May 21, 1968 J. M. HARRIS ET AL 3,383,887

COMBINATION LOCK

Filed Feb. 8, 1967 5 Sheets-Sheet 1

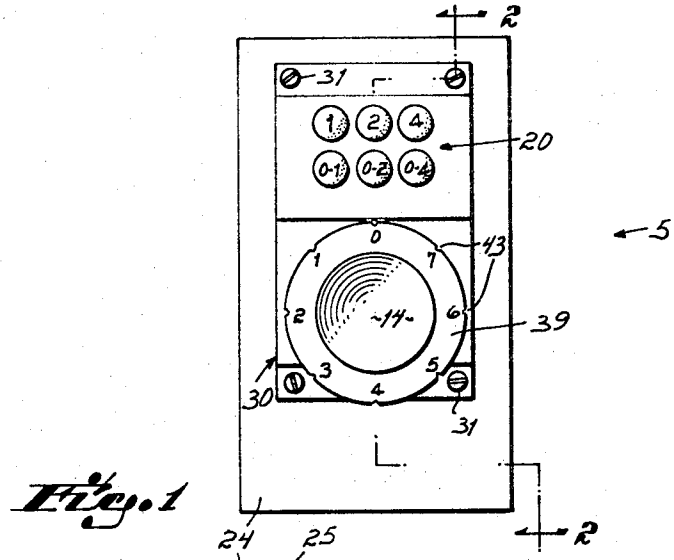


Fig. 1

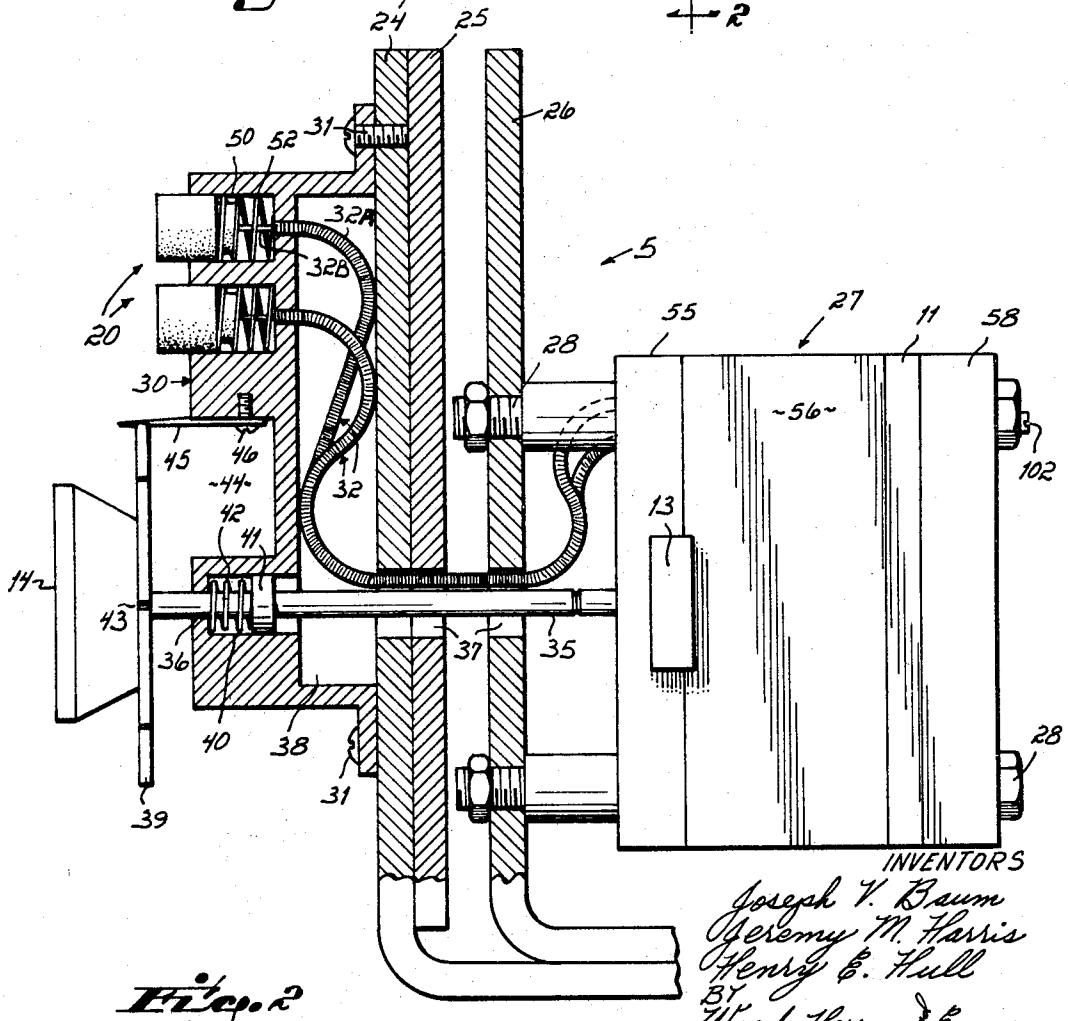


Fig. 2

INVENTORS
Joseph V. Baum
Jeremy M. Harris
Henry E. Hull
BY
Wood, Herron & Evans
ATTORNEYS

