

**PIN TUMBLER CYLINDER LOCK
WITH SHEARABLE ASSEMBLY PINS AND
METHOD AND APPARATUS OF MANUFACTURE**

Background of the Invention

5 Prior cylinder locks have included a plurality of tumbler pins and aligned driver pins urged by springs against the key. The pins are separately manufactured to selected lengths prior to lock assembly.

10 It has also been proposed to install one-piece pins in a cylinder; accomplish selected elevation of the pins using a notched key and thereafter shear each pin, as held in such elevation by the notched key, into two lock pins (U. S. Patent No. 1,953,535). Such prior method has the disadvantage that
15 any second randomly-selected insertable key would be capable of elevating the pins and, if torqued, would again shear the pins thus compromising security.

Summary of the Invention

20 Broadly, the present invention comprises a cylinder having a body, a turnable plug, a shear line therebetween, and a plurality of selectively weakened assembly pins for initial positioning by a notched key. The assembly pins are sheared by the manufacturer or locksmith using special machinery to
25 thereafter function as both driver and tumbler pins. Such assembly pins are strong enough so that torquing or otherwise forcing with an insertable key by the lock user or person with an unauthorized key or similar tool will not shear them.

30 It is a feature of the invention that the assembly pins have a plurality of selectively weakened portions or zones to control shearings at selected points provided sufficient shearing force is applied.

35 It is a further feature of the invention that the driver and tumbler pins, though sufficiently weakened, are strong enough so that torquing of a key by hand or with a tool will cause the key or tool to fail before the pins shear.

Brief Description of the Drawings

Fig. 1 is a side elevational cutaway view of the lock of the present invention including shell, plug and key-positioned assembly pins;

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Fig. 2 is a side elevational view of an assembly pin of the present invention;

Fig. 3 is a view similar to Fig. 1 in which the pins have been sheared by relative lateral movement between the shell and plug;

Fig. 4 is a plan view of the apparatus for shearing the assembly pins and crimping the shell and plug together;

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Fig. 5 is an elevational view of the apparatus of Fig. 4;

Fig. 6 is a partial sectional view along line 6-6 of Fig. 1;

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Fig. 7 is a partial sectional view along line 7-7 of Fig. 6;

Fig. 8 is an elevational view of the pin of a second embodiment;

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Fig. 8a is an enlarged view of a pin groove of the pin of Fig. 8;

Fig. 9 is a sectional view perpendicular to the horizontal axis of the plug without pins;

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Fig. 9a is a sectional view similar to Fig. 9 with pins and with the plug slightly turned;

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Fig. 10 is a plan view of a second shearing mechanism, with a longitudinal axis A, for use at retail locations;

Fig. 11 is a sectional view taken at 11-11 through longitudinal axis A of the mechanism of Fig. 10;

Fig. 12 is a front elevational view of a key-operated padlock which is a further embodiment of the invention with the plug of the shell-plug assembly protruding;

Fig. 13 is a side elevational view of the shell-plug assembly removed from the padlock of Fig. 12;

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Fig. 13a is a sectional view along 13a-13a of Fig. 13;

Fig. 14 is a view similar to Fig. 13 in which the plug has been translated in direction Y;

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Fig. 15 is a view similar to Fig. 12 in which the shell-plug assembly, after translation, has been placed in the padlock; and

Fig. 16 is an enlarged sectional view along line 16-16 of Fig. 14.

Description of the Preferred Embodiment

In Figs. 1-3, lock 10 includes a shell-plug assembly comprised of a cylinder shell 11, turnable cylinder plug 13, with plug collar 13c, and five (5) vertical pin passageways 14a-e extending up into shell as shell passageways 11 and down into plug 13 as plug passageways. Also shown are five assembly pins 15a-e, plug tail 12, brass key 16, cylinder shear line 18 and pin springs 20a-e for the assembly pins 15a-e. Each assembly pin 15a-e has eight (8) circumferential weakened zones defined by notches or grooves 17. Pins 15a-e are made of selected material and their grooves 17 are shaped and proportioned to accomplish assembly pin shearing by the manufacturer or locksmith while preventing compromise in security while the lock is in service through use of an unauthorized key or other instrument. Different manufacturers



have differing non-notch key configurations which allow the keys of a given manufacturer to be inserted in locks of that manufacturer.

