

[54] **CYLINDER LOCK**
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 [73] Assignee: **Ingersoll Locks Limited**, Ascot, Berkshire, England
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 [21] Appl. No.: **273,863**

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 July 28, 1971 Great Britain..... 35430/71

[52] U.S. Cl. 70/366, 70/377
 [51] Int. Cl. E05b 29/00
 [58] Field of Search 70/366, 365, 362, 377

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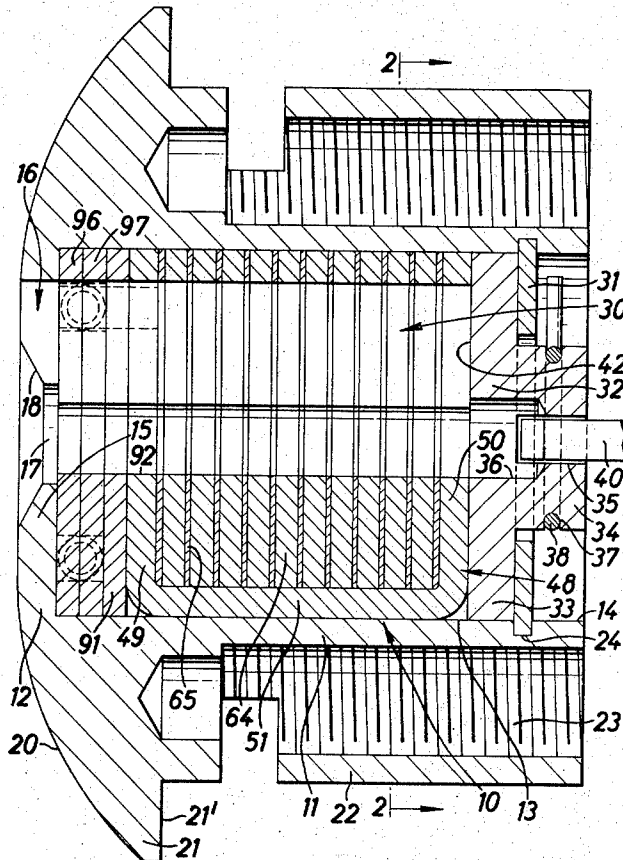
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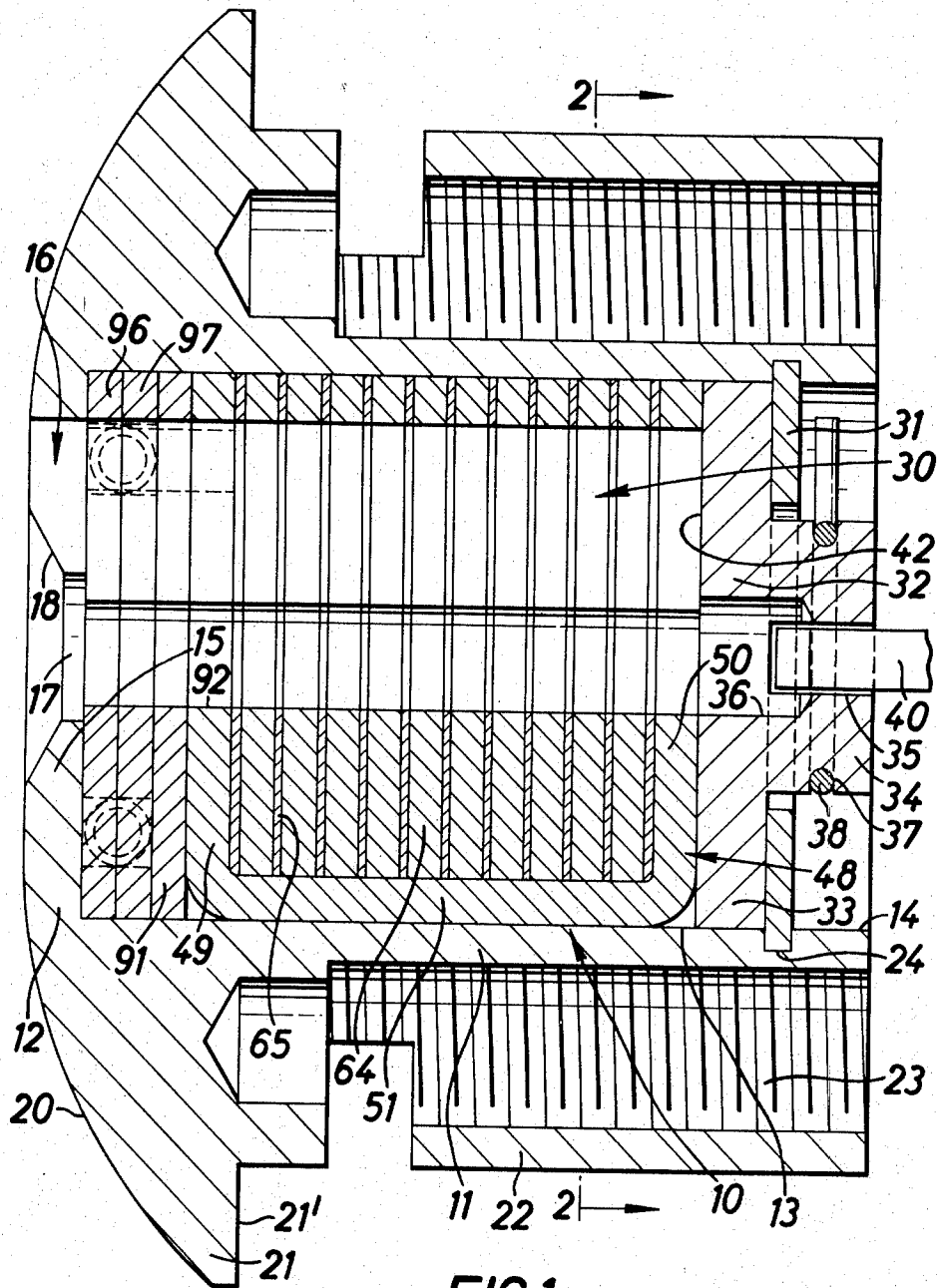
Primary Examiner—Robert L. Wolfe
Attorney, Agent, or Firm—Edwin E. Greigg

[57] **ABSTRACT**

A key operable plug mechanism having a body, a side bar movable to engage the body, a plurality of tumblers, a cylinder for said tumblers, each of said tumblers having a key engaging surface and a side bar accommodating notch the arrangement being such that on insertion of an appropriate key and rotation of the same, the key engaging surfaces are picked-up to align the notches of the tumblers and such that the rotary motion of the key is transmitted to said side bar through said cylinder.

