rung 9. Stepper 14F then recedes allowing stepper 14G to advance again and move scaffold 61 to step 5. As scaffold 61 approaches the end of its travel, resilient member 3 engages the inclined surface 65 of channel aperture 13, moving activator 23 outwardly as well as urging it in the direction indicated by arrow 64. Projection 28 is thus reseated in

recess 29. However, before projection 28 can be reseated, all of the steppers except stepper 14G must be in their normal position. Stepper 14G, however, protrudes into channel aperture 12 and therefore does not interfere with reseating of projection 28. Stepper 14G can then be withdrawn and spring 27 returns scaffold 61 to step O. Reactivation is then complete. Note that in FIGS. 2 and 15 spring 27 is shown connected between ladder 44 and member 3 whereas in FIG. 21 it is shown, for convenience only, as being connected between ladder 44 and scaffold 61 which includes member 3 in portion 47 thereof.

The operation of my invention in response to the sequential depression of pushbuttons in accordance with a predetermined opening combination and in the prescribed "walking" manner is described below with the assistance of the sequence charts shown in FIGS. 22A-22D.

1. Depressing 4A, the pushbutton to which cable A is assigned causes stepper 72A to advance and raise scaffold 60 to step 2.
2. While holding 4A, 4B is depressed causing 60 to rise to step 3 as previously described with reference to FIGS. 20A-20D.
3. 4B is held as 4A is released allowing stepper 72B to resume its advance and raise 60 to step 4.
4. 4B is still held as 4C is depressed causing stepper 72C to advance and raise 60 to step 5 where 6B is blocked by stop rung 8B.
5. 4C is held as 4B is released allowing stepper 72C to resume its advance and raise 60 to step 6.
6. 4C is still held as 4D is depressed causing stepper 72C to advance and raise 60 to step 7 where 6C is blocked by stop rung 8C.
7. 4D is held as 4C is released allowing stepper 72D to resume its advance and raise 60 to step 8.
8. This final step of scaffold 60 causes:
 - 8.1. The tip of pawl 2 to advance over the last ratchet tooth and swing over to the end of the return channel of 22 as described with reference to FIGS. 7 and 8.
 - 8.2. Projection 31 to transfer control element 1 from activator projection 24 to stop 34.
9. 4D is still held and outer knob 32 is rotated to off normal stop 36, bypassing the inner knob assembly as described with reference to FIG. 9.
10. While holding the outer knob, 4D is released, stepper D recedes off rung 7D allowing scaffold 60 to return to step O.
11. Pawl 2 descends in the return channel of 22 as described with reference to FIGS. 7 and 8.
12. When the scaffold started its return, control element 1 was allowed to return to its normal position against projection 24.
13. Outer knob 32 is now rotated back toward normal, unlocking the door as described with reference to FIG. 9.
14. If deactivation occurs at any time before the operative step described in (13) above, unlocking cannot be effected. Deactivation causes projection 24 to be extended additionally, holding control element 1 continuously against off-normal stop 34. While in this position the inner knob assembly cannot be engaged.
15. Deactivation results from any of the following deviations from the predetermined opening combination:

15.1. Depressing any 4 (E, F, G, H or I) pushbutton at any time.

15.2. Depressing any 4 (A, B, C or D) pushbutton at any time other than in the sequential order described in (1)-(A above).

15.3. Releasing any 4 (A, B, C or D) pushbutton at any time other than in the sequential order described in (3)-(A above. If, however, 4D is released before the outer knob is rotated to the point where guide member 67 starts to ride over control element 1, deactivation does not occur but unlocking cannot be effected.

16. Reactivation requires the following combination of steps:

17. Pushbutton 4E is depressed causing stepper 14E to advance and move reactivating scaffold to step 1.

18. 4E is held and 4F is depressed causing stepper 14F to advance, moving scaffold 61 to step 1½ where stepper 14E is blocked by rung 9.

