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Potzick

[11] **3,719,064**

[45] **March 6, 1973**

[54] COMBINATION LOCK WITH LINEALLY MOVABLE CAM FOLLOWERS AND NONSEQUENTIALLY ACTING TUMBLER HOLDERS

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[73] Assignee: **The Mosler Safe Company,** Hamilton, Ohio

[22] Filed: **Sept. 20, 1971**

[21] Appl. No.: **181,853**

[52] **U.S. Cl.** **70/299,** 70/315, 70/323, 70/327, 70/329

[51] **Int. Cl.** **E05b 37/00**

[58] **Field of Search**.....70/299, 315, 321, 323, 327, 70/328, 329, 364 R, 376, 377

[56] **References Cited**

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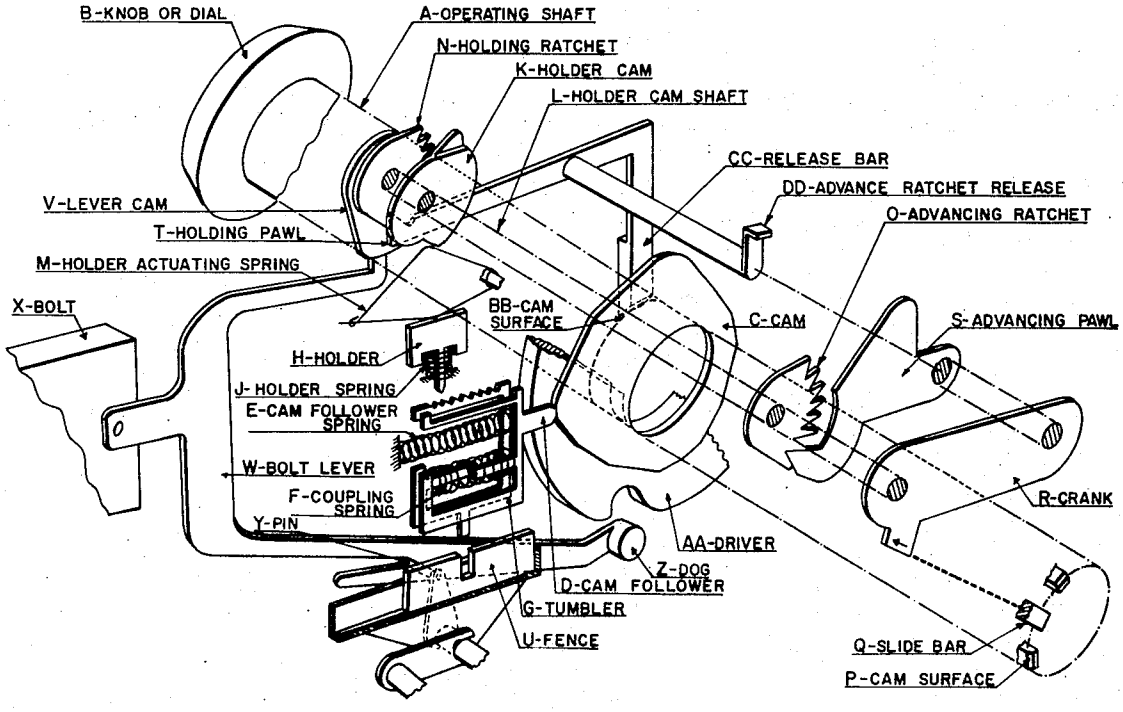
Primary Examiner—Albert G. Craig, Jr.
Attorney—James S. Hight et al.

[57] **ABSTRACT**

A combination lock having lineally movable cam followers that position corresponding tumblers. The tumblers are engageable with corresponding fences when arrested in proper positions. A spring resiliently couples each tumbler to a corresponding cam follower, and tends to cause them to move together lineally. Holders are actuated individually to prevent motion of the corresponding tumblers. The holders make edgewise engagement with the tumblers, and cam them into discrete positions. Randomly oriented holder cams operate in nonsequential order to actuate the holders to arrest the corresponding tumblers. The holder cams are rotated incrementally by a ratchet and pawl.

A bolt operating lever is held out of contact with the driver, and in turn holds the fences away from the tumblers, until all the tumblers have been engaged by the respective holders. The fences can be released with a key to permit them to be rearranged to change the combination, only when the bolt is withdrawn. The operating shaft is biased concentrically toward an axially centered position.

53 Claims, 17 Drawing Figures



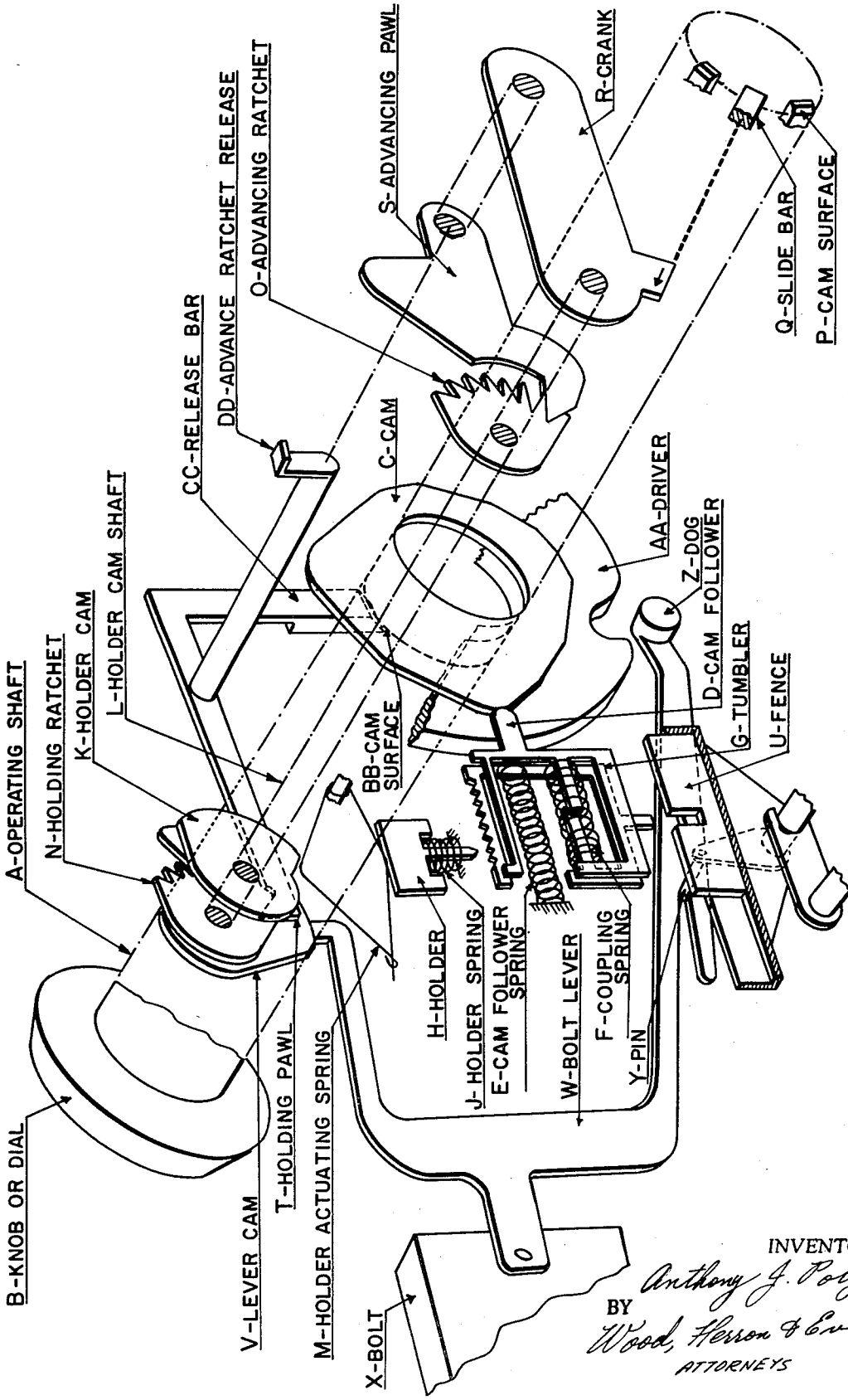


Fig. 1

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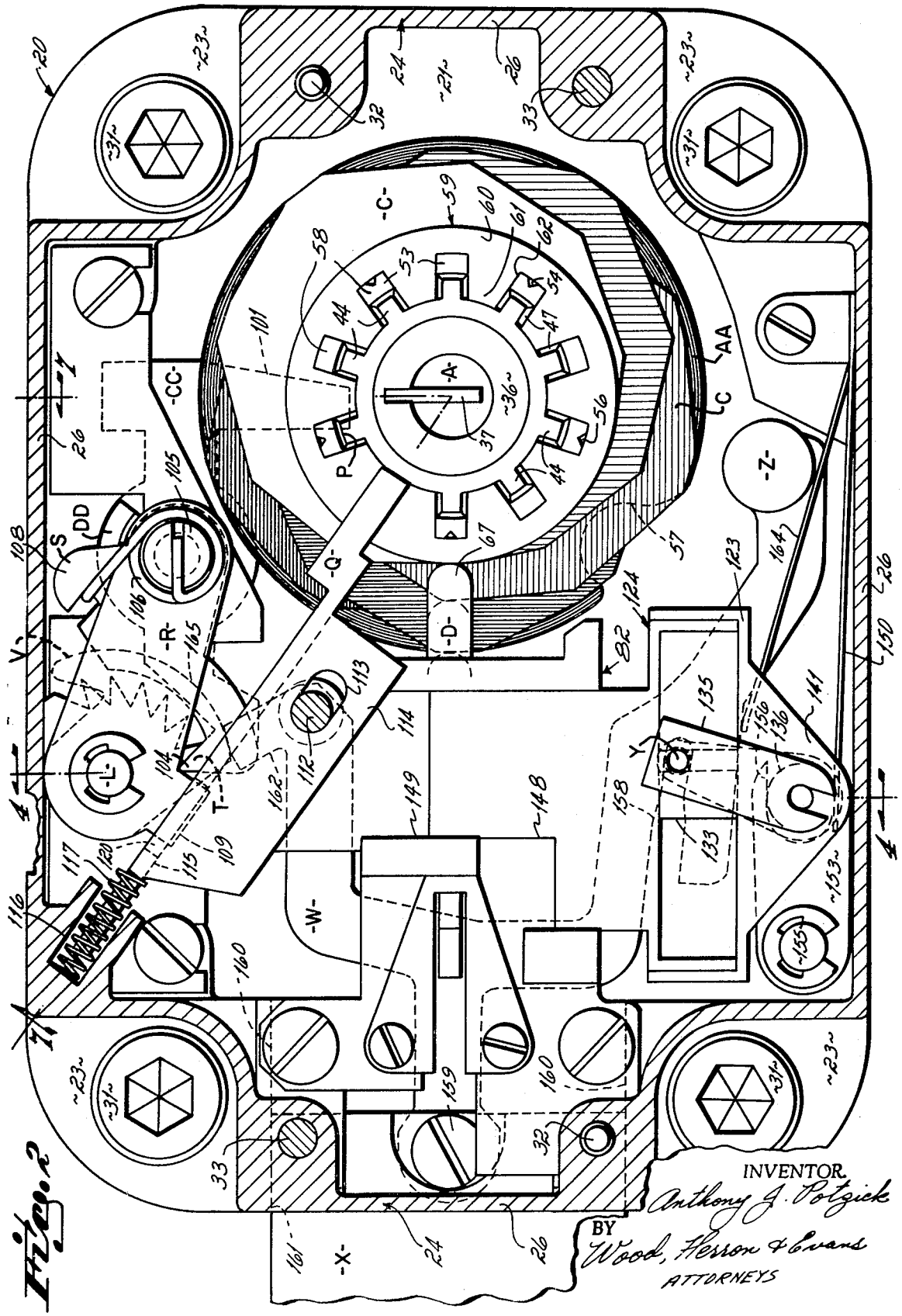

Fig. 2

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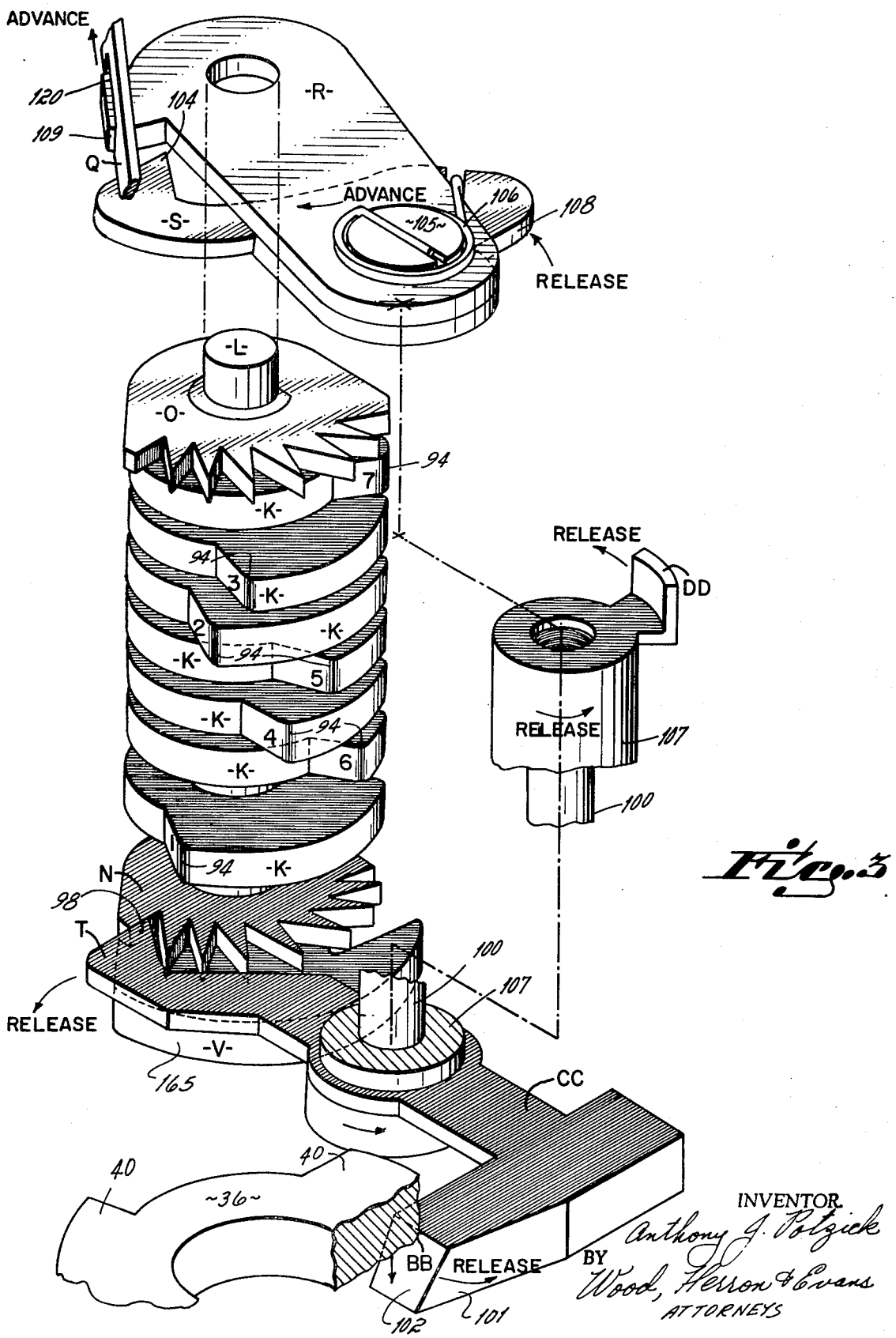

