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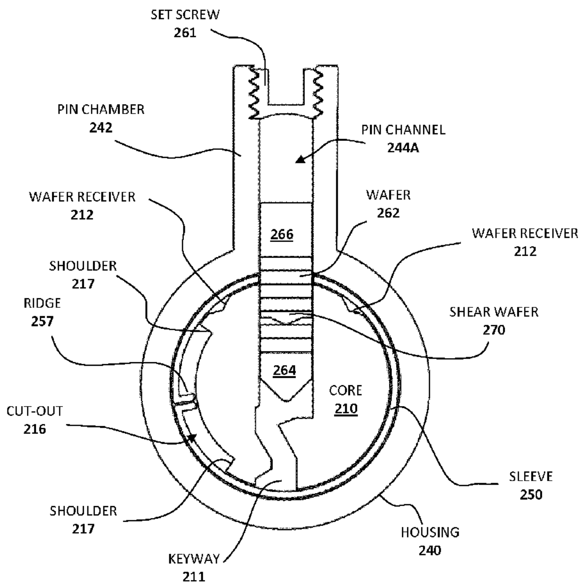

Fig. 21

(57) **Abstract:** A pick resistant lock assembly is provided. The lock assembly includes a housing having a main bore and a chamber including a plurality of channels holding a corresponding plurality of pin stacks, a core having a keyway and having a plurality of core openings configured to align with the channels of the housing, and a sleeve configured to fit within the main bore. The pin stacks are each configured to provide a plurality of decoy shear lines in which rotation of the core and the sleeve together is limited by a blocking position and a true shear line which permits rotation of the core and the sleeve together for actuation of the lock assembly when the true shear line is provided in each pin stack of the plurality of pin stacks.

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Pick-Resistant Lock Assembly

FIELD

[0001] The technology described herein relates generally to lock assemblies having enhanced security features and provides a pick-resistant lock assembly constructed with minimal specialized components.

BACKGROUND

[0002] Pin tumbler lock cylinders are susceptible to attacks by picking or bumping. In a picking attack, a first tool or torque wrench is inserted into the plug assembly keyway and a small threshold rotational torque is applied and held. A second tool or pick is inserted in the keyway and manipulated to successively move the key followers and associated cylinder pins so that the cylinder pins rise above the shear line between the cylinder body and plug assembly. The torque on the plug assembly will cause a slight misalignment of the respective key follower and cylinder pin bores, which will prevent the cylinder pins from falling back down across the shear line. During this process, the attacker must sense by feel, the cylinder pin rising above the shear line and the amount the plug rotates, and apply greater or lesser torque to keep the "set" of the picked pins while feeling for the next pin's relationship to the shear line. Other types of attacks use tools such as a snap gun, an electro-pick or a rake.

[0003] In a bumping attack, the attacker inserts a special "bump" key into the keyway and applies a threshold rotational torque. Then the attacker applies at least one axial blow to the bump key. This shock causes the cylinder pins to jump above the shear line; as the pins rise, they separate as the shock is transferred from the bottom pin to the top pin, and the applied torque will turn the plug assembly before the cylinder pins can be driven back into place by their respective springs. However, too much applied torque will "crush" a cylinder pin at the shear line, which will then absorb the shock of the applied axial blow, and the cylinder pins won't jump. Another form of attack is to "impression" the lock mechanism.

[0004] The common denominator in these types of attacks is applying, maintaining and modulating a rotational torque to the plug assembly and sensing it throughout the process.

[0005] A number of lock assemblies have been designed with an aim to preventing such attacks, some examples of which are described in PCT Publication Nos. WO2008069683A1 and WO2014089141A1, US Patents 6,397,649, 4,577,479, 4,856,309, 7,878,036, 3,857,263, 5,964,111, 5,148,690, 4,655,063, and 6,978,645, Russian Patent RU2515519C1, and UK Patent Publication No. GB2429235A, each of which is incorporated herein by reference in its entirety.

[0006] There continues to be a need for development of enhanced security pick-resistant lock assemblies.

SUMMARY

[0007] According to one embodiment, there is provided a pick-resistant lock assembly. The assembly includes a housing having a main bore and a chamber including a plurality of channels holding a corresponding plurality of pin stacks, a core having a keyway and having a plurality of core openings configured to align with the channels of the housing and a sleeve defined a sleeve bore to accept the core. The sleeve has a plurality of sleeve openings configured to align with the core openings and the channels. The sleeve is configured to fit within the main bore. The lock assembly includes a true key configured for insertion into the keyway to rotate the core and the sleeve together for actuation of the lock assembly.

[0008] The pin stacks may be each configured to provide (i) a plurality of decoy shear lines in which rotation of the core and the sleeve together is limited by a blocking position provided by the pin stacks, and (ii) a true shear line which permits rotation of the core and the sleeve together for actuation of the lock assembly when the true shear line is provided in each pin stack of the plurality of pin stacks. The a true shear line is provided by elevation of each pin stack of the plurality of pin stacks by the true key being inserted into the keyway.

[0009] The plurality of pin stacks may each include a plurality of wafers. The core may be shaped to include at least one wafer receiver adjacent to at least some of the core openings. The wafer receiver may be configured to remove one or more of a plurality of wafers from a corresponding pin stack of the plurality of pin stacks when the core is rotated.

[0010] A plurality of wafer receivers may be located adjacent to each core opening of the plurality of core openings. The plurality of wafer receivers may be located on each side of the core openings.

[0011] The wafer receivers may be in the shape of laterally extending grooves formed directly adjacent to the core openings.

[0012] The plurality of wafers in each pin stack of the plurality of pin stacks may include a shear wafer having a different shape or a different height dimension than remaining wafers of the plurality of wafers. In this arrangement, the true shear line is provided when the shear wafer is removed from the pin stack upon rotation of the core.

[0013] The plurality of wafer receivers may be in the form of shaped indentations spaced apart from the core openings. The shaped indentations may be configured to receive only the shear wafer.

[0014] The shear wafer may be shaped to have a protruding surface complementary to the shaped indentations. The protruding surface may be conical.

[0015] The plurality of channels may be five channels holding five pin stacks. The plurality of pin stacks may each include six thin wafers, one shear wafer, and one key pin. The key pin may be selected from a set of two key pins having different height dimensions.

[0016] The true shear line may be configured to place a top surface of the shear wafer at a level substantially equivalent to the level of the outer surface of the sleeve, thereby permitting rotation of the core and sleeve together.

[0017] The core may have a lock pin groove at an end of the plurality of core openings. The lock pin groove is separated from the keyway and may have an inner cam surface permitting a lock pin residing in the lock pin groove to move out of the lock pin groove when full rotation of the sleeve is permitted.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] Various objects, features and advantages of the present technology will be apparent from the following description of an example embodiment illustrated in the accompanying drawings.

Figure 1 is a cross-sectional view of one example of a pick resistant lock assembly known in the prior art.

Figure 2 is a perspective view of one embodiment of a lock assembly **100**.

Figure 3 is a perspective view of the assembly **100** as shown in Figure 1 with a key **120** removed from a keyway **111** in a core **110** of the assembly **100**.

Figure 4 is a partially exploded perspective view of the assembly **100**.

Figure 5 is another partially exploded perspective view of the assembly **100** showing separation of a sleeve component **150** from the core component **110**.

Figure 6 is another partially exploded top perspective view of the assembly **100** showing features of the sleeve **150**.

Figure 7 is a perspective view of the core **110** by itself, showing opposed wafer receivers **112** on either side of five core openings **114**.

Figure 8 is a perspective view of an open end of the sleeve **150** showing a recess **154** in an opposing end wall **155**.

Figure 9 is a side elevation view showing the key **120** inserted into the core **110**, with the core **110** shown in a transparent view, indicating elevation of each of five pin stacks **160** by the various levels of the key **120** to the true shear line extending below a shear wafer **163** of each of the five pin stacks **160**.

Figure 10 is a side elevation view of the five pin stacks **160A** to **160E** indicating the unique stacking arrangements of thin wafers **162**, a shear wafer **163** and key pins **164**, **165** in each of the pin stacks **160A** to **160E** which are matched to the key **120** to provide the true shear line for actuating the lock assembly **100**.

Figure 11A is a perspective view of a cross-section of the lock assembly **100** taken through pin stack **160E**.

Figure 11B is an end elevation view of the cross-section of Figure **11A**.

Figure 12 is a scheme of end elevation views of embodiment **100** indicating the result of rotation of the core **110** clockwise (with respect to the orientation shown) via a first decoy shear line provided when the shear wafer **163** is located below the true shear line. The top two thin wafers **162** block further rotation of the core **110**.

Figure 13 is a scheme of end elevation views of embodiment **100** indicating the result of rotation of the core **110** clockwise (with respect to the orientation shown) via a different decoy shear line provided when the shear wafer **163** is located above the true shear line. Two thin wafers **162** located below the shear wafer **163** block further rotation of the core **110**.

Figure 14 is a scheme of end elevation views of embodiment **100** indicating the result of rotation of the core **110** clockwise (with respect to the orientation shown) when the shear wafer **163** is located at the true shear line. The shear wafer **163** occupies the entire volume of the wafer receiver **112** with additional height equivalent to the thickness of the core **110** to align with the true shear line **170E**.

Figure 15 is an exploded view of a second embodiment of a lock assembly **200**.

Figure 16A is a perspective view of the housing **240** of lock assembly **200**.

Figure 16B is another perspective view of the housing **240** of lock assembly **200**.

Figure 17A is a perspective view of the sleeve **250** of lock assembly **200**.

Figure 17B is another perspective view of the sleeve **250** of lock assembly **200**.

Figure 18A is a perspective view of the core **210** of lock assembly **200**.

Figure 18B is another perspective view of the core **210** of lock assembly **200**.

Figure 18C is a top view of the core **210** of lock assembly **200**.

Figure 19 is a side elevation view of the five pin stacks **260A** to **260E** indicating stacking arrangements of thin wafers **262**, a shear wafer **270** and key pins **264**, **265** in each of the pin stacks **260A** to **260E** which are matched to the true key to provide the true shear line for actuating the lock assembly **200**. The lock pin **269** is also shown.

Figure 20A is a side elevation view of the shear wafer **270** of embodiment **200**.

Figure 20B is a top perspective view of shear wafer **270**.

Figure 21 is a lateral cross-sectional view taken across pin stack **260A**.

Figure 22 is the same cross-sectional view shown in Figure 21 with the core **210** rotated approximately 45 degrees clockwise (with respect to the orientation shown), indicating blockage of the shear line of pin stack **260A** by a thin wafer **262** while the shear wafer **270** is located in the pin stack deeper within the core **210**. The sleeve **250** cannot rotate further clockwise in this arrangement.

Figure 23 is the same cross-sectional view shown in Figures 21 and 22 with the core **210** rotated approximately 45 degrees clockwise (with respect to the orientation shown), indicating provision of the proper shear line with the shear wafer **270** contained in the wafer receiver **212**. In this arrangement, the sleeve **250** may rotate further clockwise.

Figure 24 indicates further rotation of the sleeve **250** and the core **210** together from the orientation shown in Figure 23, approximately 315 degrees clockwise (with respect to the orientation shown) to bring the core **210** and sleeve **250** to the lock actuation position.

Figure 25 illustrates a series of core **210** and sleeve **250** positions in lateral cross sectional views taken across the locking pin groove **219** indicating different positions of the locking pin **269** attained during clockwise rotation (with respect to the orientation shown) of the core **210** and sleeve **250**.

DETAILED DESCRIPTION

Rationale

[0019] There have been many attempts over the last century to make pin tumbler locks unpickable. As used herein, the term “picking” refers to manipulation of pins in a lock assembly to actuate the lock assembly without using its matched key (or true key). Some locks remained unpicked for a period of time, but eventually, every design has been picked. Almost every “high security” or “pick resistant” lock designer has increased the security of locks by adding more and more complicated elements (such as such as sidebars, security pins, and pins in different orientations) to their locks increasing the cost of production and difficulty in servicing these locks by trade professionals, even requiring locksmiths to purchase specialized equipment and parts to be able to service the locks. With the addition of more security features, complications are introduced which add to the number of elements that need to be manipulated in order to operate the locks and adding extra costs to the end user.

[0020] In one prior art example described in U.S. Patent 5,964,111 (incorporated herein by reference in its entirety), there is a conventional pick-resistant lock assembly with an intermediary cylinder between the cylinder of the lock, which is in direct contact with the key, and the outer housing of the lock to provide a shield to separate the rotating function of the first cylinder from the "picking" or pin stack manipulation process. This lock assembly is shown in Figure 1, where it is seen that upon inserting a key **4** into the keyway **18** of the inner cylinder **1**, the pin stacks either are or are not raised to the proper levels at that time, depending upon whether the correct cut depths are present on the key **4**. The inner cylinder **1** must then be rotated by an amount that allows a cam pin stack formed of pins **9** and **10** to drop down on one side or the other of the pin cam **16** groove, at which time the shear line between parts **9** and **10** will allow cylinder **2** to rotate within the housing **3**. The bottom cam pin **9** will then also become connective between the inner cylinder **1** and the intermediate cylinder **2** which then allows the key **4** to also rotate cylinder **2** as it further rotates inner cylinder **1**. Even if the wrong key has been inserted, the inner cylinder **1** will rotate to this point because of a multitude of pins (known in the trade as master pins) in each pin stack area that comprises what is known as the bottom of the pin stacks. But since it is the shear line between the intermediate pins **6** and the top pins **7** that determines whether the intermediate cylinder **2** can be rotated, if the wrong key has been inserted it will not be discovered until after inner cylinder **1** has been rotated beyond the point where any pins in any of the stacks can be further manipulated. If the correct key **4** is being used, then further rotating of inner cylinder **1** pushes upon the side of the bottom cam pin **9**, which itself conveys that force to rotate the intermediate cylinder **2**, and, since all the shear lines between the pins **6** and **7** are now properly aligned, cylinder **2** will rotate further. While this particular lock assembly provided additional security relative to conventional lock assemblies, shortcomings in its construction were recognized by the present inventor. For example, this lock assembly is susceptible to over-lifting during picking attempts and its construction cannot be easily scaled down to fit existing door hardware, such as key-in-knob arrangements, key-in-lever arrangements and padlocks. The present inventor has also recognized that multiple operating shearlines in one cylinder can be accidently created during the manufacturing or pinning of this lock assembly and that the shearline can still be detected by skilled lockpickers because the true shearline can be achieved with the core in its resting position.

[0021] To address these and other shortcomings of conventional pick-resistant lock assemblies, the present inventor has conceived of an alternative arrangement for increasing the number of shear lines in a lock assembly that can be achieved during manipulation of the locking elements while configuring only one operable shearline capable of operating an associated lock actuator. The provision of many “decoy” shearlines will cause an attempt at picking the lock to generate a shearline which will allow rotation of an inner core without rotating an outer sleeve which actuates the lock. In exemplary embodiments described hereinbelow, a five pin lock will provide 32,768 possible shearlines with only one being operable to rotate the outer core to actuate the lock. Therefore, while it is possible that the lock assembly of this particular embodiment may be picked, the odds of successfully doing so is 1 in 32,768 possible attempts. It would therefore require an inordinate and unreasonable number of attempts for a skilled lock picker to be successful.