19. 4F is held as 4E is released. Stepper 14 recedes allowing stepper 14F to resume advance, urged by pushbutton spring 20F, and allowing scaffold 61 to move to step 2.

20. 4F is still held as 4E is again depressed. Stepper 14E advances and moves 61 to step 2½ when stepper 14F is blocked by rung 10.

21. 4E is held as 4F is released. Stepper 14F recedes allowing stepper 14E to resume advance and move 61 to step 3.

22. 4E is still held as 4F is again depressed. Stepper 14F advances and moves 61 to step 4.

23. 4F is held as 4G is depressed. Stepper 14G advances and moves 61 to step 4½ where stepper 14F is blocked by rung 9.

24. 4G is held as 4F is released. Stepper 14F recedes allowing stepper 14G to resume advance and move 61 to step 5.

25. As 61 moves through steps 4 and 5, resilient reactivating member 3 moves activator 23 against spring 25.

26. Projection 24 receding allows control element 1 to return to its normal position.

27. The component of member 3 in the direction 64 reseats 28 in recess 29 if all steppers except 14G are normal. This means that stepper 14E must release at any time after sequential step (22).

28. 4G is released. Stepper 14G recedes. 61 returns to O and the opening combination is reactivated.

The security offered by my combination lock is measured by the probability that the pushbuttons will be depressed in the exact opening sequence in attempting to "break" the combination. Since it most unlikely that such experimental manipulation will meet with success on the first attempt, deactivation results. The required combination to unlatch the door then becomes the reactivating combination followed by the opening combination. As indicated in the sequence chart, the input of the regular opening combination involves eight points at which there are nine options and two points at which there are 10 options in the choice of operating or releasing a pushbutton or in rotating the knob. The probability of making all of the correct choices is $9^{-8} \cdot 10^{-2}$ or one in 4.3 billion. Similarly, the reactivating combination presents eight points at which there are nine options in the choice of operating or releasing a pushbutton. The probability of making all of the cor-

rect choices is 9^{-8} or one in 43 million. Therefore, the probability of making all of the correct choices in both the reactivating combination and the regular opening combination is $9^{-16} \cdot 10^{-2}$ or one in 185 million billion.

Familiarity with the general pattern of pushbutton operation in applying the opening combination is of no help in "breaking" the reactivating combination. The opening combination "walks" over four buttons, while the reactivating combination "rocks" on two buttons and then "walks" to a third. Thus, the security of my invention is further enhanced by the change in general pattern of pushbutton manipulation.

It is to be understood that the above-described arrangements are merely illustrative of the many possible specific embodiments which can be devised to represent application of the principles of the invention. Numerous and varied other arrangements can be devised in accordance with these principles by those skilled in the art without departing from the spirit and scope of the invention. In particular, to change the combinations, the inside cover (not shown) is unlocked by pulling the combination change control member from a recess in the latch edge of the door. Opening the cover gives access to the plug ends of the flexible cables which can be reassigned to the pushbuttons in accordance with the new combinations. It is, of course, apparent that my invention is not limited to use with only building doorways but may be readily employed to provide security for numerous other types of enclosures such as vaults and the like.

In addition, it should be noted that the logic utilized in my invention derives from the relative motion between the steppers on the one hand the rungs and activator apertures on the other. Consequently, an alternate arrangement is mounting the steppers in a fixed position with stepper action giving translatory motion to the rungs and, in turn, to the apertured logic plates. The latter, besides being translated with the rungs, would be pushed against the activator when the steppers impinge on nonapertured areas. Such a logic package would comprise the following: a housing or frame with single-pronged steppers; a validator, an assembly comprising four rungs and three rails which ride in channels under the opening steppers; an opening deactivator which is translated by the validator and has two apertures for the opening steppers; a reactivator, an assembly of three rungs which rides in channels under the reactivating steppers; a reactivating deactivator, translated by the reactivator, which has one aperture for stepper G; and an activator which now has only five stepper apertures of small size since the steppers no longer translate.