11 Claims, 24 Drawing Figures





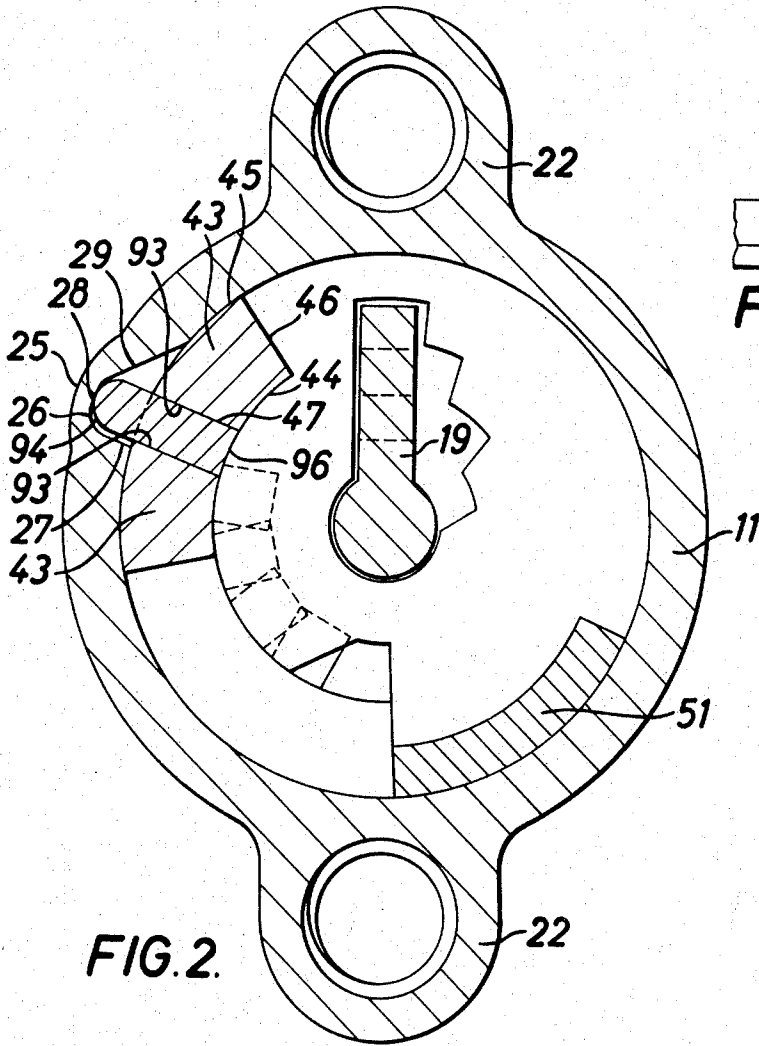


FIG. 2.

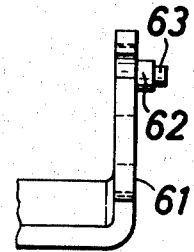


FIG. 5d.

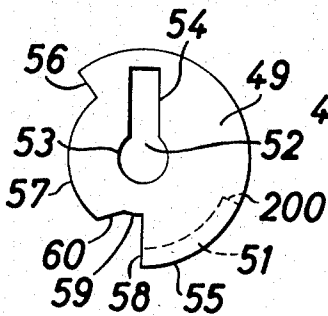


FIG. 5a.

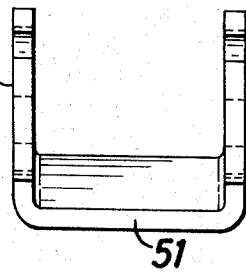


FIG. 5b.

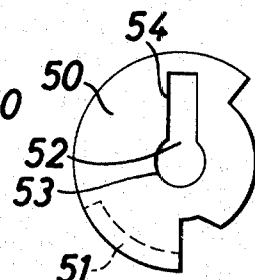


FIG. 5c.

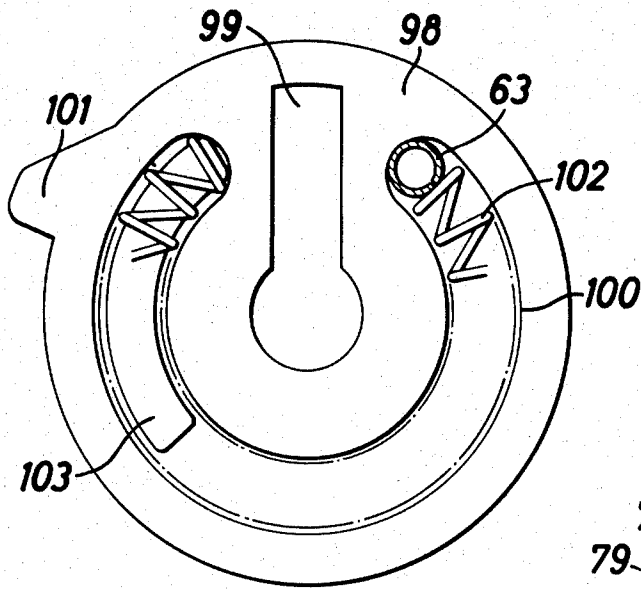


FIG. 3.

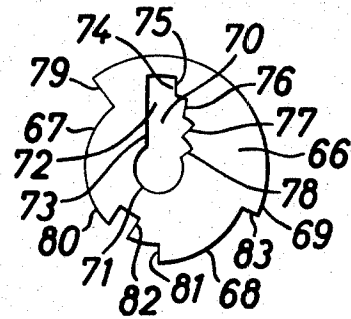


FIG. 6.

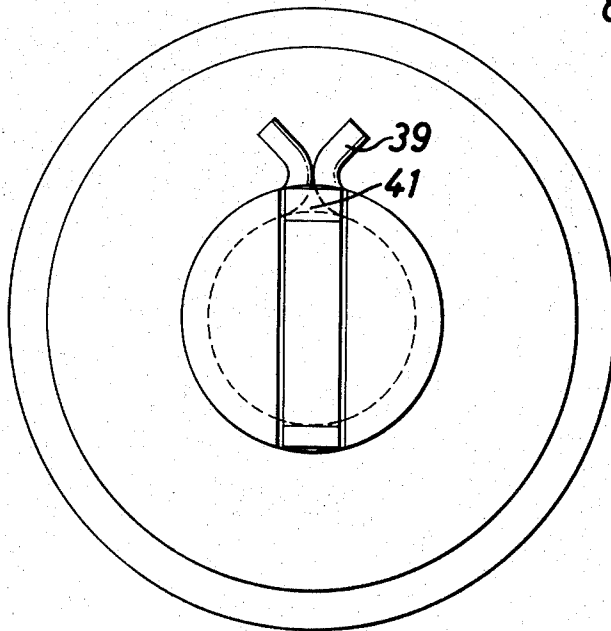


FIG. 4.

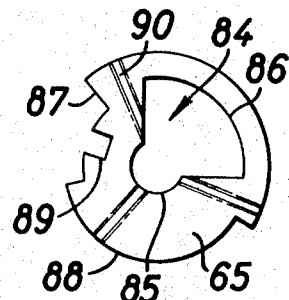


FIG. 7.

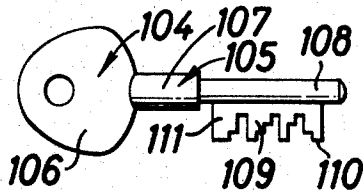


FIG. 8.

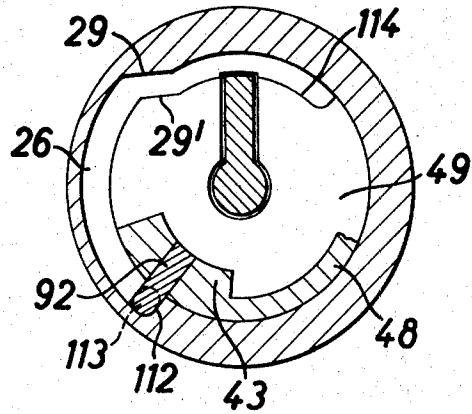


FIG. 9.

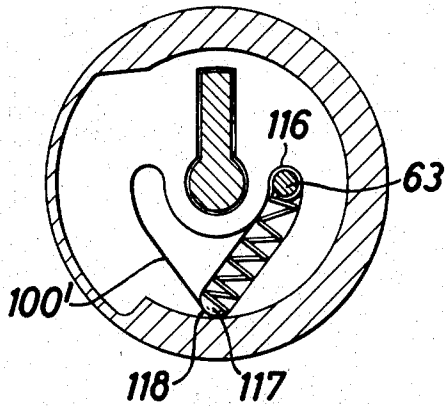


FIG. 10.

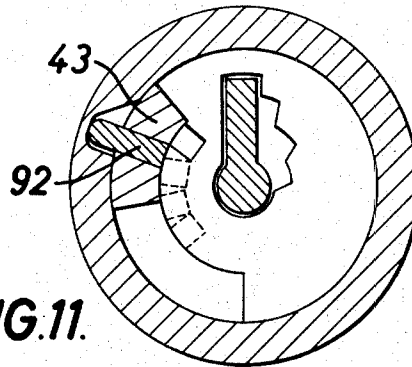


FIG. 11.