5 Assembly pins of the invention are notched or otherwise selectively weakened to reduce the force taken to shear such pins; however, they are not weakened such that an insertable key (a key with the same keyway configuration on the lock key) with a different cut could be torqued by hand or by a tool to
 10 cause the driver and tumbler pins to shear prior to key or tool failure. The pin notches have a depth and shape such that only the force of factory or locksmith equipment applied to portions of the plug, and not applied to the key, can shear the pins. Forces applied to the key or directly to plug
 15 collar 13c in a direction parallel to the axis of rotation of plug 13 are resisted and absorbed by collar 13c engaging shell 11.

The following assembly pins, with varying notch
 20 diameters, were tested:

	<u>Inner Notch Diameter</u>	<u>Average Force Per Pin To Shear</u>
	0.060 inch	95 lbs.
	0.062 inch	105 lbs.
25	0.065 inch	120 lbs.
	0.070 inch	140 lbs.
	0.074 inch	155 lbs.
	0.079 inch	180 lbs.
	0.084 inch	205 lbs.

30 Inner notch diameter (ND) was less than overall diameter or outside diameter D (see Fig. 2). An inner notch diameter of 0.062 inch is preferred for padlock pins. In the above tests D was 0.094 inch. Notch angle (C) was 20° (degrees)
 35 (Fig. 2). The ratio of ND to D is preferably in the range 63%-74%. The present invention also includes door hardware

pins where an inner notch diameter of 0.074 inch is preferred for pins having an outside diameter (D) of 0.114 inch.

In the manufacture of cylinder 10, assembly pins 15a-e, each with eight (8) weakened zones defined by circumferential grooves 17, are fabricated for use in making a quantity of locks. In the present system, preferably keys have eight (8) different cut depths and five pin cylinders, creating thirty-two thousand (32,000) combinations. Each groove 17 has a width w (Fig. 2) of about .0060-0.010 inches and the series of grooves 17 are spaced vertically (as shown in Fig. 2) about 0.0156 inch apart. In the assembly of lock 10, assembly pins 15a-e (each of which is the same within a tolerance of ± 0.0005) are placed into passageways 14a-e and then sheared. The series of spaced-apart grooves 17 are located in the assembly pins 15a-e such that they are positioned at the shear line 18 by a family of insertable keys.

Fig. 3 illustrates plug 13 being driven to the right to shear pins 15a-e as further explained below. As sheared, each assembly pin 15a-e breaks into an upper drive section 15u to function as a driver pin and aligned lower tumbler section 15l to function as a tumbler pin. Cylinder shell 11 has end ring portion 20 and plug 13 has angled portion 13a (Fig. 1). A segment 20p (Figs. 6 and 7) of ring portion 20 is crimped against portion 13a as later described.

Turning to Figs. 4-5, the pin shearing and crimping apparatus 30 includes lock fixture 31 with a configured aperture defining a lock holder recess 32. Lock 10, with its shell 11 and plug 13 and unsheared assembly pins 15a-e, is placed in aperture 32 with shell 11 abutting wall 32w. Plug tail 12 is engageable with shiftable shear pin 41. Shift shear pin 41 is shown in its rest position biased to the right as viewed in Fig. 4 by spring 42. Also included in apparatus 30 is shearing plunger 36 mounted in a cylindrical opening 37 of a stationary mount block 38, spaced from fixture 31.

Apparatus 30 further includes a crimper unit 50 including a crimping ram 52 driven by a solenoid unit E. Crimp shift pin 54 is shown in its rest position biased away from the cylinder shell 11 by crimp pin spring 55.

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In operation, lock 10, including shell 11, plug 13, plug tail 12 and key 16, as an assembly, is placed in aperture 32 of fixture 31. Shear pin 41 is hit by shearing plunger 36 to apply force F to cylinder plug tail 12 to move plug 13 in
10 direction Y. Pins 15a-e are thereby sheared (Fig. 3). Plug 13 is pushed back by hand, using key 16, to the original position. Next, crimper unit 50 drives crimp shift pin 54 to crimp ring portion segment 20p of shell 11 against plug portion 13a (see Figs. 1, 6 and 7).