This type of logic package has the following advantages: the moving parts are much lighter and simpler, requiring much less energy to move them. The steppers, cables and pushbuttons may, therefore, also be made smaller and lighter; the steppers are all uniform in shape and function; the space requirement is less resulting in a more compact lock; since the moving parts require less energy there is even less chance of decoding by "feel"; and yet all sequences and functions are exactly the same as in the previously described arrangement.

What is claimed is:

1. A combination lock for causing the deflection of a control element from a normal position to an off-normal position in response to a first sequence of operative steps comprising

1. a logic ladder comprising a first plate having a plurality of elongated first apertures therein,
2. a plurality of wedge-shaped rungs on one portion of said ladder in registration with said first apertures,
3. an opening scaffold adapted for translation with respect to a first portion of said ladder comprising
 - a. a first member thereon for deflecting said control element after said first sequence of steps is properly completed,
 - b. a plurality of movable wedge-shaped opening steppers responsive to each of said operative steps in said first sequence to extend through said first apertures and engage said rungs to that said opening scaffold is translated with respect to said ladder until said first member deflects said control element.

2. The lock of claim 1 in combination with means for deactivating said lock in response to an improper operative step comprising

1. an activator comprising a second plate having a plurality of elongated second apertures therein in registration with said first apertures of said ladder, said activator being releasably engaged to said ladder and being disposed on the side of said ladder remote from said opening scaffold, said second apertures being positioned in a pattern to permit said opening to extend therethrough only if said steppers are activated in accordance with said predetermined first sequence, and said activator being disengaged from said ladder upon the occurrence of an improper operative step which causes at least one of said opening steppers to strike a non-apertured portion of said activator, and
2. a ratchet assembly coupling said activator to said opening scaffold effective to disengage said ladder and said activator when any opening stepper is prematurely withdrawn from its corresponding first apertures in said ladder.

3. The lock of claim 2 in combination with means for reactivating said lock after deactivation has occurred comprising

1. a reactivating scaffold coupled to another portion of said ladder comprising
 - a. a reset member adapted to engage said activator after a predetermined second sequence of operative steps,
 - b. a plurality of wedge-shaped reactivating steppers responsive to said second sequence of operative steps to extend through corresponding ones of said first apertures in said ladder to engage corresponding ones of said rungs so that said reset member engages said activator which in turn re-engages said ladder.

4. The lock of claim 3 wherein said activator has first and second parallel channels and said ratchet assembly comprises

1. an elongated ratchet member disposed in said first elongated channel,
2. a pawl member having one end connected to said opening scaffold and the other end extending

through said ladder to engage said ratchet member, said other end of said pawl propagating from one end of said ratchet member to the other in response to the translation of said opening scaffold and thence returning via said second channel to one end of said ratchet member, the force of said pawl against said ratchet member and hence said activator being effective to disengage said activator from said ladder when any one of said first opening steppers is prematurely withdrawn from its corresponding first apertures in ladder.

