

July 9, 1968

G. R. SCHULL
COMBINATION LOCK

3,391,556

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2 Sheets-Sheet 1

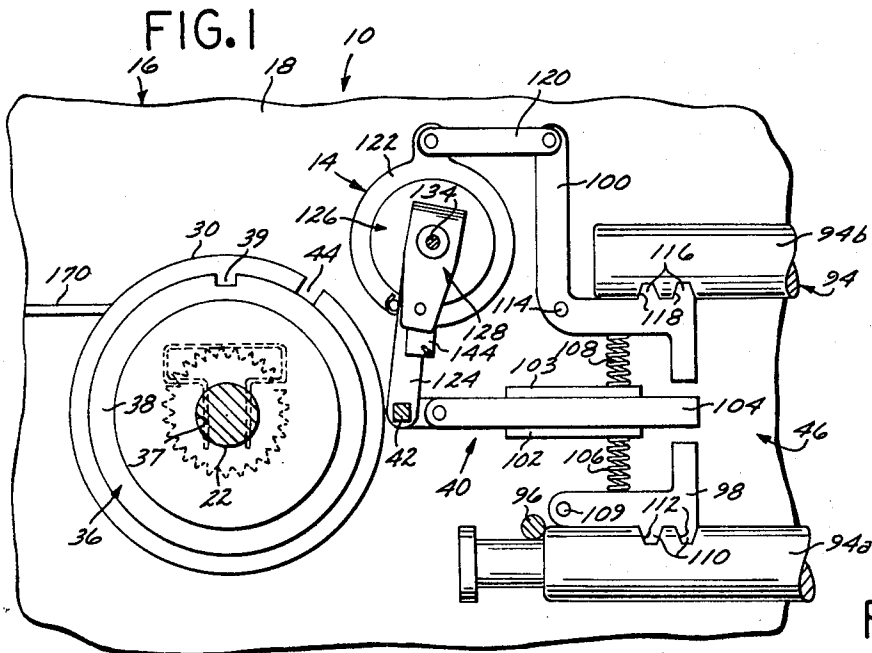
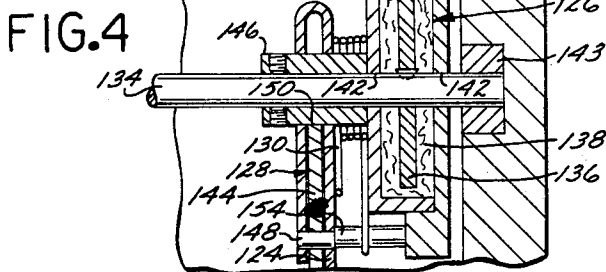
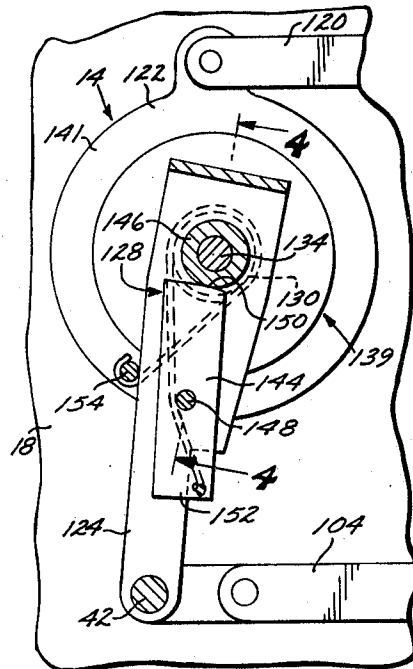
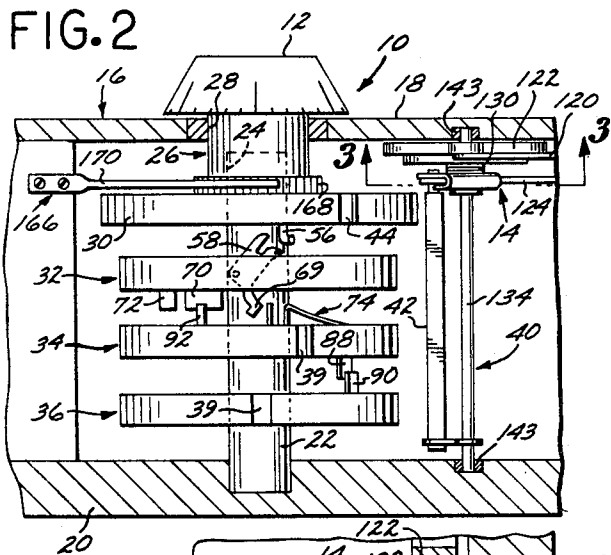