[0022] Embodiments of the present lock assembly make it essentially impossible for someone attempting to pick the lock to have control over the tension on the core in order to manipulate each pin stack at a time and verify that setting. The configurations of the pin stacks make it impossible for an over-lift attack to be successful. The example embodiment described herein has minimal customized components and this will significantly simplify the re-keying processes performed by locksmiths and eliminate the chances of accidently introducing multiple operating shearlines, as well as reducing the manufacturing cost. The configurations of pin stacks will make it possible for key cutters to use their existing machines to copy/cut keys for the end user by utilizing cut depths and key codes that manufacturers are already using.

[0023] A first example embodiment will now be described with reference to Figures 2 to 14. For the purposes of illustration, components depicted in the figures are not necessarily drawn to scale in all cases. Emphasis is placed on highlighting the various contributions of the components to the functionality of this embodiment and alternative embodiments. Alternative features are introduced during the course of this description. It is to be understood that, according to the knowledge and judgment of persons skilled in the art, such alternative features may be substituted in various combinations to arrive at different embodiments of the present technology.

[0024] In Figures 2 to 14, there is shown a first example embodiment of a pick resistant lock assembly **100** developed by the present inventor. Figure 2 shows the lock assembly **100** with a key **120** inserted into the core via a keyway (see in Figure 3). The core **110** is covered with a housing **140**. The housing **140** includes an upper chamber **142** for holding pin stacks **160** (not visible in Figure 2 but seen in Figures 4-6, 9 and 10). A cover **141** is provided above the pin channels **144** (see Figures 4 and 5) which are located inside the chamber **142**. In Figure 3, the key **120** is removed, exposing a keyway **111**.

[0025] The partially exploded view shown in Figure 4 has the housing **140** and cap **130** removed to expose an inner sleeve **150**. The cap **130** serves as a base for attachment of an actuator which operates a bolt or latch (not shown). During construction of the lock assembly **100**, the core **110** is inserted into the sleeve **150** and then the sleeve **150** is inserted into the main housing bore **143**, followed by threading the cap **130** onto the exposed end of the sleeve **150**. Then the pin stacks **160** are placed in the pin channels **144** of the chamber **142**. This is followed by installation of the cover **141**. The components and function of the pin stacks **160** will be described in more detail hereinbelow.

[0026] The exploded view of Figure 5 has the sleeve **150** separated from the core **110** to show that the sleeve has a bore **151** and a series of upper openings **152** of which the five-leftmost openings align with the pin channels **144** of the chamber when the assembly **100** is formed. Figure 5 also indicates that the rightmost pin stack is different from the others, including only two parts which are shown in more detail in Figure 9.

[0027] Turning now to Figure 6, there is shown a top perspective exploded view of part of the lock assembly **100** with the sleeve **150** removed from the core **110** to show that the five leftmost sleeve openings **152** differ from the rightmost centralizer pin opening **156**, which includes a beveled edge. It is also seen in Figure 6 that the sleeve **152** has a threaded connector **153** which is used to install the cap **130**.

[0028] Figure 7 shows the core **110** by itself, indicating that it includes five core openings **114** for retaining portions of the pin stacks **160** (which are seen in Figure 6 but omitted in Figure 7). It is to be understood that each pin stack **160** is placed in a corresponding channel of the pin channels **144** in the chamber **142** of the housing **140**. The pin channels **144** are aligned with the openings **152** in the sleeve **150** and the core openings **114** such that when the pin stacks **160** are dropped into the pin channels **144**, they will drop down into the keyway **111** of the core **110**. Figure 7 also shows that core wafer receivers **112** in the form of laterally extending grooves are provided on each side of each of the core openings **114**. The functionality of the core wafer receivers **112** will be described in more detail hereinbelow. While this embodiment **100** has two opposed wafer receivers **112**, alternative embodiments may be constructed with only one wafer receiver **112** on either side of each of the openings **114**.

[0029] Figure 8 is an end view of the sleeve **150** from its open end, indicating that the opposing end is closed with an end wall **155**. The end wall **155** has a shaped recess **154** formed therein. This recess **154** is provided to accept the end of an actuator shaft **113** which extends from an end of the core **110** (see Figures 6 and 7). The function of the actuator shaft **113** and recess **154** will be described in more detail hereinbelow during a description of operation of the lock assembly **100**.

[0030] Figure 9 is a side elevation view of selected components of the lock assembly **100** with the key **120** inserted into the core **110**. The core **110** is shown as transparent in order to visualize the key shaft which has portions of different levels to elevate each of the pin stacks **160** to different levels. Each of the pin stacks **160** includes a spring **161** which pushes against the cover **141** of the housing **140** (the cover **141** is not shown in Figure 9 in an effort to preserve clarity). Each of the pin stacks **160** includes a spring **161**, a driver pin **166**, one or more thin wafers **162** located above and below a thicker shear wafer **163** (which in this embodiment has a height dimension greater than the height of the thin wafers **162**), and either a tall key pin **164** or a short key pin **165** which is brought into contact with one of the levels of the shaft of the key **120** when the key **120** is inserted into the keyway **111** (the five different levels may be identified by the vertex of each of the five key pins **164**, **165**, which makes contact with the key shaft). The rightmost pin stack **160** has a top-to-bottom arrangement including a spring **161**, a centralizer driver **167** and a generally frustoconical centralizer pin **168** which drops into the centralizer pin opening **156** in the sleeve **150** (see Figure 6). The centralizer pin **168** is held in place by a gap in a snap ring **115** which is held in a groove in a reduced diameter portion of the core **110** from which the actuator shaft **113** extends. The centralizer pin **168** therefore does not make contact with any surface of the key **120** and does not play a role in actuation of the lock assembly **100**. Instead, the centralizer pin **168** serves to prevent undesirable rotation of the core **110** away from a centralized resting position wherein the keyway **111** is vertically disposed.

[0031] It is to be understood from Figure 9 that the true key **120** is configured to actuate the lock mechanism of the lock assembly **100**. This is accomplished by elevating the pin stacks **160** to provide a true shear line which will permit actuation of the lock mechanism. The true shear line follows a gap between the bottom of each shear wafer **163** and the outer surface of one of the wafer receivers **112** formed in the outer sidewall of the core **110** as will be described in more detail hereinbelow. In Figure 9, it is to be noted that the bottom of each shear wafer **163** of each pin stack **160** is generally aligned with the upper outer surface of the core **110**.

[0032] Turning now to Figure 10, there is shown a side elevation view of five pin stacks **160A-E** (excluding the rightmost sixth pin stack with the centralizer pin **168**, which is included in Figure 9). The five pin stacks **160A-E** are arranged in this view with the vertices of the key pins **164** and **165** aligned in order to more clearly discern the different arrangement of thin wafers **162** with respect to the shear wafer **163** within each pin stack. It is to be understood that each pin stack includes one driver pin **166**, six thin wafers **162**, one shear wafer **163** and either a tall key pin **164** or a short key pin **165**. In this particular embodiment, the difference in height between the tall key pins **164** and short key pins **165** is equivalent to half of the height of one thin wafer **162**. In this particular embodiment, all driver pins **166** have a substantially identical height; all thin wafers **162** have a substantially identical height; and all shear wafers **163** have a substantially identical height. In this particular embodiment, the proportions of relevant heights of selected components of each pin stack **160** is as follows: proportional height difference between tall key pins **164** and short key pins **165** = 1; height of thin wafers **163** = 2; and height of shear wafers **163** = 3. Alternative embodiments may be provided with pin stacks having wafers and/or key pins and driver pins of different dimensional proportions with more or fewer wafers.

[0033] It can be seen that each one of the pin stacks **160A-E** has a different vertical arrangement of thin wafers **162**, shear wafers **163** and key pins **164** and **165** (for example, pin stack **160A** has a top-to-bottom arrangement of four thin wafers **162**, one shear wafer **163**, two thin wafers **162** and one tall key pin **164** and the adjacent pin stack **160B** has a top-to-bottom arrangement of five thin wafers **162**, one shear wafer **163**, one thin wafer **162** and one tall key pin **164** – therefore the vertex of the tall key pin **164** of pin stack **160B** must be moved to a higher level than its corresponding tall key pin **164** of pin stack **160A** to align the shear wafers **163** of these two pin stacks **160A** and **160B**, as seen in Figure 9). These arrangements provide the ability to change the vertical level of the shear wafer **163** within each of the pin stacks **160A-E**. Therefore, only when the correct key **120** is inserted into the keyway **111**, will the pin stacks **160A-E** be properly elevated to align the bottom edge of each shear wafer **163** with the outer surface of the core **110** such that the shear wafer **163** will move into one of the wafer receivers **112** as the core **100** is rotated (see Figure 9). It is to be understood that many different combinations of different arrangements of pin stacks is possible and these different combinations will require corresponding different true key configurations to properly actuate the lock mechanism.

[0034] Figures 11 to 14 illustrate transverse cross sections of the lock assembly taken across pin stack **160E**. Figures 11A and 11B are provided for the purpose of labelling the main components involved in the functionality of the device in providing several decoy shear lines for pin stack **160E** so that they can be recognized with minimal labelling in Figures 12 to 14 in an effort to preserve clarity. Figures 12 to 14 illustrate rotation of the core **110** and components of the pin stack **160** in generation of decoy shear lines (Figures 12 and 13) and the true shear line (Figure 14).

[0035] Turning now to Figure 12, the cross-section image on the left side of the arrow has the core **110** in the resting centralized position. The cross-section image on the right indicates the location of the core **110** and components of the pin stack **160E** after the pin stack **160E** is dropped and the core **110** is rotated clockwise in the orientation shown, while the sleeve **150** remains stationary. It is seen in the image on the right that the shear wafer **163** has dropped below the sleeve **150** into the keyway **111** and a decoy shear line is attained between the second and third uppermost thin wafers **162**. This causes the wafer receiver **112** on the left side of the core **110** to become occupied by the uppermost two thin wafers **162**. The combined height of the two thin wafers **162** is greater than the combined height of the leftmost side of the wafer receiver **112** and the thickness of the sleeve **150.** A potential shear line between the first and second uppermost thin wafers **162** is located between the outer and inner sidewalls of the sleeve **150**. This provides the effect of blocking further clockwise rotation of the core **110** and sleeve **150**, which is required in order to actuate the lock mechanism which requires that the core **110** and sleeve **150** rotate together to press the actuator shaft **113** against the sidewall of the sleeve recess **154** (see Figure 8) in order to rotate the connected end cap **130** which is connected to an actuator of a bolt or latch mechanism (not shown).

[0036] Referring now to Figure 13, there is shown another example of a decoy shear line being attained with subsequent blockage of rotation of the sleeve **150** and core **110**. In Figure 13, the cross-section image on the left side of the arrow has the core **110** in the centralized position. The cross-section image on the right side of the arrow indicates the location of the core **110** and components of the pin stack **160E** after the core is rotated clockwise in the orientation shown. It is seen in the image on the right that the shear wafer **163** has not dropped into the keyway **111** and instead remains in the pin channel **144E** while two thin wafers **162** occupy the wafer receiver **112** to block rotation of the core **110**

and sleeve **150**. This provides the effect of blocking further clockwise rotation of the core **110** and sleeve **150** as described above for Figure 12.

[0037] With two examples of decoy shear lines in pin stack **160E** having been described with respect to Figures 12 and 13 (and understanding that more decoy shear lines are possible), the operation of the lock assembly **100** when the true shear line is attained is now described with respect to Figure 14. While not illustrated specifically in Figure 14, it is to be understood that operation of the lock mechanism requires that all five of the pin stacks **160A-E** are arranged to have their corresponding shear wafer **163** in the same position as shown in Figure 9, with the bottom surface of each shear wafer located above the upper surface of the core **110** (in other words, if one of the pin stacks **160** is not aligned properly with the true shear line, the sleeve **150** will not rotate). The completely aligned true shear line position is illustrated in the leftmost cross-section image in Figure 14. In this leftmost image, the shear wafer **163** is initially aligned with the keyway **111** and the pin channel **144E** and located between the two wafer receivers **112**. With initial clockwise rotation of the core **110** in the middle image, it is seen that the shear wafer **163** has dropped into the left wafer receiver **112**. It is to be noted in this middle image that the top surface of the shear wafer **163** is aligned with the outer surface of the sleeve **150** and therefore, there is no blockage of rotation of the sleeve **150** as occurs for the decoy shear lines illustrated in Figures 12 and 13. Because there is no blockage, true shear line **170E** is attained and both the core **110** and the sleeve **150** are permitted to rotate further clockwise to the position shown in the rightmost image, where it is seen that the shear wafer **163** held in the left wafer receiver **112** has rotated over to the right side. In attaining this position, the actuator shaft **113** then can press against the sidewall of the recess **154** of the sleeve **150** (see Figure 8) to cause the sleeve **150** and connected cap **130** to rotate and actuate the locking mechanism.

[0038] The operating principle of this embodiment **100** of the lock mechanism requires blockage of rotation of the sleeve **150** when a decoy shear line is attained and allowance of rotation of the sleeve **150** when the true shear line is attained, and in the latter case only when the true shear line is attained for all five of the pin stacks **160A-E**. In this embodiment **100**, the true shear line **170E** is attained by having the height dimension of the shear wafer **163** substantially equivalent to the depth of the wafer receiver **112** plus a transverse cross-sectional width of the sleeve **150**, thereby providing the true shear line between an upper surface of the shear wafer **163** and a sidewall of the main bore **143** of the housing **140**.

[0039] Because there are seven decoy shear lines and one true shear line for each of the five pin stacks **160A-E**, the total number of possible shear lines in this embodiment **100** is 8^5 = 32,768 and therefore the odds of successfully picking this lock assembly is 1 in 32,768. These highly challenging odds are expected to immediately deter even the most skilled of lock pickers. This embodiment has one true shear line for each pin stack. Alternative embodiments may have additional true shear lines for each pin stack to provide a master keying system. However, it is recognized that provision of additional true shear lines decreases the number of decoy shear lines.

[0040] In Figures 15 to 25, there is shown a second example embodiment of a pick resistant lock assembly **200** developed by the present inventor. In the exploded view shown in Figure 15, it is seen that the lock assembly **200** has several general features which are similar to those of embodiment **100**, such as a key **220**, a core **210** with a keyway **211**, a sleeve **250** a housing **240** with a housing bore **243** and pin channels **244** in a chamber **242** for holding pin stacks **260** and a locking pin **269**. The core **210** extends through the housing **210** and is configured to receive an end cap **230**. One difference between this embodiment **200** and the previously described lock assembly **100** is that the pin channels **244** are covered by individual set screws **261** threaded upper ends of the pin channels **244** formed in the pin chamber **242** of the housing **240** (see Figure 16A). The set-screws facilitate re-keying of the lock to a new true key by permitting a locksmith to reconfigure pin stacks **260** individually while keeping the other pin stacks contained within the pin channels **244.** The pin stacks **260** also have springs (not shown in Figure 15) located between the set screws **261** and the driver pins **266** (illustrated best in Figure 19) in an arrangement similar to the arrangement of springs **161** illustrated for lock assembly **100** (see Figure 9). The springs of embodiment **200** also provide a downward-biased force on the driver pins **266** which is overcome by placing the true key **220** (or other implement) into the keyway **211**.

[0041] The sleeve **250** is shown by itself in two different orientations in Figures 17A and 17B, indicating an arrangement of six sleeve openings **252** extending into the central bore

251 of the sleeve **250**. This sleeve **250** differs from the sleeve **150** of embodiment **100** by having an internal ridge **257** which plays a role in rotation of the sleeve **250** as described hereinbelow. The sleeve **250** in of this embodiment **200** is conveniently formed of two parts in order to conveniently form the ridge **257** which functions to move the sleeve **250** with the core **210** when the true shear lines are attained.