May 21, 1968 J. M. HARRIS ET AL 3,383,887

COMBINATION LOCK

Filed Feb. 8, 1967 5 Sheets-Sheet 2

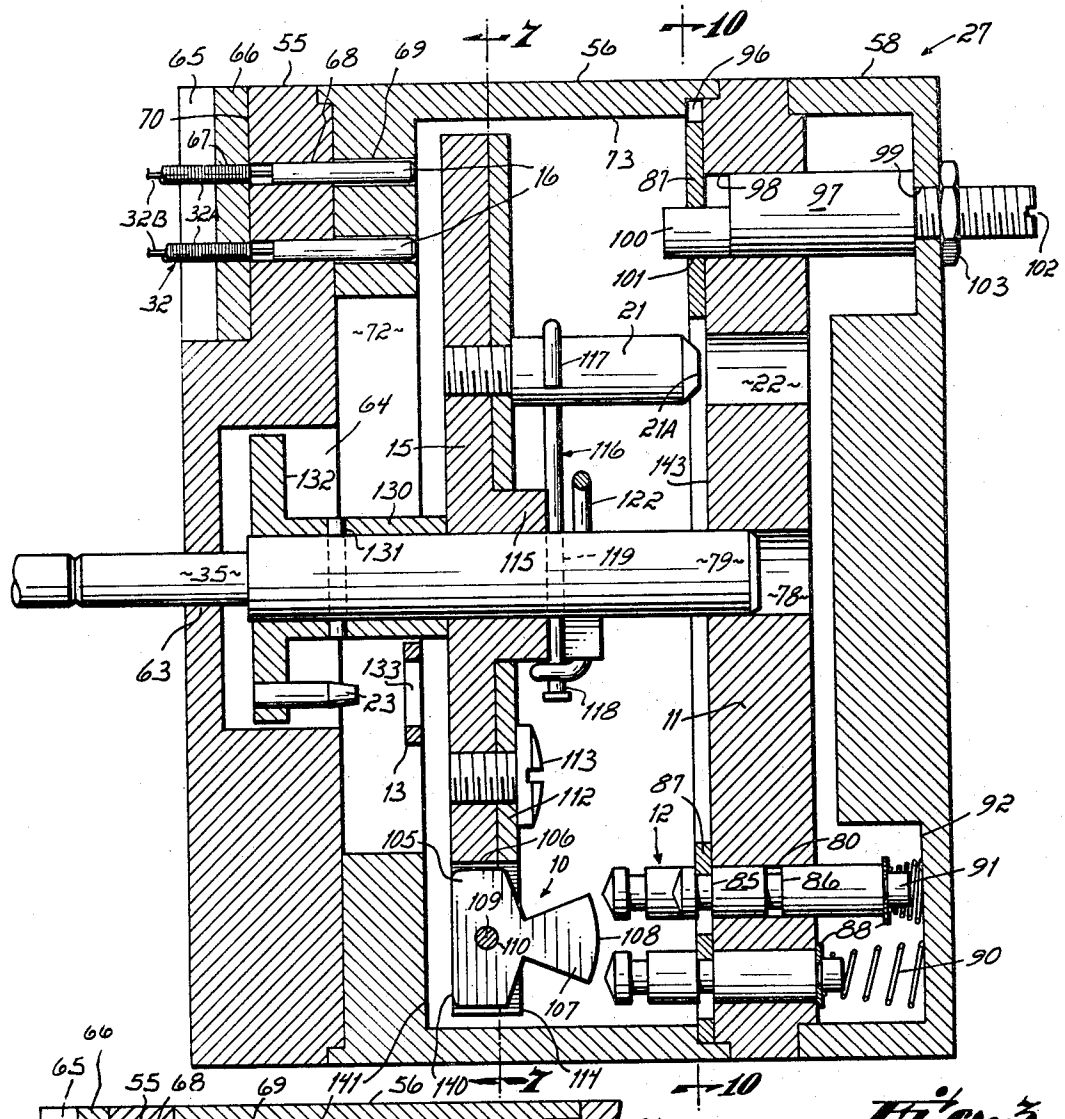


Fig. 3

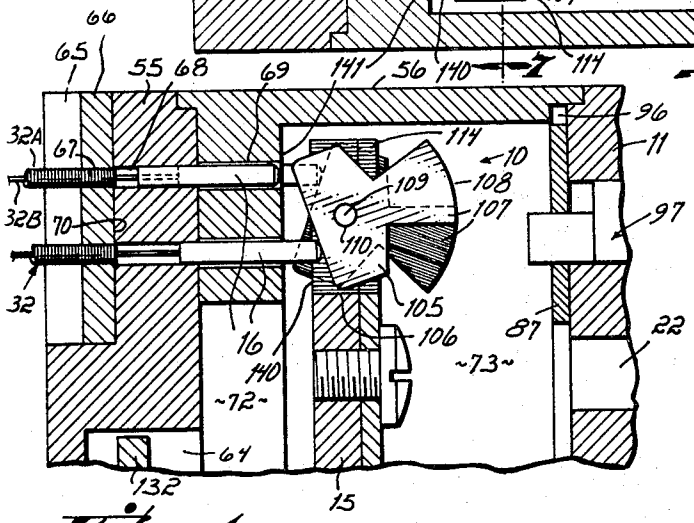


Fig. 4

INVENTORS
Joseph V. Baum
Jeremy M. Harris
Henry E. Hull
BY
Wood, Herron and Evans
ATTORNEYS

May 21, 1968 J. M. HARRIS ETAL 3,383,887

COMBINATION LOCK

Filed Feb. 8, 1967 5 Sheets-Sheet 3

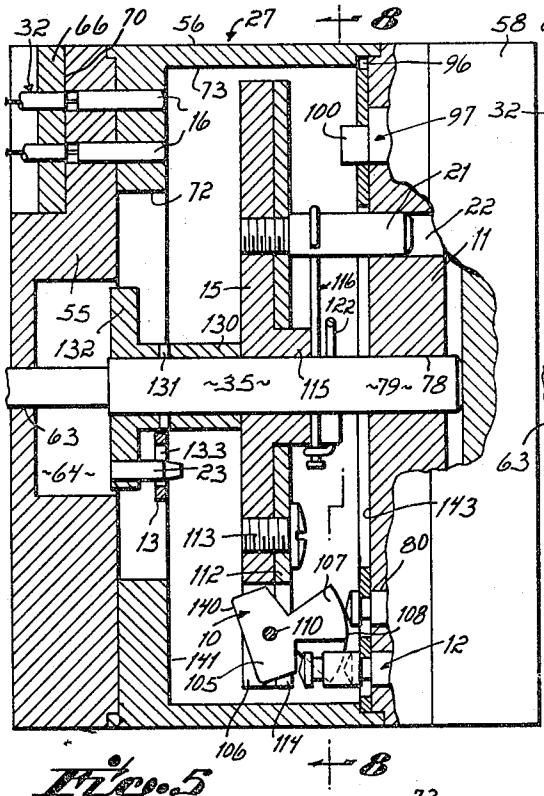


Fig. 5

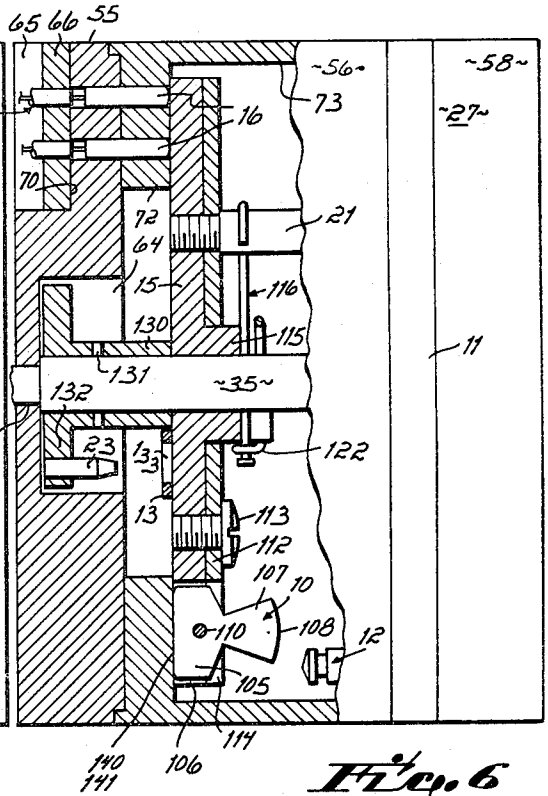


Fig. 6

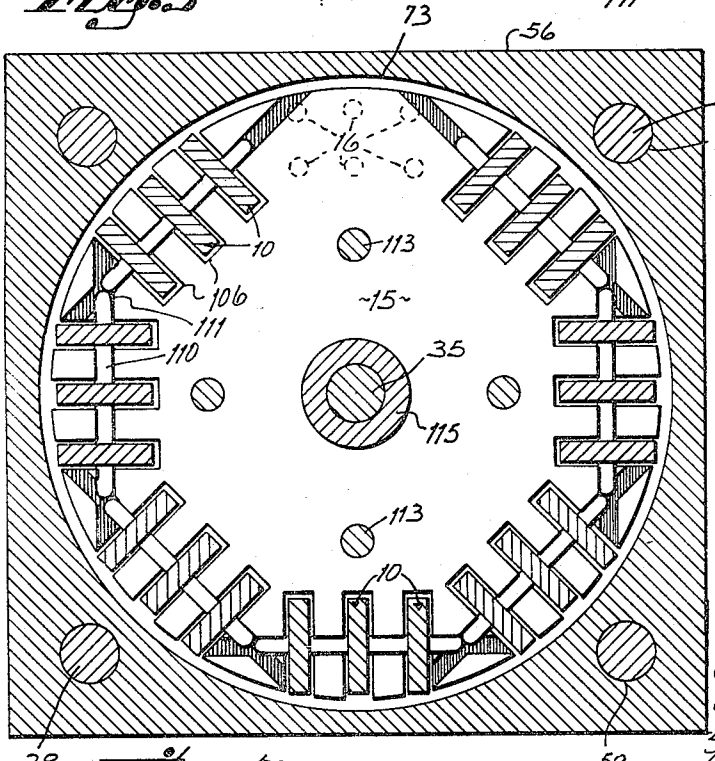


Fig. 7

INVENTORS
Joseph V. Baum
Jeremy M. Harris
Henry E. Hull
BY
Wood, Herron & Evans
ATTORNEYS