FIG. 3



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FIG. 7

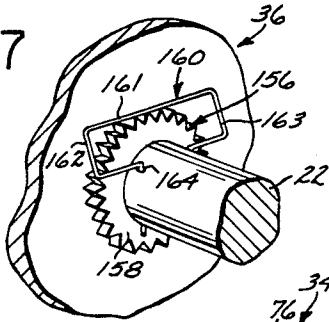


FIG. 5

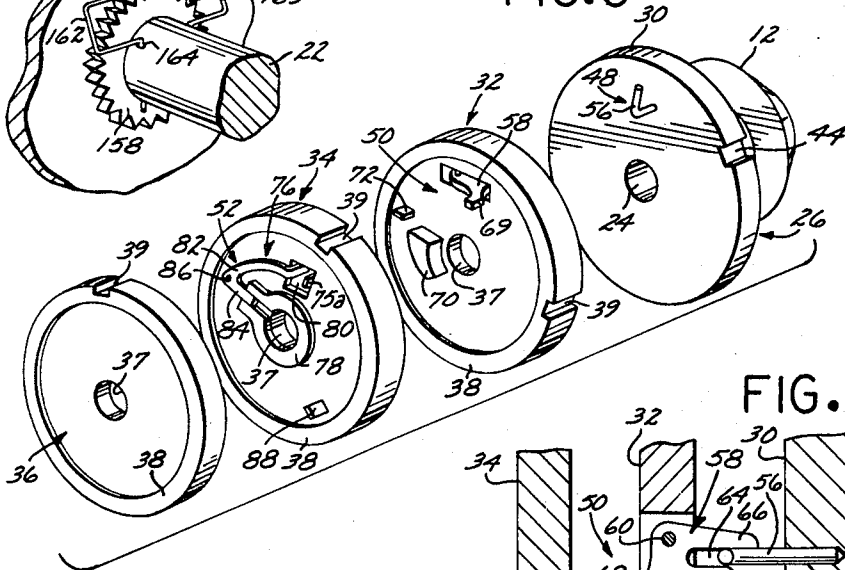


FIG. 8

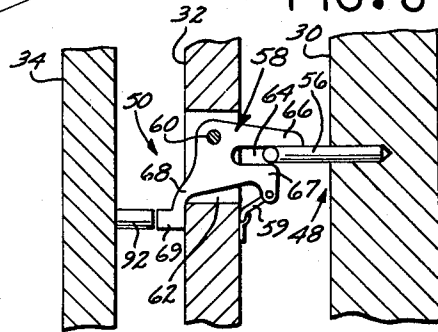


FIG. 6

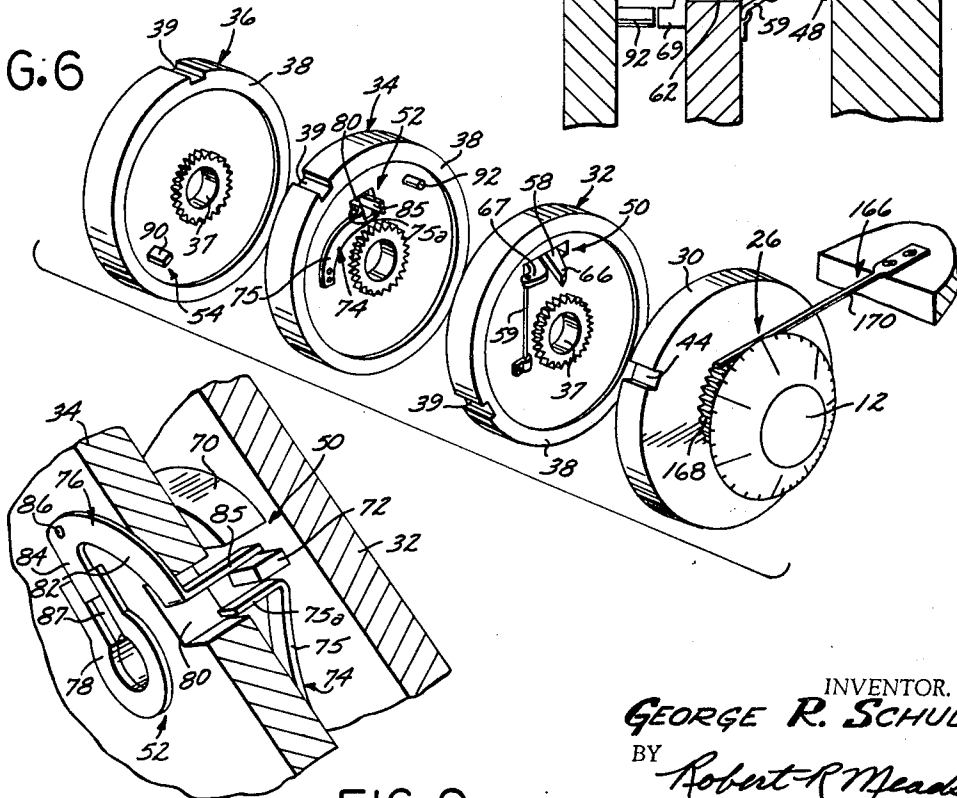


FIG. 9

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3,391,556

COMBINATION LOCK

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 16 Claims. (Cl. 70-268)

ABSTRACT OF THE DISCLOSURE

A single dial combination lock including a silent time delay mechanism which prevents the lock from opening for a predetermined period of time after each attempt to open the lock using an improper combination and comprising a plurality of driven tumblers and a dial carrying drive member for turning relative to a support shaft for the tumblers and each including cooperative means which permit the lock to be opened by turning the dial in opposite directions less than one full rotation directly to successive numbers of the combination for the lock.

The present invention relates to improvements in combination locks and, more particularly, to a novel single dial combination lock which may be opened by turning a dial in opposite directions less than one full rotation directly to successive numbers of the combination for the lock.

Commercially available, single dial combination locks are designed to handle a large number of possible combinations, only one of which will open the lock, and employ complicated and time consuming opening procedures in an attempt to reduce their chances of being opened on a trial and error basis by unauthorized personnel. For example, a typical combination for such a lock may include three or four two-digit numbers followed by the number double zero (00) which must be dialed exactly and in sequence to open the lock. Moreover, prior to setting the dial on the successive numbers in such a combination, the dial must be turned to pass over the successive numbers a predetermined and usually a decreasing number of times.

If there is even a fractional error in positioning the dial on any number in the combination or if the foregoing dialing procedure is not exactly followed, the lock will not open and the entire process must be repeated. This, of course, is the intended result for unauthorized personnel trying to operate the lock on a trial and error basis. However, the same result often occurs for authorized personnel and requires that they exercise painstaking care in opening the combination lock to avoid having to repeat the entire opening operation. Needless to say, this is very annoying to authorized personnel particularly when they are anxious to gain access to the receptacle locked by the combination lock.

In addition to employing complicated and time consuming opening procedures, conventional single dial combination locks incorporate complex internal mechanisms which are expensive to manufacture and service.

Furthermore, in the case of padlocks, such combination locks may be opened by external inertial means capable of imparting rotary impulse to the housing of the padlock. In particular, such combination locks generally include a plurality of driven tumblers supported for turning on a shaft. The tumblers each include a slot for receiving a movable gate when aligned therewith. By proper turning of the dial to the numbers in the combination for the lock and by following the foregoing opening procedures, the tumblers are selectively positioned with the slots aligned with the gate to permit its closure and entry into the slots and an accompanying

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opening of the lock. Unfortunately, the tumblers may also be turned by the inertial means to individually bring the slots into alignment and engagement with the gate when partially closed thereby permitting an unauthorized opening of the padlock without employing the combination.

In view of the foregoing shortcomings of conventional single dial combination locks, it is an object of the present invention to provide a single dial combination lock which may be rapidly and simply opened by authorized personnel without sacrificing security against opening by unauthorized personnel on a trial and error basis.

Another object of the present invention is to provide a single dial combination lock which employs a simplified opening procedure, that is a lock which may be opened by turning a dial directly to successive numbers in the combination for the lock rather than a predetermined number of times past each number before stopping it.

A further object of the present invention is to provide a combination lock of the foregoing character including a time delay mechanism which prevents the lock from opening for a predetermined period of time after each attempt to open the lock using an improper combination.

Still another object of the present invention is to provide an improved combination lock of the foregoing character including means for preventing fractional errors in the dialing of each number in the combination for the lock.

A still further object of the present invention is to provide a single dial combination lock which resists opening by external inertial means.

Still another object of the present invention is to provide an improved combination lock including a plurality of driven tumblers and a dial carrying drive member for turning relative to a support shaft for the tumblers and each including cooperative means which permit the lock to be opened by turning the dial in opposite directions less than one full rotation directly to successive numbers in the combination for the lock.