[0042] The core **210** is shown in three different orientations in Figures 18A, 18B and 18C. Like the core **110** of embodiment **100**, a series of core openings **214** is provided to hold the pin stacks **260**. The wafer receivers **212** however differ from the wafer receivers **112** of embodiment **100**. The wafer receivers **112** of embodiment **100** are in the form of laterally extending grooves on each side of the core openings. In contrast, in embodiment **200**, the wafer receivers **212** formed in the core are indentations or divots which are separated in space across the outer sidewall of the core **210** from the core openings **214** and which are shaped specifically to receive and retain a complementary shaped shear wafer **270**, which is illustrated in Figures 19 and 20. In this particular embodiment, the wafer receiver **212** is shaped to receive a lower conical protrusion **272** (see Figure 20A) of the otherwise disk-shaped shear wafer **270**. However, alternative embodiments may use other shapes such as spikes, radiused protrusions, blocks or other three-dimensional polygonal shapes, provided that the indentations and the shaped shear wafers have complementary shapes permitting the shear wafers to partially fit within the indentations such that the upper surface of the shear wafer aligns with the shear line to permit rotation of the sleeve **250**, as described in more detail hereinbelow, to permit rotation and actuation of the lock assembly **200**.

[0043] The core **210** of embodiment **200** also differs from the core **110** of embodiment **100** by being provided with a lock pin groove **219** and a threaded connector **215** for connecting the core **210** to the cap **230**. The functionality of the lock pin groove **219** will also be described in more detail hereinbelow. Figure 18C also shows a socket **231** which cooperates with a complementary protrusion in the inner sidewall of the cap **230** in the actuation mechanism (not shown).

[0044] In this embodiment **200** sleeve is not connected to the actuator. The actuator is activated by the core **210** turning past 45 degrees.

[0045] The socket **231** arrangement in this embodiment **200** is a conventional feature. It serves to lock the end cap **230** in place by having a spring pushing a pin into one of the semi-circular features in the end cap **230** so it cannot rotate and come off inside the lock housing **240**. The pin that resides in this socket **231** also serves to connect the core **210** to the actuator that is sandwiched between the core **210** and the end cap **230**.

[0046] Other arrangements of engaging structures may be provided in alternative lock actuation mechanisms.

[0047] Figure 19 illustrates a representative example of an arrangement of pin stacks **260** for embodiment **200** in a manner similar to that of Figure 10, described above. Each pin stack includes a driver pin **266**, six thin wafers **262**, a single shear wafer **270** and either a short key pin **264** or a tall key pin **265**. As indicted in the list of components below each one of the pin stacks **260A-E**, the shear wafer **270** of each pin stack can be provided at a different height matching its position on the true key to generate the true shear line for actuating the lock, as described above for embodiment **100**.

[0048] Turning now to Figure 21, there is shown a cross section of the lock assembly **200** taken across pin stack **260A**, which has a vertical arrangement from top to bottom which includes a driver pin **266**, four thin wafers **262**, a shear wafer **270**, two thin wafers **262** and a short key pin **264**. It can be seen that the core **210** is shaped differently from the core **110** of embodiment **100**. In addition to the differently shaped wafer receivers **212,** core **210** includes a longitudinal cut-out portion **216** defining a recess with a shoulder **217** at each end. The ridge **257** of the sleeve **250** is located within this cut-out **216** and is moveable therewithin when the sleeve **250** is rotated. This cross-sectional view also indicates that the wafer receivers **212** are conical-shaped divots. It can be seen in this view that the labeled thin wafer **262** has a height which blocks rotation of the sleeve **250** if the core **210** is rotated.

[0049] Figure 22 shows the result of such a clockwise rotation of the core where the labelled wafer **262** blocks rotation of the sleeve **250**. In this arrangement, the shear wafer **270** is located further down inside the core **210** and incorrectly placed for lock actuation. The rotation of the core **210** indicated in Figure 22 therefore represents a decoy shear line.

[0050] Figure 23, in contrast with Figure 22, shows the proper pin height for pin stack **260A** which would be provided by the true key pushing the pin stack 260A to the correct height. It is seen that the shear wafer **270** is at the correct height to have dropped into the wafer receiver **212**. The result of this action is that the top surface of the shear wafer **270** is at the same height as the outer sidewall of the sleeve **250**, thereby providing the true shear line for this pin stack **260A** and permitting further rotation to occur. The results of this rotation are shown in Figure 24, where the arrangement of Figure 23 is copied on the left side to facilitate visualization of the movement of components in the process. The lower shoulder **217** of the cut-out **216** of the core **210** is pushed upward against the ridge **257** of the sleeve **250**, causing the sleeve **250** to rotate clockwise as well. Continued rotation to provide the arrangement on illustrated on the right side of Figure 24 indicates that the shear wafer **270** continues to occupy the wafer receiver **212** as the core **210** and sleeve **250** are rotated together. The rotation to this position will lead to actuation of the lock in a manner similar to the actuation described above for embodiment **100**, with a cooperative interaction between complementary engaging structures provided between the inward end surface of the core **210** and an inner surface of the cap **230** serving to actuate the lock. The socket **231** seen in Figure 18B is an example of such an engaging structure which cooperates with a complementary structure (not illustrated) provided in the cap **230**.

[0051] Turning now to Figure 25, there is shown operation of the lock pin **269** and the lock pin groove **219** formed in the core **210** which is another feature of embodiment **200** that differs from embodiment **100**. The lock pin groove **219** is also shown in Figures 18A to 18C where it is seen that it is located adjacent to the connector **215**. The lock pin groove **219** has curved inner sidewalls which provide a cam surface **213** (see Figure 25) that allows the lower end of the lock pin **269** to ride up and out of the lock pin groove **219** only when the true key has activated all of the true shear lines of the pin stacks **260**. With reference to Figure 25, there is shown a series of core **210** and sleeve **250** positions as cross sections taken through the lock assembly at the section cutting through the locking pin **269**. In step A, the locking pin **269** is located in the middle of the lock pin groove **219** with the lock assembly **200** in the resting position (keyway **211** oriented vertically). Following clockwise rotation of the core **210** to the position shown in step B, the lock pin groove **219** moves to the right and the bottom of the lock pin **269** encounters the cam surface **213** of the lock pin groove **219**. As noted with respect to Figure 24, further rotation of the sleeve **250** is only permitted if the true shear line of each pin stack **260** is attained. In this case, further rotation to step C (lower left of Figure 25) causes the lower end of the lock pin **269** to slide out to the surface of the core **210**. From that point, the lower end of the lock pin **269** can move up to the outer surface of the sleeve **250**, allowing rotation to the lock actuation position of step D.

[0052] It is to be understood that the lock pin **269** moves to the outer surface of the core **210** just after the pin channels **244** are no longer accessible via the keyway **211** and just before the series of shear wafers **270** drop into their respective wafer receivers **212**. Therefore the lock pin **269** locks the sleeve **250** to the housing **240** until the core **210** is rotated to "test" the shear line. As a result, the lock pin groove **219** moves every time the core is rotated and not just when the true shearline is reached. The main purpose is to stop lock picking efforts which attempt to set pins above the sleeve to operate the lock. In some embodiments, the lock pin groove **219** may also have a slightly deeper indentation at top dead center, to help realign the core **210** while removing the key after lock operation. The sleeve **250** only serves to stop the rotation of the core after turning it about 40 degrees in either direction when a decoy shear line is selected.

[0053] The following is a summary of the order of operation of lock assembly **200** with the assembly **200** installed as a standard door lock and referring to the orientation of the cross sections of Figures 23 to 25, with the starting position of the keyway **211** defined as zero degrees. When the true key **220** (not shown in Figures 23 to 25) is inserted and used to rotate the core **210** clockwise by about 35 degrees, the lock pin **269** moves out of the lock pin groove **219**. A further clockwise rotation to about 40 degrees causes the lower shoulder **217** of the core **210** to make contact with the ridge **257** of the sleeve **250**. This action causes sufficient rotation of the core to cause the shear wafer **270** to drop into the left wafer receiver **212**. This action provides the true shear line and permits the sleeve **250** to rotate together with the core **210**. Further rotation by about 45 degrees initiates actuation of the lock. Further rotation by about 40 degrees retains the lock in the open position and the shear wafer **270** is returned to the pin stack **244**. Subsequent counter-clockwise rotation by about 35 degrees places the lock pin **269** back into the lock pin groove **219**. Continued rotation back to zero degrees (the resting position) permits removal of the key **220** from the keyway **211**. To re-lock the assembly **200**, the same operations are repeated in the reverse direction.

[0054] During a lock picking attempt using any implement other than the true key **220**, the core **210** may be rotated by up to about 35 degrees causing the lock pin **269** to move upward. Further rotation of the core **210** is possible to about 40 degrees where the core **210** engages the sleeve **250** at the ridge **257**. However, no further rotation is possible at this stage because a wafer **262** other than the shear wafer **270** blocks the rotation of the sleeve **250** and the core **210**. Further pushing of the shoulder **217** of the core **210** against the ridge **257** of the sleeve **250** is not possible.

[0055] The functionality of lock assembly embodiment **200** provides the possibility of configurations having multiple true shear lines. This is useful for alternative embodiments configured as “master keyed systems” with locks configured to be operated by more than one true key. This arrangement is provided by placing two or more shear wafers in one or more pin chambers. While this does decrease the amount of decoy shearlines, it does so by an insignificant margin and the benefits to the end user outweigh the risks. Since all master key systems are slightly less secure than non-master key systems, locksmiths would be expected to generally inform customers of the risks and benefits of master-keyed systems.

Features of Alternative Embodiments

[0056] It is to be understood that the foregoing description has focused on two main example embodiments. A number of variations are possible which are within the scope of the appended claims. For example, alternative embodiments may include more or fewer pin stacks held in more or fewer pin channels. Alternative embodiments may include more or fewer wafers than described for the example embodiment. While the wafers described in the example embodiments are disk-shaped, other shapes are possible, such as square, polygonal or alternative radiused shapes such as ellipses or ovals for example. If such alternative wafer shapes are incorporated, the shapes of the pin channels, sleeve openings and core openings would be altered accordingly to accommodate the alternative wafer shapes. Alternative embodiments may also include wafers having more than two different sizes, as long as the pin stacks are configured to provide at least one true shear line as a result of alignment of a shear wafer with the outer surface of the sleeve.

[0057] While the example embodiment includes core wafer receivers on either lateral side of the core openings, alternative embodiments may include only a single wafer receiver located on one side of the core openings. In such alternative embodiments, the alternative embodiment will be configured for rotational movement in only one direction.

[0058] While the example embodiment **100** includes an arrangement of wafers with a shear wafer having a height dimension greater than the height dimension of the remaining wafers, alternative embodiments may have the remaining wafers with a height dimension greater than the height dimension of the shear wafer. While the example embodiment **200** includes shear wafers with a conical protrusion **272**, alternative shaped protrusions such as knobs, squares, or other three dimensional polygonal shapes may be used in alternative embodiments if the wafer receiver is provided with a complementary shape to preserve the function of generating a true shear line.

Equivalents and Scope

[0059] Any patent, publication, internet site, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated material does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

[0060] Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art.

[0061] While the lock assembly is described with references to an example embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the embodiments encompassed by the appended claims.

[0062] In the claims, articles such as “a,” “an,” and “the” may mean one or more than one unless indicated to the contrary or otherwise evident from the context. Claims or descriptions that include “or” between one or more members of a group are considered satisfied if one, more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process unless indicated to the contrary or otherwise evident from the context.

[0063] It is also noted that the term “comprising” is intended to be open and permits but does not require the inclusion of additional elements or steps. When the term “comprising” is used herein, the term “consisting of” is thus also encompassed and disclosed. Where ranges are given, endpoints are included. Furthermore, it is to be understood that unless otherwise indicated or otherwise evident from the context and understanding of one of ordinary skill in the art, values that are expressed as ranges can assume any specific value or subrange within the stated ranges in different embodiments, to the tenth of the unit of the lower limit of the range, unless the context clearly dictates otherwise. Where the term “about” is used, it is understood to reflect +/−10% of the recited value. In addition, it is to be understood that any particular embodiment that falls within the prior art may be explicitly excluded from any one or more of the claims. Since such embodiments are deemed to be known to one of ordinary skill in the art, they may be excluded even if the exclusion is not set forth explicitly herein.

CLAIMS

1. A pick-resistant lock assembly comprising:

a housing having a main bore and a chamber including a plurality of channels holding a corresponding plurality of pin stacks each including a plurality of wafers;

a core having a keyway and a plurality of core openings configured to align with the channels of the housing, the core shaped to cause removal of one or more of the plurality of wafers from each one of the plurality of pin stacks when the core is rotated;

a sleeve having a sleeve bore to accept the core, the sleeve having a plurality of sleeve openings configured to align with the core openings and the channels, the sleeve configured to fit within the main bore; and

a true key configured for insertion into the keyway to rotate the core and the sleeve together for actuation of the lock assembly.

2. The lock assembly of claim 1, wherein the pin stacks are configured to (i) provide a true shear line between the sleeve and the main bore which is generated by insertion of the true key into the keyway to rotate the core and sleeve together for actuation of the lock assembly, and (ii) provide a plurality of decoy shear lines between the core and the sleeve which block rotation of the sleeve and prevent actuation of the lock assembly.

3. The lock assembly of claim 1 or 2, wherein the core is shaped to include at least one wafer receiver adjacent to one or more of the core openings, the wafer receiver configured to remove the one or more of the plurality of wafers from a corresponding pin stack of the plurality of pin stacks.

4. The lock assembly of claim 2 or 3, wherein the at least one wafer receiver is a plurality of wafer receivers located adjacent to each core opening of the plurality of core openings.

5. The lock assembly of claim 4, wherein the plurality of wafer receivers are located on each side of the core openings.

6. The lock assembly of claim 5, wherein the wafer receivers are laterally extending grooves formed directly adjacent to the core openings.

7. The lock assembly of any one of claims 1 to 5, wherein the plurality of wafers in each pin stack of the plurality of pin stacks includes a shear wafer having a different shape or a different height dimension than remaining wafers of the plurality of wafers, wherein the true shear line is provided when the shear wafer is removed from the pin stack upon rotation of the core.

8. The lock assembly of claim 7, wherein the plurality of wafer receivers are shaped indentations spaced apart from the core openings, the shaped indentations configured to receive only the shear wafer.

9. The lock assembly of claim 8, wherein the shear wafer is shaped to have a protruding surface complementary to the shaped indentations.

10. The lock assembly of claim 9, wherein the protruding surface is conical.

11. The lock assembly of any one of claims 1 to 10, wherein the plurality of channels is five channels holding five pin stacks.

12. The lock assembly of any one of claims 1 to 11, wherein the plurality of pin stacks each includes six thin wafers, one shear wafer, and one key pin.

13. The lock assembly of claim 12, wherein the key pin is selected from a set of two key pins having different height dimensions.

14. The lock assembly of any one of claims 1 to 13, wherein the true shear line places a top surface of the shear wafer at a level substantially equivalent to the level of the outer surface of the sleeve, thereby permitting rotation of the core and sleeve together.

15. The lock assembly of any one of claims 1 to 14, wherein the core is defined by a lock pin groove at an end of the plurality of core openings, the lock pin groove separated from the keyway and having an inner cam surface permitting a lock pin residing in the

lock pin groove to move out of the lock pin groove when full rotation of the sleeve is permitted.