Fig. 5

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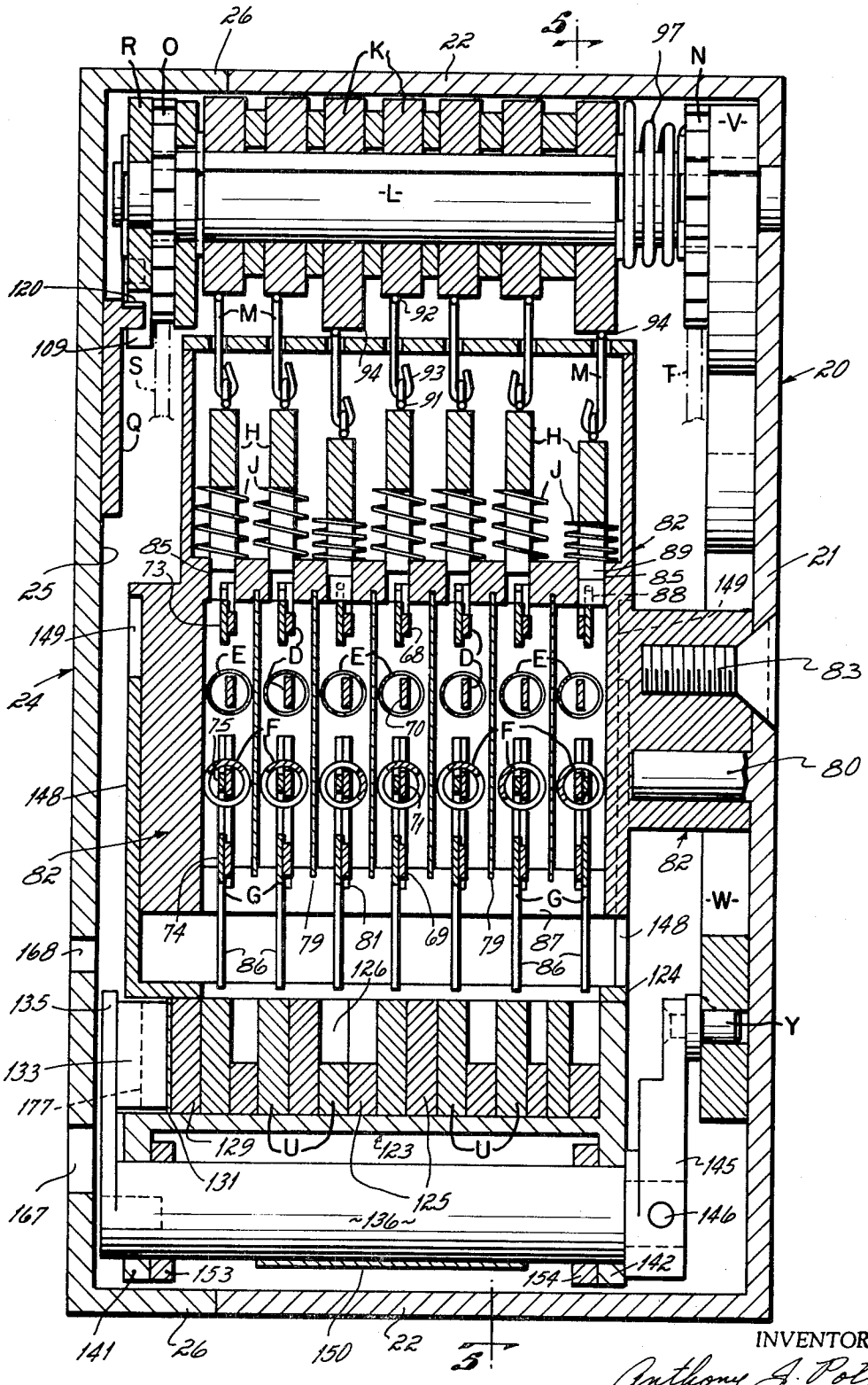

Fig. 4

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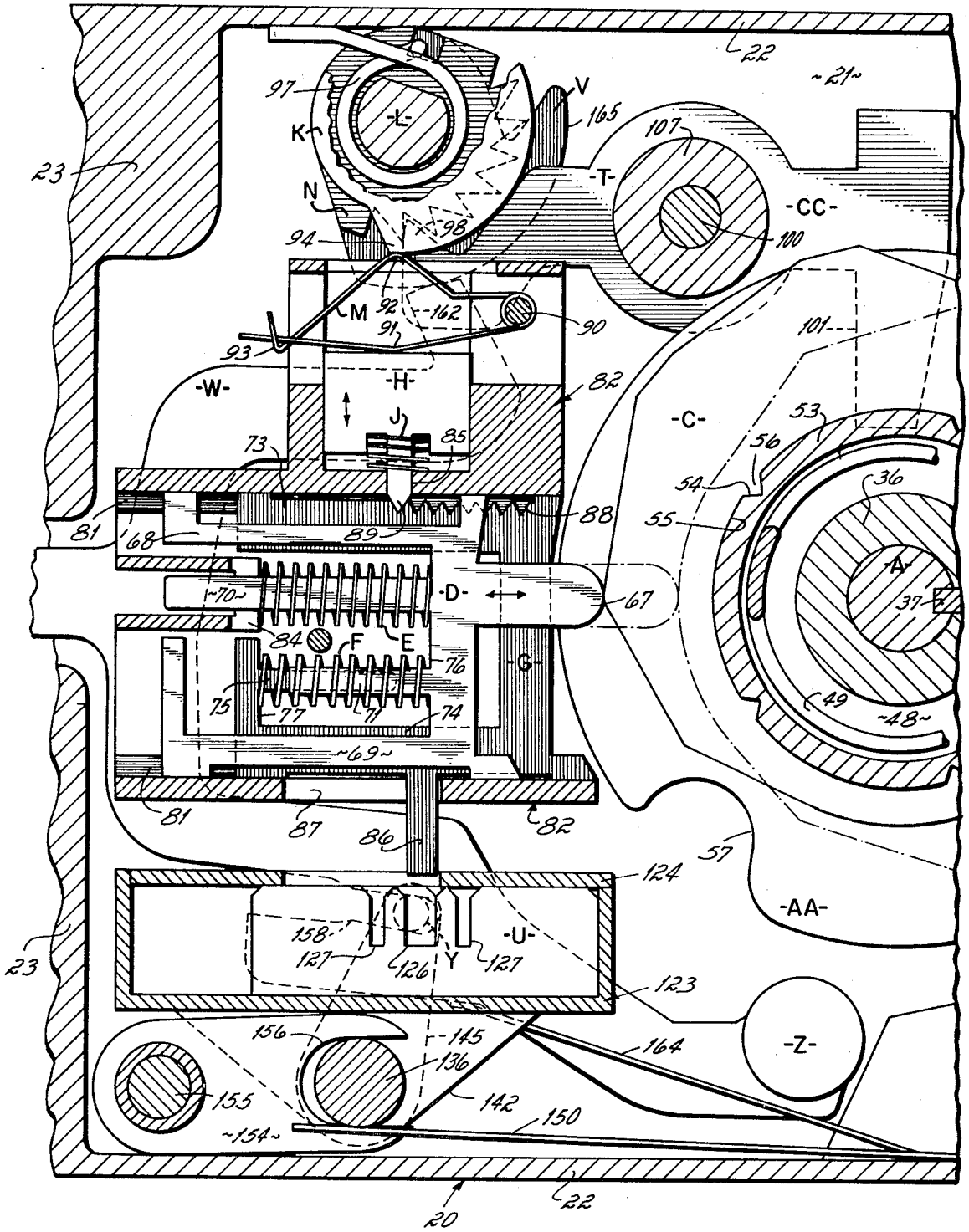

Fig. 5

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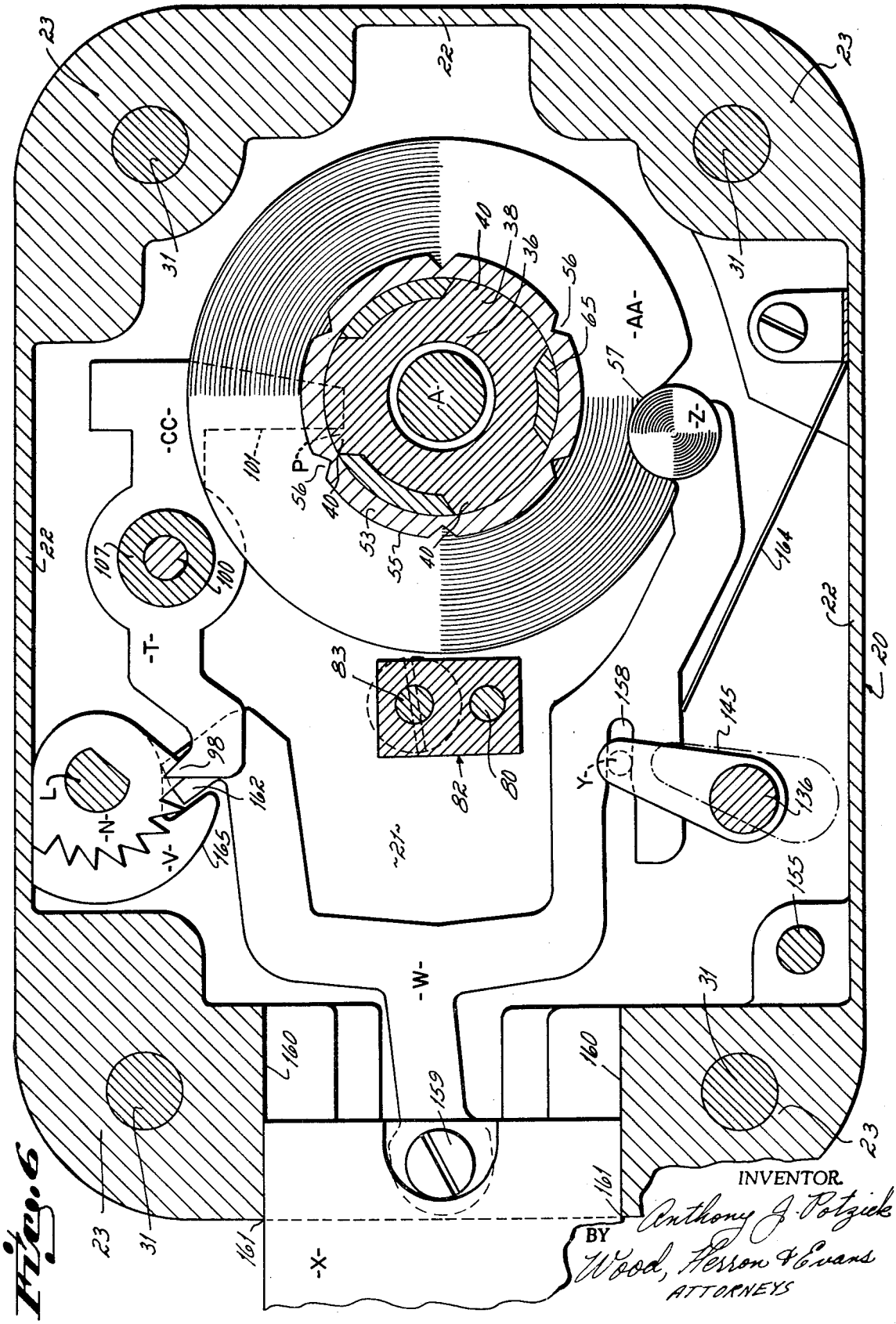

Fig. 6

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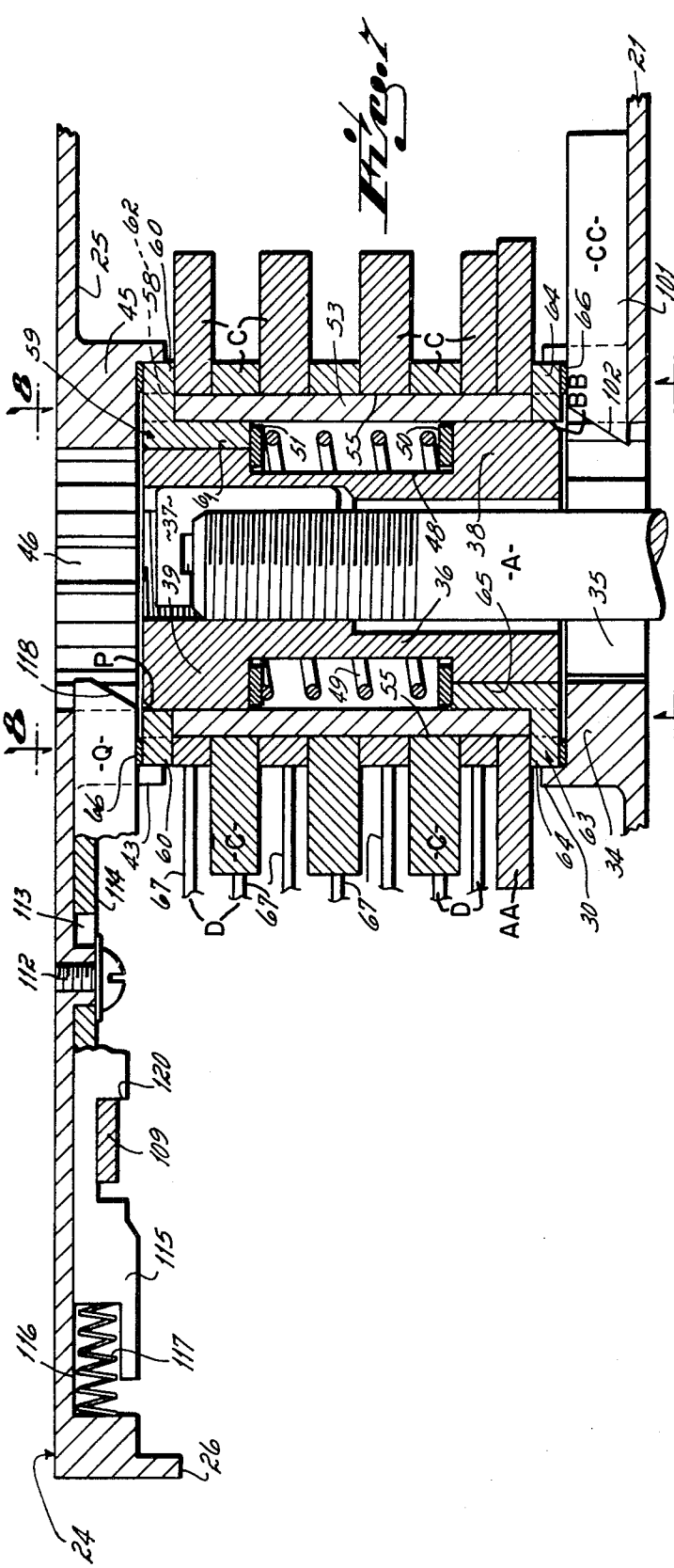
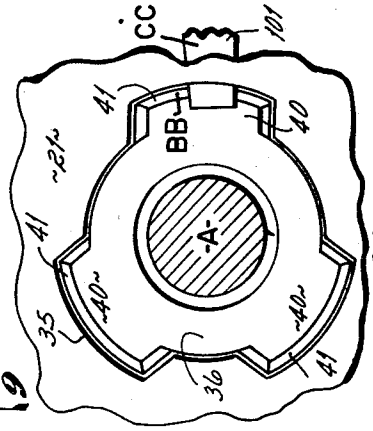