A still further object of the present invention is to provide an improved combination lock of the foregoing character wherein the plurality of driven tumblers each carries registrable means for registering with a lock releasing means whereby the lock may be opened when each registrable means is in registry with the lock releasing means and wherein the cooperative means on the drive member and driven tumblers is adapted to first releasably lock the driven tumblers to the drive member to turn therewith in a first direction and to thereafter selectively release different predetermined ones of the driven tumblers from the drive member upon each reversal of the direction of rotation of the drive member to selectively set the rotational position of each tumbler on the support shaft with its registrable means in registry with the lock releasing means within one full rotation of the drive means.

Still another object of the present invention is to provide an improved combination lock of the foregoing character including a detent mechanism on each driven tumbler for releasably locking the tumblers to the support shaft in rotational positions corresponding to whole numbers in the array of possible numbers for the lock's combination upon their release from the drive member, and for preventing the tumblers from thereafter being turned by rotational impulses from an external inertial means.

The foregoing as well as other objects and advantages of the present invention may be more clearly understood by reference to the following detailed description when considered with the drawings which, by way of example

only, illustrate one form of combination lock incorporating the features of the present invention.

In the drawings:

FIG. 1 is a fragmentary rear view partially in section, of a portion of the combination lock including the driven tumblers and drive member, silent time delay mechanism, and lock releasing means;

FIG. 2 is a fragmentary sectional top view of a portion of the combination lock including the driven tumblers on the support shaft and the dial carrying drive member adjacent the lock releasing means and silent time delay mechanism;

FIG. 3 is a fragmentary sectional rear view of the silent time delay mechanism taken along the line 3—3 in FIG. 2;

FIG. 4 is a fragmentary sectional view of a portion of the silent time delay mechanism taken along the line 4—4 in FIG. 3;

FIG. 5 is an exploded rear perspective view of the driven tumblers and the dial carrying drive member;

FIG. 6 is an exploded front perspective view of the driven tumblers and the dial carrying drive member;

FIG. 7 is a fragmentary perspective view of the detent mechanism for one of the driven tumblers designed to prevent fractional errors in dialing the combination for the lock;

FIG. 8 is a fragmentary sectional top view of the cooperative means on the drive member and the driven tumbler adjacent thereto for releasably connecting the drive member to the driven tumbler; and

FIG. 9 is a fragmentary top perspective view of the cooperative means on second and third ones of the driven tumblers for releasably connecting the tumblers upon a turning of the drive member in a first direction.

The combination lock of the present invention may be fixably secured in the door of a cabinet, safe or other receptacle or may take the form of a padlock such as utilized to lock filing cabinets and the like. Accordingly, it is by way of illustration only that the combination lock is shown in the drawings as being a padlock and represented generally by the numeral 10.

Generally speaking, the combination lock 10 is adapted for opening by direct turning of a dial 12 to each of the successive numbers in the combination for the lock rather than by turning of the dial a varying number of turns past each number before stopping on it. The operation of the combination lock 10 is therefore much simpler and quicker than conventional single dial combination locks.

For example, if the lock 10 has a three-number combination it may be cleared or preset by turning the dial 12 in a clockwise direction for three or more turns before stopping on the first number of the combination. The dial is then turned counterclockwise directly to the second number of the combination, then again clockwise directly to the third number of the combination, and finally counterclockwise to a reference number such as 00 whereupon the hasp or shackle of the lock may be pulled to immediately open the combination lock.

The foregoing procedure is simple, straight forward and much quicker than the complex opening procedures associated with conventional single dial combination locks. Moreover, the simplicity and speed of opening of the lock 10 are not gained at the expense of security against opening by unauthorized personnel on a trial and error basis. In particular, if the correct sequence of numbers in the lock's combination is not properly dialed, as when an unauthorized person is attempting to open the combination lock 10 on a trial and error basis, a pulling on the hasp or shackle of the lock operates a silent time delay mechanism 14 which prevents the lock from opening for a predetermined period of time. Each attempt to open the lock with an incorrect combination resets the time delay mechanism such that the predetermined time must elapse after the last attempt to open the lock with

an incorrect combination before the lock will open in response to the dialing of the correct combination.

More particularly, the illustrated form of the combination lock 10 incorporating the foregoing direct dialing and silent time delay lockout features comprises a hollow housing 16 including substantially parallel front and rear walls 18 and 20. A stationary shaft 22 is fixed to the rear wall and extends forward into a cavity 24 in a hand turnable drive member 26. The drive member 26, in turn, is supported for turning in an opening 28 in the front wall 18 and carries the dial 12 outside the housing 16 for hand turning of the drive member.

The dial 12 is frusto-conical in shape with its outer annular surface carrying a plurality of equally spaced divisions each corresponding to a different rotational position for the drive member 26 relative to the stationary shaft 22 and each corresponding to a different possible number in the combination for the lock. In this regard, the outer face of the front wall 18 may carry a pointer adjacent the dial 12 and each division on the dial may carry or be associated with a different number. Thus, a turning of the dial 12 relative to the shaft 22 brings the various divisions under the pointer. When the dial is stopped with a particular division aligned with the pointer, the dial is said to be set on the number associated with the division.

Within the housing 16, the drive member 26 carries a drive disc 30 for turning with the dial 12 relative to the stationary shaft 22. The drive disc 30 is adapted to control and selectively set the rotational position of a plurality of driven tumblers 32, 34 and 36 on the stationary shaft 22.

There is a separate driven tumbler for each number in the combination for the lock 10. Accordingly, in the illustrated form of the lock 10 having a three-number combination, there are three driven tumblers. The tumblers are preferably of a disc-shaped construction having central holes 37 for receiving the stationary shaft 22 and include flanged outer edges 38 carrying registrable means 39 for registering with a lock releasing means 40 to render the lock operable. By way of example only, the registrable means 39 are illustrated as comprising a radial slot in the outer edge of each driven tumbler and the lock-releasing means 40 as including a slot bar 42. The slot bar 42 is adapted to move into the slots 39 when they, as well as a slot 44 in the drive disc 30, are aligned with each other under the slot bar, the slot 44 being in alignment when the dial 12 is set on a predetermined reference number such as the number 00. When the slot bar 42 moves into slots 39, the lock 10 is opened by operation of the balance of lock-releasing means including a conventional shackle mechanism 46 which will be described in detail later.

As previously indicated, in the combination lock 10, it is the function of the drive disc 30 to successively rotate and position the driven tumblers on the shaft 22 with the slots 39 in registry with the slot bar 42 in response to a turning of the dial 12 directly to successive numbers in the combination for the lock. To accomplish this, the drive disc 30 and drive tumblers 32, 34, and 36 include cooperative coupling means 48, 50, 52, and 54, respectively. Generally speaking, the cooperative means are designed to (1) connect successive ones of the driven tumblers to the drive disc upon successive full rotations of the drive disc in a clockwise direction (a full rotation for each tumbler) and (2) thereafter to release the driven tumblers from the drive disc in reverse order and with their slots 39 in registry with the bar 42 in response to direct settings of the dial 12 on successive numbers in the lock's combination and successive reversals of the direction of dial turning between settings.