16. A lock assembly comprising:

a housing having a main bore and a chamber including a plurality of channels holding a corresponding plurality of pin stacks;

a core having a keyway and having a plurality of core openings configured to align with the channels of the housing;

a sleeve defined a sleeve bore to accept the core, the sleeve having a plurality of sleeve openings configured to align with the core openings and the channels, the sleeve configured to fit within the main bore; and

a true key configured for insertion into the keyway to rotate the core and the sleeve together for actuation of the lock assembly;

wherein the pin stacks are each configured to provide (i) a plurality of decoy shear lines in which rotation of the core and the sleeve together is limited by a blocking position provided by the pin stacks, and (ii) a true shear line which permits rotation of the core and the sleeve together for actuation of the lock assembly when the true shear line is provided in each pin stack of the plurality of pin stacks, the true shear line provided by elevation of each pin stack of the plurality of pin stacks by the true key being inserted into the keyway.

17. The lock assembly of claim 16, wherein the plurality of pin stacks each includes a plurality of wafers and wherein the core is shaped to include at least one wafer receiver adjacent to at least some of the core openings, the wafer receiver configured to remove one or more of a plurality of wafers from a corresponding pin stack of the plurality of pin stacks when the core is rotated.

18. The lock assembly of claim 16 or 17, wherein the at least one wafer receiver is a plurality of wafer receivers located adjacent to each core opening of the plurality of core openings.

19. The lock assembly of claim 18, wherein the plurality of wafer receivers are located on each side of the core openings.

20. The lock assembly of claim 19, wherein the wafer receivers are laterally extending grooves formed directly adjacent to the core openings.

21. The lock assembly of any one of claims 16 to 19, wherein the plurality of wafers in each pin stack of the plurality of pin stacks includes a shear wafer having a different shape or a different height dimension than remaining wafers of the plurality of wafers, wherein the true shear line is provided when the shear wafer is removed from the pin stack upon rotation of the core.

22. The lock assembly of claim 21, wherein the plurality of wafer receivers are shaped indentations spaced apart from the core openings, the shaped indentations configured to receive only the shear wafer.

23. The lock assembly of claim 22, wherein the shear wafer is shaped to have a protruding surface complementary to the shaped indentations.

24. The lock assembly of claim 23, wherein the protruding surface is conical.

25. The lock assembly of any one of claims 16 to 24, wherein the plurality of channels is five channels holding five pin stacks.

26. The lock assembly of any one of claims 16 to 25, wherein the plurality of pin stacks each includes six thin wafers, one shear wafer, and one key pin.

27. The lock assembly of claim 26, wherein the key pin is selected from a set of two key pins having different height dimensions.

28. The lock assembly of any one of claims 16 to 27, wherein the true shear line places a top surface of the shear wafer at a level substantially equivalent to the level of the outer surface of the sleeve, thereby permitting rotation of the core and sleeve together.

29. The lock assembly of any one of claims 16 to 28, wherein the core is defined by a lock pin groove at an end of the plurality of core openings, the lock pin groove separated from the keyway and having an inner cam surface permitting a lock pin residing in the lock pin groove to move out of the lock pin groove when full rotation of the sleeve is permitted.

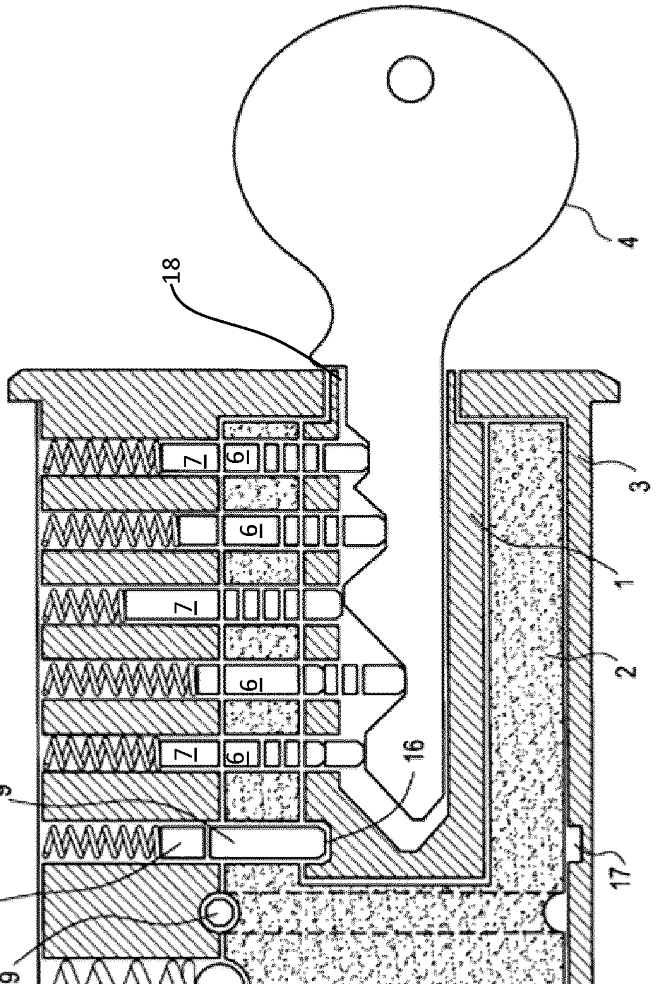
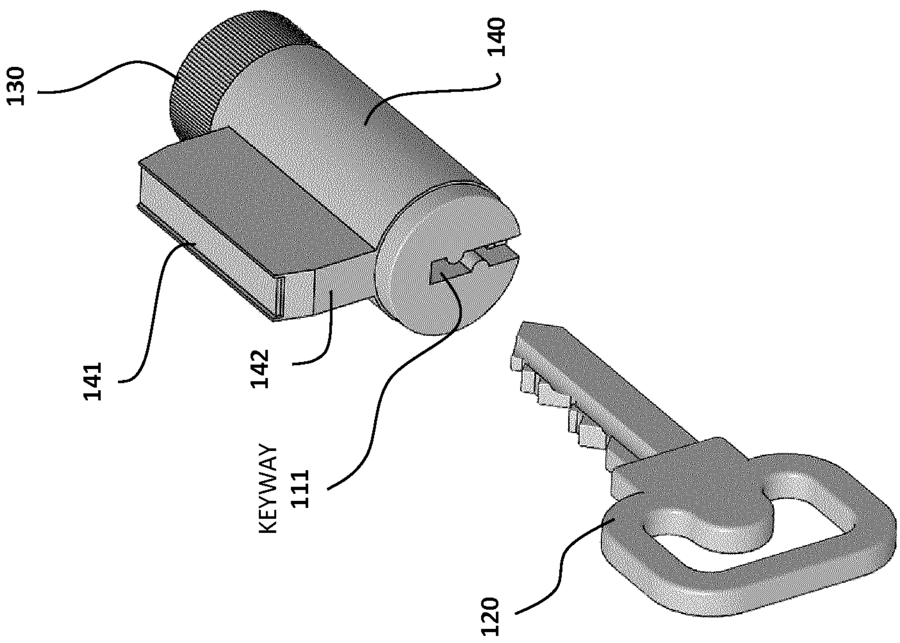


Fig. 1
(PRIOR ART)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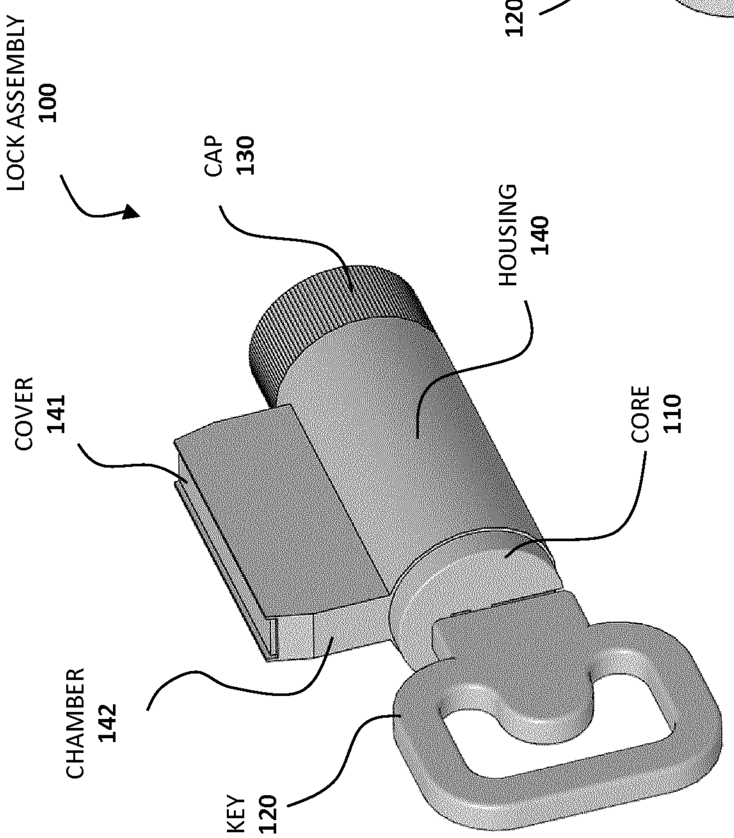
141
142
KEYWAY
111
120

Fig. 3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KEY
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Fig. 2

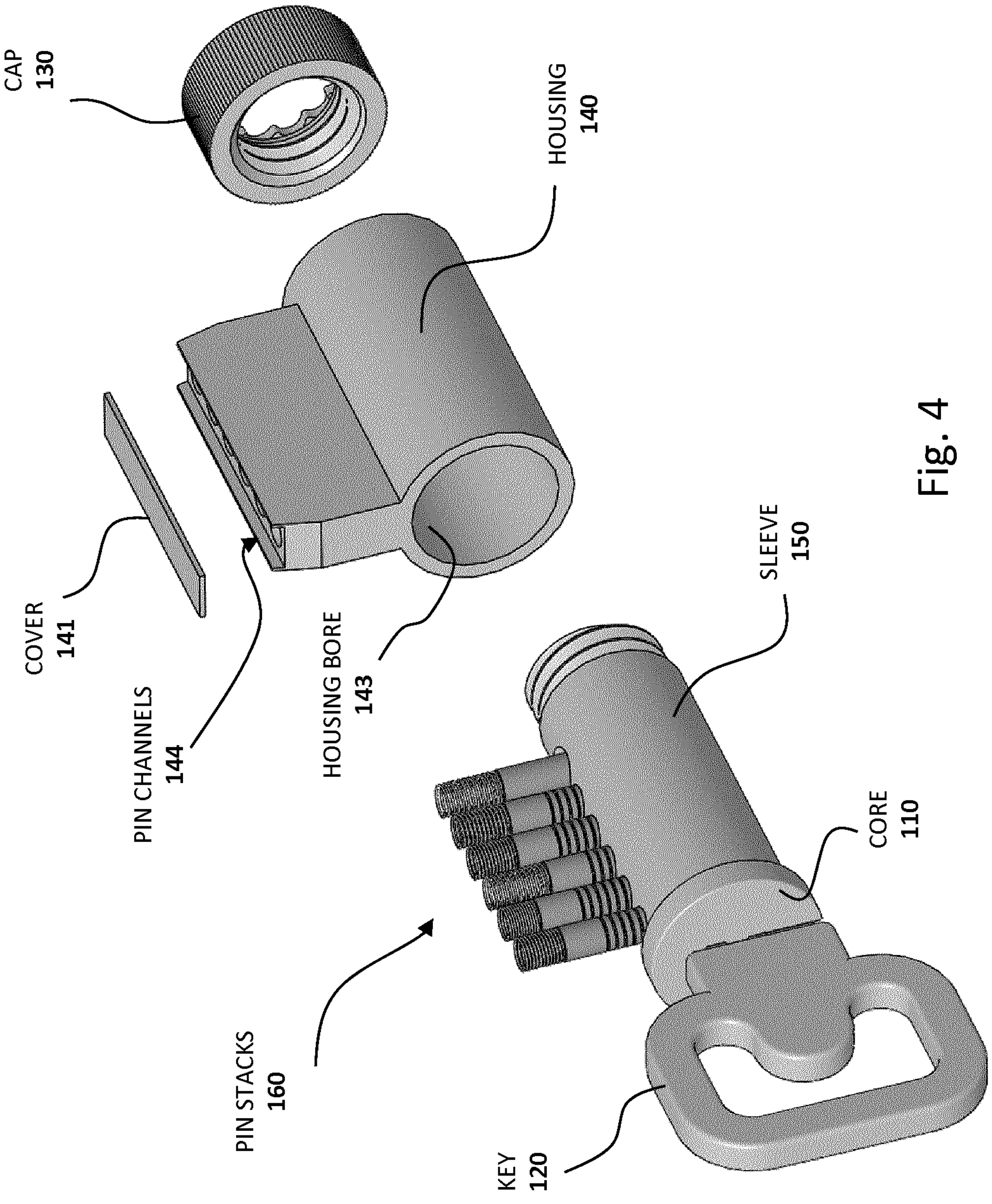
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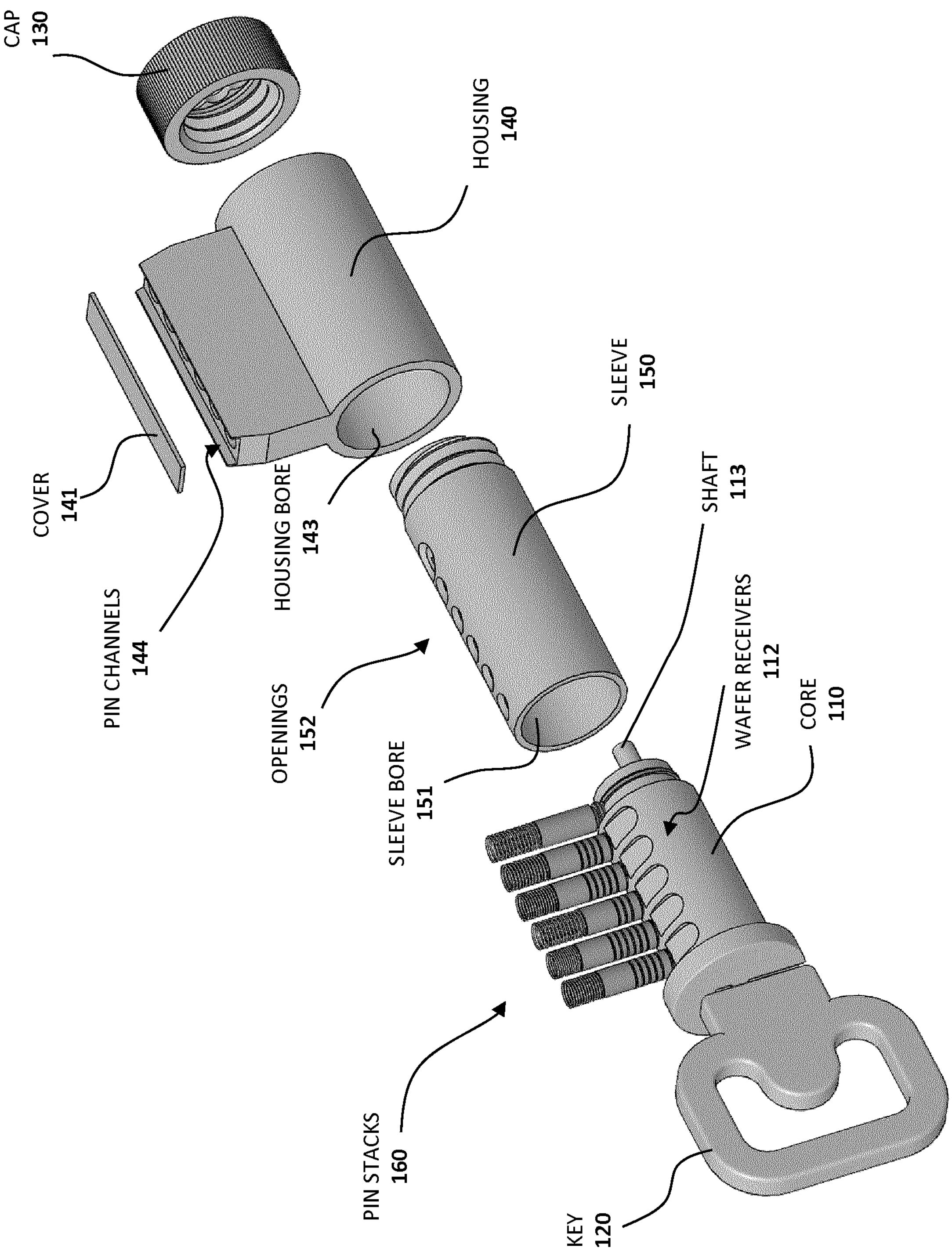
Fig. 4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WAFER RECEIVERS 112
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PIN STACKS 160
KEY 120