5. The lock of claim 4 wherein

1. said opening scaffold further comprises a first base plate having a plurality of pairs of parallel elongated third apertures of substantially equal length, said third apertures being laterally spaced from one another in side-by-side fashion, said base plate being in slidable contact with said logic ladder with said third apertures being in registration with a first subset of said first apertures of said logic ladder,
 2. said first member for deflecting said control element comprises a projection on said base plate,
 3. each of said wedge-shaped opening steppers is laterally spaced from one another in side-by-side fashion and each comprises a pair of right triangular prongs, means joining said prongs to one another along a common edge so that said prongs lie in spaced, parallel planes, and so that the hypotenuse edges of said prongs are oppositely inclined the spacing of said prongs being equal to the spacing of each of said pairs of third apertures,
 4. said wedge-shaped rungs each comprises a substantially right triangular member disposed in selected ones of said first apertures in complementary relationship with said prongs to be extended therethrough,
 5. said second apertures of said activator are positioned in pairs, each pair in end-to-end relationship laterally spaced from one another, each of said pairs of second apertures being also in side-by-side relationship and displaced vertically from one another to receive said pairs of prongs sequentially in accordance with said first sequence of operative steps, and
 6. said one end of said pawl is connected to said base plate.
6. The lock of claim 5 wherein
1. said reactivating scaffold further comprises a second base plate having a plurality of parallel elongated apertures therein in registration with a second subset of said first apertures of said ladder, and including
 2. a second set of wedge-shaped rungs in vertical registration with one of said apertures of said second subset, and wherein
 3. said reset member is affixed to said second base plate to extend through said ladder to engage said activator,
 4. each of said wedge-shaped reactivating steppers comprises a right triangular member adapted to extend through said apertures in said base plate to engage said second set of rungs on said ladder, and
 5. said said second set of rungs comprises a right triangular member substantially complementary to a corresponding one of said reactivating steppers.

7. The lock of claim 6 wherein

1. said activator has a reset channel therein having one end thereof beveled,
 2. said reset member has one end thereof shaped substantially complementary to said beveled end of said reset channel,
 3. said ladder includes a supporting recess to engage said activator,
 4. said activator includes a first projection which normally extends into said recess, and including
 5. a compressive spring connected between said ladder and said activator, and wherein
 6. said activator includes a second projection against which said control element abuts in its normal position, said second projection member being effective to force said control element to its off-normal position upon the disengagement of said first projection member from said supporting recess.
8. The lock of claim 7 for use as a pushbutton door lock comprising
1. a plurality of pushbuttons,
 2. a plurality of flexible cables connecting each of said pushbuttons to a separate one of said steppers,
 3. a door opening assembly including
 - a. an outer knob assembly rotatable about an axis comprising an outer door knob, a first elongated arm member torsionally coupled to said outer knob for rotation about said axis, a bow-shaped guide member on one end of said first arm member, a first engageable member located on said first arm member intermediate the ends thereof,
 - b. an inner door knob assembly rotatable about said axis comprising an inner door knob, a second arm member coupled to said inner knob for rotation about said axis, a second engageable member on said second arm member at a radial distance thereon from said axis approximately equal to the radial distance of said first engageable member from said axis,
 - c. said control element comprising a first arc-shaped member in radial alignment with said second arm member, an L-shaped resilient member supporting said arc-shaped member, the deflection of said resilient member by said deflecting member of said opening scaffold causing said guide member to ride over said first arc-shaped member so that said engageable members do not engage upon the rotation of said outer door knob in one direction, and
 - d. a second arc-shaped member disposed in the arcuate path of said guide member,
 - e. upon the return of said control element to its normal position, opposite rotation of said outer knob permits said engageable members to engage one another and thereby permit the rotation of said inner knob assembly and the unlatching of said door, and the further rotation of said outer knob causes said guide member to ride over said second arc-shaped member thereby disengaging said engageable members and permitting said inner knob assembly to return to normal.
9. A combination lock for causing the deflection of a control element from a normal position to an off-normal position in response to a first sequence of operative steps comprising