Thus, for example, the cooperative means 48, 50, 52 and 54 are designed to connect all the driven tumblers to the drive disc 30 within three full rotations of the dial 12 in a clockwise direction. Clockwise turning of the dial

is continued until the dial reaches the first number in the combination. The dial is stopped on the first number and then turned in a counterclockwise direction directly to the second number in the combination. As the direction of rotation of the dial is reversed from clockwise to counterclockwise, the tumbler associated with the first number is disconnected from the drive disc 30 in a rotational position with its slot 39 in registry with the bar 42. After the dial 12 is set on the second number, the dial is turned in a clockwise direction directly to the third number. As the direction of rotation of the dial is reversed from counterclockwise to clockwise, the tumbler associated with the second number is disconnected from the drive disc in a rotational position with its slot 39 in registry with the slot bar. After setting the dial on the third number, the dial is turned in a counterclockwise direction to the reference number, here 00. As the direction of rotation of the dial is changed from clockwise to counterclockwise, the tumbler associated with the third number is disconnected from the drive disc and remains in a rotational position with its slot 39 in registry with the slot bar. With the dial 12 on the reference number, the slots 39 and 44 are all in registry with the slot bar 42 and the lock 10 may be opened by moving the bar into the aligned slots.

More particularly, in the illustrated form of the lock 10, the cooperative coupling means 48 comprises a drive lug 56 connected to and extending rearwardly from a rear face of the drive disc 30 and adapted to releasably connect to a portion of the cooperative coupling means 50 on the driven tumbler 32.

The portion of the cooperative coupling means 50 for releasably connecting to the drive lug 56 comprises a toggle plate 58 and a spring arm 59. The toggle plate 58 is supported on a radially extending pivot pin 60 within an elongated opening 62 extending through the driven tumbler 32. The toggle plate 58 includes a slot 64 and a forward end portion defining axially extending fingers 65 and 67 along the right and left side of the slot 64 when viewed from the front. The finger 66 extends forward beyond the finger 67 which in turn is connected to an upper end of the spring arm 59, a lower end being secured to the forward face of the driven tumbler 32.

Thus arranged, the spring arm 59 continuously exerts a clockwise rotational force on the toggle plate 58 about the pivot pin 60 to urge the toggle plate to the position illustrated most clearly in FIGS. 2 and 6 with a rear portion of the toggle plate extending rearwardly beyond the driven tumbler 32. In this regard, the rear portion of the toggle plate 58 includes a rearwardly extending leg 68 terminating in a foot 69 facing the front surface of the driven tumbler 34.

In operation and to releasably connect the driven tumbler 32 to the drive disc 30, the drive disc is turned in a clockwise direction by a manual turning of the dial 12. Within one full rotation of the dial, the drive lug 56 engages the finger 66 causing the toggle plate 58 to rotate in a counterclockwise direction on the pivot pin 60 and to thereby capture the drive lug within the slot 64. Further turning of the drive disc 30 in the clockwise direction produces a like turning of the driven tumbler 32.

Continued turning of the driven tumbler 32 in a clockwise direction causes a portion of the cooperative coupling means 50 to releasably connect to a portion of the cooperative coupling means 52 on the driven tumbler 34 such that further turning of the driven tumbler 32 in a clockwise direction produces a like turning of the driven tumbler 34.

The portion of the coupling means 50 for releasably connecting to the cooperative coupling means 52 comprises an arcuate pawl cam 70 and a drive lug 72 fixed to and extending rearwardly from a rear face of the driven tumbler 32. As illustrated most clearly in FIGS. 5 and 9, the curved periphery of the pawl cam 70 increases in

radial dimension relative to the axis of the support shaft 22 as the driven tumbler 32 turns in a clockwise direction and the drive lug 72 is located radially outward from and follows the pawl cam 70 as the driven tumbler 32 is turned in a clockwise direction.

The portion of the cooperative coupling means 52 for releasably connecting to the drive lug 72 comprises a spring-loaded engaging lug 74, a drive lug pawl 76, and a friction ring 78 (see FIGS. 5, 6 and 9).

The spring-loaded engaging lug 74 comprises a generally L-shaped spring member having a leg 75 connected at one end to a forward face of the driven tumbler 34 and transversing an arcuate path along and curving outward from a forward face of the driven tumbler with a foot 75a extending rearwardly and into an opening 80 through the driven tumbler.

The drive lug pawl 76 comprises a bent piece of metal including long and short legs 82 and 84 and a foot 85 extending from the leg 82. The pawl 76 is pivotally connected at a junction of the legs 82 and 84 by an axially extending pivot pin 86 to a rear face of the driven tumbler 34 with the leg 82 curving along the rear face of the driven tumbler, the foot 85 extending forwardly into and through the opening 80 on a side opposite the foot 75a and the leg 84 extends radially inward into an opening 87 in the friction ring 78.

The friction ring 78 is stationed along the rear surface of the driven tumbler 34, makes a tight friction contact with the stationary shaft 22 and tends to remain stationary therewith upon a turning of the driven tumbler 34 relative thereto. Thus, with movement of the driven tumbler 34 in a clockwise direction, the friction ring 78 engages the leg 84 of the drive lug pawl 76 and causes the drive lug pawl to rotate in a counterclockwise direction on the pivot pin 86 (when viewed from the rear) and the foot 85 to move radially outward within the opening 80. Conversely, when the driven tumbler 34 is turned in a counterclockwise direction on the support shaft 22, the friction ring 78 engages the leg 84 and produces a clockwise rotation of the drive lug pawl 76 (when viewed from the rear) and movement of the foot 85 radially inward within the opening 80.

Accordingly, to releasably connect the driven tumbler 34 to the driven tumbler 32, the dial 12 is turned in a clockwise direction. Within one full rotation of the dial after the driven tumbler 32 has been connected to the drive disc 30, the drive lug 72 depresses the spring-loaded engaging lug 74. Continued turning of the driven tumbler 32 causes the outer arcuate surface of the pawl cam 70 to engage the under surface of the foot 85 of the drive lug pawl 76. As the pawl cam 70 moves under the foot 85, it forces the foot outwardly and causes the drive lug pawl 76 to rotate in a counterclockwise direction on the pin 86 (when viewed from the rear). This operation of the pawl cam 70 on the drive lug pawl 76 may be termed setting the drive lug pawl in a "connect position" whereas movement of the pawl 76 radially inward may be termed setting the drive lug pawl in a "disconnect position." Once the drive lug pawl 76 is in the connect position, further turning of the driven tumbler 32 causes the drive lug 72 to engage the foot 85 producing a like turning of the driven tumbler 34 in a clockwise direction, the drive lug 72 being captured between the foot 85 and the spring-loaded engaging lug 74.