Fig. 1



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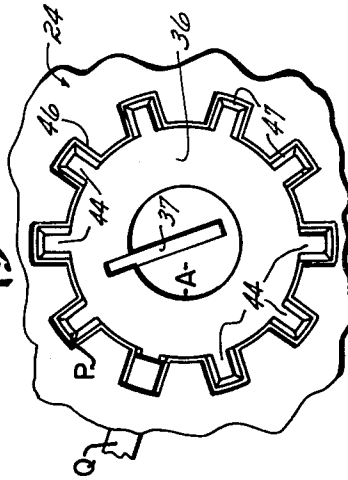

Fig. 8

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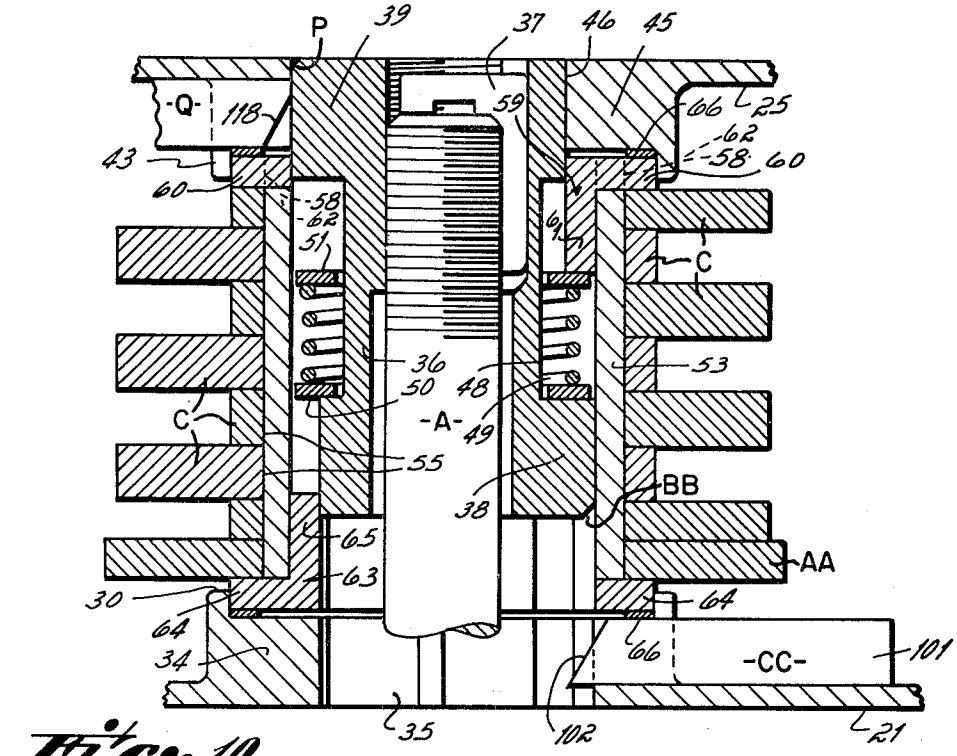

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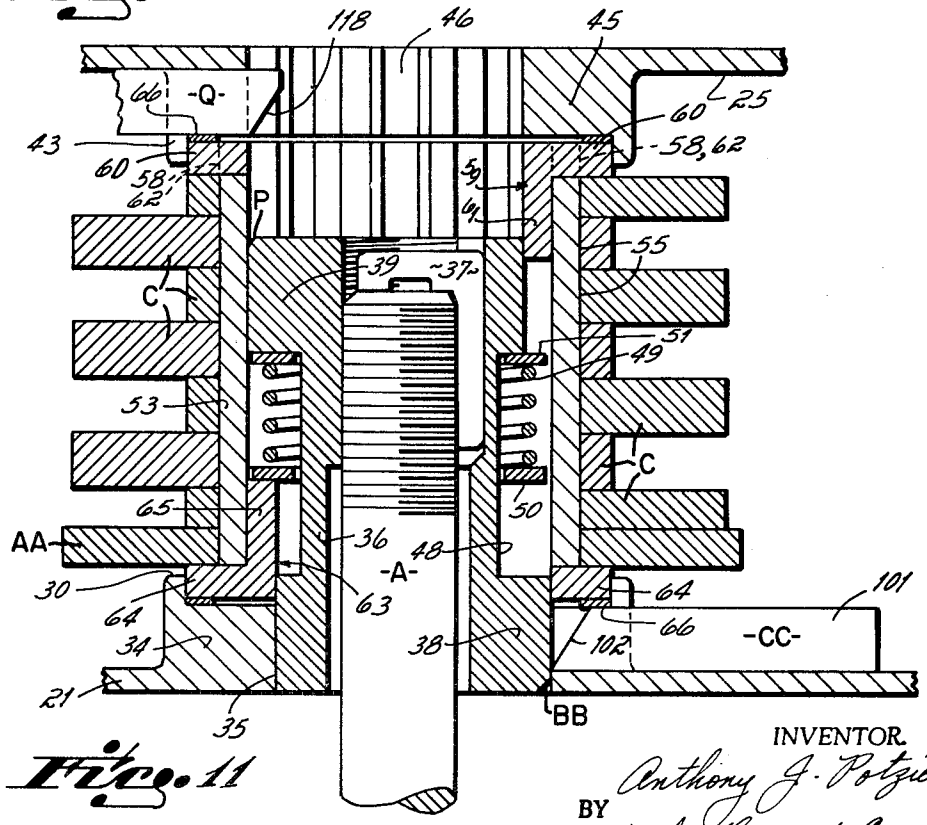

Fig. 11

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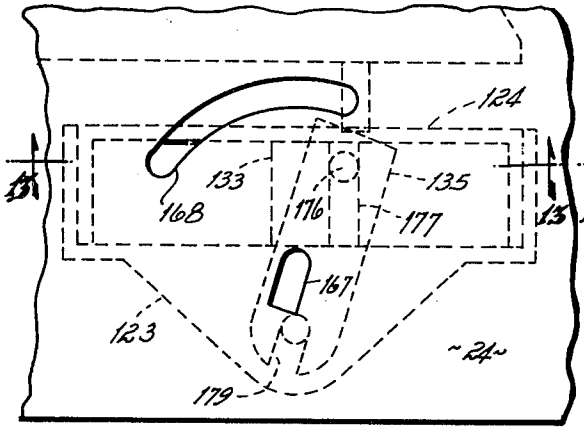

Fig. 12

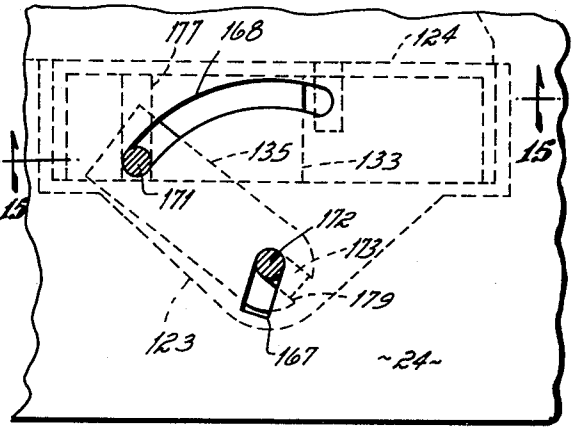

Fig. 14

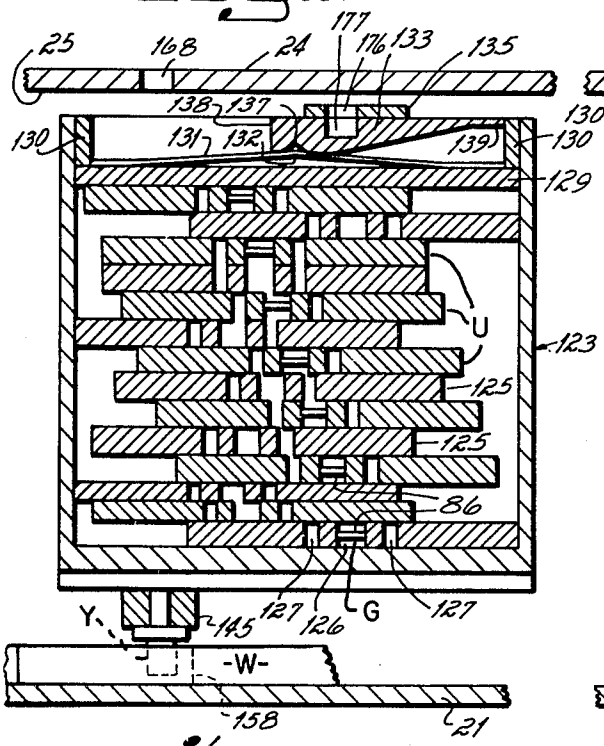

Fig. 13

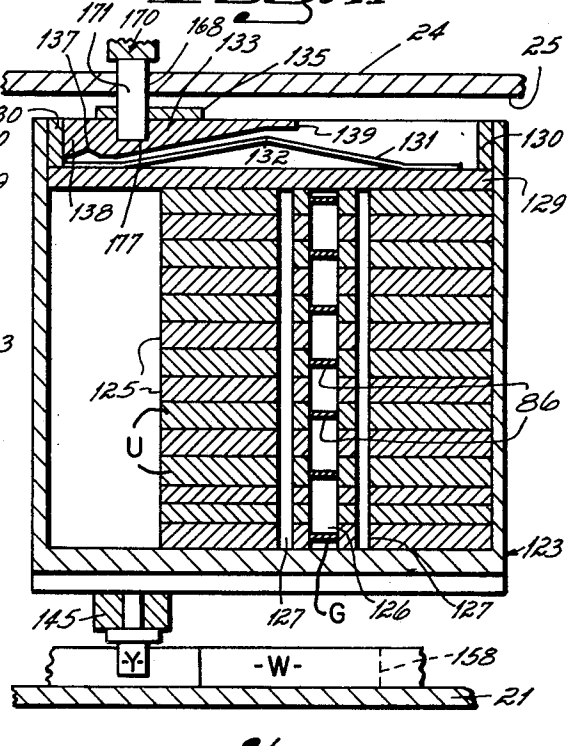

Fig. 15

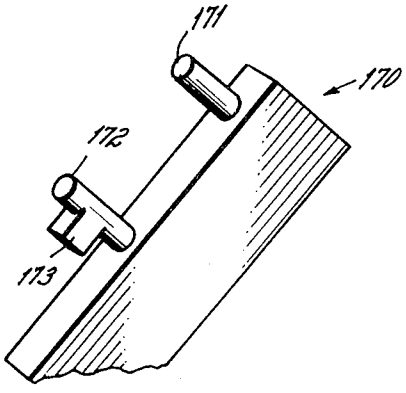

Fig. 16

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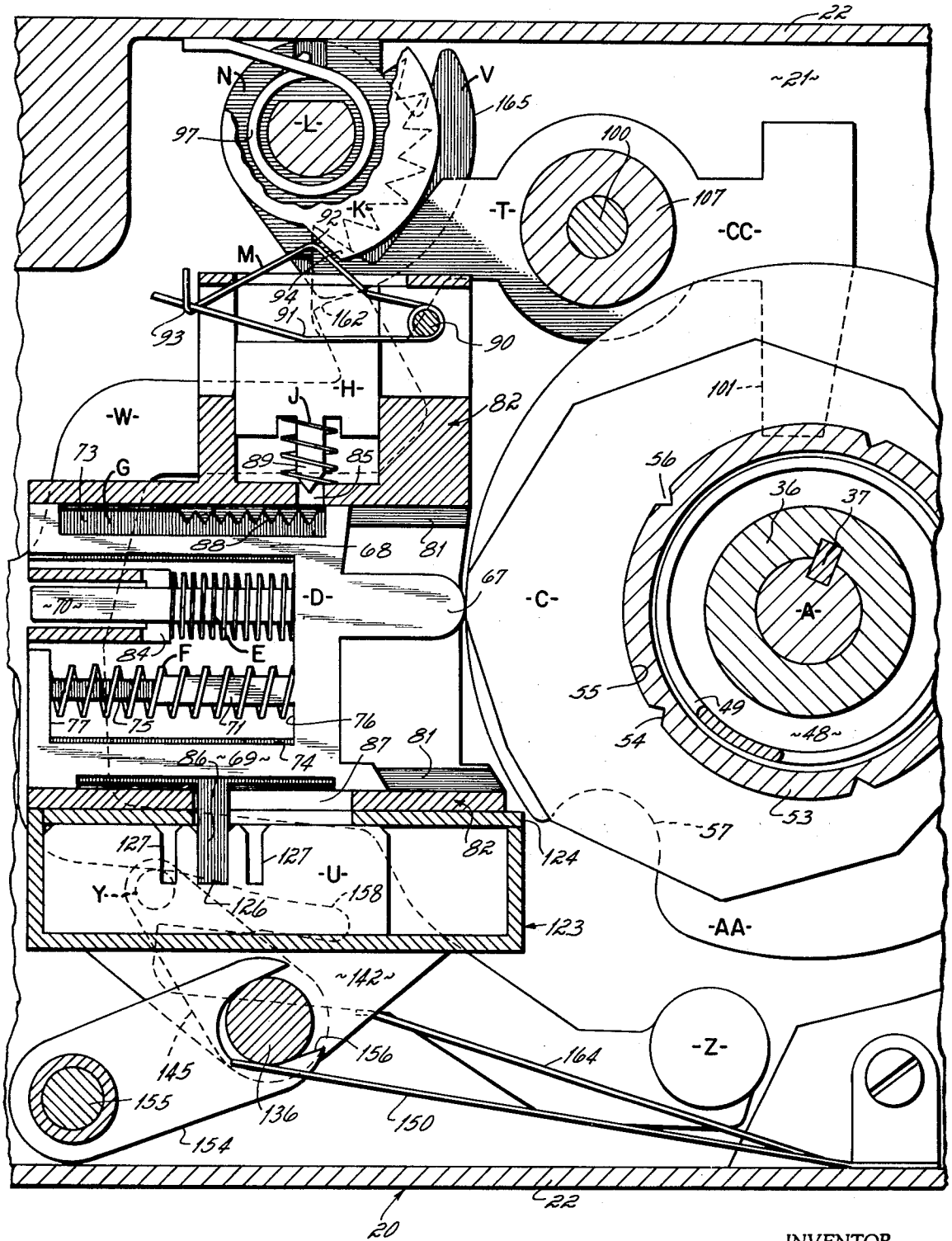

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COMBINATION LOCK WITH LINEALLY MOVABLE CAM FOLLOWERS AND NONSEQUENTIALLY ACTING TUMBLER HOLDERS

FIELD OF THE INVENTION

The invention relates to improvements in combination locks of the push knob type, that is, locks wherein the dial is turned to a given angular position and that dial position is "set" into the lock by moving a shaft axially from a neutral position thereby to cause a tumbler to retain or "remember" that angular position during the setting of the other tumblers.