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Turning to Figs. 8, 8a, 9 and 9a, a further embodiment of the invention is shown in which pins have a certain notch configuration and the plug is shaped to facilitate shearing and rotation. Each pin 60 of this embodiment has grooves or
20 notches 61, for example, the ten (10) circumferential grooves 61a-j (shown in Fig. 8). Each groove 61 has beveled surface areas or chamfers 63 to facilitate plug rotation and to make picking of the lock more difficult. Each chamfer 63 is sloped at angle C to a plane perpendicular to pin 60's longitudinal
25 axis LA (Fig. 8a). The slope of chamfer 63 is parallel to tangent line T which is perpendicular to radius R of plug 64 of shell-plug assembly 65 at the entrance edge of the plug pin passageway 71u (Fig. 9). The selection of such a chamfer slope optimizes the ease of plug rotation. Distances from the
30 bottom key-engaged end 60b of pin 60 to the center of each groove is set out in Table 1 (see also Fig. 8).

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Table 1

	<u>Letter</u>	<u>Distance in Inches</u>
	A	.166
	B	.181
	C	.196
5	D	.211
	E	.226
	F	.241
	G	.256
	H	.271
	I	.286
	J	.301

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Each notch 61 is comprised of a portion of a notch a above plane Z perpendicular to longitudinal pin axis LA and a notch portion b below line Z.

15 Plug 64 of shell-plug assembly 65 has a flat surface 66 positioned adjacent the upper shell section 67u of shell 67 to define a plug shear line. After shearing, and with the key (not shown) inserted, the formed tumbler pin 60t is raised which in turn raises the driver pin 60d. As plug 64 is turned
20 in either direction (such as the counterclockwise direction; Fig. 9a), groove chamfer surfaces 63 assist in free turning when the lower tumbler pin 60t is too high or the bottom of the upper driver pin 60d too low. Chamfer surfaces 63 reduce the likelihood that pins will catch the sides of shell and
25 plug passageways 71u, 71l in either the shell or in the plug.

Turning to Figs. 10 and 11, a pin shearing mechanism 78 is shown having body 79, housing cavity 81, a turnable drive unit 82 mounted in cavity 81 for rotation about the
30 longitudinal axis A (Fig. 11). Turnable unit 82 includes hand wheel 83 and nut 84 mounted in rotatable drive body 80. Nut 84 is turnable by a wrench (not shown) to turn drive unit 82. As drive unit 82 is turned it translates plunger 87 through mating threads 88 on body 80 of unit 82 and threads 89 on
35 plunger 87. Plunger 87 moves linearly in direction AA. Plunger 87 is held from turning by indentation 91 having flat surface 92 and by vertical post 93 which engages surface 92 to



prevent rotation. Mechanism 78 includes lock holder recess 94 including shell support wall 94 which holds the shell-plug assembly 65 against translation in direction AA. In the operation of mechanism 78, the shell-plug assembly 65 is placed in holder recess 94, plunger 87 is advanced until it touches the plug 64 and a wrench is then used to turn nut 84 to translate plug 64 relative to its shell until the assembly pins 60 shear. After the pins have been sheared, handwheel 83 can be turned in the appropriate direction to rotate drive unit 82 and thereby translate plunger 87 in a direction opposite direction AA. This releases the shell-plug assembly 65 for removal from the mechanism 78.

Example

A door lock constructed of five (5) assembly pin passageways 71u, 71l, defined by aligned shell and plug passageways and assembly pins 60 will, as explained, have each pin 60 sheared to form a pin set (a tumbler pin 60t and driver pin 60d in tandem). Each assembly pin 60 has an outside diameter D of .114 inches and a reduced weakened notch diameter (ND) in the grooves of .076 inches (see Fig. 8). Each assembly pin 60 has ten (10) grooves 61a-j prior to shearing to create the tumbler-driver pin sets.

Prior to shearing the door lock cylinder is shipped to a locksmith. A customer of the locksmith provides the locksmith with a key used by the customer in operating other locks of the customer. The locksmith inserts the customer's key in the lock, places the lock in the mechanism 78 and shears the assembly pins 60. The customer then installs the door lock in his home, which lock can be served by the customer's existing key.



Table 2
Pin Characteristics

<u>Type</u>	<u>Outside Diameter (D)</u>	<u>Notch Diameter (ND)</u>	<u>In Line F To Shear</u>	<u>Torque To Shear</u>
5 Padlock	.094 in.	.076 in.	210 lb.	200 in lb.
Door Lock	.114 in.	.076 in.	210 lb.	200 in lb.