Fig. 5

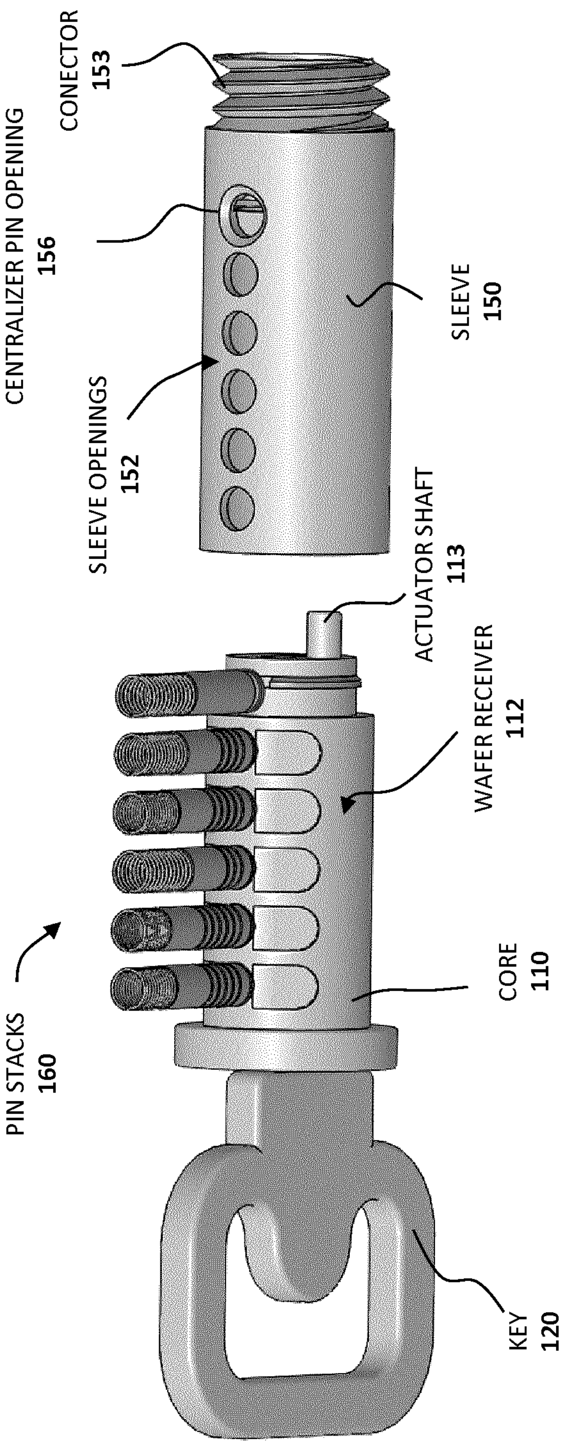


Fig. 6

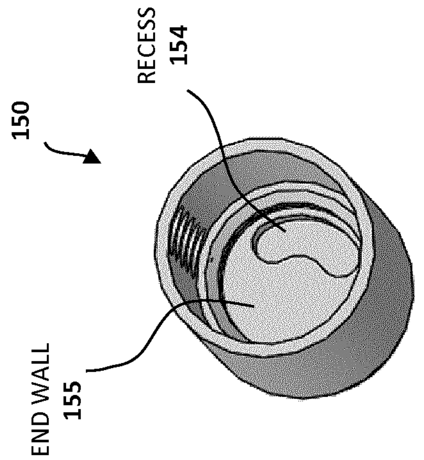


Fig. 8

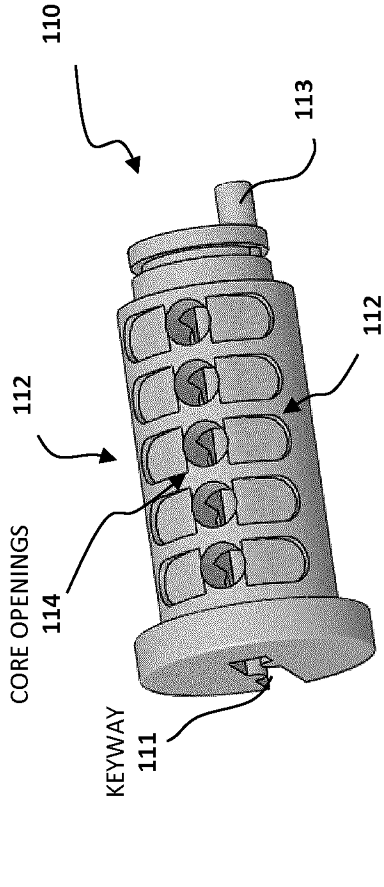
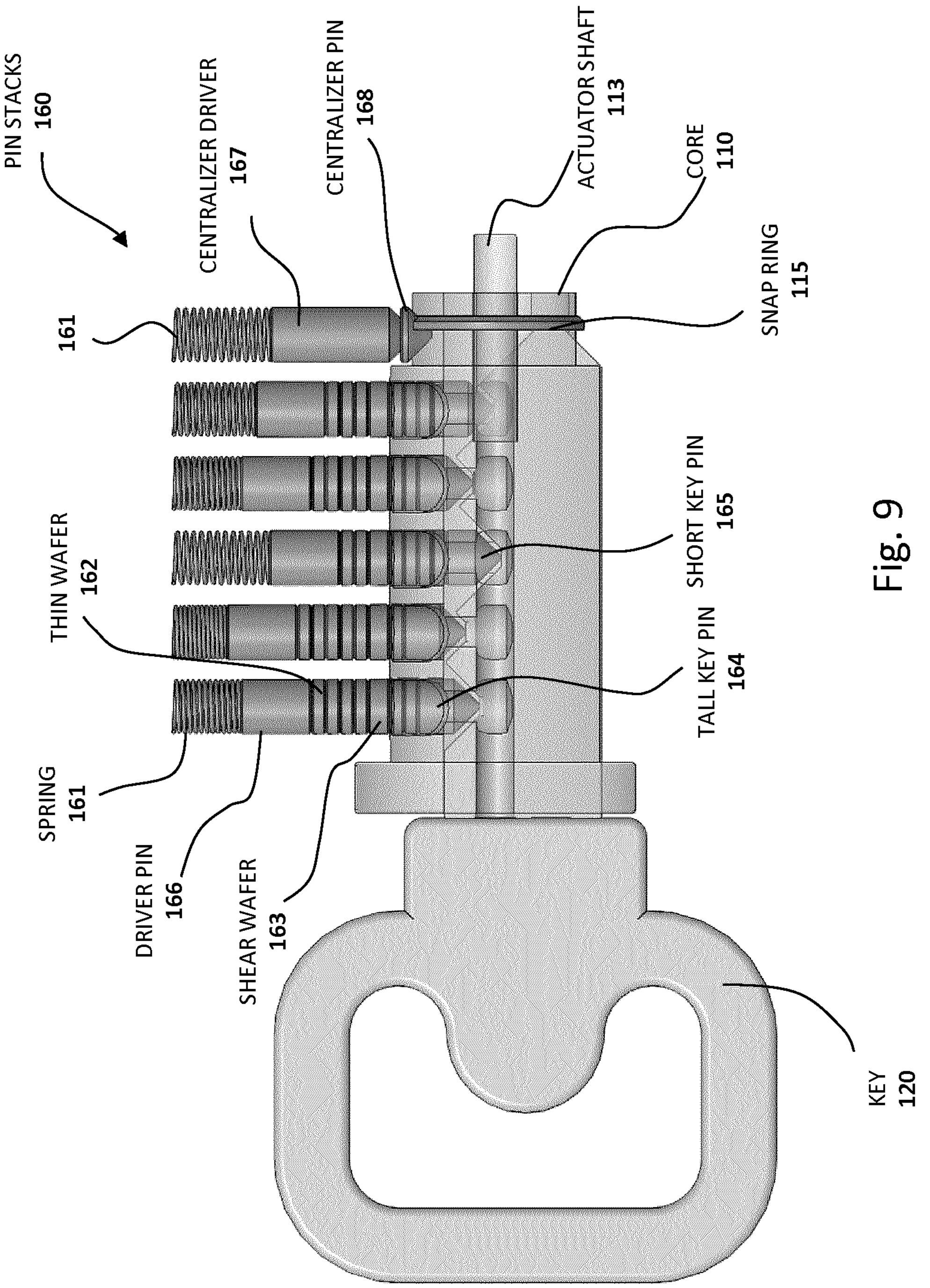


Fig. 7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167
CENTRALIZER PIN
168
ACTUATOR SHAFT
113
CORE
110
SNAP RING
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161
SHORT KEY PIN
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163
KEY
120

Fig. 9

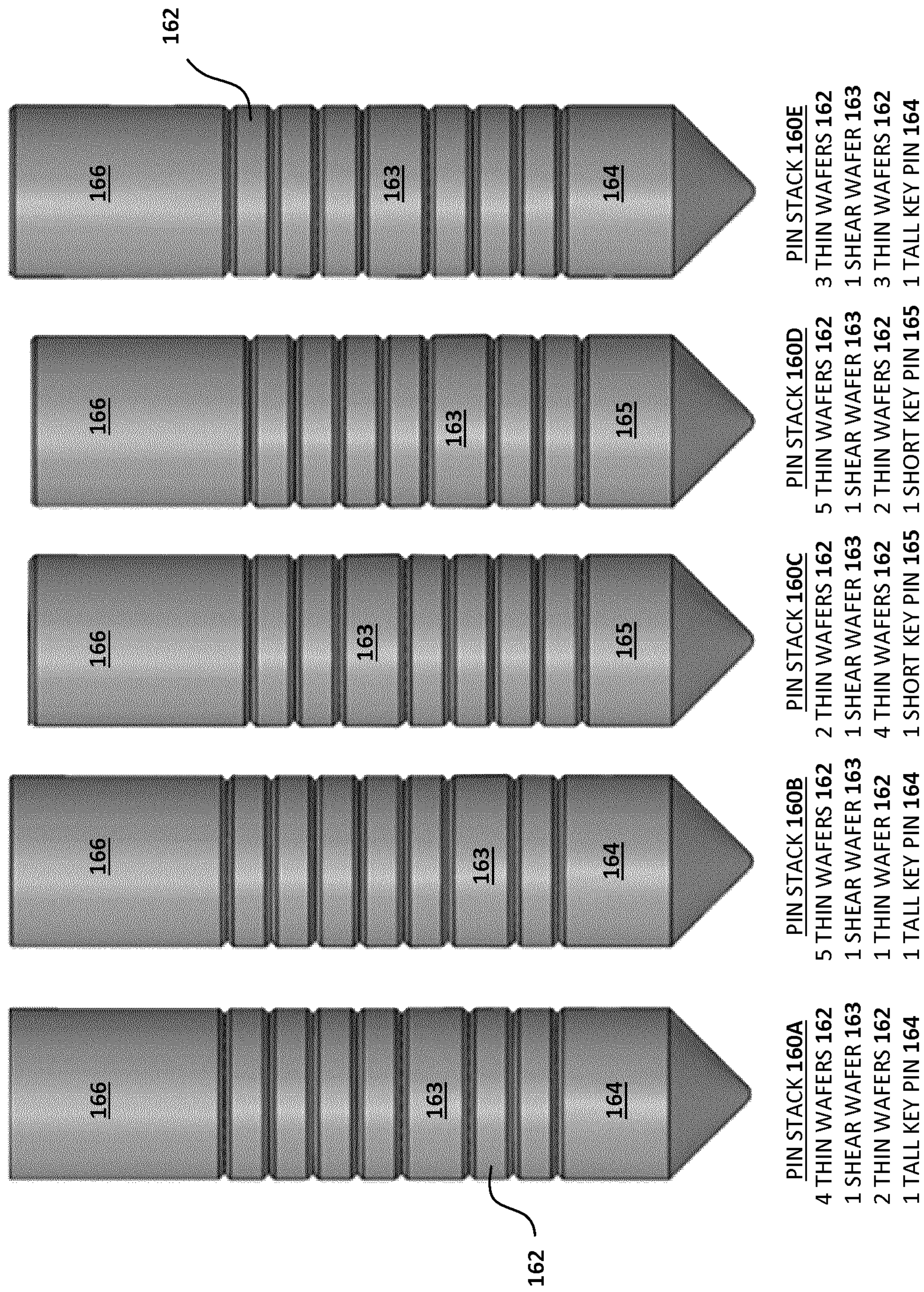

162
166
163
164
PIN STACK 160A
4 THIN WAFERS 162
1 SHEAR WAFER 163
2 THIN WAFERS 162
1 TALL KEY PIN 164
PIN STACK 160B
5 THIN WAFERS 162
1 SHEAR WAFER 163
1 THIN WAFER 162
1 TALL KEY PIN 164
165
PIN STACK 160C
2 THIN WAFERS 162
1 SHEAR WAFER 163
4 THIN WAFERS 162
1 SHORT KEY PIN 165
PIN STACK 160D
5 THIN WAFERS 162
1 SHEAR WAFER 163
2 THIN WAFERS 162
1 SHORT KEY PIN 165
PIN STACK 160E
3 THIN WAFERS 162
1 SHEAR WAFER 163
3 THIN WAFERS 162
1 TALL KEY PIN 164