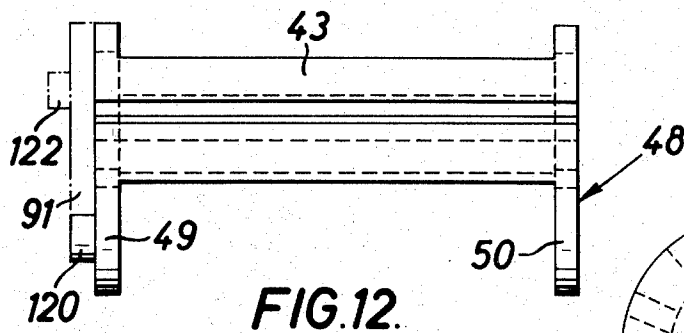


FIG. 12.

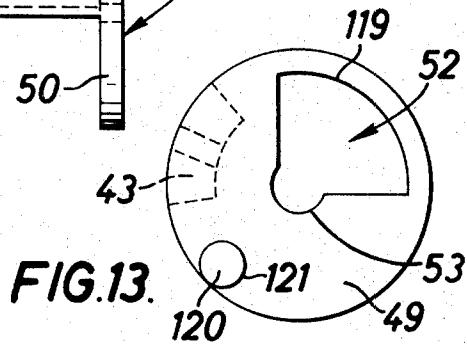
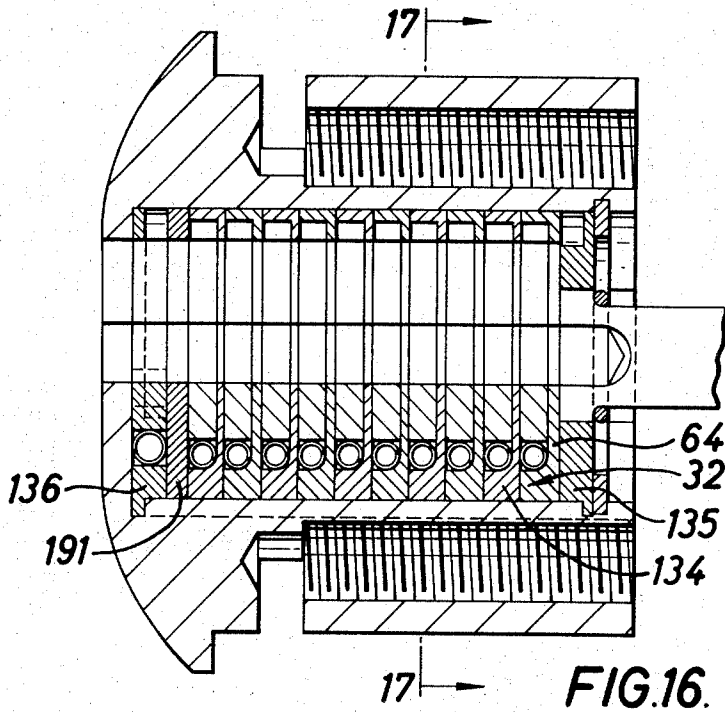
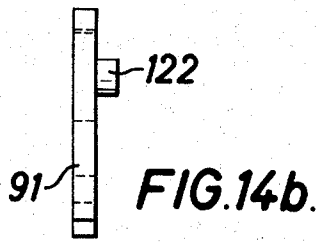
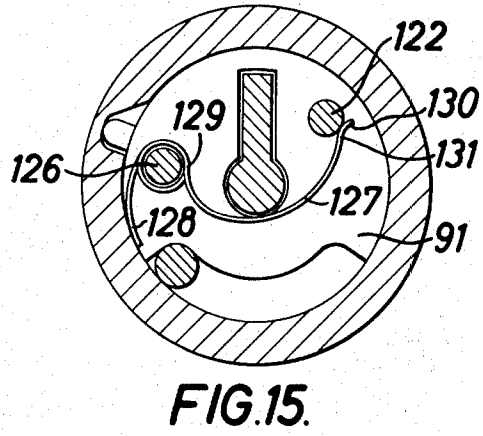
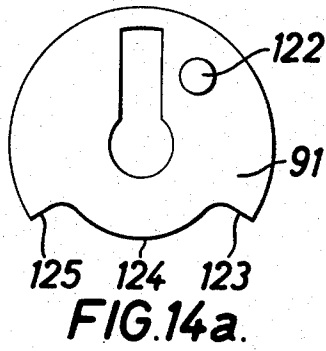


FIG. 13.



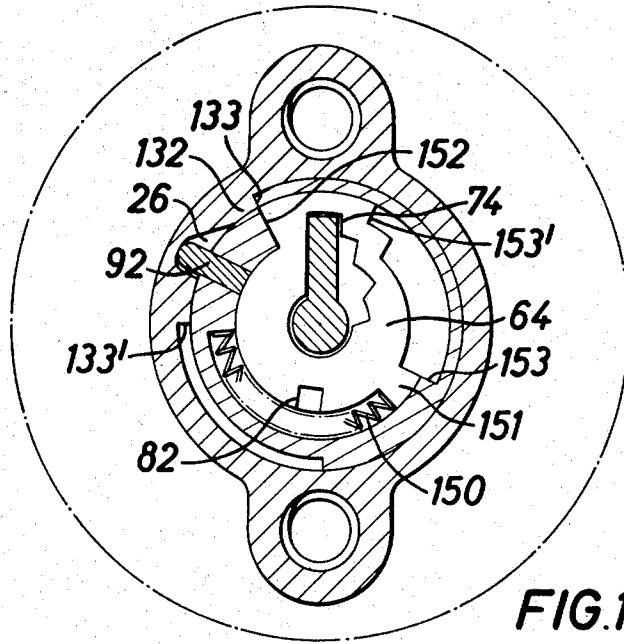


FIG. 17.

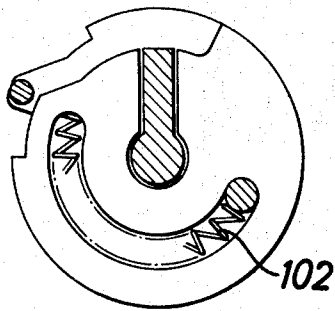


FIG. 18.

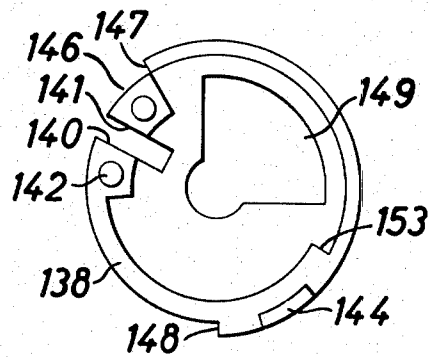


FIG. 19a.

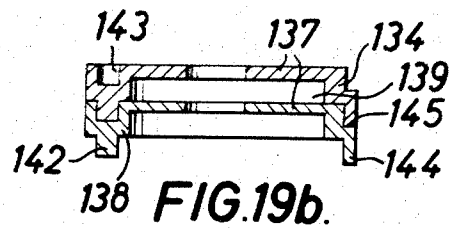


FIG. 19b.

CYLINDER LOCK

The present invention relates to a lock and with particular reference to a plug or similar mechanism suitable for inclusion in a revolving barrel type lock mechanism intended for association with or forming part of a lock.

The present invention provides a key operable plug mechanism having a body a side bar movable to engage the body, a plurality of tumblers, a cylinder for said elements, each tumbler having a key engaging surface and a side bar accomodating notch the arrangement being such that on insertion of an appropriate key and rotation of the same, the key engaging surfaces are picked-up to align the notches of the tumblers and such that the rotary motion of the key is transmitted to said side bar through said cylinder.