May 21, 1968 J. M. HARRIS ET AL 3,383,887

COMBINATION LOCK

Filed Feb. 8, 1967 5 Sheets-Sheet 4

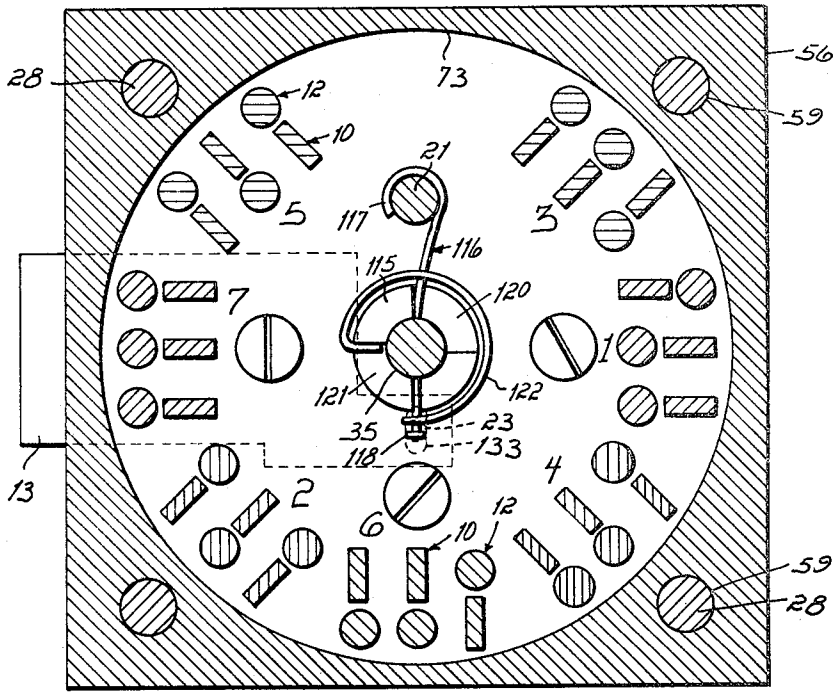


Fig. 8

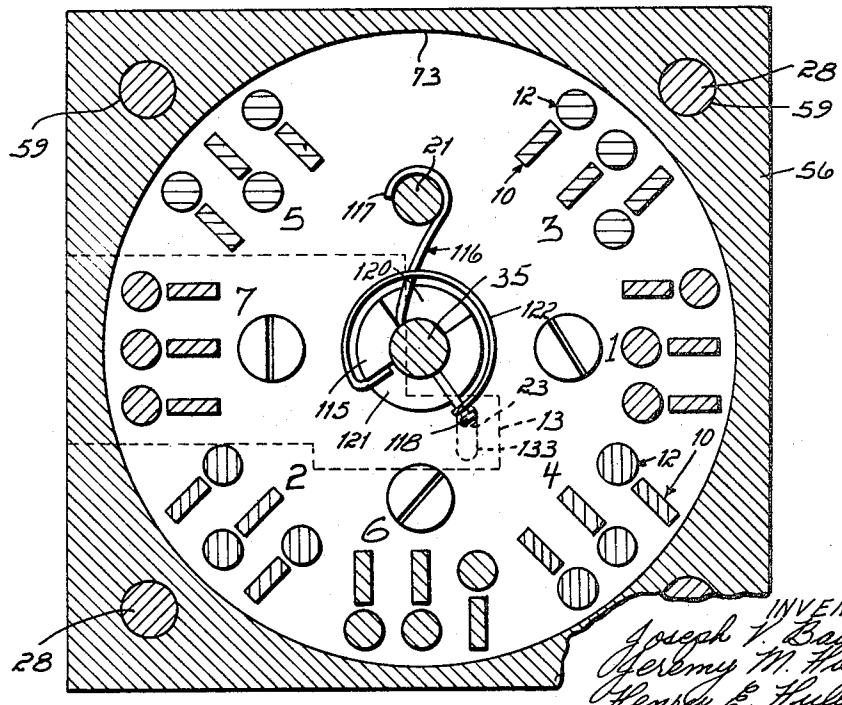


Fig. 9

INVENTORS
Joseph V. Baum
Jeremy M. Harris
Henry E. Hull
BY
Wood, Herron and Evans
ATTORNEYS

May 21, 1968 J. M. HARRIS ETAL 3,383,887

COMBINATION LOCK

Filed Feb. 8, 1967 5 Sheets-Sheet 5

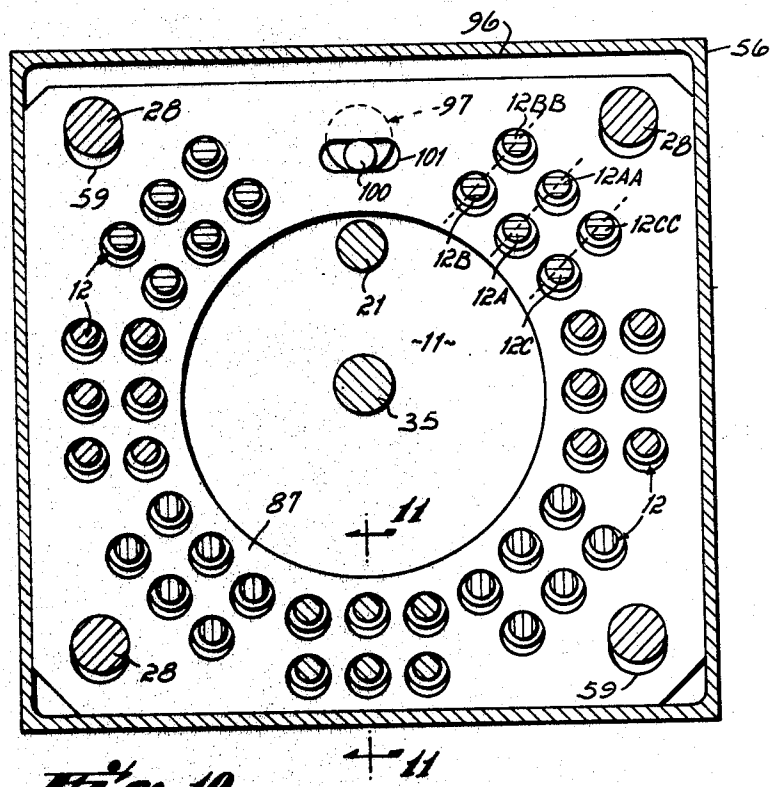


Fig. 10

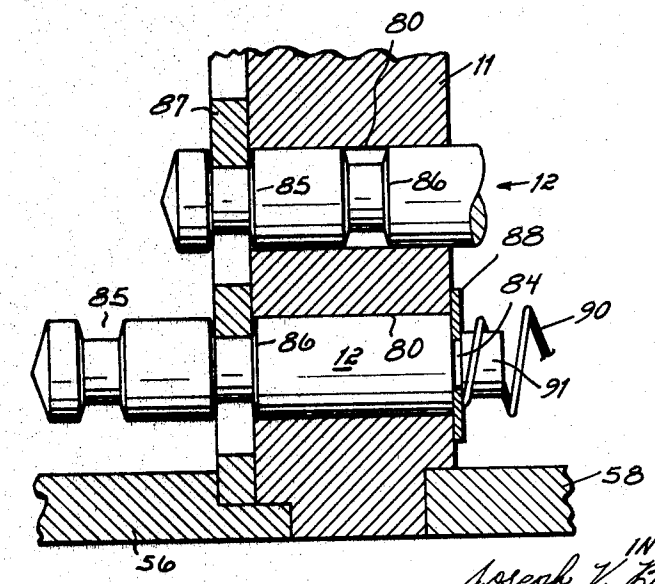


Fig. 11

INVENTORS
Joseph V. Baum
Jeremy M. Harris
Henry E. Hull
BY
Wood, Herron & Evans
ATTORNEYS