Continued turning of the dial 12 in a clockwise direction causes an additional portion of the cooperative coupling means 52 to engage the cooperative coupling means 54 on the driven tumbler 36 to effect a clockwise turning of the driven tumbler 36 within a full rotation of the dial after connection of the driven tumbler 34 to the driven tumbler 32. The portion of the cooperative coupling means 52 for connecting to the cooperative coupling means 54 comprises a drive lug 88 connected to and extending rearwardly from a rear face of the driven tumbler 34. The cooperative coupling means 54 comprises a similar

driven lug 90 connected to an extending forward from a forward face of the driven tumbler 36. The drive lug 33 is adapted to engage the driven lug 90 and to produce a clockwise turning of the driven tumbler 36 within one full rotation of the driven tumbler 34.

Accordingly, in the illustrated form of the lock 10, the cooperative coupling means 48, 50, 52, and 54 are designed such that the driven tumblers 32, 34, and 36 are successively locked to the drive disc 30 upon successive full rotations of the drive disc in a clockwise direction. Furthermore, the cooperative coupling means are designed to thereafter release the driven tumblers 36, 34 and 32, respectively, from the drive disc 30 upon successive reversals of the direction of rotation of the drive disc. Moreover, if the dial 12 is stopped on the successive numbers in the combination between the reversals in the direction of rotation of the dial, the driven tumblers are set on the shaft 22 with their slots 39 in registry with the slot bar 42 to render the lock openable.

In this manner, the cooperative coupling means permit the lock to be opened by turning the dial 12 directly to the successive numbers in the combination for the lock rather than requiring the dial to be turned a predetermined number of turns over each number before stopping on it.

In particular, after the dial 12 has been turned through three complete revolutions in a clockwise direction to connect the driven tumblers 32, 34 and 36 to the drive disc 30, the dial is stopped at the first number in the combination for the lock bringing the slot 39 in the driven tumbler 36 into registry with the slot bar 42.

The dial 12 is then turned in a counterclockwise direction less than one full revolution directly to the second number in the combination. As the dial is turned counterclockwise, the drive lug 56 bears on the finger 67 of the toggle plate 58. Normally, this would cause the toggle plate 58 to turn in a clockwise direction on the pivot pin 60 and the drive lug to disconnect from the toggle plate. However, when the driven tumbler 32 is connected to the driven tumbler 34, a blocking member or pedestal 92 extending forward from the front of the driven tumbler 34 is directly behind and engages the foot 69 to prevent the toggle plate 58 from turning (see FIG. 8). Thus the driven tumbler 32 turns in a counterclockwise direction with the dial.

As the driven tumbler 32 turns counterclockwise, the drive lug 72 bears on the spring-loaded engaging lug 74 to cause the driven tumbler 34 to turn therewith and the drive lug 88 to separate from the driven lug 90 leaving the driven tumbler 36 in place on the stationary support shaft 22 with the slot 38 in registry with the slot bar 42.

As the driven tumbler 34 is turned in a counterclockwise direction, the friction ring 78 functions in the previously described manner to cause the drive lug pawl 76 to move to the disconnect position. Accordingly, as the dial 12 is set on the second number of the combination, the slot 39 in the driven tumbler 34 is in registry with the slot bar 42 and the drive lug pawl 76 is in the disconnect position to permit a subsequent free turning of the driven tumbler 32 with the dial in a clockwise direction independent of the driven tumbler 34. In particular, as the dial 12 is turned clockwise directly to the third number of the combination, the drive lug 56 again bears on the finger 66 of the toggle plate 58 to drive the driven tumbler 32 clockwise. As this occurs, the drive lug 72 passes over the drive lug pawl 76 and the driven tumbler 34 remains on the stationary shaft 22 with its slot 39 in registry with the slot bar 42.

When the dial 12 is set on the third number in the combination, the slot 39 in the driven tumbler 32 is in registry with the slot bar 42 thus bringing all the slots 39 into registry with the lock-releasing means 40. Therefore, to place the combination lock 10 in an openable

position, it is only necessary to turn the dial 12 counterclockwise to the reference number 00.

As the dial is turned counterclockwise to the number 00, the drive lug 56 moves out of the slot 64 in the toggle plate 58 and the toggle plate rotates in a clockwise direction on the pivot pin 60 under the influence of the spring arm 59, the pedestal 92 no longer engaging the foot 69 to prevent such clockwise turning of the toggle plate. The driven tumbler 32 therefore remains stationary on the shaft 22 with its slot 39 in registry with the slot bar 42 and movement of the dial 12 to the number 00 aligns the slot 44 with the slot bar 42 permitting the lock 10 to be opened by moving the slot bar 42 into the aligned slots.

In the illustrated form of the combination lock 10, the slot bar 42 is moved into the aligned slots 39 and 44 by pulling on a U-shaped shackle 94 of the shackle mechanism 46. The shackle mechanism 46 is of a form commonly employed in padlocks and in addition to the shackle 94 comprises a shackle pin 96, a pair of shackle locking members 98 and 100, a pair of stationary guides 102, 103 for a locking pin 104, and a pair of coil springs 106 and 108 for urging the locking members against opposite legs 94a and 94b of the shackle 94 to hold the shackle in a locked position.

In regard to the latter, the locking member 98 is L-shaped and connected by a pivot pin 109 for swinging movement normal to the leg 94a of the shackle 94 with a foot 99 facing the locking pin 104. The coil spring 106 presses on the guide 102 and the member 98 to normally hold the member against the leg 94a with a pair of projections 110 seated in a pair of similar recesses or slots 112 in the leg.

In a similar manner, the locking member 100 is shaped like a bent leg connected at its knee by a pivot pin 114 for swing movement normal to the leg 94b of the shackle 94 and with a foot 101 facing the locking pin 104. The coil spring 108 presses against the guide 103 and the locking member 100 to normally hold the lower leg portion of the member against the leg 94b of the shackle with a pair of projections 116 seated in a pair of similar recesses or slots 118 in the leg 94b.

The end of the leg 100 opposite the foot 101 is connected by a link 120 to a rotational housing 122 of the time delay mechanism 14 while the locking pin 104 is connected to the slot bar 42 and in turn to a support arm 124 in the time delay mechanism.

Thus arranged, when the combination lock is ready for opening, that is when the slots 39 and 44 are aligned with the slot bar 42, outward pulling on the shackle 94 to the right produces a rotation of the shackle locking members 98 and 100 inwardly toward each other about their associated pivot pins. The rotation of the member 100 pulls the link 120 to the right to rotate the main body 122 in a clockwise direction. This in turn causes the slot bar 42 to move into the aligned slots and the locking pin 104 to move to the left permitting the feet of the locking members to move inwardly against each other. As this occurs, the projections 110 and 116 move out of their associated slots 112 and 118 permitting the shackle 94 to move outwardly and the lock to be opened. The shackle pin 96 limits outward movement of the shackle leg 94a relative to the housing 16 and prevents complete separation of the shackle from the lock 10.