The prior art

Combination locks of the push knob type are known to the art, and are useful because of the relative simplicity of their operation. Ordinary combination locks (not of the push knob type) must be operated by turning the dial a specified number of turns in a first direction, say four turns to the right, before stopping at the first letter or number of the combination, then a series of turns one less in number in the opposite direction, e.g., three turns to the left, to the next number of the combination, followed by a decreasing sequency of turns in opposite directions to set the other numbers into the lock and thereby position the tumblers.

As a practical matter, the operation of such locks is undesirably complex because of the need to remember and execute properly not only the combination itself, but also the dialing program, including both the number and direction of turns required before stopping at each number of the combination. Because of this complexity, locks with combinations of more than four numbers (or letters) are rarely used, and such locks are relatively slow to set and require careful attention. Increasing complexity of the program with longer combinations limits the number of theoretically possible combinations. Moreover, locks having three or four tumblers are at least in theory, more readily attackable by radiographic means than locks having a larger number of tumblers.

Push knob locks are easier to operate because they require no complex program of dial turning. They can be operated by turning the dial in either direction directly to each combination number, and do not require opposite rotations of the dial between successive numbers. Moreover, such locks do not require any predetermined number of turns, or indeed, any turns of the dial between succeeding numbers of the combination.

When the dial of a push knob lock has been turned to a given number, that number is set into the lock by axial movement of an operating shaft (which may be the dial shaft itself), for example by pushing the dial inwardly a short distance. Absent any requirement of complex dial turning, it is thus practicable to use combinations of large sets of numbers, up to seven or more, and corresponding numbers of tumblers. This provides great resistance to surreptitious attack.

U.S. Pat. No. 3,436,941, titled "Combination Lock With Cam-Operated Tumblers and Sequentially Engageable Tumbler Stops," and issued Apr. 8, 1969, of which I am the patentee is directed to one such push knob combination lock. In the preferred embodiment

of the lock to which that patent is directed, the operating shaft turns a cam which moves a series of tumblers. Each tumbler is in the form of a lever which is pivoted for swinging movement relative to the cam axis, and is spring biased toward the cam. Each tumbler has a gate at its free end. Rotation of the cam positions the gates; the gates must be positioned according to the proper combination before they will receive with a series of fingers that are mounted to and move with the bolt, in order for the bolt to be retracted. The tumblers move with the cam when they are riding on it, but they can be prevented from following the entire movement of the cam, so as to follow the cam movement only to a certain point, by a series of stops with which the tumblers individually coact. Each stop is a lever which is spring loaded toward its respective lever tumbler and follows the cammed movement of the lever tumbler until the stop is locked in position by moving the lock dial shaft axially. The stops determine the positions of the gates when the lever tumblers are disengaged from the cam. Locking of the stops is accomplished sequentially by a stop holder which is advanced lineally by a ratchet and pawl mechanism actuated by axial shaft motion. The ratchet and pawl mechanism is releasable by moving the shaft in the opposite axial direction. The lock dial shaft is urged toward a centered axial position by opposed spring loaded plungers which bear on a plate attached to the shaft. Shaft movement in either axial direction from the centered position is permitted only at precise whole number dial settings by pins which block the plate connected to the shaft, unless the plate is in such position that narrow openings in it are aligned to receive the respective pins.

In the '941 patent, the fingers which determine the combination are connected to the bolt, and move with it as the bolt is withdrawn or extended. The fingers are releasably clamped to the bolt by a screw which can be loosened by a screwdriver so that the fingers can be moved relative to one another and to the bolt, to change the combination. Means are provided for disconnecting the bolt from the lock operation means when the fingers are released from their fixed positions. An extra or supplemental axial movement of the operating shaft is required before the lock mechanism is conditioned to permit the bolt to be withdrawn.

U.S. Pat. No. 3,518,856, titled "Combination Lock With Cam Follower Positioned, Cumulatively Arrested Tumbler Elements," issued July 7, 1970, of which I am also the patentee, is directed to a "second generation" form of push knob combination lock. In the preferred embodiment of the lock to which that patent is directed, the operating shaft turns a set of several disk-like cams. One end of a pivoted cam follower is spring urged into contact with the shaped periphery of each respective cam. The other end of each cam follower bears upon and cams a lineally movable tumbler element. The slider tumbler is spring urged against the cam follower and is positioned in accordance with the angular position of the shaft. At the start of running of the combination, rotation of the dial operates all of the cam followers and slider tumblers, and as the combination numbers are dialed and set by axial movement of the shaft, the respective sliders are cumulatively arrested by tumbler holding means in the form of a slider holding pin which passes perpendicularly through a

hole in the slider. The slider holding pin is mounted to and moves lineally with a ratchet. The ratchet responds to axial movement of the shaft through a flapper or lever which is swung by the shaft movement. A series of fence members, interfittable with the slider tumblers if the latter are properly positioned, are mounted for movement toward and away from the slider tumblers. The fence is not rigidly connected to the bolt or to the bolt lever, but responds through an off center sliding coupling to movement of the lever.

It has been an objective of this invention to simplify and improve the structure and operation of the push knob combination locks described in the two patents referred to above. In particular, it has been the objective to provide structure which is of easier and less critical manufacture, yet which at the same time provides smoother and easier operation and which is still more resistant to surreptitious or radiographic attack.

Summary of Invention

In the preferred form of the lock of this invention, cam means on an operating shaft operate cam followers which are mounted for lineal movement toward and away from the shaft. A spring biases each follower toward the cam means. A tumbler is yieldably coupled to the respective cam follower by a coupling spring, and is mounted for lineal movement parallel to the follower. Each follower and tumbler has two oppositely facing surfaces which are perpendicular to the direction of follower movement. The coupling spring is seated between the oppositely facing surfaces of the follower and tumbler, and at all times abuts at least two of the surfaces which are opposed. The coupling spring reacts at one or the other end on the tumbler to bias it to follow the follower assembly and movement of the tumbler is prevented.

A tumbler holder is movable transversely to each tumbler in the plane of movement of the latter, and is interengageable with its respective tumbler for holding it at a given position. Each holder is operated by a separate holder cam acting on an actuating spring between it and the holder. Either the tumbler or the holder has a projection on it which is seatable in any of a series of corresponding notches on the other, to hold the tumbler in a discrete position corresponding to a whole number dial position.

The holder cams turn with a rotatable shaft, and each has a lobe which is engageable with the respective actuating spring at a certain angular position of the holder cam shaft. The holder cams are stacked on the cam shaft with their lobes randomly arranged such that they do not operate their respective holders in the sequence in which they are stacked on the shaft.

The fences are contained in a fence housing, in which they overlie one another in the form of a deck. The fences are ordinarily clamped in fixed positions inside their housing, but when unclamped can slide relative to one another in the housing to change the combination. The fence clamping means comprises a clamping spring and an element which is slidable with respect to the spring between a clamping position in which the element stresses the spring to clamp the fences against movement, and an unclamped position to which the element can be shifted so that stress on the spring is released, to permit fence movement. A key is engageable with the element for sliding it between the clamped and unclamped positions, the key having a bit which is insertable and removable through an aperture in the lock case only when the bolt has been retracted.

Means for biasing the operating shaft to a centered or neutral position include a sleeve which surrounds the shaft and is connected to it for rotational and axial movement. The sleeve has a pair of lands which are separated by an intermediate peripheral groove, and a spring is under compression and bears at each end on a washer in the groove. A connector is splined to each land for rotation with the land but is slidable relative to it. Axial movement of the shaft and sleeve is accommodated by apertures in the lock case bottom and case cover, into which the sleeve can move when the shaft is moved axially. Stop means on the case restrain axial movement of each connector into the respective aperture. Each connector has an end surface that bears on the respective washer and thereby compresses the spring when the shaft is moved from centered position. The cam follower cams reside on a cam sleeve which surrounds the shaft sleeve, and is connected to the shaft sleeve for rotation through interengaging spline means on the connectors. Each connector is received and journalled in a boss in adjacent lock case structure, so that the shaft is supported at each end for rotation.

The lock of this invention is an improvement of the locks which form the subjects of the '941 and '856 patents, above referred to, in a number of respects. As will be seen, these include:

1. The tumbler-cam follower structure;
2. The tumbler holding means;
3. The means whereby the tumbler holding means are operated;
4. The fence structure; and
5. The shaft centering and movement restricting means.

The invention can best be further described and its advantages and improvements be more easily illustrated by reference to the following drawings in which:

FIG. 1 is a diagrammatic perspective view illustrating the primary elements of one tumbler operating mechanism in a preferred form of combination lock constructed in accordance with the principles of my invention;

FIG. 2 is a cross-sectional view of a preferred form of lock, taken along a transverse plane adjacent the inner surface of the lock cover;

FIG. 3 is an exploded perspective view in enlarged form of the holder-cams and the associated holder cam operating mechanism;

FIG. 4 is a cross-sectional view parallel to the axis of the operating shaft, taken along line 4—4 of FIG. 2, with the first and fifth tumblers (from the bottom of the case) engaged by the respective holders;

FIG. 5 is an enlarged fragmentary cross-sectional view, transverse to the operating shaft, taken along line 5—5 of FIG. 4, and illustrates the first tumbler held in position, another follower (in dash-dot lines) engaged with its cam, and also illustrates the holder mechanism by which the holder-cams are held in position to place the first holder in engagement with the respective tumbler;

FIG. 6 is a cross-sectional view of the lock taken on a place adjacent the bottom of the case, showing the rela-

tion of elements after the proper combination has been run, with the bolt lever engaged with the driver preparatory to withdrawing the bolt;

FIG. 7 is a developed cross-sectional view taken along line 7—7 of FIG. 2, and illustrates details of the mechanism through which the holder cams are set;

FIG. 8 is a view taken along line 8—8 of FIG. 7;

FIG. 9 is a view taken along line 9—9 of FIG. 7;

FIG. 10 is a view similar to FIG. 7 but illustrates the positions of the elements when the operating shaft has been moved axially inward, to cause a given dial position to be set into the lock;

FIG. 11 is a view similar to FIG. 10 but illustrates the position of the elements when the operating shaft has been moved axially in the opposite direction, to cause the previously set tumblers to be released;

FIG. 12 is an elevational view of a portion of the outside surface of the lock cover, illustrating the fence release key holes, and (in dotted lines) the fence pack and a tumbler finger;

FIG. 13 is a cross-sectional view taken along line 13—13 of FIG. 12 and illustrates the fence pack as set to a certain combination (which differs from the combinations of the previous drawings);

FIG. 14 is a view similar to FIG. 12 but illustrates the fence pack in engagement with the tumblers, and the fences released or freed by the fence release key preparatory to setting a new combination;

FIG. 15 is a cross-sectional view taken along line 15—15 of FIG. 14, and illustrates the fence pack in the released condition, the fences being shown in the unscrambled positions they would occupy if the main cams were all similarly arranged on the operating shaft;

FIG. 16 is a perspective view of a preferred form of fence release key for use with the lock of this invention; and

FIG. 17 is a view similar to FIG. 5 but shows the positions of the elements with the fence pack engaged with the tumbler but in released condition, the bolt extended, and the holder-cams returned to initial or home position so that a new combination can thereafter be set into the lock.

In the preferred form of lock which has been illustrated in the drawings for purposes of explanation, seven tumbler mechanisms are provided. The dial of the lock has ten setting positions, which may correspond to the digits 0–9, and the lock therefore provides a total of 10^7 possible combinations of the digits on the dial. It will be apparent that more or fewer dial positions or tumblers could be provided if desired.

Summary of Operation

Although the lock includes a plurality of sets of tumbler mechanisms, the general principles of its operation can be explained by reference to the operation of a single tumbler mechanism. In FIG. 1 a single tumbler mechanism and associated elements for operating it and changing its part of the combination are shown. The preferred lock illustrated includes a total of seven tumbler mechanisms, as will be seen, but their structure and operation are generally similar to this.

The lock is mounted on a safe door, file cabinet, or other lockable enclosure, not shown. The lock is operated by an operating shaft, shown in the figures at A, which extends through the closure, and is actuated by a knob or dial B on the outside of the closure. Shaft A is journalled for both rotational and axial movements. Rotational movement of shaft A moves the tumblers with respect to the fences; axial movement of shaft A in one direction from a home or centered position causes the tumblers, one at a time, to be set or held at a given position to which they have been moved in response to the rotation of shaft A. Axial movement of shaft A in the opposite direction from the home or centered position releases the tumblers from positions to which they have previously been set, when the bolt is extended, preparatory to the running of another combination. A preferred form of dial B, operable both rotationally and axially, for use with locks of the type to which this invention is directed is described and claimed in my copending patent application Ser. No. 157,405 filed June 28, 1971, titled "Dial Structure For Mechanism Requiring Both Lineal And Rotary Input Operating Movements," the disclosure of which is incorporated by reference herein. It will be understood, however, that this lock is not limited to use with that particular type of dial mechanism, and that the dial itself does not comprise part of this invention.

A cam C at its peripheral edge engages and actuates a cam follower D which is biased by a follower spring E toward engagement with cam C. Cam follower D is resiliently coupled by spring means in the form of a coupling spring F to a tumbler G. As cam C is turned, causing cam follower D to move toward and away from the axis of rotation of cam C, tumbler G moves with the cam follower D, unless the tumbler G is restrained from such movement. (Means for positioning each cam follower D and tumbler G for guiding their movement are provided, but for purposes of simplicity these guide means are not shown in FIG. 1).