United States Patent Office 3,383,887 Patented May 21, 1968

3,383,887

COMBINATION LOCK

Jeremy M. Harris, Worthington, and Joseph V. Baum and Henry E. Hull, Columbus, Ohio, assignors to The Mosler Safe Company, Hamilton, Ohio, a corporation of New York

Filed Feb. 8, 1967, Ser. No. 614,745
19 Claims. (Cl. 70—305)

ABSTRACT OF THE DISCLOSURE

A combination lock having a multiplicity of binary tumblers positionable in groups by means of a set of manually actuatable push buttons.

Background of the invention

Combination locks have traditionally operated on the principle of manipulating a plurality of tumblers so as to co-linearly align notches of the tumblers for reception of a fence. When the fence dropped into the aligned notches, it then permitted a bolt of the lock to be thrown from a locked to an unlocked position. In the most widely used version of this type of lock, the tumblers are rotatably mounted upon a dial shaft and are so interconnected that by properly rotating the dial through varying numbers and degrees of rotations in varying directions, it is possible to sequentially align the tumbler notches in linear alignment for reception of a lock fence.

Rotatable tumbler combination locks are subject to the criticism that the dials of the locks must be properly rotated through a relatively complex series of manipulative steps involving a proper number of rotations in the proper directions in order to sequentially position the tumblers of the lock. A mistake in either the direction or the number of rotations of the dial between numerical inputs results in an input error so that the lock will not open.

Therefore, it has been a primary objective of this invention to provide a combination lock which is operable through a much simpler set of operating instructions than that required to operate a rotatable tumbler combination lock and to accomplish this objective without sacrificing lock security. To this end, the combination lock of this invention operates upon the principle of setting a multiplicity of binary or two position tumblers in accordance with a predetermined schedule by proper actuation of a set of push buttons.

Prior to this invention, there have been attempts to develop push button actuatable combination locks operable upon the principle of utilizing push buttons to set a plurality of binary tumblers. However, these attempts have all met with little or no commercial acceptance for numerous reasons, primary among which was their inability to achieve a high degree of security. Specifically, while these locks were theoretically capable of numerous permutations, usually 2^n, where n was equal to the number of tumblers or push buttons, it was relatively easy for an unauthorized person to detect the combination. For example, if there were twenty tumblers and twenty push buttons, one easy method of breaking the combination was simply to observe which buttons were worm from use or to check for fingerprints by dusting the buttons with fingerprint detecting powder. Those buttons required to be actuated to set a combination into the lock were then very easily discernible. Another method of attacking such a lock was by "feel." This method involved the checking of resistance to bolt or tumbler movement and was particularly successful if the bolt of the lock was movable independently of the tumblers.

Another basic objection to prior push button actuatable combination locks was the excessive length of the lock combination which made it difficult to memorize. For example, if the lock contained twenty tumblers and twenty push buttons for actuating those tumblers, some scheme had to be found for coding a twenty number combination so that it was relatively easy to memorize.

Therefore, one objective of this invention has been to provide a push button actuatable combination lock in which the combination is not detectable by simply observing which of the push buttons were actuated the last time the lock was opened.

Still another objective of this invention has been to provide a push button actuatable combination lock in which the position of the tumblers of the lock cannot be determined by "feel."

And yet another objective of this invention has been to provide a combination lock in which the number of combination number input numerals required to open the lock is minimized.

Summary

The objectives of this invention are achieved by placement of the lock tumblers on a movable plate so that groups of the tumblers may be selectively aligned with a group of push button controlled tumbler actuators. Preferably, movement of the tumblers into alignment with the actuators is controlled by a lock dial which, after all of the tumblers have been positioned in accordance with a predetermined schedule, may be moved axially to operably connect the lock dial to the lock bolt so that rotation of the dial then opens the lock. The tumbler setting push buttons are preferably coded in accordance with a binary coding system so as to facilitate setting of a group of tumblers upon the input of a single digital numerical value.

In order to minimize the possibility of an expert determining the proper combination of the lock by "feeling" the proper position of the tumblers, all of the tumblers of the lock must be moved from a neutral position to one of two different active positions each time the lock is opened. Preferably, each tumbler is mounted upon the tumbler support plate for pivotal movement in either a clockwise or counterclockwise direction. Each tumbler will move in either direction with equal facility and only after all of the tumblers have been moved in one of the two directions from a neutral position, may the tumblers and tumbler support plate be moved relative to a combination determining plate to determine whether all of the tumblers are properly located according to the predetermined combination schedule.

The combination determining plate of the lock comprises a stationary plate having a pair of pins cooperable with each tumbler to block movement of the tumbler and the tumbler support plate if a single tumbler has been incorrectly moved to the wrong one of two active positions from a neutral position. Only if all of the tumblers are correctly positioned relative to their cooperating pins may the tumbler support plate be moved relative to the pins so as to operably connect the tumbler support plate and connected dial to the lock bolt so that rotation of the dial will then open the lock.

The primary advantage of this combination lock is the ease with which it may be opened. So long as the tumblers or the groups of tumblers are properly positioned, the lock will open, irrespective of the order or sequence in which the tumblers are positioned. Therefore, the dial may be moved from any one position to any other position through any number of rotations in any direction without upsetting the result. Furthermore, the push buttons may be actuated in any sequence without voiding the input combination.

These and other objects and advantages of this invention will become more readily apparent from the following description of the drawings in which:

FIGURE 1 is a front perspective view of the inventive combination lock of this application attached to a mounting bracket,

FIGURE 2 is a side elevational view of the lock, partially in cross-section, taken along line 2—2 of FIGURE 1,

FIGURE 3 is a cross-sectional view of the tumbler support plate and tumbler actuating mechanism of the combination lock of FIGURE 2,

FIGURE 4 is an enlarged cross-sectional view illustrating the two different active positions of a single tumbler,

FIGURE 5 is a cross-sectional view, similar to FIGURE 3, illustrating the position of the tumbler support plate when the dial is moved inwardly to engage the lock bolt actuator with the bolt of the lock,

FIGURE 6 is a cross-sectional view, similar to FIGURE 5, illustrating the position of the tumbler support plate when the dial of the lock is pulled outwardly to move all of the tumblers of the lock to a neutral position,

FIGURE 7 is a cross-sectional view of the tumblers and tumbler support plate taken along line 7—7 of FIGURE 3,

FIGURE 8 is a cross-sectional view of the tumblers and tumbler stop pins taken along line 8—8 of FIGURE 5,

FIGURE 9 is a cross-sectional view, similar to FIGURE 8, illustrating the position of the dial shaft when the shaft is rotated relative to the tumbler support plate to move the bolt to an unlocked condition,

FIGURE 10 is a cross-sectional view through the tumbler stop pins taken along line 10—10 of FIGURE 3, and

FIGURE 11 is an enlarged cross-sectional view through a pair of the tumbler stop pins.