Fig. 10

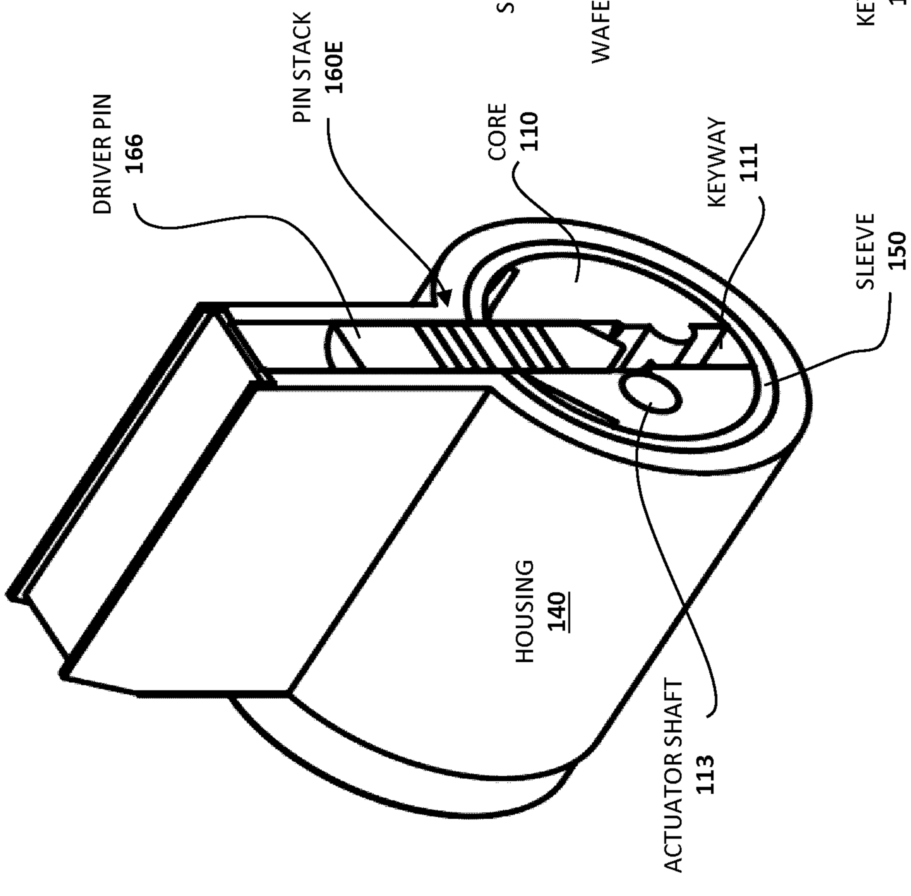


Fig. 11A

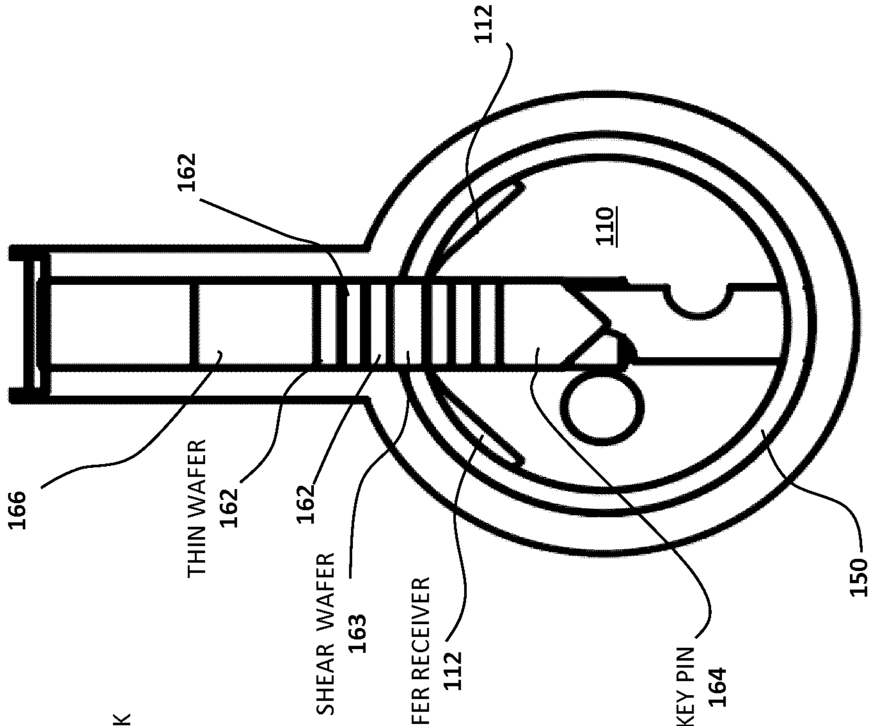


Fig. 11B

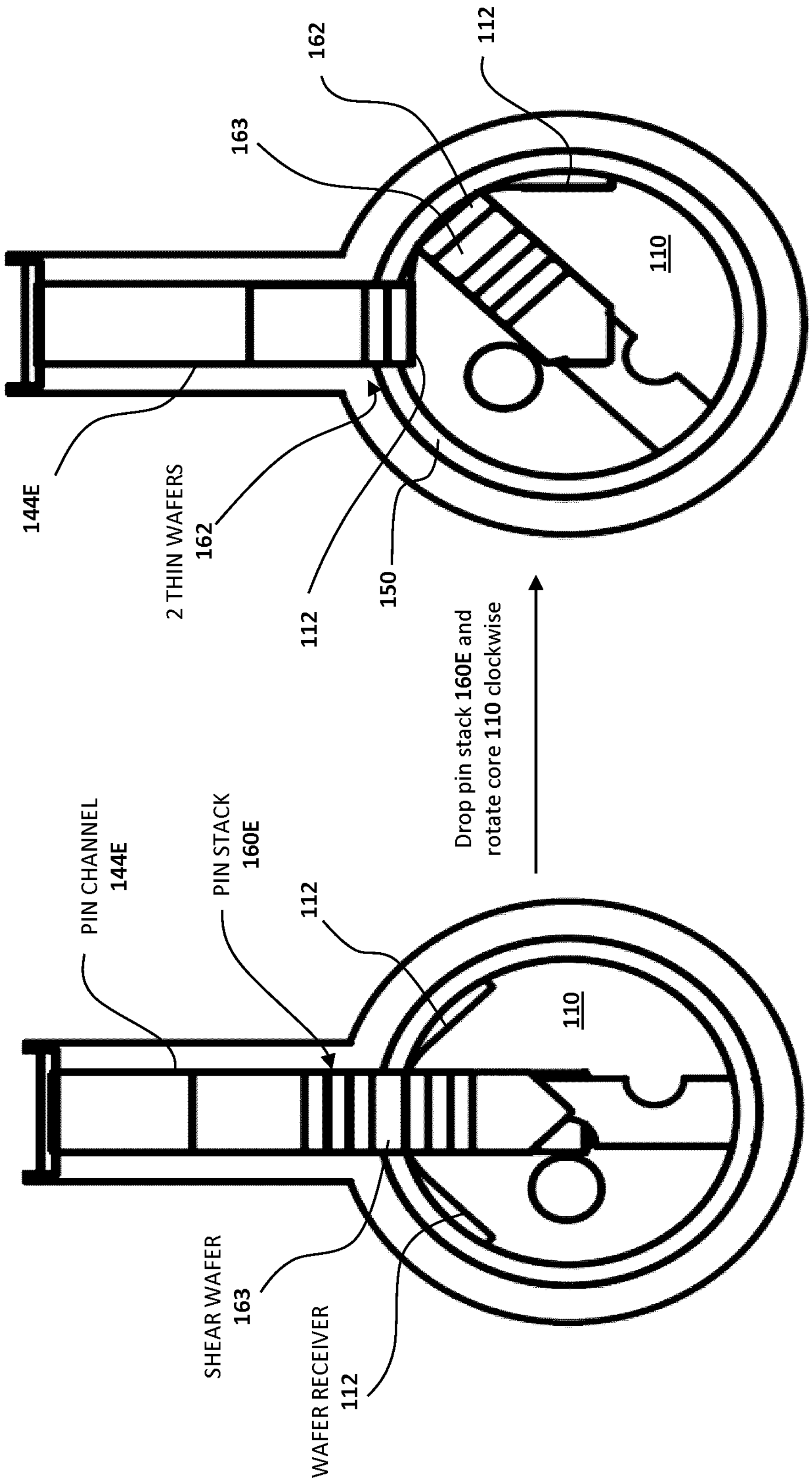

PIN CHANNEL
144E
PIN STACK
160E
112
110
SHEAR WAFER
163
WAFER RECEIVER
112
Drop pin stack 160E and
rotate core 110 clockwise
144E
2 THIN WAFERS
162
112
150
163
162
112
110

Fig. 12

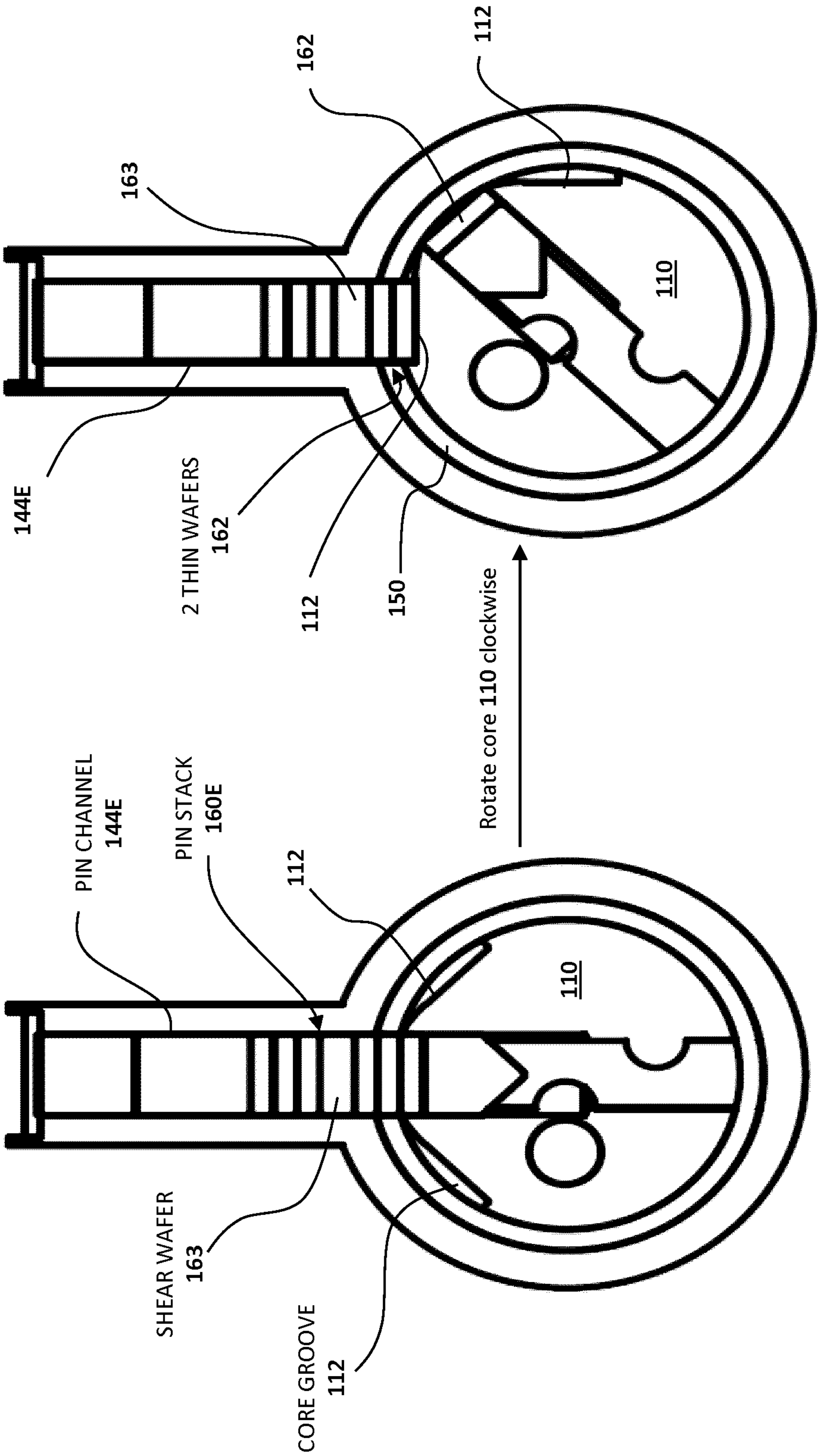

PIN CHANNEL
144E
PIN STACK
160E
112
110
SHEAR WAFER
163
CORE GROOVE
112
Rotate core 110 clockwise
144E
2 THIN WAFERS
162
112
150
163
162
112
110

Fig. 13

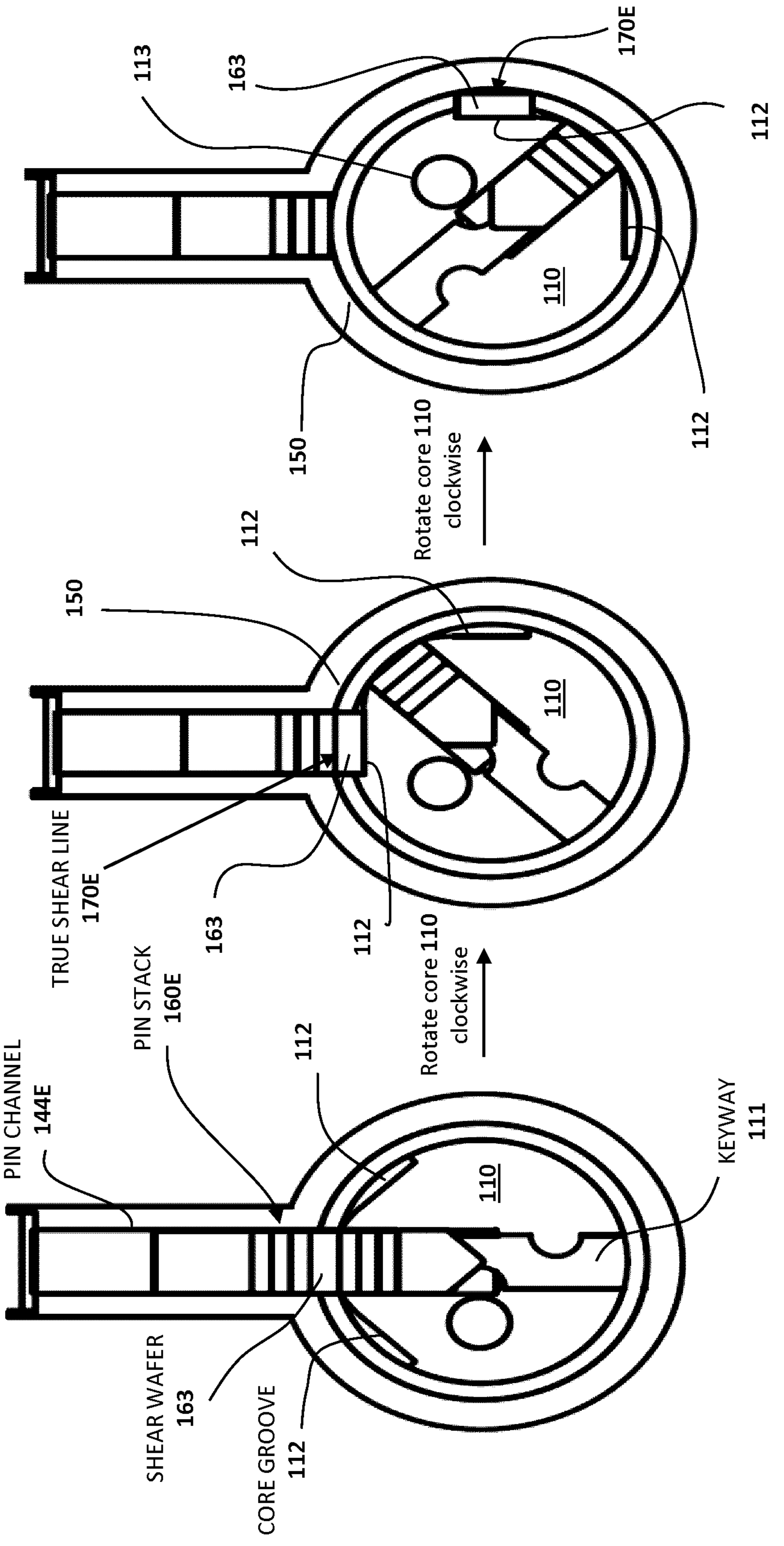

PIN CHANNEL
144E
PIN STACK
160E
112
SHEAR WAFER
163
CORE GROOVE
112
110
KEYWAY
111
Rotate core 110
clockwise
TRUE SHEAR LINE
170E
163
112
150
112
110
Rotate core 110
clockwise
150
113
163
170E
112
110
112