When an improper combination has been dialed for the lock 10, a pulling on the shackle 94 does not produce an opening of the lock but rather sets the time delay mechanism 14 which then prevents the lock from opening for a predetermined period of time. In particular, as the shackle 94 is pulled to the right, the locking members 98 and 100 are rotated inward a short distance and the housing 122 is turned in a clockwise direction (when viewed from the rear). The slot bar 42, however, is blocked by the periphery of at least one of the driven tumblers from entering the slots 39 and 44. Therefore, the locking pin 104 remains in place and limits further inward movement

of the feet of the members 98 and 100 and prevents the projections 110 and 116 from disengaging and the lock from opening. The turning of the housing 122 relative to the slot bar 42 and support arm 124 also sets the time delay mechanism 14.

In this regard, the time delay mechanism 14 basically comprises a dashpot 126, a unidirectional drive coupling means 128, and a spring 130 arranged such that the slot bar 42 will move into the aligned slots 39 and 44 upon a pulling on the shackle mechanisms 46 without setting the time delay mechanism. However, if the slot bar 42 is prevented from moving into the slots as by misalignment of one of the slots, an attempt to open the shackle mechanism 46 by a pulling thereon moves the dashpot 126 with the shackle mechanism and stores energy in the spring 130 to slowly return the shackle mechanism to its original position against operation of the dashpot. The time required for the spring 130 to return the shackle mechanism 46 to its original position against operation of the dashpot 126 is the time delay introduced by the time delay mechanism 14 into the operation of the combination lock 10. Each time the shackle mechanism 46 is pulled when the slots in the drive disc 30 and driven tumblers 32, 34 and 36 are not in alignment with the slot bar 42, the dashpot 126 again moves with the shackle mechanism to reset the time delay mechanism 14 and to restore energy in the spring 130 which upon release of the shackle mechanism again commences the slow return of the shackle mechanism to its original position against operation of the dashpot.

In the preferred form of a time delay mechanism 14, the dashpot 126 is a rotary dashpot and the unidirectional drive coupling means 128 is a rotary drive coupling means.

In this regard, the dashpot 126 includes a chamber 132 in the main body 122, a drag shaft 134, a drag disc 136, and a quantity of viscous damping material 138 filling the chamber 132. The chamber 132 is formed by a cup 139 seated in a circular recess 140 in the rear face of a mounting plate 141 for the main body 122, the plate like the cup including an opening 142 for receiving the drag shaft 134. The drag shaft 134, in turn, extends freely through the openings 142 and is supported at opposite ends by bearings 143 seated in the front and rear walls 18 and 20 of the housing 16 parallel to the stationary shaft 22. Within the chamber 132, the drag shaft 134 supports the perforated or nonperforated drag disc 136 for turning in the quantity of damping material 138 which, by way of example, may be a very heavy grease having a high melting point or such commercially available materials as "Dow-Corning DC-4" or "Silly Putty." Capillary attraction prevents such viscous material from leaking around the drag shaft 134 so that no seal is required between the chamber 132 and the shaft. Thus arranged, the drag shaft 134 is free to rotate relative to the housing 16 and the main body 122 may turn on and relative to the drag shaft with the drag disc 136 turning in and against the damping material 138 in the chamber 132. In this respect, the friction between the drag disc 136 and material 138 is such that the drag disc and drag shaft 134 will turn with the main body 122, as when the link 120 is pulled during an attempt to open the lock, unless prevented by independent and external means.

Further, in the preferred form of the time delay mechanism 14, the unidirectional drive coupling means 128 comprises the support arm 124 and a locking arm 144. The support arm 124 is connected for turning on a metal sleeve 146 fixably secured to the drag shaft 134 adjacent the main body 122 with one end being connected to the slot bar 42 and to the locking pin 104 of the shackle mechanism 46. The locking arm 144 is connected by a pivot pin 148 to the support arm with a curved cam end 150 bearing on the sleeve 146 and an opposite end 152 connected to one end of the spring 130.

The spring 130 passes over a side of the pivot pin 148 facing the driven tumblers and coils around the sleeve 146 to connect to a stop pin 154. The stop pin 154 extends rearwardly from the mounting plate 141 of the main body 122 and acts as a stop for limiting movement of the support arm 124 toward the driven tumblers independent of rotation of the main body on the drag shaft 134. Thus arranged, the spring 130 continuously urges the locking arm 144 in a clockwise direction (when viewed from the rear) around the pivot pin 148 with the cam end 150 bearing tightly against the sleeve 146. Accordingly, movement of the link 120 to the right (when viewed in FIGS. 1 and 3) produces a clockwise turning of the main body 122 with the drag shaft 134 and produces a like clockwise turning of the support arm 124 with the drag shaft, the support arm 124 being held in contact with the stop pin 154 by the spring 130.

Although the connection of the spring 130 to the locking arm 144 urges the cam end 150 tightly against the sleeve 146 to cause the support arm 124 to turn in a clockwise direction with the drag shaft 134 in response to a clockwise turning of the main body 122, the locking arm and support arm are free to turn against the spring torque in a counterclockwise direction relative to the drag shaft. As this occurs, energy is stored in the spring 130 tending to oppose such a counterclockwise turning of the support arm 124.

Accordingly, in the unidirectional drive coupling means 128, the support arm 124 is adapted for turning with the drag shaft 134 in a clockwise direction (when viewed from the rear) and is adapted to move independently of the drag shaft in a counterclockwise direction. This means that when the slot bar 42 is prevented from moving fully into the slots 39 and 44 (as when all of the slots are not in alignment due to the dialing of an improper combination for the lock), an attempt to open the lock by a pulling on the shackle 94 will produce a counterclockwise turning of the support arm 124 relative to the drag shaft 134. That is, movement of the link 120 to the right (FIGS. 1 and 3) produces a clockwise turning of the main body 122 and a similar turning of the drag shaft 134 therewith relative to the support arm 124, the support arm being held stationary by the slot bar 42 bearing against the periphery of one of the driven tumblers. As this occurs, the spring 130 is extended and energy stored therein. The spring 130 then functions as before to urge the cam end 150 tightly against the sleeve 146. Therefore, when the clockwise turning of the main body 122 is terminated, the locking arm 144 is locked tightly to the sleeve 146 and hence to the drag shaft 134 in a manner similar to that of a pipe wrench. The force of the spring 130 then slowly turns the support arm 124, locking arm 144, and a drag shaft 134 in a clockwise direction (when viewed from the rear) with the viscous damping material 138 retarding the rate of motion of the drag disc 136 and locking and support arms. These continue to turn in the clockwise direction under influence of the spring 130 until the support arm 124 engages the stop pin 154.