Basically, the combination lock of this invention operates upon the principle of positioning twenty-one binary or two position tumblers **10** according to a predetermined schedule so as to enable those tumblers, after all have been positioned according to the schedule, to be moved relative to a combination determining plate **11** so as to operably connect a bolt actuator **23** of the lock with a lock bolt **13**. When the actuator is connected to the bolt, a dial **14** of the lock may be rotated to move the lock bolt **13** between a locked and an unlocked position.

The twenty-one tumblers of the lock are arranged in seven groups of three (FIGURE 7) and are mounted upon a rotatable tumbler support plate **15** which enables the seven groups of tumblers to be successively positioned at a tumbler setting station immediately behind a plurality of tumbler setting pins **16**. When so positioned, the tumbler setting pins **16** may be actuated by a group of push buttons **20** so as to position the three tumblers of the group located at the setting station in a predetermined position. After all seven groups of tumblers have been properly positioned according to a predetermined schedule, the lock dial **14** may be pushed inwardly to engage the dial with the bolt actuator and the dial may then be rotated to move the bolt between locked and unlocked positions.

The operational sequence for opening the lock is thus one of sequentially positioning the dial of the lock in seven different index positions at each one of which the push buttons **20** of the lock are actuated according to a predetermined code. After the dial has been rotated through all seven index positions and the push buttons have been actuated according to a predetermined schedule at each position, the dial may be rotated to an eighth or home position and pushed inwardly. If all of the tumblers have been correctly positioned, the dial will move inwardly so as to operably connect the dial of the lock with the lock bolt and the dial may then be rotated so as to lock or unlock the bolt mechanism.

Referring first to FIGURES 1 and 2, the lock **5** is illustrated as mounted upon a support bracket which comprises a main support plate **24**, a reinforcing plate **25**, and a lock mechanism mounting plate **26** spaced from the main and reinforcing plates so as to enable the lock mechanism housing **27** to be attached to the mounting plate **26** by bolts **28**. In most applications, the bracket **25** would be representative of a door or other mechanism to be secured by the combination lock and the mounting plate **26** would represent a lock mounting plate attached to the rear of the door.

The combination lock comprises a dial and push button support bracket **30** attached to the front of the bracket **24** by screws **31**. This bracket **30** supports the push buttons **20** of the lock which are mounted on the front side of the support bracket and are interconnected to the lock mechanism contained within the housing **27** by flexible cables **32**. Each one of the cables **32** comprises a casing **32A** and an enclosed wire **32B** which interconnects one push button **20** with one tumbler actuator pin **16** located within the lock mechanism housing **27**. Thus, each of the six push buttons **20** are individually interconnected to one of the six tumbler actuator pins **16** through the six flexible cables **32**.

The dial **14** of the lock is mounted on the outer end of a dial shaft **35** which extends through an aperture **36** of the dial support bracket **30** and a co-axial aperture **37** of the lock mounting plates **24**, **25**, and **26**. Preferably, the six flexible cables **32** extend through the same mounting bracket aperture **37** as the dial shaft **35** so that there need be only one relatively large hole in a door rather than one large shaft aperture and six small cable apertures. This single aperture construction is preferred because it is generally considered to be more secure than a multiple aperture construction.

To accommodate the cables **32** between the buttons **20** and the dial shaft aperture **37**, the dial support bracket **30** has a large recess **38** in its rear side. The dial shaft aperture **36** of the bracket **30** is counterbored or has a large diameter section **40** which receives and supports a flange **41** of the dial shaft **35** for sliding movement therein. A compression spring **42** surrounds the shaft **35** between the flange **41** and the bottom of the counterbored hole **40** so as to bias the dial shaft **35** inwardly or toward the dial mechanism housing **27**.

The dial **14** is generally configurated as a truncated cone having a large radial flange **39** extending outwardly from its smaller rear side. Eight equidistantly spaced detents or recesses **43** are cut from the peripheral surface of the flange and are numbered 0–7.

As may be most clearly seen in FIGURE 2, a relatively large recess **44** is formed in the front of the bracket **30** immediately behind the flange **39** of the dial. A combination pointer and detent spring **45** extends forwardly from this recess **44** and is secured to the top of the recess **44** by a screw **46**. The outer end of the pointer engages the periphery of the flange **39** and is receivable within the recesses **43** so as to enable the dial to be accurately located in each of the eight different dial index positions.

The six push buttons **20** of the lock are slidably mounted within six counterbored apertures **50** of the mounting bracket **30**. As stated above, each push button **20** is operatively connected by the wire **32B** within one of the cable casings **32A** to one of the tumbler actuator pins **16**. A compression spring **52**, located between the rear of each push button **20** and the bottom of the surrounding counterbored hole, biases each push button outwardly to a position in which the connected actuator pin **16** (FIGURE 3) is out of contact with the tumblers **10**.

Referring now to FIGURE 3, it will be seen that the lock mechanism housing **27** comprises a rectangular front plate **55**, a hollow rectangular center plate **56**, the rectangular pin supporting plate **11**, and a rectangular rear plate **58**, all of which are secured in a stacked assembly by the bolts **28** which extend through co-linearly aligned corner apertures **59** of the assembly.

The front plate **55** has a central aperture **63** co-linearly aligned with a rear counterbore **64**. On its front side, the plate **55** has a rectangular recess **65** machined along

its top edge for reception of a stop plate **66**. Six apertures **67** of the stop plate **66** are co-linearly aligned with six apertures **68** in the front plate **55** and six apertures **69** in the center plate **56**. These apertures receive the pins **16** which are slidable therein and are arranged in the same configuration as the six push buttons **20** in the front bracket **30**; i.e., with three spaced apertures in a common horizontal plane and three other apertures located in a common horizontal plane immediately beneath the upper apertures. Those apertures **67** in the stop plate **66** are slightly smaller in diameter than the pins **16** and the apertures **68** of the front plate so that the inner surface **70** of the stop plate **66** acts as a limit or stop for the tumbler actuating pins **16** to preclude the pins from being pulled from the housing **27**.

The hollow center plate **56** of the housing has a large circular cavity or bore **73** interconnected with a smaller diameter aperture **72** in the front of the plate.

A central aperture **78** in the stop pin support plate **11** rotatably supports the rear end **79** of the dial shaft **35**. In addition to this central aperture **78**, this plate **11** has forty-two other apertures **80** which slidably support the combination determining stop pins **12**. As may be seen most clearly in FIGURES 10 and 11, the apertures **80** and the stop pins **12** are arranged in seven groups of six each. In each group of six pins **12** and apertures **80**, two pins **12A**, **12AA**, and apertures **80** are located in a common radial plane and two additional pins **12B**, **12BB**, and **12C**, **12CC** are located on both sides of the radial plane, in planes parallel to the radial plane of the pins **12A**, **12AA**. As is explained more fully hereinafter, each pair of pins located in a radial plane or in a plane parallel to a radial plane is cooperable with one of the twenty-one tumblers of the lock to determine the position in which the tumbler must be placed in order for the lock to be opened.