AT different angular positions of cam C, the cam follower and tumbler are at different positions. The tumbler can be arrested in any of these positions by a holder H which is movable in a direction parallel to the plane of the tumbler G. The holder H preferably has a pointer or finger that is interengageable with corresponding notches on an edge of the tumbler G. The holder H is normally biased away from the tumbler by a holder release spring J, but the force of this spring J can be overcome by operation of a holder-cam K, so that holder H is moved toward the tumbler. Holder-cam K may be mounted on a holder-cam shaft L (indicated by dot-dash lines in FIG. 1). When rotated to a certain position, holder-cam shaft L brings a lobe on the holder-cam K into engagement with a holder actuating or holding spring M which it compresses so that the spring exerts a force on holder H that compresses holder release spring J and moves the holder into engagement with edge I of tumbler G to set the latter at its then position. When the tumbler G is thus engaged by a holder H, it no longer follows the movement of its cam follower D; however, the cam follower can still respond to movement caused by cam C because the resilient coupling spring F can compress or expand as the cam follower D moves with respect to tumbler G.

The operation of holder-cam shaft L is governed by incrementally advanceable ratchet and pawl means. Preferably, as shown in FIG. 1, a holding ratchet N and an advancing ratchet O are fixed to the holder-cam shaft L. These are operated by actuating means which

are responsive to an axial motion of the operating shaft A, to rotate the cam shaft L in fixed increment. When operating shaft A is moved axially in one direction (for purposes of explanation, it is assumed that this direction is inwardly, that is, toward the lockable enclosure and toward the lower right-hand corner in FIG. 1), a cam surface P on shaft A cams a slidebar or member Q radially outwardly, away from the axis of shaft A. The motion of slidebar Q is transmitted to a projection on a crank R, causing the latter to turn (in a clockwise direction in FIG. 1) about the axis of the holder-cam shaft L upon which it is journalled. The other or outer end of crank R is pivotally connected to an advancing pawl S, and the clockwise swinging movement of the crank moves the advance pawl in the direction of the arrow in FIG. 1. A tooth on the advancing pawl S is spring urged (by an advancing pawl spring not shown in FIG. 1) into engagement with advancing ratchet O. Movement of pawl S thereby turns advancing ratchet O clockwise, which in turn rotates holder-cam shaft L. The size relationship are such that the extent of inward axial movement of operating shaft A is sufficient to cause advancing ratchet O to be turned incrementally by an amount equal to one tooth. The corresponding turning movement of holder-cam shaft L moves holding ratchet N, attached to it, by an amount equal to one tooth on the latter. At a predetermined angular position of holder-cam shaft L, the lobe of holder-cam K on shaft L is brought into engagement with holder actuating spring M. This causes holder H to engage and set tumbler G.

When the operating shaft is returned from its axially inward position to its neutral or centered position by centering springs (not shown in FIG. 1), crank R and advancing pawl S return to their original positions, and the tooth of the advance pawl drops back into the next following tooth of the advancing ratchet O. While this is occurring, a tooth on a holding pawl T is engaged with the holding ratchet N to prevent return movement of the holder-cam shaft L.

In the preferred embodiment, each tumbler is set by a corresponding holder-cam and the latter are desirably oriented at different positions on shaft L such that the lobes of the respective holder-cams will come into engagement at different positions with their corresponding holder actuating springs to actuate holders. All of the tumblers G must be set before any attempt can be made to open the lock.

Each tumbler G has a finger or other interengageable means that cooperates with a corresponding fence U; in FIG. 1, for purposes of illustration, the tumbler has a finger which is interengageable with a gate on the fence, but this relation may be reversed. The dimensions of the tumbler and fence interengaging means are such that the tumbler can interengage the corresponding fence only at a certain discrete position, corresponding to a predetermined part of the combination. There are as many true fences as there are tumblers (however, as explained below, it is preferable also to include false additional fences and/or tumblers). Each tumbler is interengageable with its respective fence. The fence members collectively form a group or fence pack which is shiftable toward and away from the tumblers, (i.e., the pack can be moved in the vertical direction in FIG. 1).

Movement of fence U (and the pack) toward the corresponding tumbler, to interengage it if the tumbler has been set in the proper position, is prevented until all of the tumblers have been set. Such movement is prevented by a lever cam V that rotates with holder-cam shaft L. The lever cam V has a lobe which bears against a cam follower on a yoke-shaped bolt lever W and holds the latter in a remote position until the holder-cam shaft L has been rotated to a position such that the lobe of lever cam V is disengaged with the cam follower on lever W. The lobe is oriented so that this occurs only after all of the holders H have been engaged with their respective tumblers G.

Bolt lever W, which is pivotally connected to the bolt X, has a slot formed in one arm in which rides a pin Y that projects from the fence pack. Bolt lever W is so positioned by the lever cam V (during the time that it is engaged by the cam lobe, and until all of the tumblers have been set), that pin Y and fence U are prevented from moving. A biasing spring, not shown in FIG. 1, urges fence U (and the entire pack) toward the respective tumbler G. After the last number of the combination has been set, a lever biasing spring, not shown in FIG. 1, pivots bolt lever W about its connection to bolt X, in the counterclockwise direction in FIG. 1, and during this movement fence U is moved by the fence pack spring toward tumbler G.

If tumbler G is properly positioned with respect to its corresponding fence U, and all of the other tumblers are also properly set with respect to their corresponding fences, then the finger and gate interfit. The rotation of bolt lever W is thereby permitted to continue until a dog Z on the lever interfits with a corresponding gate or notch in a driver AA mounted on operating shaft A. When bolt lever W is thus engaged with driver AA, rotation of operating shaft A in the counterclockwise direction in FIG. 1 draws a dog Z and bolt lever W to the right, withdrawing bolt X. While this occurs, pin Y slides in the slot in the bolt lever, and the fences do not move relative to the tumblers.

If, on the other hand, any tumbler is not properly oriented with respect to its corresponding fence, then the end of its finger will prevent further movement of the fence pack toward the tumblers, and pin Y will block rotation of bolt lever W so that dog Z does not engage with driver AA. In this circumstance, the lock cannot be opened without beginning again, and running the entire combination.

To release previously set tumblers, operating shaft A is moved axially in the opposite direction from the direction it is moved to set the tumblers; with reference to FIG. 1 it is pulled outwardly, i.e., toward the upper left-hand corner and away from the lockable enclosure. As shaft A is so moved, another cam surface BB on the shaft bears against and cams a foot of a release bar CC which is connected to holding pawl T. Release bar CC and holding pawl T are pivotally mounted on the lock case (not shown in FIG. 1), and the radially outward displacement of release bar CC, away from the axis of operating shaft A, swings holding pawl T in the counterclockwise direction about its pivot, out of engagement with holding ratchet N. Also connected to release bar CC is an advance ratchet release DD which (swinging counterclockwise in FIG. 1) engages advancing pawl S and swings it so that its tooth is disengaged with

advancing ratchet O. The advancing ratchet O and the holding ratchet N are thereby released from their respective pawls, and a spring (not shown) returns the holder-cam shaft L to an original or starting position in which the holder-cams K are disengaged from the holders H, and the tumblers G are free to move with their corresponding cam followers D. Movement of operating shaft A from its axially outward displaced position, back to the centered position, restores holding pawl T to engagement with holding ratchet N, and lever cam V again engages the foot of bolt lever W, so that dog Z is held away from driver AA, and the pin Y and the respective fences U are held away from the tumblers G.

The foregoing summary explanation does not include all of the features and advantages of the invention, but it will facilitate an understanding of the detailed explanation which follows.

Detailed Description

The lock elements are contained and mounted within a housing that comprises a lock case **20** which is generally rectangular in form and is defined by a bottom wall **21** and from side walls **22**. A reinforcing boss **23** is formed (see FIG. **6**) at each corner between adjacent side walls. Case **20** is provided with a top closure or cover **24** (see FIGS. **2** and **4**) having an inner surface **25**. The depending sides **26** of cover member **24** meet the corresponding sides **22** of the case (see FIG. **4**).

Case **20** is mounted to the safe by four bolts **31** which pass through openings in the corner bosses **23**. The cover is precisely aligned with respect to the case by pins at **32** which project from the case side walls and seat in corresponding holes provided in the cover. The cover is secured to the case by screws **33**.

An opening at **35** is formed in a boss **34** in the case bottom wall **21** (see FIGS. **7** and **9**), and operating shaft A extends through the safe door and this aperture **35** into the interior of the lock case. This boss **34** has a raised rim or curb **30** at its inner end, which confines and centers the rotating element, as described below. As can be seen from FIGS. **7** and **9**, aperture **35** is substantially larger than the diameter of shaft A, and has a nonsymmetric shape by which it can function to prevent release of previously set tumblers except at a certain rotational position of the shaft, as will be described.

Shaft A is threaded at its inner end into a shaft sleeve **36** (see FIG. **7**) and is secured to it by a key **37**.

Sleeve **36** has a land **38** at its inner end, adjacent case bottom wall **21** (see FIG. **7**) and another land **29** at its outer end, adjacent the cover inner surface **25**. The axial dimension of the sleeve is slightly less than the dimension between the inner surface of cover bottom wall **21**, and cover inner surface **25**, such that ordinarily the sleeve does not extend into the plane of the cover or the case.

As shown in FIG. **9**, inner sleeve land **38** is configured longitudinally so that it is rotationally asymmetric, by a series of splines separated by grooves. Preferably, three spline **40** are provided, unequally spaced, as shown in FIG. **9**. These are chamfered at their inner ends as at **41**. The aperture **35** in case bottom wall **21** is similarly configured or slotted to receive these splines when shaft A is properly aligned rotationally. The relation of the splines is such that the splines **40** on sleeve land **38** can interfit with opening **35** in the case when the shaft is moved axially only at a single discrete rotational position of shaft A. Typically but not necessarily this will be when the dial is set at the O position. The chamfer **41** around the inner end of the sleeve lands **38** can cam the shaft slightly to the proper position, if the shaft is only slightly misaligned with respect to the position at which the splines can be received in their corresponding case slots. As will be explained, this relation of sleeve **38** and opening **35** prevents pull-out movement on shaft A except at the zero dial position.

AT the other or outer end of sleeve **36**, the outer sleeve land **39** is configured with splines **44** separated by grooves. The splines **44** correspond in number to the number of dial digits, **10** in the example shown. In contrast to the non-symmetric splines **40** on inner sleeve land **38**, the splines **44** are equally spaced to correspond to equal increments of dial rotation. Cover **25** has a raised boss **45** formed in line with outer sleeve land **39**, and an opening **46** extends through this boss **45**. A rim **43** is formed around the face of boss **45**. The cover shaft opening **46** is configured or slotted to receive and interfit with the splines **44** on outer sleeve land **39**, provided the shaft A is set at whole number dial positions. To correct minor shaft misalignments, the ends of splines **44** thereon are slightly chamfered, as at **47**, so that the sides of opening **46** will cam the shaft A into angular position corresponding to a discrete or whole number dial setting. As will be seen, this preferred structure prevents shaft A from being pushed in (to set a tumbler) except at a whole number dial position, e.g., at **8** or **9**, but blocks push in at any position in between.

Sleeve **36** contains an intermediate peripheral groove **48** between the lands **38** and **39**. A centering spring **49** is captured in compression in this groove **48**. At its inner end spring **49** bears against an annular washer **50** which it urges against the adjacent end of land **38**. At its other (outer) end spring **49** bears against an annular washer **51** which it urges against the adjacent end of outer sleeve land **39**. This spring biases the sleeve and shaft A to the centered position shown in FIG. **7**, in which neither of lands **38** or **39** interengage the case or cover, as will be explained.

A cam mounting sleeve **53** is received on shaft sleeve **36** and mounted to it by means which maintain the angular position of the cam mounting sleeve **53** (and the cams C to be described, mounted thereon) with shaft A and shaft sleeve **36**, but which permit the shaft and shaft sleeve **36** to be shifted axially with respect to the cam sleeve.

As seen in FIG. **5**, cam mounting sleeve **53** is a tube, and on its outer surface has a plurality of longitudinal grooves **54**, there preferably being five such grooves equally spaced around the circumference of tube **53**. The grooves **54** interengage with splines or teeth **56** formed on a central opening **55** in each of the cams C. In the preferred embodiment shown, seven cams C are used, and they are mounted in different angular positions or orientations on cam mounting sleeve **53**. To facilitate manufacture, these cams may be similar in outline, but they are oriented in different angular positions on the sleeve. The similar shapes of the cams make it difficult to discriminate among them radio-

graphically. Each cam can be slipped on mounted sleeve 53 with its teeth 56 engaged in the grooves 54 along sleeve 53. In the arrangement shown, each cam C can be placed on sleeve 53 in any of five angular positions, and with either large planar surface facing up, thus making a total of ten possible cam orientations on the shaft. The preferred outline of a simple cam C is shown in FIG. 2; around its periphery it has eight rises, each of which will establish a discrete position of the associated cam follower D and tumbler G. By changing the angular position of the cam on the sleeve, and/or by turning the cam over, a given rise can be associated with any dial digit. Since each cam is individually arranged on the shaft, the over-all cam stack may be individualized from lock to lock.

In addition to the several cams C, the driver AA is similarly mounted to sleeve 53 (see FIGS. 5 and 6). Driver AA may be generally circular in outline, and has a lever dog engaging notch 57 provided in its periphery. As shown in FIG. 7, driver AA resides adjacent boss 34 on case bottom 21.

The assembly or stack of cams C and driver AA on cam mounting sleeve 53 is connected to the shaft sleeve 36 by connecting means at each end that intermesh with the splines on sleeve lands 38 and 39. At the outer end thereof, adjacent to cover sleeve land 39, the end of cam mounting sleeve 53 is slotted to provide longitudinally extending teeth 58 which are positioned radially in alignment with the corresponding splines 44 (see FIG. 2). These teeth 58 are in radial alignment with the splines 44 on sleeve land 39. As shown in FIGS. 2 and 7, the end of cam sleeve 53 that is adjacent the cover is connected to the shaft sleeve 36 by a connector or member 59. It comprises a flat annular disc-like or flange portion 60 from which tines or prongs 61 project, parallel to the axis of shaft A, into the grooves between the splines 44 of sleeve land 39, so that this connector member is splined to the land. Surface 60 is cut away or notched as at 62, to receive slidingly the projecting teeth 58 on sleeve 53. The purpose of this connector 59 is to connect cam mounting sleeve 53 and cams thereon to the shaft sleeve 36 for rotation therewith, but at the same time to permit axial displacement of shaft A with respect to the cam pack, when the shaft is moved inwardly or outwardly relative to the case. Flange 60 is confined radially by the curb 43 of boss 45, so that connector 59, and hence the end of shaft A, are supported and journalled for precise rotation in the case cover.

As seen in FIGS. 7, 10 and 11, washer 51 is urged by spring 49 against either the lateral edge of land 39 or the inner ends of the prongs 61 of connector 59, whichever is innermost. The length of the prongs 61 is substantially equal to the longitudinal dimension of land 39, and in the centered or neutral position shown in FIG. 7, washer 51 bears against the ends of both prongs 61 and of land 39.