The time required for the support arm 124 to return essentially to its original position against the stop pin 154 represents the time during which the time delay mechanism 14 prevents opening of the combination lock after each attempt to open the lock employing an improper combination. In this respect, each pull on the link 120 to rotate the main body 122 in a clockwise direction without the slot bar 42 being in alignment with all slots 39 and 44, resets the time delay mechanism 14 such that the full time delay must elapse after an abortive attempt to open the combination lock before the lock is able to open in response to the dialing of the proper combination. In particular, only after the support arm 124 has returned nearly to its original position against stop pin 154 will a pull on the shackle 94 with the slots 39 and 44 in alignment with the slot bar 42 produce sufficient movement of the locking pin 104 to permit opening of the lock.

Accordingly, while the combination lock of the present invention is simpler and quicker to open by authorized personnel knowing the proper combination, security is no way sacrificed since each attempt to open the combination lock employing an improper combination renders the lock unopenable for a predetermined period of time thereafter. An unauthorized person attempting to open the combination lock using trial and error methods must therefore wait a period of time, which is unknown to him, after each abortive attempt to open the lock. Such timed lockout by the time delay mechanism 14 results in a combination lock of increased security against opening by unauthorized personnel and permits the internal mechanism of the combination lock to be very simple and inexpensive in design in addition to be easily and quickly openable by authorized personnel using the proper combination.

The speed of opening the combination lock is further enhanced by the elimination of fractional number errors in the dialing of the combination for the lock 10. This is accomplished by a detent mechanism 156 incorporated for each driven tumbler in the combination lock. The detent mechanism 156 also preclude unauthorized opening of the combination lock by inertial means capable of imparting rotary impulses to the lock.

Generally speaking, the detent mechanisms 156 include an annular array of detent means for each driven tumbler coaxial with the stationary shaft 22. Each detent means corresponds to a different division on the dial 12 and is adapted to stop its associated driven tumbler in a rotational position corresponding to a division upon its release from the drive disc 30. The detent means are further adapted to lock the driven tumblers in such rotational positions upon release from the drive disc to prevent rotation thereof by inertial means capable of imparting rotary impulses to the combination lock.

In the illustrated form of the lock 10, and as most clearly represented in FIGS. 1 and 7, each detent mechanism 156 comprises an annular triangular toothed spur gear 158 and a spring member 160. Each gear 158 is secured to a forward face of its associated driven tumbler coaxial with the stationary shaft 22 and includes a number of teeth equal to the number of dial divisions or possible values for each number in the combination for the lock. Each spring member 160 includes a horizontal top portion 161 tangential to its associated gear 158. Opposite end portions 162 and 163 of the spring member connect to the horizontal top portion 161 and extend downwardly then inwardly toward the shaft 22 and then again downwardly into vertical openings 164 extending through the shaft.

Thus supported, the horizontal portion 161 of the spring member 160 bears tightly on the periphery of its associated gear 158 such that upon release of the associated driven tumbler from the drive disc 30, the spring member causes the driven tumbler to assume a rotational position wherein the horizontal portion of the spring member extends between and contacts adjacent edges of adjacent teeth of the gear (as illustrated in FIG. 1). In the stable positions for the detent mechanism 156, the associated driven tumbler is in a rotational position corresponding to a division on the dial 12.

In this manner, the detent mechanisms 156 prevent fractional errors in the dialing of numbers of the combination for the lock. Either the number is dialed exactly or there is at least a one-unit error in the dialing which may be easily detected on a visual basis. The operator of the combination lock may then rotate the dial in a clockwise direction and start the opening process anew without completing the dialing of the combination and setting the time delay mechanism 14.

Furthermore, since the spring members 160 bearing on the gears 158 hold the driven tumblers 32, 34, and 36 in stable stationary positions on the shaft 22 when disconnected from the drive disc 30, unauthorized personnel

cannot independently rotate the driven tumblers and bring the slots 39 and 44 into alignment with the slot bar 42 with inertial means capable of imparting rotary impulses to the combination lock.

A similar detent mechanism 166 is provided for the drive member 26 to encourage only the dialing of whole numbers with the dial 12. The mechanism 166 comprises a ring gear 168 around the drive member between the drive disc 30 and the dial 12, and a stiff spring arm 170 secured to the housing 16 and in tangential contact with the gear 168. The gear 168 includes a number of teeth corresponding to the number of divisions on the dial 12. The spring member 170 urges the drive member 26 to a rotational position with the spring engaging edges of adjacent teeth. In such a stable position, the dial 12 is on a whole number.

While a particular form of combination lock has been described in some detail herein, changes and modifications may be made in the illustrated form without departing from the spirit of the invention. It is therefore intended that the present invention be limited in scope only by the terms of the following claims.

I claim:

1. A combination lock, comprising:
 - a housing;
 - a support shaft mounted in said housing;
 - lock-releasing means in said housing;
 - a plurality of driven tumbler means spaced from each other and supported for turning on and relative to said support shaft within said housing, each of said driven tumbler means being associated with a different number in a combination for said lock and each carrying registrable means for registering with said lock releasing means, said lock being openable when each of said registrable means, is in registry with said lock-releasing means;
 - drive means for turning within said housing; and
 - cooperative means on said drive means and on each of said driven tumbler means for first releasably locking said driven tumbler means to said drive means to turn therewith in a first direction and for thereafter releasing a different predetermined one of said driven tumbler means from said drive means upon each reversal of the direction of rotation of said drive means to selectively set the rotational position of each of said driven tumbler means on said support shaft with its registrable means in registry with said lock-releasing means within one full rotation of said drive means.
2. The combination lock of claim 1 wherein said cooperative means includes means for locking successive ones of said driven tumbler means to said drive means upon each full rotation of said drive means in said first direction and for releasing said driven tumbler means from said drive means in reverse order upon each subsequent reversal of the direction of rotation of said drive means.
3. The combination lock of claim 1 wherein:
 - said plurality of driven tumbler means includes first and second driven tumbler means, said first driven tumbler means being remote from said drive means; and
 - said cooperative means includes first and second means on said first and second driven tumbler means respectively for releasably connecting said first driven tumbler means to said second driven tumbler means within a first full rotation of said second driven tumbler means in said first direction and for releasing said first driven tumbler means from said second driven tumbler means immediately upon rotation of said second driven tumbler means in a second direction, and
 - third and fourth means on said second driven tumbler means and on said drive means re-

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spectively for releasably connecting said second driven tumbler means to said drive means within a first full rotation of said drive means in said first direction and for releasing said second driven tumbler means from said drive means immediately upon rotation of said drive means in said first direction after a rotation in said second direction.