Referring to FIGURE 11, it will be seen that each pin **12** has a pair of axially spaced annular grooves **85**, **86** adapted to receive a slidably mounted lock plate **87** so as to secure or lock each pin **12** in one of two different axial positions. Additionally, each pin has a groove **84** located near the rear of the pin within which a snap ring **88** is secured. Compression springs **90** mounted over a small diameter portion **91** of each pin **12** are located between the snap rings **88** and the bottom of an annular recess **92** (FIGURE 3) in the front wall of the rear plate **58** of the housing **27**. These springs **90** bias or force each of the pins **12** forwardly when the pins are released for repositioning by lock plate **87**. The snap rings **88** limit the forward movement of the pins **12** relative to the pin support plate.

As may be seen most clearly in FIGURES 3 and 10, the lock plate **87** is rectangular in configuration and includes forty-two circular apertures co-axially aligned with the apertures **80** of the stop pin support plate **11**. The plate is vertically slidable within a rectangular recess **96** machined in the rear surface of the center plate **56** of the housing **27**. The recess **96** is of approximately the same width as the width of the plate but is higher in the vertical plane than the height of the plate so that the plate is free for vertical movement within the recess **96**. To move the plate **87** vertically within the recess **96**, a lock combination changing pin **97** is rotatably mounted within an aperture **98** of the stop pin support plate **11**. This pin **97** has a small diameter threaded section which extends rearwardly through an aperture **99** of the rear plate **58**. A screwdriver slot **102** in the rear end of the pin enables it to be manually rotated by a screwdriver. At the forward end, the pin **97** has an eccentric extension **100** which extends into a horizontally elongated slot **101** of the lock plate **87**. Upon rotation of the pin with a screwdriver fitted into the slot **102**, the eccentric portion **100** of the pin causes the plate **87** to move vertically within the recess **96**. When moved to its upper limit, the plate **87** releases all of the pins **12** for forward movement by the springs **90**. A nut **103** threaded over the rear end of the pin **97** locks the eccentric extension **100** against rotational movement after the pins have been set in an adjusted position as is explained more fully hereinafter in connection with the operational sequence of changing the lock combination.

The tumblers **10** of the lock are all identical and are all pivotally mounted upon the common circular support plate **15**. Each tumbler has a generally rectangular base section **105** from which a generally triangular section **107** extends rearwardly. The rear end of the triangular sections **107** terminate in a circular arcuate surface **108** circumscribed about the pivotal axis **109** of each tumbler.

The tumblers are mounted in groups of three for pivotal movement within peripheral slots **106** (FIGURE 7) of the support plate upon seven support or pivot shafts **110**. Each of the pivot shafts **110** is receivable within one of seven chordal recesses **111** machined in the rear surface of the support plate **15**. A cover plate **112** is secured in juxtaposition on the rear of the support plate **15** by screws **113** so as to maintain the shafts **110** in assembled relation within the slots **111**. Slots **114** in the cover plate **112** form extensions of the slot **106** of the support plate **15** so as to accommodate the rearward portions **107** of the tumblers **10**.

As may be seen most clearly in FIGURE 7, the seven groups of tumblers **10** mounted upon the seven support shafts **110** are mounted in seven adjacent ones of eight pie shaped sectors of the tumbler support plate **15**. The eighth sector represents the eighth or home index position of the dial and support plate to which the dial must be moved before the dial may be moved axially inwardly to interconnect the dial **14** with the bolt **13** of the lock. In all but this eighth index position, axial rearward movement of the dial and the attached tumbler support plate is precluded by engagement of the rear surface **21A** of a stop pin **21** with the forward wall of the pin support plate **11**. In the eighth position of the dial **14** and plate **15**, the pin **21** is aligned with an aperture **22** of the pin support plate and is, therefore, free to be moved rearwardly upon rearward movement of the dial **14**.

Since the bolt **13** of the lock is actuated by rotational movement of the dial **14** after the dial and connected support plate **15** are moved inwardly, some provision must be made for limited rotation of the dial **14** while the plate **15** is secured against rotational movement. To this end, the support plate **15** is rotatably mounted upon the dial shaft **35**. A spring type lost motion connection interconnects the hub **115** of the tumbler support plate to the dial shaft **35** so that the shaft **35** and plate **15** normally rotate together. If the plate **15** is secured against rotational movement, the shaft **35** may be rotated relative to the support plate by overcoming the biasing force of the spring connection. As may be seen most clearly in FIGURES 8 and 9, this lost motion spring connection comprises a leaf spring **116**, one end **117** of which is wrapped around the post **21** and the opposite end of which extends through a pair of pie-shaped recesses **120**, **121** cut from the hub **115** of the support plate **15** and through an aperture **119** of the shaft **35**. To prevent the spring **116** from pulling out of the hole **119**, a wire **122** partially circumscribes the hub **115** of the support plate **15** with one end wrapped around the headed end **118** of the spring **116** and the opposite end bent into the recessed sector **121** of the plate hub **115**.

As may be seen most clearly in FIGURES 8 and 9, the spring **116** usually forces the dial shaft **35** and tumbler support plate **15** to rotate together but permits the shaft **35** to be rotated relative to the support plate **15** if the support plate is held against rotation while the shaft is rotated.

The actuating mechanism for interconnecting the dial shaft **35** of the lock to the lock bolt **13** comprises a sleeve **130** drivably keyed to the shaft **35** by a drive pin **131**. This sleeve has a radial flange **132** from which the bolt actuating pin **23** extends rearwardly. As may be seen most clearly in FIGURES 3, 8, and 9, the pin **23** is engageable

with a slot 133 of the bolt 13 when the shaft 35 is moved inwardly to a position in which the post 21 of the tumbler support plate is received within the aperture 22 of the stop pin support plate. When engaged with the slot 133 of the bolt, rotation of the pin 23 as a consequence of rotation of the dial 14 results in lateral sliding movement of the bolt 13 between the locked position of FIGURE 8 and the unlocked position of FIGURE 9.

Operation

As may be seen most clearly in FIGURE 1, the six push buttons of the lock are arranged in three vertical pairs numbered 1, 0; 2, 0; and 4, 0. For purposes of clarifying the following references to the three 0 buttons, they are hereinafter designated as 0–1, 0–2, and 0–4, the dashed digit following 0 indicating the number of the buttons with which the 0 button is cooperable to position a tumbler.

The numbers 1, 2 and 4 are utilized as the indicia on the top row of buttons so as to enable a binary numbering system to be used to position the lock tumblers in groups of three. In the binary system, the number 1 represents 2^0, the number 2 represents 2^1 and the number 4 represents 2^2. By utilizing this coding system, it is possible to position any group of three binary tumblers in any one of eight different permutations or combination of positions with a single digital number input which varies between 0 and 7. In other words, since there are seven groups of three tumblers, and since one digital number controls the position of three tumblers, this system enables seven digital number inputs to control the positioning of 2^{21} tumbler combinations.

In order to avoid the possibility of a professional lock picker determining the proper lock combination by "feeling" the resistance of the tumblers to movement, this lock operates upon the principle that each tumbler of the lock must be moved from a neutral position (shown in FIGURE 3) to one of the two active positions (shown in FIGURE 5) with each input of the lock combination. Therefore, the operating instructions of the lock require that one of the two buttons numbered 1, 0–1; one of the two buttons numbered 2, 0–2; and one of the two buttons numbered 4, 0–4 must be actuated with each combination number input so that all of the tumblers are moved out of a neutral position during each operational cycle of the lock.

Before initiating the input of the first combination number during the opening cycle of the lock, or after relocking the lock by moving the bolt 13 to a locked position, all of the tumblers of the lock are moved or "scrambled" by pulling the lock dial 14 to an extreme forward position against the bias of the compression spring 42. This results in the rear surface 140 of each of the tumblers 10 being moved into engagement with the vertical surface 141 of the center plate 56 so that all of the tumblers are moved to the neutral position illustrated in FIGURE 6. Since the tumblers are counterbalanced about their pivotal axes 109, they all remain in this neutral position until moved to another position by actuation of one of the push button actuating pins 16.