According to the present invention, there is provided a key operable assembly for a lock which comprises a body member having a generally cylindrical bore, a rotatable plug disposed within said bore, side bar means movable between a locking position in which said side bar means engages said body member to prevent substantial relative rotation between said plug and said body member and a free position in which said side bar means is disengaged from said body member to permit said relative rotation therebetween, a plurality of tumblers disposed within said plug and each capable of rotation about the plug axis, each tumbler having a key engaging surface and a peripheral notch, the said notch being adapted to accomodate at least part of said side bar means and being disposed in fixed angular relationship with said key engaging surface whereby when the side bar means is in the locking position the peripheral notches of said tumblers are dispersed so that the periphery of at least one of said elements prevents movement of the side bar means out of engagement with said member, and a cylinder for said tumblers, the arrangement being such that on insertion and rotation of an appropriate key, the tumblers will be engaged by said key on rotation thereof to produce relative rotation between said tumblers or sets of tumblers to align said notches to allow movement of said side bar means, the rotary motion of said key being transmitted to said cylinder to rotate said plug with respect to said body member.

With the tumblers dispersed in the locked position, that is to say, with the notches and the tumblers misaligned, the key engaging surfaces may also be dispersed so that on rotation of the key, lost motion between some of said tumblers is taken up until all of the key engaging surfaces are abutting the key whereupon the notches are aligned.

The cylinder may comprise a front plate, a back plate and a bridge piece to maintain said front plate and said back plate in spaced parallel relationship. The side bar may be a longitudinal member slidable radially of the plug out of and into the aligned notches of the tumblers. Alternatively, the side bar may be a pivotable member having a projection longitudinal of the plug and adjacent thereto whereby said projection may enter into the aligned notches and the side bar may move out of engagement with an associated co-operating portion of the body member.

The co-operating portion of the body member may comprise a longitudinal recess in a surface adjacent the plug which recess is adapted to accomodate a portion

of the side bar when the side bar is disposed in the locking position. The recess may have a chamfered longitudinal cam surface whereby on rotation of the key, the rotation is imparted to said side bar by means of the cylinder to urge an extremity of the side bar against the cam surface to cause the side bar to react against the surface and to enter the aligned notches of the plug to permit continued rotation of the plug relative to the body member. In one embodiment of the present invention the side bar may be arranged for rotation with the cylinder so that rotation of a key from a datum position causes rotation of the plug until the extremity of the side bar abuts said cam surface, the rotation of the key permitting the take up of the lost motion provided between some at least of the tumblers, thereby permitting alignment of the notches at the periphery thereof. Continued rotation of the key results in presentation of the aligned notch juxtaposed an inner extremity of said side bar whereby continued rotation of the key causes the outer extremity of the side bar to coact with said cam surface to urge the side bar inwardly of the plug thereby permitting continued rotation of the plug relative to the body member.

Alternatively, the side bar may be disposed between a pair of spaced longitudinal guides located towards the periphery of the plug and parallel to the longitudinal axis thereof. The guides may serve to support said side bar for rotation therewith about the axis of the plug. The guides may be connected to or form part of drive means for connection to a lock device per se. The cylinder may be arranged for rotation about the plug axis in response to rotation of the key about the same axis, and may include a bridge piece adapted to abut an adjacent portion of the side bar guide when the notches of the tumblers are aligned to receive the side bar, whereby continued rotation of the key results in withdrawal of the side bar into the aligned notches and out of engagement with said body member.

In another embodiment of the present invention each of the tumblers may be spring loaded to a datum position so that on removal of a key applied turning moment each detainer will return to its own datum with respect to the cylinder. This is in an additional advantage in the lock construction of the present invention since in order to pick the lock, a lock pick having a number of pick elements corresponding to the number of tumblers will be required. It will be appreciated, therefore, that where the number of tumblers is of the order of ten the problems involved in picking such a lock are immense.

The following is a description by way of example only with reference to the accompanying drawings of embodiments of locks in accordance with the present invention.

FIG. 1 is a longitudinal section through a barrel lock assembly in accordance with the present invention;

FIG. 2 is a vertical section along the lines 2 — 2 of FIG. 1;

FIG. 3 is a front end view of the spring plate assembly at the front end of the lock in FIG. 1;

FIG. 4 is a rear elevation of the lock of FIG. 1;

FIGS. 5a, 5b, 5c and 5d are details of the cylinder of the lock of FIG. 1;

FIG. 6 is an end elevation of a tumbler of the lock of FIG. 1;

FIG. 7 is an end view of a tumbler spacer of FIG. 1;

FIG. 8 is a side view of a key suitable for use in conjunction with the lock of FIG. 1;

FIG. 9 is a section illustrating an alternative embodiment of the present invention;

FIG. 10 is a part section showing an alternative arrangement of the spring plate assembly for a dead lock;

FIG. 11 is a section of a further embodiment of the present invention.

FIG. 12 is a detail of FIG. 11;

FIG. 13 is an end view of the embodiment of FIG. 11;

FIGS. 14a and 14b are details showing the front plate modification of FIG. 11;

FIG. 15 is a dead lock arrangement for the lock of FIG. 11;

FIG. 16 is a longitudinal section on another embodiment of the present invention;

FIG. 17 is a section on line 17 — 17 of FIG. 16;

FIG. 18 is a detail of the spring plate of FIG. 16;

FIGS. 19a and 19b are details showing a tumbler for use in the assembly of FIG. 16.

Turning now to FIG. 1, the lock comprises a cylinder body indicated generally at 10 comprising a cylindrical portion 11 terminating at a forward end in a face piece 12. The cylindrical portion 11 of body 10 has an internal cylindrical bore 13 which is open at its rearward end 14 and terminates at its forward end in an inwardly projecting flange 15. Flange 15 is configured to provide a key aperture 16. The key aperture 16 has a central cylindrical opening 17, a forward entrance of which is chamfered at 18, adapted to receive the shank of a key. The aperture 16 extends in a radial direction into a rectangular radially disposed bit-accommodating portion 19 (see FIG. 2). The face piece 12 is provided with a generally planar forward surface at the extremity thereof and is thereafter convexedly curved towards the radial extremity of the face piece at 20 to terminate in a flange 21 which projects substantially radially outwards of cylindrical portion 11. The rearward edge 21' of flange 21 is adapted to abut a surface to which the lock assembly is to be fitted.

The cylindrical body portion 11 is provided with a pair of diametrically spaced outwardly extending screw accommodating portions 22 juxtaposed face piece 12, each of which portions 22 is defined by a longitudinal hemi-cylindrical portion integral with body 11 and accommodating a tapped bore 23 adapted to accommodate connecting screws for securing body 10 to a door or like element housing the locking assembly.

The cylindrical bore 13 is provided towards its rearward end with an annular recess 24 of generally square cross-section.

The cylindrical portion 11 is provided in its external surface with a longitudinally extending enlarged area 25 symmetrically disposed about a radius of cylindrical bore 13 and in angular spaced relationship with the diameter containing the diametrically disposed screw accommodating portions 22. The inner surface of cylindrical body portion 11 defining cylindrical bore 13 is provided adjacent to the enlarged area 25 and a corresponding longitudinally extending side bar recess 26. Recess 26 is defined by first radial surface 27, an outer surface 28 and a chamfered or cam surface 29, the recess extending in the surface of cylindrical bore 13 rearwardly from face piece 12.