The pin notch diameter ND of each of the grooves is selected to provide sufficient strength so that the assembly pins 60 will not fail when a key (or tool of cross section to permit penetration into the keyhole) is torqued. The key (or tool) will fail through breaking, shearing or twisting before the pins 60 shear. As an example, a hardened steel key was inserted into the keyhole of a lock of the present invention and a torque of 240 lb/in was applied to the key. The tool broke without shearing the pins 60. The pin grooves 61a-j are also shaped to create fracture or shear surfaces on both tumbler and driver pins which are non-flat and which facilitate lock operation. Finally, grooves 61a-j are shaped so that upon fracturing during manufacture or customizing by a locksmith, tumbler and driver pins 60 having end configurations including chamfer surfaces 63 are formed which assist in plug rotation during subsequent operation.

Turning to the embodiment as shown in Figs. 12-16, padlock 103 includes lock body 104 having shell-plug assembly 104a comprised of plug 105 and shell 106. Also shown is shackle 107, key 108 and serrated assembly pins 110.

Plug 105 includes collar 105c, plug circumferential undercut 109, plug surface 105s, and plug tail 111. Undercut 109, having bottom 109b and sides 109s, circumscribes plug 105 (see Fig. 13a). Shell 106 includes upper housing portion 113 and lower housing portion 114. Upper housing portion 113 includes five shell pin passageways 116. Plug pin passageways 117 in the lower housing portion are aligned with shell

passageways 116. The serrated pins 110 are disposed in these passageways. Key 108 includes four (4) notches 108a, which are aligned with the bottoms of the pins 110 when the key is inserted into the keyway of the plug 105. The distance
5 between laterally adjacent centers of passageways 116 and 117, as shown in Fig. 13, is distance X. Also shown in Figs. 13 and 14 are springs 112 engaging the tops of the pins 110 and urging them downwardly toward the key 109.

10 Turning to Fig. 14, plug 105 has been translated in direction Y by a force necessary to shear pins 110 at selected serrations 115 along shear line (SL). By such shearing upper driver pins 119a-e and lower tumbler pins 121a-e are formed. In addition, the four lower tumbler pins 121a-d nearest the
15 keyhole entrance are each moved a distance X to align with the four upper driver pins 119b-e. Upper driver pin 119a drops down into plug undercut 109 where it is held against undercut bottom 109b by spring 112a. With upper driver pin 119a so positioned, plug 105 can turn but cannot be withdrawn from
20 shell 106 because sides 109s engage upper driver pin 119a. This anti-withdrawal feature adds to the security of padlock 103. Lower tumbler pin 121e becomes inactive in its plug passageway 117, which serves as pin section entrapment hole.

25 As is seen in the Figures, passageways 116 and 117 have diameter dimensions of d. Pins 110 are substantially the same but slightly less in diameter than the passageways. The spacing between the passageways is small enough so that an adjacent pin, such as tumbler pin 121a supports an upper
30 driver pin such as driver pin 119b before tumbler pin 121b has moved out from under driver pin 119b (see Fig. 14).

Alternatively, the anti-withdrawal feature of the present invention is also useful in conventional pin tumbler locks
35 where tumbler and driver pins are first formed and then assembled. In such a lock an additional shell passageway and aligned plug passageway are formed into which is placed a

shearable pin. The plug includes an undercut. When the plug and a shell are assembled, the pin is sheared and a portion enters the plug undercut to prevent plug withdrawal while permitting plug rotation in the shell.

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WE CLAIM:

1. In a cylinder lock having a shell with a longitudinal shell axis, a turnable plug mounted within the shell for rotation about said shell axis, a keyhole in the plug, said
5 keyhole extending along said shell axis, a plurality of aligned pin passageways in the shell and said plug, said passageways communicating with said keyhole, assembly pins slidable positioned in the passageways, said assembly pins each having a longitudinal pin axis and a series of weakened
10 zones spaced along said longitudinal pin axis, each of said assembly pins being shearable along said weakened zones into an upper driver pin and a lower tumbler pin upon application of a shearing force applied to said assembly pin, the improvement wherein:
 - 15 a) said assembly pins have a strength sufficient to prevent said shearing thereof by the application of the greatest rotative force that can be applied to said plug through said keyhole by a key-like tool inserted into said keyhole.
- 20 2. The cylinder lock of claim 1 wherein:
 - a) said plug has an outer surface through which said pin passageways in the plug extend; and
 - b) the outer surface of the plug through which said
25 pin passageways extend is flat.
3. The cylinder lock of claim 2 in which:
 - a) each weakened zone is shaped to define, after shearing, a driver pin with a lower end having a
30 chamfered outer edge.
4. The cylinder lock of claim 1 wherein:
 - a) said passageways in said plug are spaced along said longitudinal shell axis;
 - 35 b) the outer surface of said plug, laterally of said longitudinal shell axis and said passageways therealong, defines a cylindrical shape;