After the dial of the lock has been pulled outwardly so that all of the tumblers 10 of the lock are "scrambled" or moved into a neutral position, the spring 42 biases the dial shaft of the lock inwardly to the position shown in FIGURE 3 in which the post 21 of the stop support plate rides against the outer surface 143 of the stop pin support plate 11 if the dial is in any of the index positions numbered 1–7. If the dial is in the 0 position in which the pin 21 is aligned with the aperture 22, the dial can be moved inwardly until the curved surface 108 of the tumblers 10 abuts against the outer surface of the pins 12. Since the centers of curvature of the tumbler surfaces 108 are the pivotal axes 109 of the tumblers, engagement of the tumblers with the stop pins 12 while in the neutral position will not tend to rotate the tumblers about their axes.

For purposes of illustration, assume that the combination of the lock is 5–7–2–6–4–1–3.

To place this lock combination into the lock, the dial 14 is first rotated to a position in which the dial indicia number 1, representative of the first index position of the dial, is aligned with the detent spring 45 and the detent spring 45 rests within the recess at the number 1 position of the dial. In this position of the dial, the first group of three tumblers are at the twelve o'clock position and each of the three tumblers is aligned with two vertically spaced push button actuatable pins 16. The first combination number of the lock is 5 so that the buttons numbered 1 and 4 must be pushed inwardly. Since the operating instruction of the lock require that one of each vertical pair of push buttons must be actuated with each numerical input, the 0–2 button (which is vertically aligned with the unactuated number 2 button) must also be pushed inwardly. When the number 1 button is pushed inwardly, it causes that tumbler which is aligned with the two pins 16 actuated by the push buttons 1, 0–1, to move in a clockwise direction as viewed in FIGURE 4. Actuation of the 0–2 button causes the tumbler aligned with the 2, 0–2 button actuatable pins 16 to be moved in a counterclockwise direction as viewed in FIGURE 4. When the 4 button is actuated, that tumbler aligned with the 4, 0–4 button is moved in the clockwise direction as viewed in FIGURE 4. Thus, all of the three tumblers of the first group are moved from a neutral position to a position representative of the numeral 5 for the combination of tumblers.

The dial is next rotated to the number 2 index position. Since the second combination number is 7, the 1, 2, and 4 push buttons are all actuated for this numerical input and the three 0 buttons are all left unactuated. Thus, all three tumblers in this second group are moved in a clockwise direction as viewed in FIGURE 4.

The next step in the operation of the lock is to index the dial to the third index position. The combination lock number for this third index position is 2, so that the 2 push button is actuated at this index position of the dial. Since one of each vertical pair of buttons must be actuated, the buttons numbered 0–1 and 0–4 are also pushed inwardly at this index position of the dial.

For the fourth index position of the dial, the push buttons 0–2, 2, and 4 are pushed inwardly for a numerical input of 6. At the fifth dial index position, for which the combination number is 4, the push buttons number 0–1, 0–2, and 4 are pushed inwardly. To place the sixth combination number, number 1 into the lock, the dial 14 is rotated to the sixth index position and the buttons numbered 1, 0–2, 0–4 are pushed inwardly. The seventh combination number, number 3, is placed into the lock by moving the combination lock dial to the seventh index position at which the push buttons numbered 1, 2, and 0–4 are pushed inwardly.

After this sequence of operations, all of the tumblers of the lock are in the proper position for the combination lock setting 5–7–2–6–4–1–3. To open the lock, the dial is next rotated to the 0 or eighth index position in which the stop pin 21 is aligned with the aperture 22 of the stop pin support plate. In this position of the tumbler support plate, the dial may be pushed inwardly, as shown in FIGURE 5, so as to move the dial shaft 35 and the attached tumbler support plate axially in a rearward direction. Since the tumblers are all in the correct positions, the stop pins 12 will permit the tumblers to move axially when the dial is pushed inwardly. If one or more of the tumblers had been incorrectly positioned, inward movement of the tumbler support plate would be blocked by that pin 12 aligned with the tumbler which had been incorrectly positioned. If all of the tumblers are correctly positioned and the dial is moved inwardly to locate the pin 21 in the aperture

22, the bolt actuating pin 23 will engage the slot 133 of the bolt. Thereafter, the dial may be rotated by overcoming the force of the leaf spring 116 so as to retract the bolt 13.

If an attempt is made to force the dial inward by hammering it or by any other means of applying force, the drive pin 131 will simply act as a shear pin and shear off so that the bolt actuating pin 23 will remain disengaged from the slot 133 of the bolt 13.

Changing the combination of this lock is a relatively simple operation. It involves simply loosening the nut 103 on the rear of the lock mechanism housing 27 so that the pin 97 may be rotated by a screwdriver. The pin 97 is then rotated one-half turn so that the stop plate 87 is moved vertically by the eccentric pin 100 on the end of the pin to a position in which all of the stop pins 12 are released from engagement with the plate 87. The springs 90 then move all of the pins forwardly until the snap rings 88 abut against the rear surface of the stop pins support plate 11.

With all of the pins 12 moved forwardly, the rearwardmost slot 86 in each of the pins is located in the vertical plane of the stop plate 87. The new combination of the lock is now inserted into the lock by actuation of the dial and push buttons in the same manner as if the lock were to be opened by the new combination. For example, if the new combination were to be 2–2–2–2–2–2–2, the lock dial 14 would be rotated through the index positions 1 through 7 and at each of these index positions the buttons 0–1, 2, and 0–4 would be actuated. The lock is then moved to the eighth or index position and the dial pushed inwardly as far as it will move. When the dial is pushed inwardly, each tumbler engages one of the twenty-one pairs of pins 12 and forces that pin with which it is engaged to move inwardly until the outermost groove 85 of the pin is vertically aligned with the stop plate 87. With the dial held in this inward position, the pin 97 is then rotated through 180° so as to move the stop plate 87 downwardly relative to the stop pins and into one of the two grooves in each pin. The pins are then positioned in accordance with the new combination and will remain in this position until such time as they are released for movement by rotation of the combination changing pin 97.

There are numerous advantages to this push button combination lock over the conventional rotary tumbler combination locks. Particularly, the push button style of lock is much easier to operate because of the simplicity of the manipulative steps required to position the tumblers of the lock. Additionally, the dial may be rotated in either direction to any index position without effecting the operational cycle of the lock. In other words, the combination numbers may be inserted into the lock in any sequence and the same numbers may even be inserted twice so long as the correct combination number is used to actuate the push buttons at the correct dial position.

Another advantage of this lock is attributable to the binary coding system of the push buttons which enables the six push buttons to position any group of three tumblers in any one of eight different active positions in response to a single digital numerical input.

Since the same push buttons are repeatedly utilized to position the several different groupings of tumblers, the combination of the lock cannot be learned by dusting the buttons to determine which buttons were utilized to position the tumblers during the last operational cycle. This is very advantageous since it overcomes one inherent weakness of prior art attempts to produce a satisfactory push button type lock.

While only one preferred embodiment of the push button combination lock of this invention has been illustrated and described herein, those skilled in the art to which this invention pertains will readily appreciate numerous modifications and advantages which may be made without departing from the spirit of our invention. Therefore, we do not intend to be limited except by the scope of the appended claims.