Fig. 14

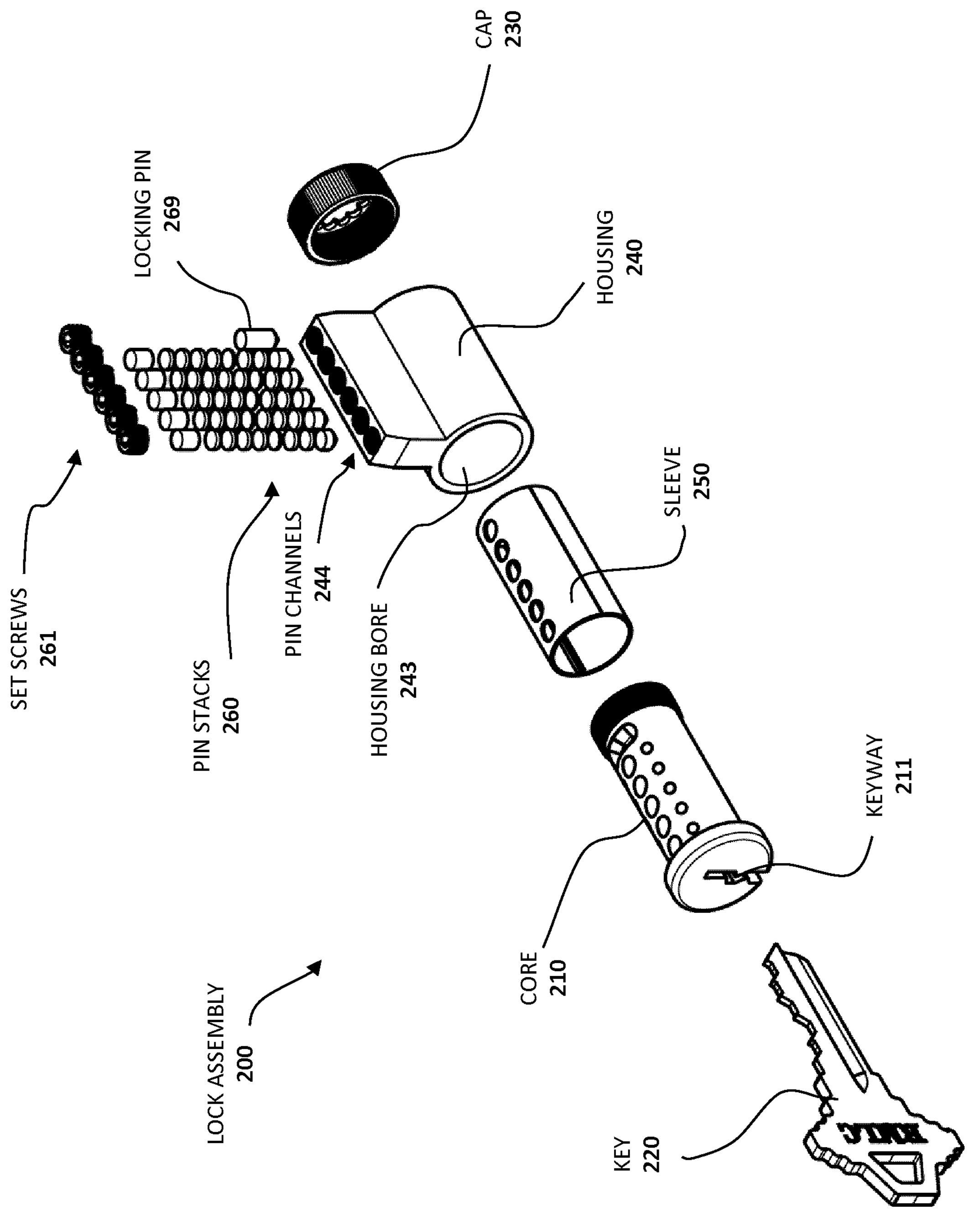

CAP
230
LOCKING PIN
269
HOUSING
240
SET SCREWS
261
PIN STACKS
260
PIN CHANNELS
244
HOUSING BORE
243
SLEEVE
250
KEYWAY
211
CORE
210
LOCK ASSEMBLY
200
KEY
220