A similarly functioning connector 63 is provided at the inner portion of shaft A, adjacent the case bottom aperture 35. This connector has an annular flange 64 which is notched to intermesh with longitudinally extending teeth on land 38. Flange 34 rides within the curb 30 of boss 34, so that connector 63, and hence the inner portion of shaft A, is journalled and axially centered in the case. Tines or prongs 65 project longitudinally and interfit in the grooves in land 38 between the splines 40 thereon. These tines 65 are of the same axial length as land 38, so that in the centered or neutral position the washer 50 rests against both the ends of the tines and the sidewall of land 38, under the bias of spring 49. As can be seen with reference to FIGS. 10 and 11, the washer 50 is urged against either the lateral edge of land 38 or the inner ends of the prongs 65 of connector 63, whichever is innermost.

Stop means in the form of washers 63, 63 (FIG. 7) are confined within the curbs of case bosses 34 and 45 and axially space connectors 63 and 59 respectively from the apertures 46 and 35. These prevent axial movement of the connectors and prevent any possible interference between the tines of the connectors and the grooves of the adjacent aperture as shaft A is rotated.

An assembly or mechanism of a single cam follower D and tumbler G is shown diagrammatically in FIG. 1, and in elevation in FIG. 5. The cam follower D has a projecting nose 67, spaced parallel legs 68 and 69 with ears at each end that provide guide and bearing surfaces that slide in ways to be described, and fingers 70 and 71 that are parallel to the legs and nose.

The tumbler G is mounted closely parallel to the cam follower D, and has two spaced parallel legs 73 and 74 having ears at each end that slide in the same ways as those in which the follower ears slide. Tumbler G also includes a finger 75 that lies closely parallel to finger 71 of the cam follower D. It can be seen that finger 71 of the cam follower projects away from shaft A, whereas finger 75 of the tumbler G projects generally toward the shaft; thus, these fingers 71 and 75 extend from oppositely facing surfaces 76 and 77 respectively of cam follower D and tumbler G. As best shown in FIGS. 1 and 5, the coupling spring F loosely encircles the two fingers 71 and 75 and is in compression between the oppositely facing surfaces 76 and 77 of the tumbler and follower. These surfaces are perpendicular to the direction of tumbler and follower movement in the housing ways. It can be seen that the spring F thus biases these two surfaces 76 and 77 apart from one another. Each cam follower-tumbler mechanism is preferably identical to that just described, in order to confuse radiographic analysis. The ears on the legs 68, 69, 73, 74 of each pair slide in guide slots or ways 81, 81 provided in a tumbler pack housing indicated generally at 82, see FIGS. 4 and 5. The several sets of tumblers and followers are in parallel overlying relation, and thereby form a deck or tumbler pack. The ways 81 guide the respective mechanisms in sliding movement toward and away from the axis of shaft A, in the planes of the respective cams C with which the followers are associated. This housing 82 facilitates installing and servicing the several sets of mechanisms as a unit without disassembling any tumbler-follower pair or set. The housing is positioned and fastened, as by a pin 80 and machine screw 83, to the case base 21. Each cam follower is biased by a cam follower spring E toward engagement with its respective cam. As shown in FIGS. 4 and 5, each follower spring E loosely encircles the finger 70 of the respective cam follower D, and bears at one end against the surface 76 of the follower D and at the other end against a boss 84 of the tumbler pack housing 82.

Each tumbler G has a finger or projection **86** which extends from its leg **74** in the direction perpendicular to the direction of tumbler sliding movement but in the plane thereof, and through an opening **87** in the tumbler pack housing **82**. As will be described, the several fingers **86** form a part of interengageable means for engagement with the respective fences U, upon proper tumbler alignment.

The edge of leg **73** of tumbler G is multiply toothed or notched as indicated at **88** in FIG. **5**. The notches **88** of the respective tumblers are engageable by a tip or holding finger **89** of their corresponding holders H, as shown in FIGS. **4** and **5**. Thus, the holder finger **89** and the notches **88** form interengageable means for holding a tumbler in a certain position. The holders H are supported by the tumbler pack housing **82** for sliding lineally in guide means or ways **85** toward and away from the notched edges of the respective tumblers G. When holding finger **89** is seated in a given notch **88**, the tumbler is held in fixed position and cannot respond to the forces imparted to it by its coupling spring F. As indicated by the arrow in FIG. **5**, the direction of movement of each holder H is transverse or perpendicular to the direction of movement of its respective tumbler, but is in the same plane as the latter. Thus, the holders also form a deck in which they are in parallel overlying relation.

A holder biasing spring J encircles finger **89** of each holder, bearing on the holder at one end and on the case **82** at the other end, thereby biasing the holder away from engagement with the notches **88** of the respective tumbler G.

Each holder H also has associated with it a holder actuating spring M which is in the form of a safety pin. Each holder actuating spring M is prestressed, and the reaction of the force due to this stress is taken by a hook **93** which is integrally formed with spring M. Each spring M has two legs which are bent as at **91** and **92**, and the legs are hooked together under stress by the hook **93**. This stress tends to separate the legs, or move them apart. The springs M are mounted for swinging movement on a shaft or pin **90** in case **82** which is perpendicular to the plane of holder movement. Each spring M is engageable at bend **91** with the edge of the respective holder H, and at the opposite bend **92** is engageable by the lobe of the corresponding holder cam K. The force required to increase the stress in the springs M is greater than the force required to compress the holder release spring J. The rise on the holding cams K is greater than the distance between the holding finger **89** and the toothed notch **88** in the tumbler G. Until a spring M is engaged by its holder-cam it exerts no biasing force on the holder or the cam.

In FIG. **4** it can be seen that the tumbler pack housing **82** includes separators **79** in the form of flat plates between each tumbler-cam follower pair. The purpose of these is to prevent interference between the springs E or F of one set with those of an adjacent set, which otherwise might affect the position of an unset tumbler.

The holder-cam stack, which is best shown in FIG. **3**, will next be described. Each holder-cam K (one of which is shown partially broken away and in plan view in FIG. **5**) has a lobe or rise **94** which, when engaged with the bend **92** of holder actuating spring M, causes the latter to swing about shaft **90** and to exert a biasing force on holder H that exceeds the force of the spring J, and thereby cause the holder to lock its tumbler in the position in which the latter has been set by the follower D.

The holder-cams K, corresponding in number to the seven holders as illustrated in the preferred embodiment, are mounted on holder-cam shaft L for rotation therewith, positioned according to the positions of the respective holders H and springs M in the tumbler pack housing **82**. Shaft L is journalled at each end by support means connected to the case. Holding ratchet N is also mounted to holder-cam shaft L, and has a series of ratchet teeth corresponding in number to the number of tumblers plus **1**, (see FIG. **5**). Spring means in the form of a torsion spring **97** biases the holder-cam shaft L (counterclockwise, as seen in FIG. **5**) toward an initial position in which the first tooth of the ratchet is presented for engagement by the holding pawl T, to be described.

The holding pawl T is shown in plan view in FIG. **6** and in perspective in FIG. **3**, and includes a tooth or tip **98** shaped to engage a single notch on holding ratchet N. The holding pawl T is formed at one end of an L-shaped member or release bar CC which is rotatable about a shaft **100** that extends from case bottom **21**. The foot **101** of release bar CC projects toward the axis of shaft A, and has an angulated cam surface **102** (see FIGS. **1** and **3**) formed on it for engagement with a correspondingly sloped cam surface at the inner end of shaft sleeve **36**, as designated at BB in FIGS. **3**, **7** and **11**. With reference to these figures, it can be seen that when shaft A is moved outwardly from the case (downwardly as seen in the figures), cam surface BB on the shaft sleeve engages cam surface **102** on leg **101**, swinging leg **101** radially away from the axis of shaft A, and pivoting release bar CC counterclockwise about the pivot of shaft **100**. This releases the tip **98** of the holding pawl T from the notch of the ratchet N. As will be explained, when this occurs the advancing pawl S on shaft L is also released from the advancing ratchet O, and the shaft L is returned to its starting position under the influence of the biasing spring **97**.

The advancing ratchet O is connected to the outer end of holder-cam shaft L (see FIGS. **3** and **4**), and has a series of notches in its periphery. Advancing pawl S and crank R are pivotally jointed by a stub shaft **105** through their outer ends, for swinging movement together and for relative pivoting of pawl S with respect to crank R. A spring **106** biases advancing pawl S (clockwise as seen in FIGS. **2** and **3**), in the direction such that its tip **104** is moved toward engagement with the notches in the advancing ratchet O.

A tubular member **107** (see FIGS. **3** and **5**) is journalled on shaft **100**, and at its upper end (adjacent the case cover) this tube has an offset shoulder which forms advancing ratchet release DD shown in FIGS. **1-3**. At it lower end, tube **107** is connected to the release bar CC for rotation with it. As the latter bar is rotated counterclockwise (as seen in FIGS. **1** and **3**), the tube **107** and the advancing ratchet release DD rotate with it, and this movement brings the leading edge of the release DD into contact with a projecting shoulder **108** on advancing pawl S. This engagement pivots the advancing pawl S against the bias of spring **106**, and disengages its tooth **104** from the advancing ratchet O. By

the same movement of release bar CC, holding pawl T is also released from engagement with holding ratchet N, holder-cam shaft L is then free to return to original position under the urging of its biasing spring 97.

Crank R is pivoted for rotation on holder-cam shaft L and includes a shoulder or abutment 109 which projects from it and is engaged by the slidebar Q. As shown in FIGS. 2 and 7, actuator or slidebar Q is slidably mounted on the inside surface 25 of lock cover 24 by a T-shaped retaining screw 112 which passes through an elongated slot 113 in a flange portion 114 of the actuator. The crank actuator has an elongated shoulder 115 formed at right angles of flange 114. At one end the shoulder 115 extends into a recess 116 formed in a corner of the lock case cover, and a spring 117 (also contained in the recess 116) biases the bar on a line of movement toward the center of shaft A (see FIG. 2). At its other end, opposite shoulder 115, the slidebar Q is angulated to form a cam surface 118 (see FIG. 7). This cam surface 118 is disposed in alignment with a cooperating cam surface P formed around the outer edge of shaft sleeve land 39. By reference to FIG. 10 it can be seen that when shaft A is moved toward cover 24, cam surface P will engage surface 118 of the slidebar Q and will move the slidebar radially away from the axis of shaft A.

Shoulder 109 on crank R projects into a notch or cutout 120 on slidebar shoulder 115, and when the slidebar Q is thus cammed outwardly by axial movement of shaft A, the edge of cut-out 120 bears on shoulder 109 and pivots crank R clockwise (with reference to FIG. 2) about holder-cam shaft L. As the crank swings in this manner, stub shaft 105 swings the outer end of advancing pawl S with it. Since tip 104 of advancing pawl S is engaged in one of the notches of advancing ratchet O, this movement incrementally turns ratchet O and shaft L and cams K on shaft L. The parts are so dimensioned that one such increment of rotation is sufficient to bring the lobe of at least one holder-cam into engagement with its spring M to lock a holder H.

Fence U is shown in perspective in FIG. 1 and in plan in FIG. 5. The group of several fences—in number at least equal to the number of tumblers—are arranged as a stack, located in the form of a deck in a fence case 123. A fence case cover 124 retains them in case 123, and the case 123 and cover 124 defined a fence housing. The cover is suitably connected to the case. The fences U are shorter in length than case 123 so that they can be slid along their length and located at various positions in the fence pack housing (see FIGS. 5 and 12-15). The number of fences is preferably greater than the number of digits in the combination of the lock, some fences being dummies or false fences. In use, the dummy fences can assume random positions in the fence housing. In the preferred embodiment, a dummy fence 125 is positioned between each true fence U (see FIG. 4). The positions of the dummy fences camouflage the positions of the true fences and thereby protect against radiographic attach. Each fence U and 125 has a true gate 126 and one or more false gates 127 on either side of the true gate 126.

From FIG. 17 it will be noticed that the true gate 126 is just wide enough to accommodate the tumbler finger 86, and that the entrance to the true gate 126 is slightly angulated to provide a minor degree of camming action. The false gates are slightly narrower than the true gate to avoid any possibility of their accepting tumbler finger 86.

The housing defined by and between elements 123 and 124 is open at the end next to the case cover 24, see FIGS. 4 and 13. Clamping means prevent unintended relative movement between the fences in the housing. Specifically, a pressure plate 129 is facially imposed over the uppermost fence in the stack. Pressure plate 129 extends for the full width of the fence housing, that is, from side to side thereof, and fits inside of projections or end pieces 130, 130 on cover 124, which prevents the pressure plate from becoming separated from the fences. Outwardly of pressure plate 129 there is a fence clamping leaf spring 131 within the fence housing, which bears at its outer ends on the pressure plate and which has an intermediate arch or bend at 132. A wedge-shaped member 133 overlies spring 131 within the confines of the fence housing. Outwardly of wedge 133 is an arm 135 (see FIG. 13) which is connected to a shaft 136 (see FIG. 4) for rotation therewith. The arm 135 is adjacent the inside surface 25 of the lock case cover 24.

When wedge 133 is in the clamping position shown in FIG. 13, its thicker portion 138 is pressed downwardly by arm 135 against the arch 132 of spring 131, and the spring thereby exerts a clamping force on the pressure plate 129 and the stack of fences beneath it within the housing. This holds the fences in fixed relation to one another. As will be described, when arm 135 is moved so that wedge 133 is shifted (leftward as seen in FIG. 15) to an unclamp position, the thicker point 138 of the wedge is shifted out of engagement with the arch 132 of the spring, and the spring no longer exerts clamping pressure on the fences. The fences are then free to move relative to one another within the confines of the fence housing. It is preferred that a detent or notch 137 be formed at the thicker end 138 of wedge 133; this detent cooperates with arch 132 to prevent the wedge from shifting accidentally and relieving pressure on the spring, except when shaft 136 is turned deliberately for that purpose. The wedge 133 is sufficiently long that its thin end 139 then overlies but is spaced from the arch of the spring, thereby to confine the spring within the housing 123, 124 and prevent it from separating from the pressure plate. Together the fence housing, the fences, wedge and pressure plate comprise what may be called a fence pack, a subassembly which may be handled as a unit for installation or removal from the lock case.

The fence pack case 123 has ears or tabs 141, 142 at its upper and lower ends (see FIGS. 2 and 4), and the shaft 136 extends through and is rotatable in openings in these tabs 141 and 142. As shown in FIG. 4, the arm 135 projects from the upper end of shaft 136. At its lower end, that is, adjacent the case bottom 21, a swing arm 145 projects from and is pinned to the tip of shaft 136, as at 146. Pin Y projects from arm 145 toward the case bottom.

The fence housing is guided for movement parallel to the tumbler fingers 86 by a pair of guides 148, 148 which extend from cover 124 and which are received in corresponding ways 149, 149 presented by the tumbler pack housing 82. A fence biasing spring 150 (see FIG.

5) bears on shaft 136 and biases the fence pack toward the tumbler fingers 86. Spring 150 is connected to the case housing as shown in FIG. 2.