c) each weakened zone is shaped to define, after shearing, a tumbler pin with an upper end having a chamfered outer edge; and

5 d) said chamfered outer edge is oriented about parallel to a tangent line to the outer surface of said plug which is cylindrically shaped and immediately adjacent to said pin passageways.

5. The cylinder lock of claim 4 in which the weakening
10 zones are each defined by a notch having shearable portions lying in a plane perpendicular to said pin axis.

6. In a cylinder lock having a shell with a longitudinal shell axis, a turnable plug mounted within the shell for
15 rotation about said shell axis, a keyhole in the plug, said keyhole extending along said shell axis, a plurality of aligned pin passageways in the shell and the plug, said passageways communicating with said keyhole, assembly pins
20 each having a longitudinal pin axis and a series of weakened zones spaced along said longitudinal pin axis, each of said assembly pins being shearable along said weakened zones into an upper driver pin and a lower tumbler pin upon application of a shearing force applied to said assembly pin, the
25 improvement wherein:

a) said plug has an outer surface through which said pin passageways in the plug extend; and

b) the outer surface of the plug through which said pin passageways extend is flat.

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7. The cylinder lock of claim 6 in which:

a) each weakened zone is shaped to define, after shearing, a driver pin with a lower end having a chamfered outer edge.

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8. In a cylinder lock having a shell with a longitudinal shell axis, a turnable plug mounted within the shell for





rotation about said shell axis, a keyhole in the plug, said keyhole extending along said shell axis, a plurality of aligned pin passageways in the shell and the plug, said passageways communicating with said keyhole, pins slidable
5 positioned in the passageways for movement toward and away from said keyhole, said pins each having a longitudinal pin axis and a series of weakened zones spaced along said longitudinal pin axis, each of said pins being shearable along any of said weakened zones and being sheared along one of said
10 weakened zones into an upper driver pin and a lower tumbler pin, the improvement wherein:

a) said driver and tumbler pins have a strength sufficient to prevent shearing thereof along said weakened zones by the application of the greatest
15 rotative force that can be applied to said plug through said keyhole by a key-like tool inserted into said keyhole.

9. A method for manufacturing a lock having a shell, a
20 turnable plug rotatably mounted within said shell and having a keyhole for insertion of a key which fails structurally when torqued by application of a first force, a shear line between the shell and plug, and a plurality of aligned shell and plug passageways, comprising the steps of:

25 a) assembling the shell and plug with the shell passageways aligned with the plug passageways;

b) positioning within each aligned shell and plug passageway an assembly pin having a series of spaced weakened zones and a strength such that application of a
30 second shearing force to said assembly pins equal to or less than the first force will not shear said assembly pins along said weakened zones;

c) aligning a selected weakened zone of each assembly pin with each other for shearing; and

35 d) thereafter shearing said assembly pins along said selected weakened zones by application of a third shearing force larger than the first force along the





shear line to shear each assembly pin into two pin sections.

10. The method of claim 9 in which the plug has a flat outer surface through which said pin passageways in the plug extend, the method wherein:

a) said third force is applied along said flat surface.

10 11. A method for manufacturing a lock having a shell with a longitudinal shell axis, a turnable plug with a longitudinal plug axis and a keyhole for insertion of a key along said plug axis; a plurality of aligned pin passageways in said shell and plug, said plug having an outer flat surface through which said pin passageways in said plug extend, and a shear line between said shell and plug; comprising the steps of:

a) assembling the shell and plug with the pin passageways aligned in said shell and plug;

20 b) positioning within each aligned pin passageway an assembly pin having a series of spaced weakened zones;

c) aligning a selected weakened zone of each assembly pin with each other for shearing; and

25 d) thereafter shearing said assembly pins along said selected weakened zones by application of a shearing force applied along said flat surface in the direction of said plug axis to shear each assembly pin into two pin sections.