The cylindrical bore 13 of cylindrical portion 11 accommodates a lock cylinder 30 capable of rotation within bore 13 relative to body 10. The cylinder 30 is

retained within said bore 13 by means of an annular circular clip 31 accommodated within annular recess 24 towards the rearward end 14 of cylindrical bore 13, the arrangement being such that the cylinder 30 is retained within said bore between forward flange 15 and the circular clip 31. The cylinder 30 comprises towards its rearward end, a plug element 32 including a disc 33 of substantial thickness and a rearwardly extending boss 34. The boss has a diametric slot 35 across its rear surface and terminating in the plane containing the rear face of the disc 33. Disc 33 is counterbored from its forward face to communicate with said slot 35. The outer cylindrical surface of boss 34 is provided, intermediate disc 32 and its rear surface, with a peripheral recess 37 adapted to accommodate a generally toroidal split circular clip 38 having a pair of outwardly extending divergent arms 39 whereby the juxtaposition of the abutting portion of the arms 39 may be prised apart by means of a screwdriver or like element, the said juxtaposition being coincident with an open end of the slot 35. A connecting bar 40 having a pair of opposed projections 41 at its forward end is disposed in diametric slot 35 so that the projections 41 are disposed forwardly of the circular clip 38 to maintain the connecting bar 40 for rotation with the plug element 32. The arrangement of the circular clip is such that by prising apart arms 39, one of projections 41 may be hooked over a portion of the retainer disposed across said slot diametrically opposite said arms 39 and the remaining projection 41 may be slipped between the open end of the circular clip 38 forwardly of the plane containing the same so that on closure of the arms 39 the projections 41 of the connecting bar 40 are trapped by said retainer.

The annular front surface 42 of disc 33 is provided at a periphery thereof with a pair of arcuately spaced guide elements 43 extending forwardly of disc 33. Each guide element is defined by means of an inner arcuate surface 44, an outer arcuate surface 45, a radial surface 46 and a guide surface 47. The guide surfaces 47 of each of guide elements 43 are in spaced parallel relationship one with the other. The outer arcuate surface 45 of each guide element 43 is continuous with the cylindrical periphery disc 33 of plug element 32.

Forwardly of plug element 32 there is accommodated within the bore 13 a cylinder 48. Cylinder 48 comprises a front end member 49 of generally disc-shaped configuration, a rear end member 50 also of generally disc-shaped configuration and a bridge element 51 extending between a circumferential part of each said front and said rear end members to maintain said front end member 49 and rear end member 50 in spaced parallel relationship. The said bridge element is of generally arcuate configuration extending through an arc defining an angle of substantially 60° at the axis of bore 13.

The front end member 49 and the rear end member 50 (see FIGS. 5a and c) are each provided with a key accommodating opening 52 corresponding in form to key aperture 16 in face piece 12 and having a central circular aperture part 53 and a radially disposed rectangular aperture part 54 communicating therewith, the arrangement being such that the circular and rectangular apertures defining the key opening accommodate the shank 108 and bit 109 portions respectively of the key (see FIG. 8) suitable for insertion therein. The longitudinal axis of rectangular portion 54 is contained by the diameter of the disc constituting said front and said

rear end members which also contains the radial edge of arcuate bridge element 51.

The peripheral edge 55 of front member 49 is cut away in a portion extending substantially 135° if an arc from the said diameter, the cut away portion being defined by first radial abutment surface 56, and inner arcuate surface 57 and a second radial abutment surface 58 coincident with said diameter containing the longitudinal axis of rectangular portion 54, comprising the key opening 52. A notch surface 59 is disposed adjacent said second radial abutment surface 58 and spaced inwardly of the arc defining inner arcuate surface 57; a cam surface 60 extends between notch surface 59 and inner arcuate surface 57 and extends divergently outwardly of the radius containing the contiguity of cam surface 60 and notch surface 59. The rear end member 50 has a configuration which is a mirror image of that of the front end member, and the arrangement is such that the cut-away portion defined by said surfaces is adapted to accommodate guide elements 43 of plug element 32 for limited relative rotation therebetween, the arcuate extent of the cut-away portion permitting lost motion between said guide elements 43 and plug element 32 when rotary drive is applied to carrier 48.

The front face 61 of front cylinder member 49 carries in spaced arcuate relationship with the rectangular portion 54 of key opening 52 on a side thereof remote from the said cut-away portion a forwardly projecting substantially cylindrical pin 62, the forward portion of which is reduced at 63.

The cylinder 48 is arranged to accommodate a plurality, in this embodiment ten, tumblers 64 each of which is maintained in spaced parallel relation with an adjacent tumbler and/or front and rear members 49 and 50 respectively of carrier 48 by means of spacers 65.

Each tumbler 64 (see FIG. 6) comprises a generally disc-shaped element 66 having a first cut-away portion 67 and a second cut-away portion 68 in a periphery 69 of disc 66. Each tumbler 64 has a key hole 70 comprising a circular portion 71 and a bit accommodating portion 72 corresponding to and adapted to co-operate with the rectangular part of key opening 52 in front and rear end members 49 and 50 respectively of the carrier 48. The bit accommodating part 72 and keyhole 70 is defined by a first surface 73 lying on a chord of the circle containing peripheral edge 69 and a plurality of pick-up steps 74 defined by a first pick-up step 75 which is in spaced parallel relationship with first surface 73, a second pick-up step 76 disposed inwardly of first step 75 and defining a finite angle with said surface 75 to provide an increased dimension of the keyhole between surface 73 and pick-up surface 76, a third pick-up step 77 disposed inwardly of second step 76 and defining an increased angle with first step 75 and a fourth step 78 which is disposed at a still further increased angle with respect to first step 75 and is disposed at a still further increased angle with respect to first step 75 and is disposed inwardly of the surface of third step 77. The arrangement of the pick-up steps 74 is such that insertion of the key into keyhole 70 provides for the bit to be disposed adjacent pickup steps 74. The bit is then cut or contoured (see FIG. 8) and adapted to engage with one of said pick-up steps so that on commencing to turn the key, a bit contoured to engage, say, third pick-up step 77, would take up a certain amount of lost motion before engagement with said step to "pick-up" said tumbler whereby different configuration along the bit en-

ables different steps to be picked up on each tumbler thereby providing a different degree of lost motion between each tumbler on rotation of the key and thereby providing a limited amount of relative rotation between each tumbler on rotation of the key.

The first cut-away portion 67 in a peripheral edge 69 of tumbler 64 corresponds with the corresponding cut-away portion of the front and rear end members 49 and 50 respectively of the cylinder 48. The first cut-away portion is defined by a shoulder 79, an arcuate edge 80 and a step 81, the said step 81 lying on the diameter containing the longitudinal axis of the generally rectangular portion of keyhole 70. Arcuate surface 80 contains an inwardly extending notch 82 of generally square cross-section. The notch in each tumbler is in fixed angular relationship with the pick-up step adapted to be engaged by the key, the arrangement being such that on insertion of the key and rotation thereof the tumblers will be differentially rotated to align the notches 82 in arcuate edge 80 of each tumbler.

The second cut-away portion 68 of each tumbler extends from step 81 defining the extremity of the first cut-away portion arcuately above the periphery so that in the datum position of the tumblers with respect to the cylinder, the radius determining the extremity of the second radial edge 83 will engage the adjacent edge 200 of cylinder bridge element 51.

Each of the tumblers 64 are spaced apart from each other and the adjacent front end member and rear end member of the carrier 48, by means of spacers 65. Each of spacers 65 is in the general form of a Belleville type washer (see FIG. 7), and serves to provide the flexibility necessary to ensure that each spacer imposes sufficient friction to provide free movement of the tumblers and yet to permit each tumbler to be rotated independently by the key. Each spacer 65 comprises a keyhole 84 having a circular central portion 85 and a sectoral portion 86 adapted to accommodate the bit of the key during rotational movement of the key to engage the appropriate pick-up steps on the tumblers 64. Each spacer is cut-away at a peripheral edge to define a first inner cut-away portion 87 and a second outer cut-away portion 88, the first inner cut-away portion is generally arcuate in form and defined at each end by a radius, the inner arcuate surface of said first cut-away portion incorporates a notch 89, the ends of said inner cut-away portion 87 embracing guide elements 43 of plug 32. The second cut-away portion is a shallower arcuate portion communicating with the first and extends arcuately thereof so that the sum of the first and second cut-away portion corresponds with the extremity of the first and second cut-away portion of each tumbler. The extremity of the first cut-away portion 87 of each spacer is arranged so that the first cut-away portion accommodates guide elements 43 of plug element 32, the notch 89 being disposed to correspond with the spaced parallel guide faces 47 of each of elements 43, the arrangement being such that in operation the spacers rotate with the plug element 32 and the tumblers 64 rotate relative to the spacers.