Since spring 150 urges shaft 136 in a direction which does not necessarily pass precisely through the center of mass thereof, this may exert a couple tending a disalign guides 148 with their ways 149. To avoid any possibility of binding or sticking, shaft 136 is supported and restrained for movement parallel to the plane of ways 149 by a pair of clevis jaws 153, 154 which engage it at its upper and lower ends adjacent the ears 141 and 142 (see FIG. 4). Each clevis has a slot in its outer end to accommodate the relative motion of shaft 136, and the clevises are mounted for rotation on a clevis tube which is journalled for rotation on a shaft 155 mounted by the lock case (FIG. 5).

The lock bolt X is supported for sliding movement by ways 160 formed on either side of an opening 161 in the side wall 22 of the lock case. Bolt lever W is connected to bolt X and has a dog Z at its inner end, as previously described and as shown in FIG. 6. The lever is pivotally connected to the bolt by a machine screw 159. A slot or opening 158 is formed in one leg of the lever W, and the pin Y on arm 145 can slide in this slot as the lever is moved to withdraw the bolt, that is, in the direction generally transverse to the direction of fence movement toward the tumblers, but moves with the lever in the direction toward the tumbler.

As shown in dashed lines in FIG. 5, lever W has a projecting foot 162 which is cooperable with a lobe 165 of lever cam V. As will be seen, this cam V acts to permit only abrupt contact of the fence pack and the tumblers. In the ordinary operation of the lock, lever foot 162 rides on the lobe 165 and is thereby positioned so that dog Z is maintained out of contact with the periphery of driver AA, and further so that the fences U are all spaced (by the bearing of slot 158 on pin Y) away from the tumbler fingers 86. While the combination is being set, there is no possibility of "feeling" the positions of the tumbler fingers with respect to the gates 126, and the lever dog Z is not riding on the periphery of driver AA.

Lever spring 164 and fence spring 150 bias the lever W toward the driver and thereby tend to move the fence pack toward the tumblers, but such lever movement is prevented by the engagement of lever foot 162 with cam surface 165 until the last number of the combination has been set. At that time the final increment of rotation of holder-cam shaft L turns cam V thereon to the position shown in FIG. 6, where foot 162 drops abruptly off the lobe 165, swinging lever W counterclockwise about pivot 159 and carrying fence pack toward the tumbler fingers. Thus, only uncontrollable contact can occur between the fence and tumblers, and even that only after all of the digits of the combination have been set.

One of the features of the lock of this invention is the ease with which the combination can be changed. For this purpose a combination change key 170 (see FIG. 16) is provided. The combination change key has two bits 171 and 172. It is insertable only through limited apertures in the lock cover. Specifically, bit 171 is cylindrical and fits through a crescent-shaped slot 168 in lock cover 24. The other bit 172 of the key is asymmetrical and contains a projection 173. Once the key has been inserted with bit 171 in slot 168 and bit 172 in hole 167, and the key has been turned, projection 173 rotates under the cover of the lock and thus prevents removal of the change key until it is returned to the original or inserting position.

A circular hole 176 is formed through arm 135 in the end thereof which overlies wedge 133. This hole is shaped to receive the cylindrical bit 171 of key 170. A transverse slot 177 is formed across wedge 133, having a width equal to the diameter of hole 176 in the arm above it (see FIGS. 12 and 13). A keyhole 179 (see FIG. 14) is formed in the end of shaft 136, and shaped to receive the other bit of key 170 comprising elements 172 and 173.

When the lock is locked, keyhole 179 in the end of shaft 136 and hole 176 in arm 135 are respectively out of alignment with the keyholes 167 and 168 in the lock cover, and arm 135 is in the position shown by the dashed lines in FIG. 12. The combination change key 170 therefore can be inserted only when the lock is unlocked. As will be described, in that circumstance keyhole 179 is aligned with cover hole 167, and hole 176 is aligned with slot 168, so that the key can be inserted and arm 135 turned (see FIG. 14).

Running the Combination

When the lock is locked, and prior to setting of any tumblers, each cam follower D bears on the periphery of its corresponding cam C. The holders H do not engage any of the tumblers, and the tumblers are all free to follow the movement of the cam followers. The foot 162 of bolt lever W is supported on the lobe of bolt lever cam V (as shown in dotted lines in FIG. 5), and the bolt dog Z is thereby held spaced away from the periphery of driver AA. Lever slot 158 bears against pin Y and holds the fence pack in the position shown in FIG. 5 in which the tumbler fingers 86 are spaced from the corresponding fence members U and do not contact the latter.

The combination is determined by the positions of the true gates 126 of the fences U; the respective tumblers G must be positioned and held by the holders in positions such that their fingers 86 are in alignment to be interengaged with the true gates of the respective fences.

When the dial B is turned, shaft A always turns all of the cams C on sleeve 53. The rotation of shaft A is imparted to the cams C through the shaft sleeve 36 via the connector 59 which rotates with it, the cam mounting sleeve 53, and the cams through the interengagement of the teeth on the cam with the grooves 54 on the cam mounting sleeve. The cams move the respective followers D, and the movement of the latter is followed by the respective tumblers G by the action of springs E and F until the holders are actuated to set the respective tumblers in particular positions.

It will be understood that the holders are not necessarily operated in the order in which they are arranged in the housing 82. On the contrary, the holders are set in a sequence determined by the sequence in which the holder-cams K contact and actuate the respective holder actuating springs M; that is, the order in which the holders are caused to engage and set the respective tumblers depends upon the arrangement of the cams K on holder-cam shaft L. In FIG. 3 it can be appreciated

that the lobes of the cams K are so arranged that the holder-cam marked 1 (which in this instance is the lowermost cam on shaft L) has the leading edge of its lobe in the clockwise most position, and it will be the first to operate a holder. The other cams actuate holders in the sequence 2–3–4–5–6 and 7, as shown on the drawings, with the lobe of the cam number 7 being the last to be brought into engagement with its respective holder actuating spring M as the holder-cam shaft L is sequentially advanced by ratchet 0. The arrangement of holder-cams K on the shaft L can be individualized from lock to lock so that the sequence of each lock will be different; it can be appreciated that this will further discourage radiographic analysis and surrepitious attack.

The combination is run by turning the dial B either clockwise or counterclockwise to the first number of the combination. As this occurs, the cams C will cause all the tumblers to shift relative to their respective fences U. At the dialed position corresponding to the first number of the combination, shaft A is pushed toward the closure; this would comprise upward shaft movement as seen in FIG. 10. As the shaft is thus moved, the thrust on it is transferred to shaft sleeve 36. The sleeve is constrained against such axial movement by misalignment of the splines 44 thereon with the respective openings 46 in the case top, unless the dial has been set at an integer or whole number dial position. If the dial is at a position just slightly away from a whole number position, chamfers 47 will cam it rotationally into a position of alignment, thereby enabling the push-in movement to be effected.

Push-in movement of shaft A is transferred through the edge of land 38 through washer 50 to spring 49, compressing the latter so that it then exerts a restoring outward force that will return the shaft to its centered axial position. It will be seen that the other washer 51 remains in engagement with the downwardly extending prongs 61 of connector 59.

The in-push on shaft A brings cam surface P on shaft sleeve 36 into camming relation with the cam surface 118 on slidebar Q. The slidebar is thereby cammed radially away from the axis of shaft A (see FIGS. 2 and 10), compressing spring 117. This movement of the slidebar causes the edge of cut-out 120 to bear against the shoulder 109 on crank R, and this in turn causes the crank to pivot clockwise around the axis of cam shaft L, as seen in FIGS. 2 and 3. The swinging movement of crank R is imparted to the advancing pawl S through stub shaft 105. Tooth 104 of advancing pawl S (which at this time is seated in the first notch of advancing ratchet O) turns ratchet O incrementally and thereby rotates shaft L and all the elements on it (see FIG. 3).

The holder-cam shaft L is rotated clockwise (as seen in FIGS. 3 and 5) in equal degree increments of X/7 degrees for a lock with a seven digit combination. At each increment of rotation a lobe or ramp 94 on at least one of the cams K is brought into the range of position in which it causes a corresponding holder actuating spring M to rotate about its axis 90. This rotation of the spring M compresses a spring J and causes the holding finger 89 to slide in its way until its motion is stopped by engagement in one of the toothed notches 88 of tumbler G. Provision of the springs M between the cams K and holders H insures proper holder engagement, and reduces critically of manufacturing tolerances.

The small angular movement of cam K is transformed into a relatively large lineal movement of holder H. Stopping (holding) of the particular tumbler occurs before the tumbler cam has actually rotated X/7 degrees. Continued rotation of the cam shaft increases the stress in holding spring M, thereby causing the bends 91 and 92 of the spring M to move toward each other. Hook 93 of the holding spring M then no longer takes the reaction of the force due to the stress in the spring. When the holding cam has been rotated X/7 degrees, the reaction of the force due to the stress in spring M is taken by spring J and by the bearing of the point 89 in the toothed notch 88. It is this force of engagement of the holding finger in the toothed notch in the tumbler which holds the tumbler in position.

The rotation of holder-cam shaft L brings the lobe of holder-cam 1 into that range of angular positions in which it is engaged with its associated holder actuating spring M, thereby pushing the respective holder H downwardly in its guideways 85, and its tip engages in one of the teeth 88 on the leg 73 of tumbler G.

The lobes on the cams C are so designed that at each whole number dial position the follower and tumblers are positioned by it at such location that one of the notches 88 is presented for engagement by holder finger 89. Once a tumbler is engaged by the holder finger 89, the tumbler finger 86 thereafter remains in fixed relation to its corresponding fence U. However, because of the resilient coupling spring F between the tumbler and its associated cam follower, the cam follower is free to continue to follow the rotation of the cam shaft as the latter is turned.

The force of spring F holds the follower and tumbler in fixed relation to one another only as long as the tumbler is not held by the holder point 89. The follower spring E is under compression and is guided by the finger 70 of the follower, and acts to cause the follower and tumbler both to follow cam C as long as the tumbler is not fixed in position by the holder. If the tumbler is held, then the follower can still follow the cam to higher rises on the cam because the follower spring E and coupling spring F are free to compress to shorter lengths.

When the shaft A is pushed in the manner described, the centering spring 49 is compressed between the washers 50 and 51 at each end thereof, and it exerts a force which biases the shaft outwardly to the point of minimum spring compression, which is the centered position shown in FIG. 7. Thus, the shaft automatically returns to centered position when the inward force on it is removed. When the shaft thus moves outwardly, spring 117 on slidebar Q restores the slidebar and the crank to their original positions. As the crank swings counterclockwise (as viewed in FIG. 3) the tip 98 of holding pawl T is seated in holding ratchet N, preventing holder-cam shaft L from returning to its original position under the influence of the holder-cam biasing spring 97. The counterclockwise swinging movement of crank R is transmitted to advancing pawl S, and as the latter swings, its tip 104 is drawn out of the first notch of the advancing ratchet O, and under the influence of the biasing spring 106 the tip drops into the next following notch for subsequent advancement.

At each subsequent push-in on the dial, another holder-cam K actuates its corresponding holder and pins the corresponding tumbler. The order of tumbler arresting is predetermined but is not necessarily sequential along the cam stack. Thus, the cams can be stacked in random order on the shaft.

It will be noted that the tip of holder finger **89** is V-shaped or pointed, and that each of the tumbler notches **88** is similarly shaped. This provides a camming relation such that the holder will cam the tumbler into a predetermined position in which the tumbler will be held, even if it was not removed precisely to that position by the cam follower.

During the entire tumbler setting operation, cam surface **165** of lever cam V engages the foot **162** of bolt lever W and thereby positions the latter to hold the fence pack away from the tumbler fingers **86**, as previously explained. When the last digit of the combination has been set, the incremental rotation of cam shaft L has proceeded to a point such that the lobe **165** of lever cam V is turned out from under the lever foot **162**. Lever W thereupon is swung counterclockwise about its pivot **159** by biasing springs **164** and **150**. As this occurs, the side of lever slot **158** bears upon the lower side (as seen in FIG. **6**) of pin Y, urging it and the fence pack toward the tumblers. The movement of the fence pack is guided by the sliding movement of the guides **148**, **148** thereof in the corresponding guideways **149**, **149**.

If the proper combination has been set, the fingers **86** of the respective tumblers will be directly aligned with and will be received in the true gates **126** of the respective fence members U. In this case the swinging movement of lever W will continue until dog Z rides on the periphery of driver AA. When the driver is then turned via shaft A to the zero (or another pre-established) position, a dog Z will drop into driver notch **57** (see FIG. **6**). The bolt can then be withdrawn by counterclockwise rotation (as seen in FIG. **6**) of shaft A which draws the lever to the right in that figure. As this occurs, it will be seen that the slot **158** accommodates such lateral movement of lever W with respect to pin Y, and the lever exerts no force on and transmits no motion to the interengaged fences and tumblers.

If the proper combination has not been run, one or more of the tumbler fingers **86** will be misaligned with respective true gates **126**. When lever foot **162** drops off cam surface **165**, the misaligned finger will arrest movement of the fence pack toward the tumblers, and this in turn will prevent sufficient movement of the lever to bring dog Z into contact with the periphery of driver AA.

When the bolt is to be extended, dial B is turned so that driver AA is rotated clockwise, as seen in FIG. **6**. Since dog Z is engaged in notch **57**, the rotation of the driver causes leftward extension of lever W and bolt X, with pin Y again sliding in lever slot **158**. Once the bolt is extended, continued rotation of the driver cams dog Z out of notch **57** and thereby swings the lever about its pivot **159**. The swinging movement of the lever causes the side of slot **158** to bear on pin Y, moving the fence pack downwardly (as seen in FIG. **6**), and moving arm **145** (and the entire fence pack which is connected to it through shaft **136**) from the solid line position to the dotted line position shown in FIG. **6**, thereby disengaging the fingers from the respective fences. The lock is returned to starting condition by an outward pull on the dial shaft.

After the bolt has been thrown, or at any time during the setting of the tumblers, the tumblers can be cleared and the lock returned to original condition by a "-clearing" axial movement of shaft A. This is assumed to be the outward direction for the purpose of this description, i.e., away from the case. This can be done only at one predetermined position at which the splines **40** on shaft sleeve **38** are aligned with the respective slots formed in the case aperture **35**; it is assumed that this is at the zero dial position, at which the bolt is extended. The axial pull on the shaft (in the downward direction as viewed in FIG. **7**), is transmitted by washer **51** to spring **49**, compressing the latter and biasing the shaft back toward its neutral position. During this movement the shaft sleeve **36** slides relative to the connectors **59** and **63** at each end thereof and relative to the cams C which do not move axially. Cam surface BB at the end of sleeve land **38** is brought into engagement with cam surface **102** on release bar CC (see FIG. **11**). This force on the release bar swings foot **101** thereof radially away from shaft A and causes the release bar and tube **107** to turn on shaft **100**. As this occurs, tip **98** of holding pawl T is swung out of engagement with the holding ratchet N and thus no longer exerts a restraint on the holding cam shaft. The rotation of release tube **107** brings advancing ratchet release DD into engagement with surface **108** on advancing pawl S, stressing spring **106** and causing pawl S to pivot counterclockwise about stub shaft **105**. Its tip **104** is thereby disengaged from advancing ratchet O. All holding restrains on cam shaft L having thus been removed, that shaft is returned to its original position by its stressed spring **97**. When this occurs the lobes of all of the holder cams V are turned out of contact with their respective spring. M, and holder release springs J push the respective holders H upwardly and out of contact with the tumblers. As lever cam V turns, its lobe **165** is repositioned under and in engagement with lever foot **162**. Once released from the restraint of holding fingers **86**, coupling springs F cause tumblers G to move to scrambled positions. The lock is then ready for another combination to be run.