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12. Apparatus for shearing assembly pins in a lock having a shell with a longitudinal shell axis and a plug with a longitudinal plug axis rotatably mounted therein, by application of a force on said plug parallel to said plug axis, comprising:

a) a frame;





b) a lock holder recess in the frame to receive a shell-plug assembly comprising said shell and said plug, said recess including shell holding means for holding said shell against movement during shearing; and

5 c) plug translation means for translating the plug while the shell is held, said plug translation means, in turn, comprising:

i) a plug engageable plunger means for movement toward and against the plug, and

10 ii) rotatable drive means connected to said plunger means to translate said plunger means against the plug to move the plug as the shell is held.

15 13. In a lock having a shell and a plurality of shell passageways in said shell, a turnable plug within the shell, a keyhole and a plurality of plug passageways in the plug, aligned with said shell passageways, the improvement comprising:

20 a) an annular undercut in said plug aligned with one of said shell passageways;

b) a sheared first pin section in said one of said shell passageways, said sheared first pin section also extending into said plug undercut; and

25 c) a second pin section positioned in an adjacent plug passageway, said second pin section being a sheared part of said first pin section.

14. In a lock having a shell with a plurality of
30 adjacent shell passageways, a turnable plug mounted within said shell and having a keyhole and a plurality of adjacent plug passageways aligned with said shell passageways, the improvement comprising:

a) an annular undercut in said plug aligned with
35 one of said shell passageways;





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b) a first section of a sheared first pin in said one shell passageway, said first section also extending into said annular undercut;

5 c) a second section of said sheared first pin in the plug passageway next adjacent to said one shell passageway; and

10 d) additional pairs of pin sections disposed within each of the rest of said aligned shell and plug passageways, with each section of any pair abutting the other section of that pair along a shear line between the shell and the plug when a key for the lock is inserted into said keyhole.

15 15. The lock of claim 14 wherein:

15 a) the pin section in each shell passageway is a sheared part of the pin section in the next adjacent plug passageway.

20 16. In a lock having a shell with a plurality of adjacent shell passageways, a turnable plug mounted within said shell and having a keyhole and a plurality of adjacent plug passageways aligned with said shell passageways, and a pair of sheared pin sections in each of said aligned shell and plug passageways, the improvement wherein:

25 a) the pin section in any one shell passageway is a sheared part of the pin section in the next adjacent plug passageway, with each pin section of any pair abutting the other pin section of that pair along a shear line between the shell and the plug when a key for the lock is
30 inserted into said keyhole.

17. A method for manufacturing a lock having a shell, a turnable plug having a keyhole and an annular undercut, a shear line between the shell and plug, a plurality of shell
35 passageways in the shell, and a plurality of aligned plug passageways in the plug, comprising the steps of:





- a) assembling the shell and plug with a selectively-weakened assembly pin in each of said aligned shell and plug passageways;
- 5 b) thereafter shearing each assembly pin by application of a shearing force which translates the plug along the shear line to shear each pin into two pin sections, one a shell driver pin and the other a plug tumbler pin; and
- 10 c) further translating the plug in the shell to align a shell passageway with said plug undercut.

18. The method of claim 17 in which each sheared driver pin other than the driver pin which enters the undercut is supported by an adjacent tumbler pin after said further plug
15 translating.

19. The method of manufacturing a lock having a shell with a longitudinal shell axis and a plurality of adjacent shell passageways disposed along said shell axis, a turnable
20 plug having a longitudinal plug axis, mounted within said shell for rotation about said plug axis and having a keyhole and a plurality of adjacent plug passageways disposed along said plug axis and aligned with said shell passageways, said shell and plug defining a shear line between the shell and the
25 plug, the method comprising:

- a) moving said plug axially along said shell axis and into said shell to a first axial position in which said shell and plug passageways are in a first aligned position;
- 30 b) placing a shearable assembly pin in each aligned shell and plug passageway;
- c) moving said plug axially within said shell to a second axial position to shear each assembly pin along said shear line into a sheared driver pin disposed in
35 each shell passageway and a sheared tumbler pin disposed in each plug passageway; and





d) aligning said shell passageways with said plug passageways in a second aligned position in which the sheared driver pin in any one aligned shell passageway is a sheared part of the tumbler pin in the next adjacent aligned plug passageway, with the tumbler pin in each plug passageway abutting the driver pin in the aligned shell passageway at said shear line when a key for said lock is inserted into said keyhole.