Each spacer has one or more radially extending longitudinal ribs 90 and the spacers are manufactured in beryllium/copper or nickel silver alloys and provide a similar function to a Belleville washer.

Forwardly of the cylinder 48 there is disposed in bore 13 of body 10 a front plate 91. The front plate 91 is of

generally disc-shaped configuration and is adapted for rotation with the key and cylinder 48. The front plate 91 is manufactured from sintered carbide or other hardened material and serves to prevent or restrain attack on the locking mechanism by means of drilling. The front plate 91 is provided with a central key-hole indicated generally at 92 of a configuration identical to and corresponding with key opening 17 and cylinder front end member 49. The arrangement is such that the front plate 91 is contiguous with the front surface of the cylinder front end member 49. The front plate has a circular hole adjacent the key opening adapted to receive the thicker shank portion of pin 62 so that in the assembled position the reduced portion 63 of pin 62 projects forwardly of front plate 91, the arrangement being such that the pin engages said front plate 91 for rotation with detainer carrier 48.

The guide elements 43 of plug 32 encompass a generally rectangular side bar 92 having a length corresponding to the space between the front face of cylinder front end member 49 and of the rear face of cylinder rear end member 50, said side bar 92 being of longitudinal cross-section and adapted as a sliding fit relative to guide elements 43, and radially of cylinder 30. The side bar 92 has planar rectangular surfaces 93 adjacent the guide surfaces 47 and has a convex semi-circular outer surface 94. The inner surface 96 is radiused to correspond with the arcuate edge 80 of first cut-away portion of each tumbler. The edge defining the contiguity of one surface 93 and the radiused inner surface 95 is chamfered in each of the portion juxtaposed the cylinder front end member 49 and the cylinder rear end member 50 for engagement with the cam surface 60 of the cut-away portion of the said members.

The arrangement is such that in the datum position of cylinder 30, the inner arcuate surface 80 of each of the tumblers 64 and the corresponding inner arcuate surface 57 of each of the front end member 49 and rear end members 50 of the cylinder cylinder is disposed adjacent the radiused inner surface 96 and side bar 92, and maintains the side bar 92 in a position such that it projects from the periphery of the cylinder assembly 30 into side bar recess 26.

The space between the front face of front plate 91 and the rear face of inwardly directed flange 15 is occupied by a front spring plate 96 and a rear spring plate 97, the front spring plate 96 being contiguous with the rear surface of flange 15 and body 10 and the rear spring plate being disposed between the front spring plate 96 and front plate 91. Each of the spring plates 96 and 97 comprises a generally disc-shaped plate element having a keyhole 99 corresponding to that in the front plate. An arcuate slot 100 extends about the central portion of the keyhole and terminates at a point spaced on either side of said keyhole 99. The width of the slot is sufficient to accommodate the reduced portion 63 of pin 62, the arrangement being such that the pin can pass above the slot to permit the cylinder 48 to rotate about the axis of bore 13 with respect to plate element 98. The periphery of plate element 98 is provided with a projection 101 extending outwardly and in the plane thereof and configured to fit into the side bar recess 26, the arrangement being such that the projection secured each of spring plates 96 and 97 against rotation with respect to body 10.

The slot 100 accommodates a flexible compression spring 102. A first end of compression spring 102 re-

mote from pin 63 is carried about an arcuate abutment 103 of circular cross-section. The second end of compression spring 102 acts against pin 63 to bias pin 63 and the cylinder secured thereto to a datum position at the extremity of slot 100.

A key suitable for use in conjunction with the lock described above is shown in FIG. 8 of the accompanying drawings. This key 104 comprises a shank 105 projecting from a finger grip or bow 106. The portion of the shank 107 adjacent bow 106 is in the form of a collar and the major portion of the shank extending from an extremity of the collar is of reduced diameter and serves to define a pin 108. The annular face defined between pin 108 and collar 107 acts to locate the key with respect to the lock on insertion therein. The pin 108 carries a generally planar bit 109 extending radially outwardly of the pin 108, the thickness of bit 109 being substantially uniform. The outer edge 110 is profiled with a plurality of steps each step corresponding to the key engaging surface of a tumbler in cylinder 30. The front portion 111 extends to the extremity of edge 110 for the purpose of engaging with front plate 91 and the front end member 49 of detainer carrier 48.

It will be appreciated that the steps in contoured edge 110 of key 104 are adapted to correspond with the first, second, third or fourth steps of the pick-up steps 74 of each tumbler 64. The contour each step in the key bit will relate to the angular spacing between notch 82 and the corresponding pick-up step. The constant angular relationship between the selected step and the notch is maintained so that when the key is turned the notches will be aligned.

In operation, the spring 102 biases pin 63 on the front end member 49 of cylinder 48 to abut the adjacent extremity of slot 102, thereby defining a datum position for the assembly. At the same time, radial edge 200 of bridge element 51 abuts radial edge 83 of each tumbler to maintain each tumbler in its corresponding datum position with shoulder 79 abutting adjacent side bar guide 43. In consequence, a peripheral arcuate edge 80 of each tumbler 64 is juxtaposed at the radiused inner surface 96 of side bar 92 to maintain the side bar 92 in the projected position so that the convex outer surface 94 of side bar 92 is disposed in side bar recess 26. In this position the keyholes in each of the spring plates 96 and 97, the front plate 91, the front end member 49 of cylinder 48, each of the tumbler 64 and the rear end member 50 of cylinder 48 are aligned and maintained in the aligned location by the spring bias applied to pin 63 carried by cylinder front end member 49.

The key 104 described above and illustrated in FIG. 8 is inserted into the key apertures 16 of the body member 10. Insertion of the key is continued until the annular rear face of collar 107 abuts the front face of front spring plate 96. In this location the bit 109 of key 104 is disposed and accommodated within the keyhole in each of front plate 91, cylinder front end member 49, each of cylinder 64 and their corresponding spacers 65. The pin projection at the rear of the key enters bore 36 for accommodation therein.

The key 104 is, therefore, supported for rotation about the shank axis by the bore 36 and plug 32 and the spring plates 96 and 97. Rotation of the key in a clockwise direction with respect to FIG. 2 produces corresponding movement of the cylinder due to coaction between portion 111 of the key bit 108 and the longitudinal walls of rectangular portion 54 of key opening 52

in both cylinder front end member 49 and in front plate 91. The initial rotation of the key produces rotation of the cylinder with respect to the tumblers to remove the radial extremity of bridge piece 51 from its abutting relation with radial edge 83 of each tumblers. Continued rotation will bring the extreme portions of the key bit 109 into abutment with the first pick-up step 74 of the tumblers contiguous with said portion of the key. Thus, the "picked-up" tumblers will be caused to rotate under the influence of the key while the portions of the bit of reduced radial extent from the axis of the key shank will not abut a pick-up step and thus some of the tumblers will be caused to rotate about the axis of bore 13 with respect to the remainder. Further rotation of the key will produce contact between slightly reduced portions of the key bit and the second pick-up step of the appropriate detainers contiguous with said slightly reduced portion, thereby aligning the notches in the secondly picked up tumblers. Continued rotation of the key will produce a corresponding pick up of the third pick up step and the fourth pick up step, the arrangement being such that the notches 82 in each tumblers will be aligned. Continued rotation will bring second radial abutment surface 58 into abutting relationship with the adjacent side bar guide 43 whereby the notched surface 59 in each of cylinder front end member 49 and cylinder rear end member 50 together with the notches 82 in each of the tumblers 64 will be aligned contiguous to the radiused inner surface 95 of side bar 92. Continued rotation of the key about its axis will produce continued rotation of cylinder 48 and will serve to drive the plug 32 about its axis by virtue of the abutment of the second radial abutment surface 58 of the cylinder against the corresponding surface of the adjacent side bar guide 43. The side bar 92 is thus urged arcuately about the axis of bore 13 and the convex outer surface 95 of side bar 92 is caused to react against cam surface 29 of longitudinal side bar recess 26 to urge the talon inwardly of spaced talon guide 43 so that the radiused inner surface 95 enters the aligned notches 82 of each of the detainers. Continued rotation of the key about its axis results in the side bar 92 being urged into the notch until the extremity of the convex outer surface 94 of side bar 92 is contiguous with or disposed within the peripheral circumference of cylinder 30. The rotational motion of the cylinder 48 serves to drive side bar guides 43 and hence plug 32 in rotary motion about the plug axis and thus connecting bar 40 is caused to rotate to operate the lock to the unlocked position in which the pin 63 abuts an extremity of abutment member 103. It will be appreciated that since face plate 91 rotates with cylinder 48 and the spring plates 96 and 97 remain stationary, it is not possible to withdraw the key from the lock when the lock assembly is in the unlocked position. Accordingly, in order to withdraw the key, it is necessary to return the key to its datum position (anti-clockwise as viewed in FIG. 2) or to release the key whereupon the first radial abutment surface 56 of front end member 49 and rear end member 50 of detainer carrier 48 abut the adjacent side bar guide 43 and drive the side bar guide and plug towards its datum location. As the spaced guide surfaces 47 approach recess 26 the cam surfaces 60 on each of said front end member 49 and said rear end member 50 act on the chamfered portion of the side bar 92 to urge the side bar outwardly of the cylinder assembly. Continued rotation of the plug 32 and the side bar guides 43 under