Changing the combination

In the ordinary operation of the lock, when the combination is not to be changed, wedge **133** is in the position shown in FIG. **13** relative to the fences, in which it stresses spring **131** and thereby holds pressure plate **129** against the stack of fences to hold them in their then positions.

The combination is changed by use of the key **170** to release the force of the wedge on spring **131**, thereby to permit the positions of the fences with respect to one another to be changed. As previously explained, when the bolt is extended keyhole **179** in shaft **136** is disaligned with respect to case opening **167**, and opening **176** in arm **135** is also disaligned with respect to case slot **168** (see FIG. **12**). In this condition key **170** cannot be inserted in the lock to release the wedge. The key can be inserted only when the bolt has been retracted. When the fence pack has been moved into engagement with the fingers of the respective tumblers, the holes

176 and 179 have been shifted and are aligned with the case holes 168 and 167, so that key 170 can then be inserted and turned (compare FIGS. 12 and 14). Key bit 171 is passed through opening 168 and into hole 176 in arm 135 and projects into the slot 177 in wedge 133 (see FIG. 15). The other bit 172 of the key extends through case opening 167 into the keyhole 179 in shaft 136. When the change key is turned counterclockwise (see FIG. 14), bit 171 cams arm 135 to the dotted line position shown in FIG. 14 and simultaneously shifts wedge 133 from the position shown in FIG. 13 to the position shown in FIG. 15, in which wedge 133 has been shifted off of spring 131 and the spring is relaxed. With the force on spring 131 released, the fences can now be moved relative to one another within the housing. Since the lock is unlocked, the tumbler fingers 86 remain engaged in the respective gates 126. The same turning of key 170 which moved the wedge also turns shaft and arm 145 and thereby swings pin Y out of lever slot 158. This permits the bolt to be extended without moving the fence pack away from the tumblers and without disengaging the fingers 86 from gates 126. After the bolt has been extended, shaft A is then pulled outwardly to operate the release bar and thereby release the holders from the respective tumblers. With the holding forces removed, the tumblers respond to the forces of their coupling springs F, and they thereafter follow the movement of the cam followers when shaft A is rotated.

A new combination is then run in the same manner as for unlocking. As this occurs, the fences remain engaged with and move with the respective tumblers to new positions. After the new combination has been set, the dial is turned to retract the bolt; then then the combination change key is turned back to shift wedge 133 back to the position shown in FIG. 13 and lock the fences in their new positions. This also engages the fence with the lever. The key 170 is removed with the bolt retracted and the lock unlocked.

Having described my invention what is claimed is:

1. In a combination lock,
a cam operating a cam follower,
a movable tumbler interengageable with a fence only at a predetermined position,
a follower spring biasing the cam follower toward the cam,
and a coupling spring acting at each end on said cam follower and said tumbler, and biasing said tumbler to move with said follower unless movement of said tumbler is prevented.

2. The invention of claim 1 wherein said follower and tumbler are mounted side by side in ways for sliding movement.

3. The invention of claim 2 wherein the cam follower and tumbler are mounted in a tumbler housing,
said housing comprising a unit which can be removed from said lock for replacement without disassembly of the tumbler from the follower.

4. The invention of claim 1 wherein said follower and said tumbler each have two oppositely facing surfaces,
said surfaces being perpendicular to the direction of follower movement,
said coupling spring being seated between the oppositely facing surfaces of said follower and tumbler,
said coupling spring at all times abutting at least two of said surfaces which are opposed.

5. The invention of claim 1 wherein each of said tumbler and follower has two edges which face one another, and wherein said coupling spring is a coil spring having its ends bearing on the said edges of said tumbler and follower.

6. The invention of claim 5 further wherein said follower has a finger on one of said edges projecting toward its other said edge, and wherein said tumbler has a similar finger but projecting from an opposite edge than the finger of the follower,
the fingers overlying one another,
said coupling spring encircling said fingers.

7. The invention of claim 6 wherein said follower has a second finger parallel to its first mentioned finger, and a part of said follower spring encircles said second finger to bias the follower toward the cam.

8. The invention of claim 1 further wherein said tumbler has a projection extending perpendicularly to the direction of tumbler movement but parallel to the plane thereof,
and a fence having a gate for receiving said projection therein if said tumbler is held in a predetermined position of alignment with respect to said gate.

9. The invention of claim 8 further including means permitting only abrupt contact of said fence with said tumbler.

10. In a combination lock,
a cam operating a cam follower,
a movable tumbler interengageable with a fence only at a predetermined position of the tumbler,
spring means resiliently coupling the tumbler to the cam follower for movement therewith,
a holder movable transversely to the tumbler in the plane of movement thereof and interengageable with the tumbler for holding the tumbler in a given position,
and a holder cam for moving said holder into interengagement with said tumbler.

11. The invention of claim 10 wherein one of the holder and the tumbler has a projection thereon which is interengageable with a series of corresponding notches on the other of the holder and tumbler, to hold the tumbler in a given position.

12. The invention of claim 11 wherein said series of notches is formed in an edge of said tumbler.

13. The invention of claim 11 wherein each of said notches and said projection is V-shaped, and interengagement of said projection in a notch can cam said tumbler into a discrete position corresponding to a whole number position on a lock dial.

14. The invention of claim 11 further including a holding spring compressible between said holder cam and said holder so that when said spring is compressed by said holder cam it then pushes said holder into engagement with said tumbler.

15. The invention of claim 14 wherein said cam has a lobe which bears on said holding spring only in a certain range of angular positions of said cam.

16. The invention of claim 14 wherein a holder release spring biases said holder away from engagement with said tumbler, said holder release spring being weaker than said holding spring.

17. The invention of claim 14 wherein said holding spring is a preloaded hairpin-type spring which reacts on itself and which exerts no biasing force on said holder until the holder cam loads it beyond its preload.

18. The invention of claim 17 wherein said holding spring is mounted for pivoting movement on a shaft extending perpendicularly to the plane of movement of said holder.

19. In a combination lock,
- a movable tumbler interengageable with a fence only at a predetermined position of the tumbler,
- a holder movable transversely to the tumbler in the plane of movement thereof and interengageable with the tumbler for holding the tumblers in a given position,
- a holder actuating spring stressable by a holder cam to exert a biasing force on the holder urging the latter into interengagement with the tumbler to hold the tumbler in a given position,
- and means for rotating the tumbler cam to stress said spring.

20. A lock in accordance with claim 19 wherein the spring is a hairpin type spring which reacts on itself.

21. A lock in accordance with claim 20 wherein the spring is rotatable about an axis.

22. A lock in accordance with claim 20 which also includes a releasing spring biasing the holder away from interengagement with the tumbler.
- the releasing spring being weaker than the actuating spring.

23. In a combination lock,
- cam follower means for positioning a plurality of tumblers with respect to corresponding fences,
- a plurality of holders for holding the respective tumblers as positioned by said cam follower means,
- and a plurality of holder cams for actuating the respective holders to hold the respective tumblers,
- said cams being fixed on a rotatable shaft, each cam having a lobe operating the respective holder at a certain angular position of said shaft, the angular shaft positions at which the cams operate the respective holders varying from cam to cam.

24. The invention of claim 23 wherein said holders are mounted as a deck in parallel overlying relation,
- and further wherein said tumblers and follower means are mounted as a deck in parallel overlying relation.

25. The invention of claim 24 further including guide means limiting each holder to lineal movement along a fixed path, toward and away from the corresponding tumbler, the path of movement of each holder lying in the plane of movement of the corresponding tumbler.

26. The invention of claim 23 wherein said cams are stacked on the cam shaft with their lobes randomly arranged such that the cams do not operate the holders in the sequence in which they are stacked on the shaft.

27. The invention of claim 23 wherein said cam shaft is journalled at opposite ends in a lock case.

28. The invention of claim 23 further including spring means rotationally biasing said shaft to a starting position in which none of the cam lobes operate the holders.

29. In a combination lock,
- an operating shaft movable both rotationally and axially,
- a plurality of sets of mechanisms each comprising,
  - a tumbler positionable by rotation of said operating shaft,
  - a holder movable in a plane of movement of said tumbler, said holder movable toward and away from an edge of said tumbler,
  - interengageable means for holding said tumbler in a given position, said interengageable means provided in part of said holder and in part on said edge of said tumbler,
  - and a holder cam for moving said holder with respect to said edge so that said interengageable means are brought into interengagement to hold said tumbler at said position;
- the holder cams of said sets being mounted on a common rotatable cam shaft,
- ratchet and pawl means for rotating said cam shaft in increments, each increment causing at least one holder cam to move the corresponding holder into interengagement with the corresponding tumbler,
- and actuating means for said ratchet and pawl means, said actuating means responsive to an axial motion of said operating shaft to operate said ratchet and pawl means to rotate said cam shaft incrementally.

30. The invention of claim 29 wherein the holder cams are randomly arranged on the cam shaft to move the corresponding holders in nonsequential order.

31. The invention of claim 29 wherein said actuating means includes a member cammed by axial movement of said operating shaft, said ratchet and pawl means being operated by the camming of said member.

32. The invention of claim 29 further including
- a bolt and a lever for operating said bolt,
- a driver engageable with said lever to withdraw the bolt only if a predetermined combination has been set,
- and a lever cam on said cam shaft holding said lever out of contact with said driver until all of said tumblers are held by the corresponding holders.

33. In a combination lock,
- a settable tumbler,
- a holder movable relative to the tumbler to interengage and hold the latter at a position to which the tumbler has been set,
- a holder cam turnable to a position at which it causes the holder to interengage the tumbler,
- a ratchet connected to the holder cam for turning the latter,
- a pawl for turning the ratchet
- a spring rotationally biasing the cam toward a home position in which it does not actuate the holder,
- release means for releasing the pawl from the ratchet to permit the ratchet and cam to return to said home position, said release means being responsive to an axial movement of an operating shaft to disengage the pawl from the ratchet.

34. A lock in accordance with claim 33 wherein the release means includes a cam surface on an operating shaft, a member cammed in a transverse direction with respect to said shaft by axial movement of said shaft,
- said member being connected to said pawl to move the pawl out of operating relation with said ratchet when the shaft is moved axially.

35. In a combination lock,
- a group of fences,
- each fence being interengageable with a corresponding tumbler only at a certain tumbler position,

means mounting said fences and permitting sliding movement of said fences relative to one another, thereby to change the combination to which the group of fences is set,

and clamping means for preventing relative movement between said fences, said clamping means comprising,

a fence clamping spring for exerting a clamping force on said group, an element slidable with respect to said spring, in a direction parallel to the direction of fence sliding movement, said element being slidable between a clamping position in which said element stresses said spring to clamp said fences against relative movement and an unclamp position in which stress on said spring is released to permit relative sliding movement between said fences.

36. The invention of claim **35** further including,

a key engageable with said element for sliding said element between the clamping and unclamp positions,

a lock case having a limited aperture through which said key must pass to slide said element,

said aperture positioned to permit insertion of said key only when said lock is in unlock condition, and to permit withdrawal of said key only when said element is in clamping position.

37. The invention of claim **35** wherein said fence clamping spring is a leaf spring.

38. The invention of claim **36** wherein said element coacts with a detent tending to hold it in clamping position.

39. The invention of claim **35** further including a lock case having mounting means supporting the fence mounting means for movement in said case toward and away from the tumblers.

40. The invention of claim **39** wherein said mounting means comprise a clevis swingably mounted in said lock case, said clevis supporting the fence mounting means for movement in said case relative to said tumblers.

41. The invention of claim **39** further including a pin projecting from the fence mounting means,

a bolt and a lever for operating said bolt,

said pin extending into an opening in the lever, said opening permitting movement of said lever with respect to said housing in the direction transverse to the direction of fence movement toward the tumblers, but connecting the lever to the housing for movement therewith in the direction toward the tumblers.

42. The invention of claim **41** wherein said pin is connected to move with said element relative to said fences, such that when said element is moved to unclamping position, said pin is disconnected from said lever.

43. The invention of claim **35** which further includes dummy fences indistinguishable radiographically from the first mentioned fences,

the dummy fences being included in the group of fences but not in positions for interengaging the tumblers.

44. The invention of claim **35** wherein at least some of said fences include false gates not interengageable with the tumblers but radiographically appearing like true gates.

45. In a combination lock of the push knob type wherein an operating shaft is both rotatable about its axis and shiftable axially, means biasing said shaft toward a centered axial position comprising,

a sleeve around said shaft and connected to the shaft for rotational and axial movement with it,

said sleeve having a pair of lands separated by an intermediate peripheral groove,

a spring under compression in said groove and bearing at each end on a washer in said groove,

a connector member splined to each land for rotation with the land but slidable relative to the land,

stop means restraining axial movement of each splined member relative to the lock from a centered position

each said connector member having a transverse end surface engageable by the respective washer when the shaft and sleeve are moved from centered position and thereby further compressing said spring.

46. The biasing means of claim **45** wherein tumbler operating cams are mounted on a cam sleeve telescoped over the first mentioned sleeve,

said cam sleeve being connected to said shaft through the connector members for rotation but not axial motion with the shaft.

47. The biasing means of claim **45** which further includes a lock case presenting an aperture adjacent each end of said sleeve, into which said sleeve can move.

48. The biasing means of claim **47** which further includes means limiting the angular positions at which said shaft can be moved axially,

the limiting means being presented in part on the sleeve and in part on the aperture into which said sleeve moves.

49. The biasing means of claim **48** wherein said limiting means include splines and grooves on said aperture and sleeve, said splines and grooves being interfittable only at predetermined angular shaft positions.

50. The biasing means of claim **45** wherein the lock is mounted in a case which includes a journal for each said connector member.

51. The biasing means of claim **45** wherein a cam surface is formed on a land and is brought into engagement with lock operating mechanism upon axial movement of said shaft.

52. In a combination lock,

a shaft operated rotatable cam operating a cam follower,

a follower spring biasing the cam follower toward the cam,

a movable tumbler engageable with a fence only at a predetermined position,

the cam follower and the tumbler being mounted side by side for lineal movement in parallel planes toward and away from the cams,

and means yieldably coupling the tumbler to the follower and biasing said tumbler to move with said follower unless movement of said tumbler is prevented.

53. The invention of claim **52** wherein the lock includes a plurality of said cams and a cam follower and tumbler pair is associated with each cam,

the pairs of cam followers and tumblers being mounted as a subassembly in a housing removable from the lock.

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