20. The method of claim 19 further comprising:
a) fixing the plug in said second axial position.

21. The method of manufacturing a lock having a shell with a longitudinal shell axis and a plurality of adjacent shell passageways disposed along said shell axis, a turnable plug having a longitudinal plug axis, mounted within said shell for rotation about said plug axis and having a keyhole, an annular undercut and a plurality of adjacent plug passageways disposed along said plug axis and aligned with said shell passageways, said shell and plug defining a shear line between the shell and the plug, the method comprising:

- a) moving said plug axially along said shell axis and into said shell to a first axial position in which said shell and plug passageways are in a first aligned position and said annular undercut is spaced along said plug axis from said first aligned position of said shell and plug passageways;
- b) placing a shearable assembly pin in each aligned shell and plug passageway;
- c) placing a spring means in each of said shell passageways to urge said assembly pins into said plug passageways;
- d) moving said plug axially within said shell to a second axial position to shear each assembly pin along said shear line into a sheared driver pin disposed in each shell passageway and a sheared tumbler pin disposed in each plug passageway; and





e) aligning said shell passageways with one shell passageway aligned with said plug undercut and with the driver pin in the one shell passageway extending into said plug undercut under the influence of said spring means and with the remaining shell passageways aligned with plug passageways in a second aligned position in which the sheared driver pin in any one aligned shell passageway is a sheared part of the tumbler pin in the next adjacent aligned plug passageway, with the tumbler pin in each aligned plug passageway abutting the driver pin in the aligned shell passageway at said shear line when a key for said lock is inserted into said keyhole.

22. A lock comprising:

a) a padlock body;

b) a shell-plug assembly including:

i) a shell with a plurality of spaced shell passageways,

ii) a turnable plug rotatably mounted in said shell at a first position, said plug having a keyhole and a plurality of plug passageways aligned with said shell passageways and movable to a second position with some of said plug passageways aligned with the next adjacent shell passageways from those with which they were aligned in said first position,

iii) a selectively-weakened assembly pin in each of said aligned shell and plug passageways when said plug is in said first position, and

iv) means urging said assembly pins into said aligned plug passageways;

c) said shell-plug assembly being mounted in said padlock body with said plug in said first position and for moving thereof to said second position; and

d) locking means for retaining said plug in said second position.





23. A lock comprising:

a) a padlock body;

b) a shell-plug assembly including:

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i) a shell with a longitudinal shell axis and a plurality of shell passageways spaced from each other, by a predetermined distance, along said shell axis,

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ii) a turnable plug, with a longitudinal plug axis, rotatably mounted in said shell at a first position along the shell axis, said plug having a keyhole at one end thereof and a plurality of plug passageways spaced from each other, by said predetermined distance, along said plug axis, said plug being mounted within said shell for movement, along said shell axis, from said first position with said shell and plug passageways aligned with each other to a second position with said plug moved along said shell axis by said predetermined distance and with some of said shell passageways aligned with the next adjacent plug passageways from those with which they were aligned in said first position,

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iii) an assembly pin positioned in each of said aligned shell and plug passageways, each assembly pin having a series of spaced shearable weakened zones, selected ones of which shear when said plug is moved from said first position to said second position, and

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iv) spring means in each of said shell passageways urging said assembly pins into said aligned plug passageways;

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c) said shell-plug assembly being mounted in said padlock body with said plug in said first position and for moving of said plug, inwardly of said padlock body, from said first position to said second position; and

d) locking means for retaining said plug in said second position against movement along said shell axis





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once said plug has been moved from said first position to said second position.

24. The lock of claim 23 wherein:

5 a) said locking means includes an annular undercut in said plug, sized to receive a sheared part of one of said assembly pins when said plug is in said second position, said undercut being spaced, by said predetermined distance, along said plug axis from the
10 shell plug passageway nearest said one end of said plug, when said plug is in said first position.

25. The lock of claim 24 wherein:

15 a) said one end of said plug is located outwardly of said lock body when in said first position and is located within said body when in said second position.

38. The lock of any one of claims 13-16 and 19-25, wherein:

20 a) said pins have a strength sufficient to prevent shearing thereof by the application of a rotative force applied to said plug through said keyhole.

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