4. The combination lock of claim 3 wherein said third means includes means for capturing said fourth means within a first full rotation of said drive means in said first direction and responsive to motion in said second direction for releasing said fourth means to permit subsequent turning of said drive means in said first direction independent of said second driven tumbler means.

5. The combination lock of claim 3 wherein:

a portion of said third means is movable between a connect and disconnect position relative to said fourth means as said second driven tumbler means turns in said second direction; and

said drive means carries means for setting said portion in said connect position with movement of said drive means in said first direction to engage said fourth means and thereby produce a turning of said second driven tumbler means with said drive means upon further turning of said drive means in said first direction.

6. The combination lock of claim 1 wherein:

said plurality of driven tumbler means include first, second, and third driven tumbler means; and said cooperative means includes

first and second means on said first and second driven tumbler means respectively for releasably connecting said first driven tumbler means to said second driven tumbler means within a first full rotation of said second tumbler means in said first direction and for releasing said first driven tumbler means from said second tumbler means immediately upon rotation of said second driven tumbler means in a second direction,

third and fourth means on said second and third driven tumbler means respectively for releasably connecting said second driven tumbler means to said third driven tumbler means within a first full rotation of said third tumbler means in said first direction and for releasing said second driven tumbler means from said third driven tumbler means immediately upon rotation of said third driven tumbler means in said first direction after a rotation in said second direction, and

fifth and sixth means on said third driven tumbler means and on said drive means respectively for releasably connecting said third driven tumbler means to said drive means within a first full rotation of said drive means in said first direction and for releasing said third driven tumbler means from said drive means immediately upon rotation of said drive means in said second direction after said release of said second driven tumbler means.

7. The combination lock of claim 6 wherein said second driven tumbler means carries blocking means for preventing the release of said fifth means from said sixth means while said second driven tumbler means is releasably connected to said third driven tumbler means.

8. The combination lock of claim 7 wherein said blocking means is adapted to engage said fifth means when said second driven tumbler means is releasably connected to third driven tumbler means and to move with said second driven tumbler means relative to said third driven tumbler means and out of engagement with said fifth means upon release of said second and third driven tumbler means.

9. The combination lock of claim 1 further including:

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a dial outside said housing and connected to said drive means for turning therewith and carrying a circular array of equally spaced divisions each associated with a different rotational position or said drive means and each corresponding to a different possible number in said combination; and

an annular array of detent means for each driven tumbler means and coaxial with said support shaft, each detent means corresponding to a different division on said dial, for stopping its associated driven tumbler means in a rotational position corresponding to a division on said dial upon its release from said drive means.

10. The combination lock of claim 9 wherein said array of detent means includes:

gear means on each driven tumbler means with teeth corresponding to different divisions on said dial; and stationary spring means bearing on an outer surface of each gear means for forcing said driven tumbler means to rotational positions on said support shaft corresponding to divisions on said dial upon their release from said drive means.

11. A combination lock of claim 1 further including time delay means connected to said lock releasing means for blocking the opening of said lock for a predetermined period of time in response to each attempt to open said lock when all of said registrable means are not in registry with said lock releasing means.

12. A combination lock of claim 11 wherein:

said lock releasing means includes a first member movable during an attempt to open said lock and a second member connected to said first member and movable therewith when all of said registrable parts are in registry with the said lock releasing means; and said time delay means as connected between said first and second members and comprises

dashpot means including a main body having a viscous damping material contained therein and a drag arm extending from and movable in said viscous damping material within said main body, unidirectional drive coupling means connected to one of said main body and said drag arm and to one of said first and second members,

spring means connected to said one of said first and second members and to the other of said main body and drag arm, and

means connecting the other of said main body and drag arm to said other of said first and second members whereby movement of said first member in a first direction from an original position relative to said second member during an attempt to open said lock and without said second member produces movement of said dash pot means therewith and stores energy in said spring means to slowly return said first member to said original position relative to said second member against operation of said dash pot means.

13. The combination lock of claim 12 wherein:

said drag arm includes a drag disc in said main body and a drag shaft extending from said disc outside said main body;

said main body is supported for turning on an axis coaxial with said drag shaft;

said unidirectional drive coupling means is a rotary drive coupling means; and

said spring means is adapted to rotate said one of said main body and drag arm relative to said other of said main body and drag arm in response to said energy stored therein.

14. The combination lock of claim 13 wherein:

said main body is connected to said first member; said spring means loops around said drag shaft with one end connected to said main body;

said unidirectional drive coupling means comprises a

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support arm connected for turning on and relative to said drag shaft and connected to said second member and a locking arm connected by a pivot pin to said support arm for turning about said pivot pin with one end for bearing on said drag shaft and an opposite end connected to an opposite end of said spring means such that said spring means continuously urges said locking arm in one direction around said pin and said one end against said drag shaft to turn therewith in said one direction and to turn freely with said support arm on and relative to said drag shaft in an opposite direction to extend said spring means whereby movement of said first member from its original position in its said first direction with said registrable means in registry with said lock releasing means produces movement of said second member to enable opening of said lock and whereby movement of said first member from its original position in its said first direction without said second member produces a turning of said main body and drag shaft relative to said support arm to extend said spring means and lock said support arm to said drag shaft to slowly return said support arm and said second member to their original position relative to said first member with said drag disc acting against said viscous damping material.

15. In a combination lock including driven tumbler means with registrable means for registering with a lock releasing means to render said lock openable, said lock releasing means including first and second members, said first member being movable during an attempt to open said lock and said second member being movable with said first member when said registrable means are in registry with said lock releasing means, a silent time delay for blocking the opening of said lock for a predetermined period of time in response to each attempt to open said lock when all of said registrable means are not in registry with said lock releasing means comprising:

dash pot means including a main body having a viscous damping material therein and a drag arm extending from and movable in said damping material within said main body;

unidirectional drive coupling means connected to one of said main body and said drag arm and to one of said first and second members;

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spring means connected to said one of said first and second members and to the other of said main body and drag arm; and

means connecting the other of said main body and drag arm to the other of said first and second members whereby movement of said first member in a first direction from an original position relative to said second member during an attempt to open said lock and without said second member produces movement of said dash pot means and stores energy in said spring means which then slowly effects a return of said first member to said original position against operation of said dash pot means.

16. In a combination lock;

a plurality of driven tumbler means carrying registrable means for registering with a lock releasing means to render said lock openable;

said lock releasing means including first and second members, said first member being movable during an attempt to open said lock and said second member being movable with said first member when said registrable means are in registry with said lock releasing means; and

a time delay means between said first and second members and responsive to movement of said first member without said second member for blocking the opening of said lock for a predetermined period of time in response to each attempt to open said lock when all of said registrable means are not in registry with said lock releasing means.

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