the influence of spring 102 or the return of the key to its datum position causes the side bar to be urged outwardly of the plug and into side bar recess 26 until the adjacent rectangular surface 96 of side bar 92 abuts radial surface 27 of side bar recess 26 thereby preventing further rotation of the plug assembly and locating the plug assembly 32 in its datum position. At the same time the spring 102 continues to bias pin 63 towards its datum position at the extremity of slot 100. The notches 82 in the tumbler 64 are now free to be dispersed. Lost motion then occurs between the respective tumblers 64 until the radial edge 83 is "picked-up" by edge 200 of bridge element 51. Rotation continues until the cylinder and each tumbler reaches its datum position, in which the shoulder 79 on each detainer abuts the radial surface 46 of side bar guide 43.

It will be appreciated that dummy notches of some 10 or 15 thousandths of an inch depression in the periphery of the arcuate edge 80 of each tumbler can provide additional hazard to picking of the lock. It is necessary to pick accurately 10 members and at the same time to maintain a bias on the cylinder to urge side bar 92 to the commencement of cam surface 29. The presence of dummy notches will result in one or more dummy notches being engaged, in which case the only means of releasing the dummy notch is to release the cylinder to allow the cylinder 48 to return to its datum under the spring bias and to start again.

An alternative embodiment of the present invention is illustrated in FIG. 9. In this embodiment the talon guides 43 are secured to and form part of the cylinder 48 so that the side bar 92 is arranged for rotation with the cylinder 48. The side bar recess 26 is of substantial arcuate extent, extending over substantially 90° of an arc and extends from a datum defining edge 112 to cam surface 29. The recess 26 defines an arcuate track within which the extremity of side bar 92 may move during rotation of the cylinder 48 to obtain pick up of the pick up steps 74 of each of tumblers 64. The side bar is provided with a pair of axially extending projections 113 at each end thereof and the front face of plug element 32 is provided with a track to accommodate the rearwardly projecting element 113 while the spring 96 and 97 are provided with a cut-away portion 114 to define a track for the forward projection 113 of side bar 92.

In operation of the embodiment, insertion of a key and rotation thereof produces rotation of the cylinder 48 and front plate 91 associated therewith about the axis of bore 13 to produce corresponding movement of side bar guides 43 and side bar 92. Continued rotational movement of the key produces corresponding arcuate movement of the side bar within the track defined by recess 26. At the same time pick up of the step 74 of the tumblers 64 occurs as before and the notches 82 are aligned as the side bar approaches cam surface 29. Continued rotation of the key produces reaction between side bar 92 and cam surface 29 to urge the side bar inwardly of cylinder 30 to cause projection 113 to enter the track defined by the cut-away portion 114 of each of the spring plates and the corresponding track provided in the front face of plug 32 and by permitting continued rotation of the key until pin 63 engages abutment member 103.

On returning the key to its datum position or allowing the key to return to its datum position under influence of spring loading of compression spring 102, the side

bar is caused to rotate with the cylinder 48 until the extremity of the side bar 92 is juxtaposed cam surface 29. Thereupon the projection 113 engage cam surfaces in each of the spring plates and in the corresponding surface in plug 32 to urge the side bar outwardly of cylinder 30.

In the embodiment, illustrated in FIG. 10, the spring plate assembly illustrated in FIG. 3 may be substituted by a spring plate assembly as illustrated in FIG. 9. In this case a toggle spring 115 may be employed, having an end 116 disposed about pin 63. A second end of the toggle spring may contain a hemi-spherical element 117 adapted to abut against and swivel about arcuate portion 118 of the spring recess.

In operation, movement of the pin arcuately within the recess 100 results in compression of the spring against hemi-spherical element 118 until the centre point of pin 63 passes "over centre" of arcuate portion 118 with the result that the spring acts to urge pin 63 to the upper extremity of the recess 100, thereby providing an "over centre" arrangement for the lock. In this case a return action has to be provided from the key against the spring loading of pin 63 into the second extremity of recess 100 until the pin again passes over the centre, whereupon the spring urges pin 63 to a datum position and a corresponding urge applied to the cylinder 48 and tumblers carried thereby.

In a further embodiment of the present invention, the cylinder may be arranged so that there is lost motion between the key and the cylinder until the notches 82 in each of the tumbler are aligned.

This embodiment is illustrated in FIGS. 11 to 15 of the accompanying drawings. In order to achieve this variant of the lock assembly of the present invention, the cylinder 48 comprises the carrier front end member 49 and the cylinder rear end member 50, the said members being disposed in spaced parallel relationship. The members 49 and 50 are maintained in a spaced parallel relationship by means of spaced side bar guide members 43. Each of these members have a configuration corresponding to that described with reference to FIG. 1. The front and rear end members 49 and 50 respectively, comprising a disc of material adapted for a rotational fit in bore 13 of body member 10. The front end member of 49 of cylinder 48 has a keyhole 52 comprised by a circular aperture part 53 adapted to accommodate the shank or pin of the key itself and a sector portion 119 which attends an angle of substantially 90° at or towards the centre of the disc constituting front end member 49, the arrangement being such that the key is free to turn through an angle of substantially 90° without abutting an extremity of key opening 52, thereby providing clearance for key rotation to align the notches 82 in each of tumbler 64 prior to commencing turning of the cylinder 48. The front face of front end member 49 has a forwardly projecting spigot 120 of circular cross-section, the centre of which lies in a diameter which substantially bisects the angles subtended by the radial extremity of centre portion 119 of the key opening 52. Spigot 120 is disposed so that the cylindrical surface 121 has a common tangent with the periphery of the disc constituting front end member 49.

The tumblers and spacers are disposed between front end member 49 and rear end member 50 in a manner described with reference to FIG. 1, the configuration of the cut-away portion of each tumbler member being such as suitably to accommodate the side bar guides 43.

The front plate 91 has a keyhole corresponding to that of the front plate of the assembly described with respect to FIG. 1 and adjacent the keyhole a spring drive pin 122 is carried to extend forwardly of the front surface of front plate 91. The portion of the periphery remote from the rectangular portion of the keyhole of front plate 91 is cut-away to define a substantially radial drive face 123, an arcuate surface 124 spaced inwardly of the periphery of the disc defining front plate 91 and a second radial spigot abutment surface 125. The pin 122 is adapted to enter into slot 100 of spring plates 96 and 97 to act in the manner described above.