Having described our invention, we claim:

1. A combination lock having a bolt movable between locked and unlocked positions, a bolt actuating mechanism for moving said bolt between said positions, and a blocking mechanism for preventing movement of said bolt from a locked to an unlocked position until after said lock has been properly manipulated according to a predetermined numerical lock combination, the improvement wherein said blocking mechanism comprises

a plurality of binary condition control elements each of which must be conditioned according to a predetermined schedule in order to permit said actuating mechanism to move said bolt from a locked to an unlocked position,

a plurality of push buttons for controlling the conditioning of said control elements, said push buttons being fewer in number than said elements so that each of said push buttons is operable to successively condition a plurality of said elements, said push buttons being coded according to a binary coding system so as to facilitate conditioning of a group of said elements with each numerical input of the lock combination.

2. The combination lock of claim 1 wherein each of said binary condition control elements comprises a tumbler movable from a neutral position to one of two active positions.

3. The combination lock of claim 2 wherein each of said tumblers is pivotally mounted for movement from the neutral to one of said two active positions.

4. A combination lock having a bolt movable between locked and unlocked positions and a bolt actuator for moving said bolt between said positions, a blocking mechanism for preventing movement of said bolt by said actuator from a locked to an unlocked position, the improvement wherein said blocking mechanism comprises

a plurality of movable tumblers mounted upon a movable support plate, said support plate being movable so as to successively align said tumblers with at least one tumbler setting positioner so that said tumblers may be set according to a predetermined permutation by said positioner, and

means cooperable with said tumblers after said tumblers have all been properly conditioned according to said predetermined permutation to permit said bolt to be moved from a locked to an unlocked position.

5. The combination lock of claim 4 wherein said tumbler cooperable means comprises a plurality of stop pins.

6. A combination lock having a bolt movable between locked and unlocked positions and a bolt actuator for moving said bolt between said positions, said actuator being movable between an active position in which it is operably coupled to said bolt and an inactive position in which it is operatively uncoupled from said bolt, a blocking mechanism for preventing movement of said actuator from an inactive to an active position, the improvement wherein said blocking mechanism comprises

a plurality of movable tumblers mounted upon a movable support plate, said support plate being movable so as to successively align said tumblers with at least one tumbler setting positioner so that said tumblers may be set according to a predetermined permutation by said positioner, and

tumbler engageable stops cooperable with said tumblers, said stops being positioned so as to permit said bolt actuator to be moved from an inactive to an active position whenever all of said tumblers are positioned according to said predetermined permutation.

7. A push button combination lock having a bolt movable between locked and unlocked positions and a bolt actuator for moving said bolt between said positions, said actuator being movable between an active position in which it is operably coupled to said bolt and an inactive position in which it is operatively uncoupled from said bolt, and blocking mechanism for preventing movement

of said actuator from an inactive to an active position, the improvement wherein said blocking mechanism comprises

a plurality of movable tumblers alignable with a group of tumbler setting elements, each of said elements being operatively connected to a single one of a group of push buttons, said push buttons being fewer in number than said tumblers so that each of said push buttons is operable to successively position a plurality of said tumblers according to a predetermined permutation, said push buttons being coded according to a binary coding system so as to facilitate setting of a group of said tumblers with each numeral of the permutation, and

tumbler engageable stops cooperable with said tumblers after said tumblers have been properly positioned according to said predetermined permutation, said stops being positioned so as to permit said bolt actuator to be moved from an inactive to an active position whenever all of said tumblers are positioned according to said predetermined permutation.

8. A combination lock having a bolt movable between locked and unlocked positions and a bolt actuating mechanism for moving said bolt between said positions, said lock including blocking mechanism operable to preclude said bolt from being moved from an unlocked to a locked position until said blocking mechanism has been properly conditioned, the improvement wherein said blocking mechanism comprises

a plurality of binary condition tumblers, each of which must be positioned according to a predetermined schedule in order for said actuating mechanism to move said bolt from a locked to an unlocked position, means mounting each of said tumblers for movement from a neutral position to one of two active positions during each operational cycle of said combination lock,

at least one tumbler positioner for moving each of said tumblers from a neutral position to one of said active positions during each operational cycle of said lock, and

means cooperable with said tumblers after said tumblers have all been properly conditioned according to said predetermined schedule to permit said bolt to be moved from a locked to an unlocked position.

9. The combination lock of claim **8** which further includes means for simultaneously moving all of said tumblers to a neutral position.

10. The combination lock of claim **8** wherein each of said tumblers is mounted upon a pivot post and is movable in either a clockwise or counterwise direction from said neutral position.

11. A combination lock having a bolt movable between locked and unlocked positions and a bolt actuator for moving said bolt between said positions, said actuator being movable between an active position in which it is operably coupled to said bolt and an inactive position in which it is operatively uncoupled from said bolt, a blocking mechanism for preventing movement of said actuator from an inactive to an active position, the improvement wherein said blocking mechanism comprises

a plurality of movable tumblers mounted upon a movable support plate, said support plate being movable so as to successively align groups of said tumblers with a plurality of tumbler setting positioners so that said tumblers may be set in groups by said positioners according to a predetermined permutation, and

means cooperable with said tumblers and operable to permit said bolt actuator to be coupled to said bolt only after all of said tumblers have been positioned according to said predetermined permutation.

12. The combination lock of claim **8** wherein said tumbler cooperable means comprises a plurality of sets of stop pins arranged in pairs, each pair of stop pins being operative to determine the combination of one of the tumblers.

13. The combination lock of claim **8** wherein said tumbler cooperable means comprises a plurality of stop pins, each of said pins being settable in at least two different positions, the settings of said pins determining the combination of the lock.

14. The combination lock of claim **10** wherein each of said pins has a pair of axially spaced slots adapted to receive a transversely slidable locking plate, said plate being movable to one position out of engagement with the slots of said pins to release said pins for the setting of a new combination into the lock and movable to another position in which a portion of said plate resides within one of the slots of each of said pins to lock said pins against movement after a new combination has been set into the lock.

15. The combination lock of claim **8** wherein said tumbler support plate is mounted for rotation upon a support shaft, said shaft being drivably connected to a combination lock dial.

16. The combination lock of claim **12** wherein said tumbler setting positioners comprise a plurality of manually actuatable push buttons.

17. The method of operating a combination lock so as to enable a bolt of the lock to be opened after the lock tumblers have been positioned in accordance with a predetermined schedule, said lock having a multiplicity of binary tumblers arranged in groups, which method comprises the steps of sequentially

positioning an indicia bearing member at a location indicative of the location of one group of the groups of tumblers at a tumbler setting station,

actuating a plurality of push buttons so as to position that group of tumblers located at the station in accordance with a predetermined schedule,

repositioning the indicia bearing member so as to locate a second group of tumblers at said tumbler setting station, and

actuating said push buttons so as to position said second group of tumblers in accordance with the predetermined schedule.

18. The method of claim **1** which further comprises the steps of repeating the positioning of said indicia bearing member and actuating said push buttons until all of the groups of tumblers have been set in accordance with the predetermined schedule.

19. The method of claim **1** in which the indicia setting member is a dial and which further comprises the step of moving said dial axially after all of the groups of tumblers of said lock have been positioned according to the predetermined scheduled so as to operably connect a bolt actuating member with the bolt of the lock, and

rotating the dial of the lock so as to open the lock bolt.

References Cited

UNITED STATES PATENTS

3,343,385 9/1967 Marti et al. ---------- 70—313

MARVIN A. CHAMPION, *Primary Examiner.*

R. L. WOLFE, *Assistant Examiner.*