1. a frame having first and second T-shaped channels having their longitudinal axes parallel and coplanar and a third channel having its longitudinal axis parallel and noncoplanar with said axes of said first and second channels,
2. a first planar surface of said first channel having a first plurality of pairs of elongated first apertures extending parallel to said axes and a corresponding second planar surface of said second channel having a second plurality of elongated second apertures extending parallel to said axes,
3. a first plurality of wedge-shaped first rungs, one of said rungs being disposed in registration with each of said first apertures but one, alternate ones of said rungs being oppositely inclined,
4. a second plurality of wedge-shaped second rungs all of which are disposed in registration with one of said second apertures,
5. an opening scaffold adapted for translation in said first channel and on said first planar surface in response to said first sequence of operative steps comprising
 - a. a first housing including a first base plate having a plurality of pairs of parallel elongated third apertures of substantially equal length, said third apertures being laterally spaced from one another in side-by-side fashion in registration with said first apertures,
 - b. said base plate including a first projecting member thereon for deflecting said control element after said first sequence of steps is properly completed,
 - c. a plurality of wedge-shaped opening steppers movably supported in said housing and responsive to each of said operative steps in said first sequence to extend through said first apertures and engage said first rungs so that said opening scaffold is translated with respect to said first planar surface until said first projecting member deflects said control element, each of said opening steppers comprising
 - i. a pair of right triangular prongs,
 - ii. means joining said prongs to one another along a common edge so that said prongs lie in spaced, parallel planes in registration with a pair of said first and third apertures and so that the hypotenuse edges thereof are oppositely inclined, and
 - iii. spring means connecting said opening scaffold to said frame so that said scaffold is urged away from said control element.
10. The lock of claim 9 in combination with means for deactivating said lock in response to the improper insertion of the prongs of at least one of said opening steppers through said first apertures comprising
 1. an activator including
 - a. a second plate slidably positioned in said third channel and having a plurality of pairs of elongated parallel fourth apertures in registration with said first apertures, said frame having a supporting recess and said second plate having a second projecting member releasably disposed in said recess, and
 - b. spring means connecting said second plate and said frame so that said second plate is urged toward said control element,

- c. said fourth apertures being positioned to permit the prongs of said opening steppers to extend therethrough only if said prongs are inserted through said first apertures in accordance with said predetermined first sequence and said second projecting member being forced out of said supporting recess upon the occurrence of an improper operative step which causes a prong of at least one of said opening steppers to strike a non-apertured portion of said second plate of said activator.
11. The lock of claim 10 in combination with means for deactivating said lock in response to the improper withdrawal of the prongs of at least one of said opening steppers from said first apertures comprising
 1. a ratchet assembly coupling said activator to said opening scaffold effective to force said second projecting member of said activator out of said recess when any opening stepper is prematurely withdrawn from said first apertures, said ratchet assembly comprising
 - a. an elongated ratchet member,
 - b. said second plate of said activator having fourth and fifth elongated adjacent channels therein, said ratchet member being disposed in said fourth channel, and said first planar surface in said first channel of said frame having an elongated pawl-aperture therein parallel to said first apertures and in registration with said ratchet member,
 - c. a resilient pawl member having one end connected to said first base plate of said opening scaffold and having its other end extending through said pawl-aperture into said fourth and fifth channels alternately, said one end propagating from one end of said ratchet member to the other in response to the translation of said opening scaffold and thence returning via said fifth channel to said one end of said ratchet member, the force of said pawl against said ratchet member, and hence said activator, being effective to force said second projecting member out of said supporting recess upon the premature withdrawal of any of said opening steppers.
 12. The lock of claim 11 wherein said activator has a reset channel having one end thereof beveled and in combination with means for reactivating said lock after deactivation has occurred comprising
 1. a reactivating scaffold including a second housing having a second base plate mounted in said second channel of said frame and having a plurality of fifth apertures in registration with said second apertures of said second planar surface of said frame, said second surface also having an elongated reset aperture parallel to said axes,
 2. a reset member having a first portion connected to said second base plate and an inclined second portion extending through said reset aperture into said reset channel,
 3. spring means connecting said frame and said second housing for urging said reactivating scaffold away from said supporting recess,
 4. a plurality of wedge-shaped reactivating steppers movably mounted in said second housing and

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responsive to a second sequence of operative steps to extend through said second apertures to engage said second rungs so that said reset member engages said beveled portion of said reset channel to cause said second projecting member to be reset in said supporting recess, said reactivating steppers

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each comprising a right triangular member adapted to extend through said second apertures and having its hypotenuse inclined oppositely to said second rungs.

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