In operation, the key is inserted into the keyhole with the bit entering the appropriate portion of the hole provided therefor in each of the tumblers. The key is thus inserted at the datum position in which the second radial pin abutment surface 125 is in abutting relationship with the spigot 120 of cylinder front end member 49. The spring 102 acting on pin 122 to bias said front plate 91 to the datum position. Rotation of the key causes the bit thereof to engage the side of the keyhole in front plate 91 to drive front plate 91 about its axis against the spring bias acting on pin 122. The said portion of keyhole 52 in the cylinder front end member 49 allows the key to turn without imparting motion thereto. As progressive rotation of the key produces alignment of the notches 82 in tumblers 64 carried by the cylinder 48 in the manner described above, when the notches are aligned the drive face 123 of front plate 91 engages the diametrically opposite extremity of spigot 120 on cylinder front end member 49. Continued rotation of the key imparts drive to the cylinder 48 through spigot 120. In this position the notches 82 are aligned contiguous the radiused inner surface of side bar 92 and further rotation of the key causes rotation of side bar guides 43 to urge the extremity of the side bar against cam surface 29 to permit rotation of the cylinder with respect to body 10 to the unlocked position. On return or release of the key the spring 102 urges pin 122 towards its datum position until the side bar 92 is juxtaposed in the side bar recess 26, whereupon the side bar returns to recess 26 and the cylinder 48 is maintained in the stationary position and the pin 122 on front plate 91 is urged to its datum position, whereby the notches 82 in each of the tumblers 64 are dispersed and the key can then be withdrawn.

In a modification of the embodiment described, the spring assembly may be modified in a manner shown in FIG. 15. The spring plate is provided with a spring support pin 126 carried by the front spring plate 91 which pin 126 carries a leaf spring 127 formed of spring steel. A first end 128 of spring 127 is biased against the cylindrical surface of bore 13 of the body 10. The spring then passes about pin 126 in a coil 129 and the second end 130 is partially cranked at 131 to provide a convex surface which acts against pin 122 to bias it to its datum position. The spring leaf 127 extending across the front surface of front plate 91 over a path shorter than a circumferential path.

In operation, rotation of the key drives front plate 91 in the manner described above. The pin 122 moves against the bias of spring 127 to flex the same against stationary pin 126. Continued rotation of the key results in continued rotation of front plate 91 until pin 122 has urged leaf spring 127 to flex outwardly of a circumferential path contained by the radial extremity of pin 122. At this point the pin 122 rides under the

cranked portion 131 of leaf spring 127 and the spring bears against the pin 122 to provide resistance to turning so that the lock may be turned to a dead lock position. Upon returning to the datum position, as the pin 122 passes about the cranked portion 131 of leaf spring 127 the said portion engages the pin and biases the pin towards the datum position in the manner described above.

In a further embodiment of the present invention as set out in FIGS. 16 to 19 of the accompanying drawings, each of the individual tumblers is spring loaded to its datum position. This renders the locks substantially pick proof, and in order to pick the lock it would be necessary to employ a lock picking device having N+1 elements where N is the number of tumblers.

In this embodiment (see FIG. 17) the talon recess 26 is accommodated within an inwardly raised portion 132 defined by a pair of radial shoulders 133 and 133'. A plug indicated generally at 32 comprises a plurality of cylinders 134 each of which interlocks one with the other, the number of cylinders 134 being equal to the number of tumblers 64 employed in the assembly. The plug also includes a rear spring plate 135 and a front spring plate 136, a front plate 191 being disposed between front spring plate 136 and the first cylinder 134.

Each cylinder comprises a disc 137 having a forwardly extending generally annular projection 138 defining a substantially cylindrical depression 139 adapted to carry a tumbler 64. Each detainer carrier is provided with a substantially radial slot 140 adapted to accommodate the side bar, the opposed faces of slot 140 define the guide surfaces for the side bar itself. Juxtaposed on each side of slot 140 there is provided on the front face of each tumbler a forwardly extending stud 142 which is adapted to engage with a corresponding recess 143 in the rear face of the preceding cylinder element to lock one with respect to the other. An arcuate flange 144 is located on the periphery of disc 137 and extends forwardly of the front forward extremity of the annular projection 138 to mate with a corresponding recess 145 in the rearward surface of the preceding tumbler, the arrangement being such that by interlocking of the projecting parts with the corresponding recesses on the preceding element a cylinder can be built up.

The peripheral edge of the tumblers is cut away at 146 to provide a first shoulder 147 and a second shoulder 148 each of which is adapted to abut shoulders 133 and 133' respectively at different attitudes of the cylinder.

The keyhole 149 of tumbler 134 is sectored so that the key disposed therein is capable of an arcuate movement through an angle of substantially 90° without corresponding movement of the carrier.

Each tumbler 134 carries a tumbler 64 configured and adapted to be accommodated therein. A first tumbler projection 151 engages a tumbler spring 150 which is biased against the corresponding abutment as part of the thickened portion of the annular projection 138 juxtaposed the side bar accommodating slot 140, the arrangement being such as to bias the tumbler to its datum position whereby a second abutment surface 152 engages the corresponding surface of the other thickened portion with the forward annular projection 138 of the adjacent to side bar slot 140.

The remainder of the assembly is similar in construction with the embodiments described above. The spring

plate illustrated in FIG. 18 is provided with a track to accommodate a side bar projection in the manner described above, and the spring assembly of the spring plate is also described in detail above.

In operation, insertion of the key with the lock elements in the datum position permits the key to engage the spring plate the front plate and the tumblers themselves. Rotation of the key about its axis causes pick-up of the various pick-up steps on the tumblers until the notches 82 are aligned for subsequent accommodation of the side bar. At the same time, the tumblers are rotated about their axis against their spring loading until shoulder 133' abuts corresponding third shoulder 153 on the. At this stage the notches 82 are aligned juxtaposed side bar 92 and reaction of the extremity of the side bar 92 against the cam surface of recess 26 urges the side bar inwardly and permits rotation of the composite cylinder. Rotation of the tumblers together with the tumblers contained therein and the side bar now accommodated within the aligned notch 82 continues until shoulder 148 abuts shoulder 133' on the body.

It will be appreciated that the compression spring 102 should be greater in strength than the combined compressed strength of each of the tumbler springs 150 so that the drive will not be transmitted to the cylinder until the tumbler have been partially rotated against their spring bias to align the notches 82 to accommodate the inner portion of the side bar 92.

What I claim is:

1. A lock comprising a housing having a recessed area on the inner wall thereof, a lock cylinder in said housing having spaced front and rear end walls, a plurality of key-operated tumblers in said cylinder, pin means carried by the front wall of said lock cylinder capable of oscillating the lock cylinder from a locking position to an unlocking position, means abutting the rear wall of said lock cylinder associated with an axially disposed connecting bar and means capable of actuating the tumblers in succession to urge a side bar into said recess to permit the connecting bar to move to an unlocking position.
2. A lock as claimed in claim 1, wherein resilient means cooperate with said pin means.
3. A lock as claimed in claim 2, wherein the spring means is interposed between plural oscillatable plate means.
4. A lock as claimed in claim 3, wherein the front wall of the lock cylinder and said oscillatable plate means are maintained in spaced relation by front plate means.
5. A lock as claimed in claim 2, wherein the resilient means is controlled by a V-shaped slot and serves to confine the pin means in an arcuate path of travel from a locking position of the cylinder to an unlocking position thereof and vice-versa.
6. A lock as claimed in claim 4, wherein the front plate means is arranged to be rotated by a key against the spring bias of a second pin means.
7. A lock as claimed in claim 2, wherein the resilient means comprises a leaf spring.
8. A lock as claimed in claim 1, wherein the side bar cooperates with a radial slot in said tumblers.
9. A lock as claimed in claim 8, wherein the radial slot is straddled by offstanding studs.
10. A lock as claimed in claim 1, wherein the tumblers are spring-loaded into their locking position.
11. A lock as claimed in claim 1, wherein spacer elements are interposed between the inner walls and each of said tumblers.

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