Fig. 15

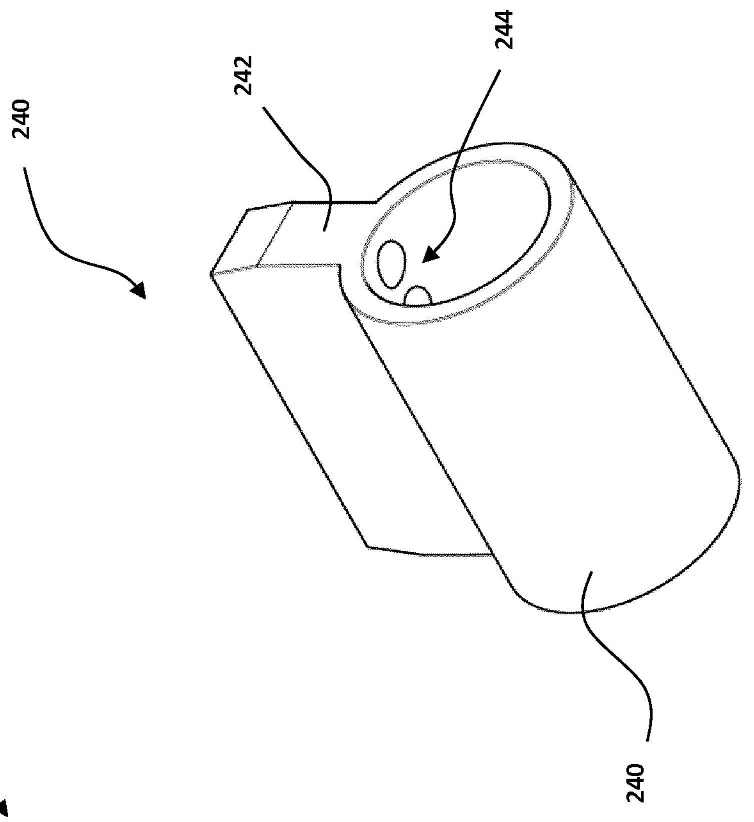


Fig. 16B

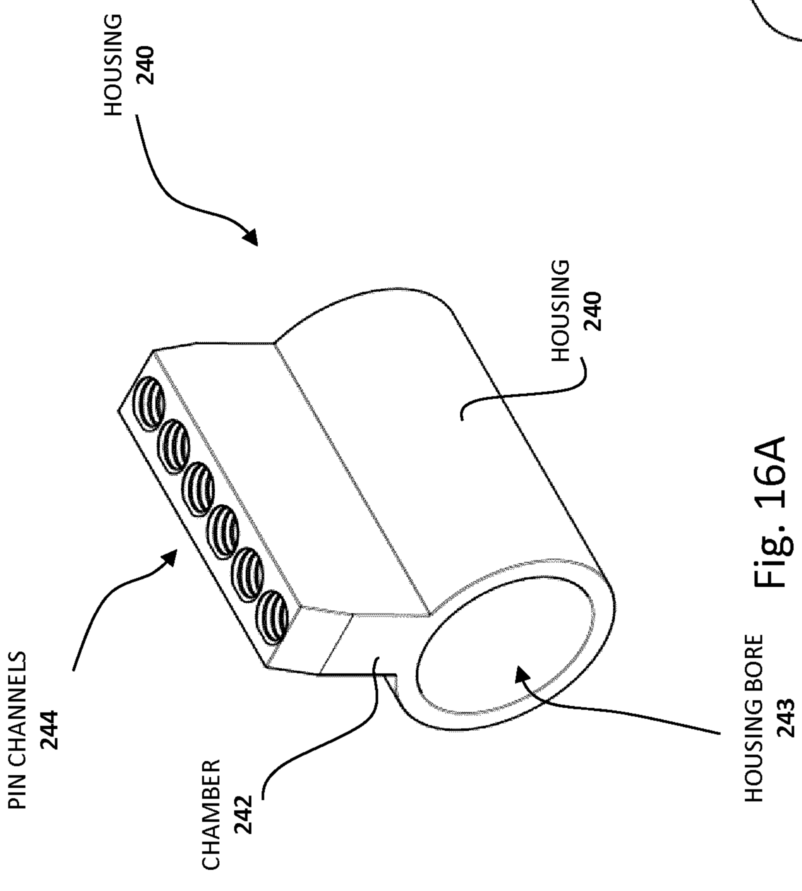


Fig. 16A

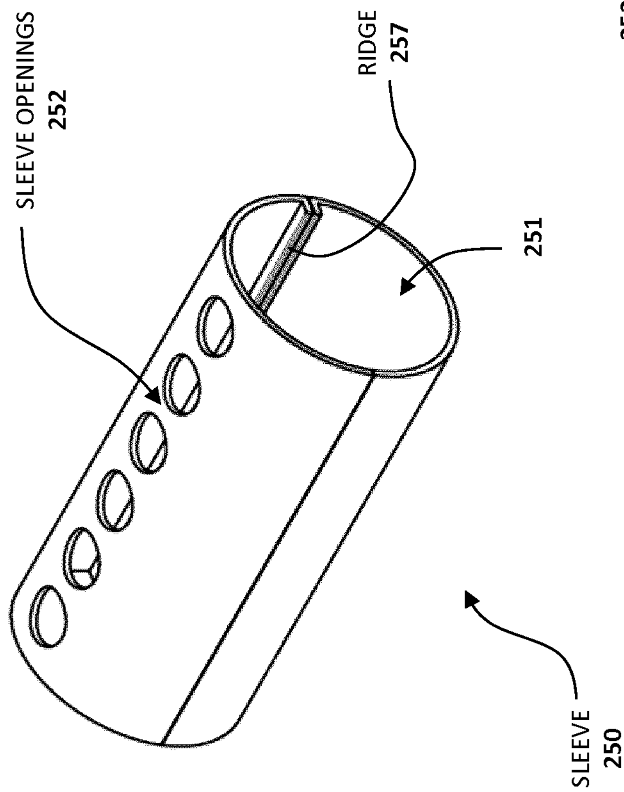


Fig. 17A

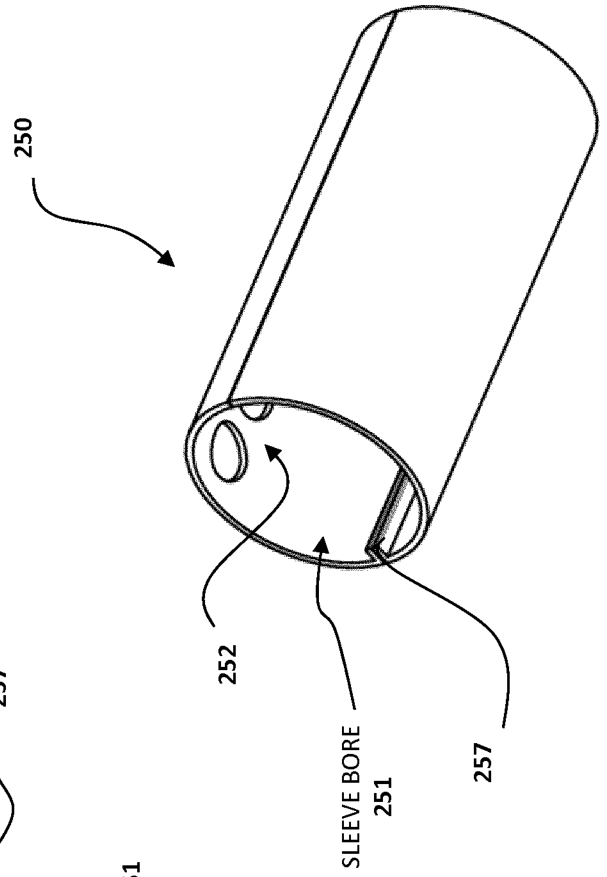


Fig. 17B

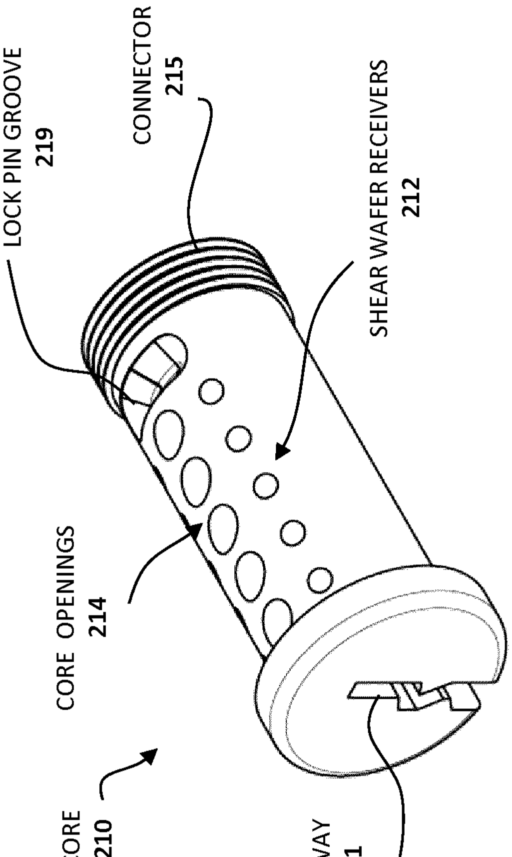


Fig. 18A

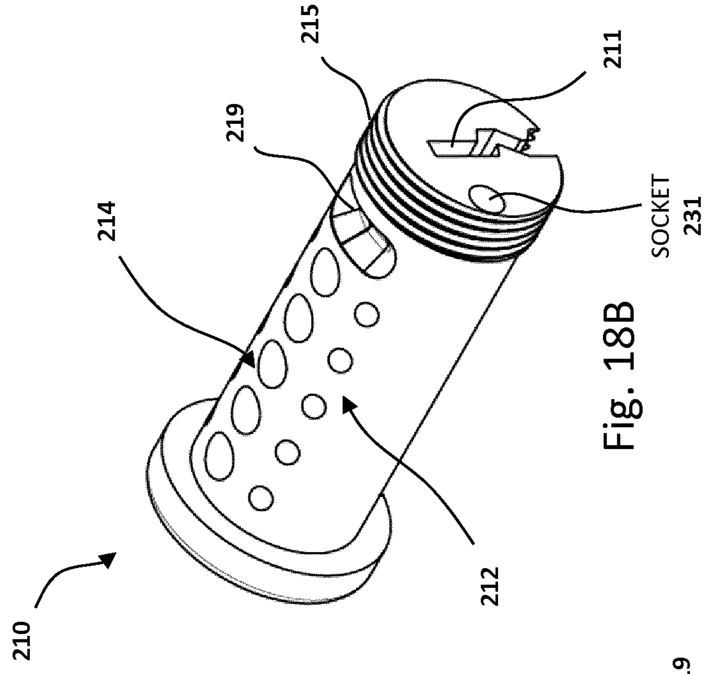


Fig. 18B

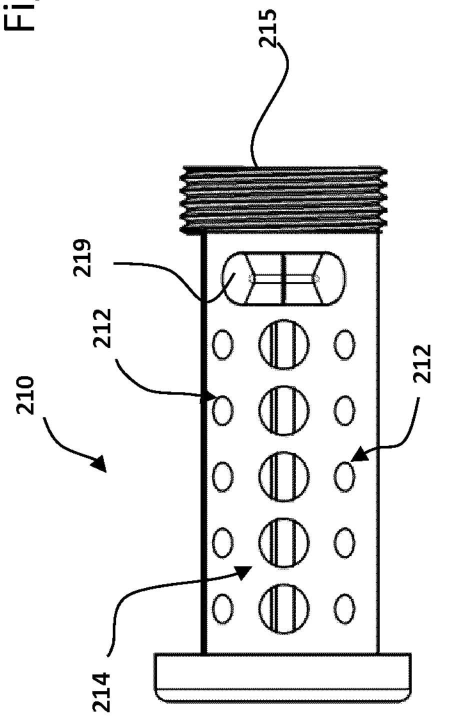


Fig. 18C

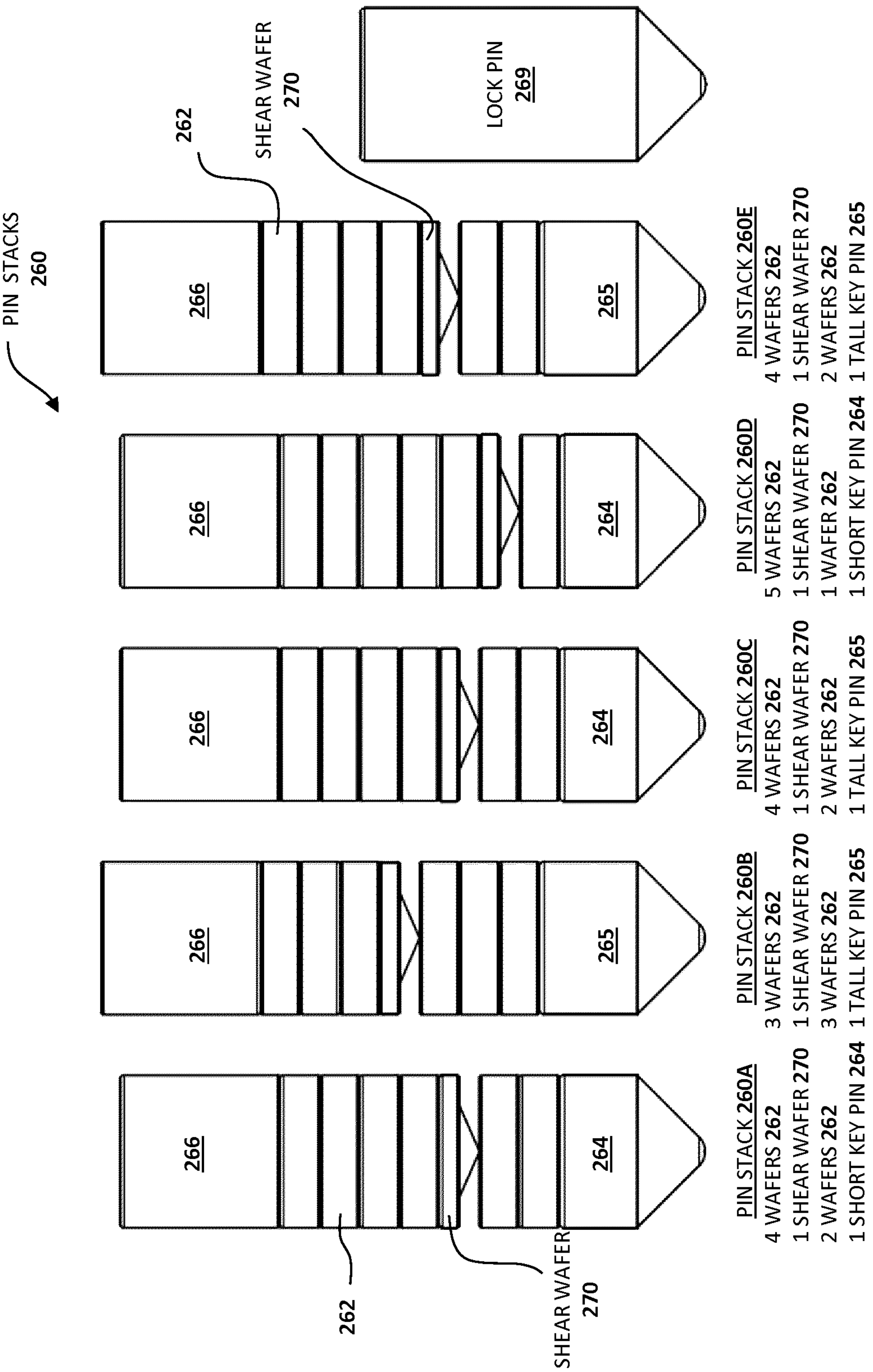

PIN STACKS
260
262
SHEAR WAFER
270
LOCK PIN
269
266
265
264
262
SHEAR WAFER
270
PIN STACK 260A
4 WAFERS 262
1 SHEAR WAFER 270
2 WAFERS 262
1 SHORT KEY PIN 264
PIN STACK 260B
3 WAFERS 262
1 SHEAR WAFER 270
3 WAFERS 262
1 TALL KEY PIN 265
PIN STACK 260C
4 WAFERS 262
1 SHEAR WAFER 270
2 WAFERS 262
1 TALL KEY PIN 265
PIN STACK 260D
5 WAFERS 262
1 SHEAR WAFER 270
1 WAFER 262
1 SHORT KEY PIN 264
PIN STACK 260E
4 WAFERS 262
1 SHEAR WAFER 270
2 WAFERS 262
1 TALL KEY PIN 265

Fig. 19

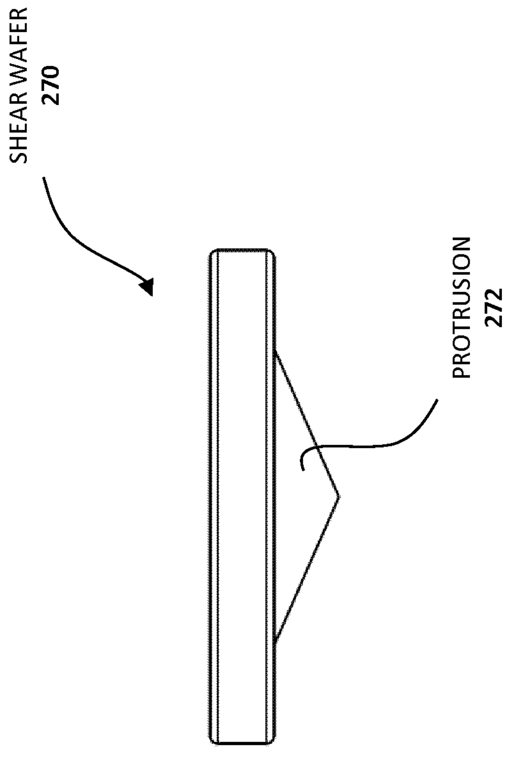


Fig. 20A

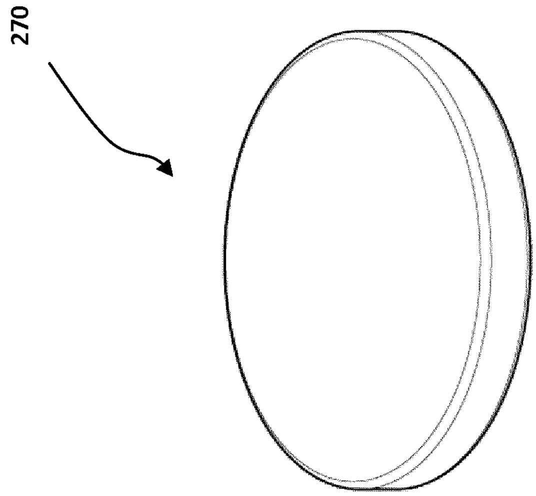


Fig. 20B

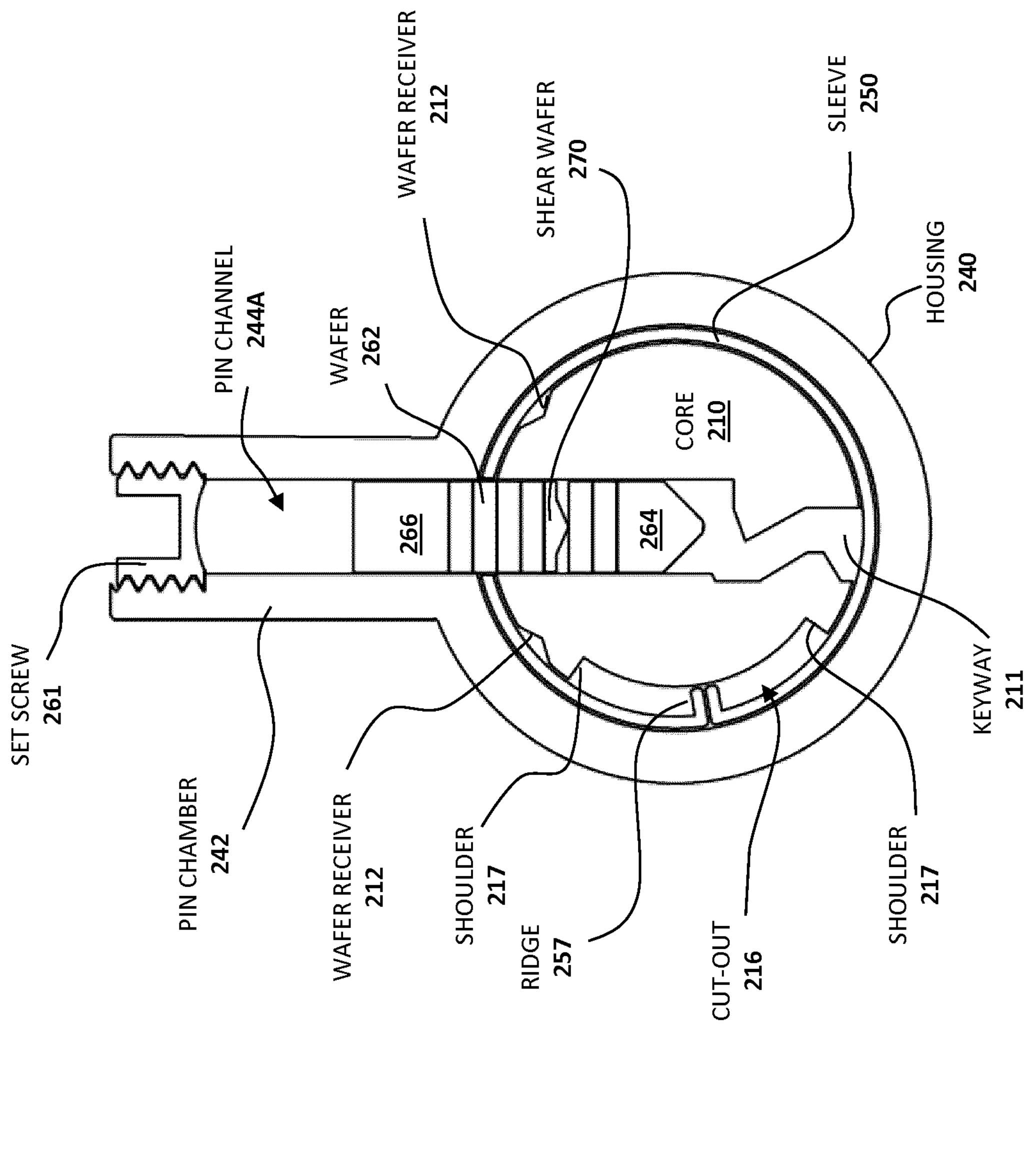
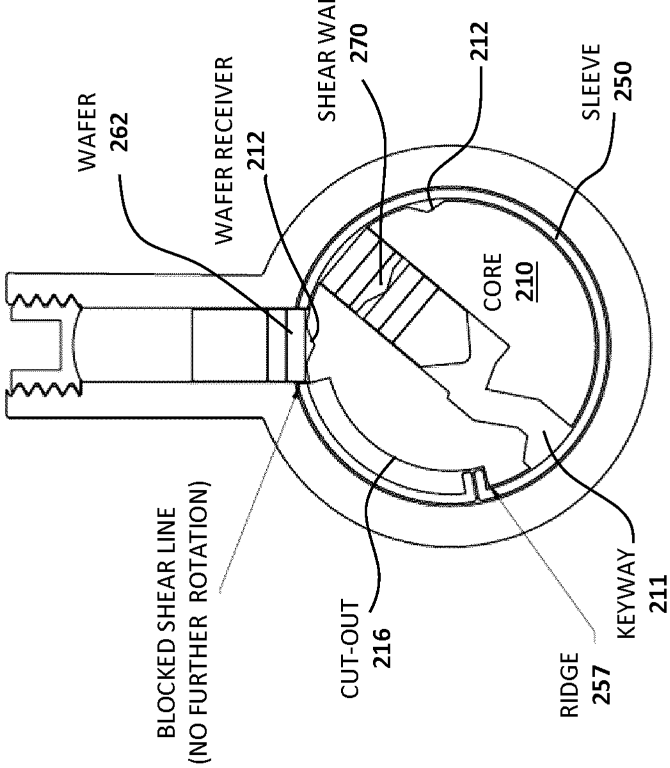
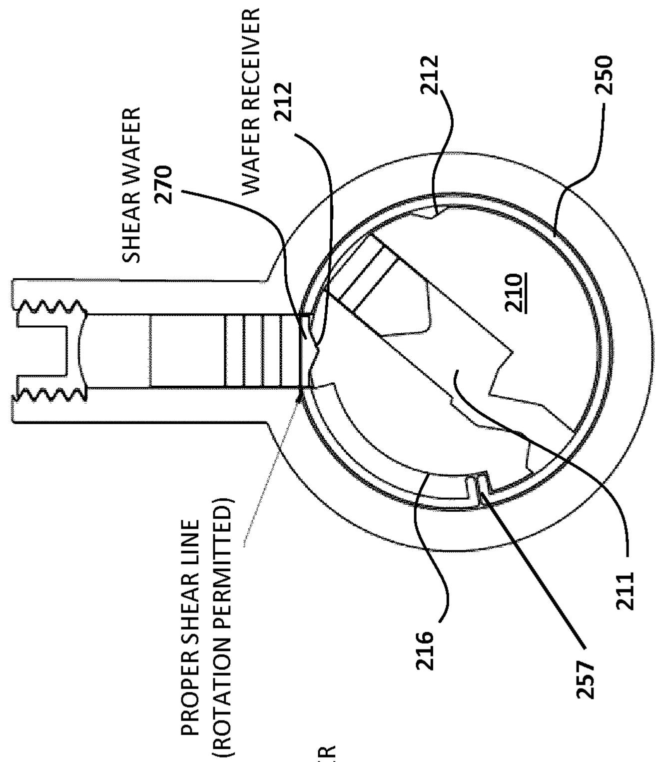

SET SCREW
261
PIN CHAMBER
242
PIN CHANNEL
244A
WAFER
262
266
264
WAFER RECEIVER
212
SHEAR WAFER
270
SLEEVE
250
HOUSING
240
CORE
210
KEYWAY
211
SHOULDER
217
CUT-OUT
216
RIDGE
257
SHOULDER
217
WAFER RECEIVER
212

Fig. 21



CORE ROTATED CLOCKWISE FROM FIG. 21

Fig. 22



PROPER PIN HEIGHT ATTAINED BY TRUE KEY
& CORE ROTATED CLOCKWISE FROM FIG. 21

Fig. 23

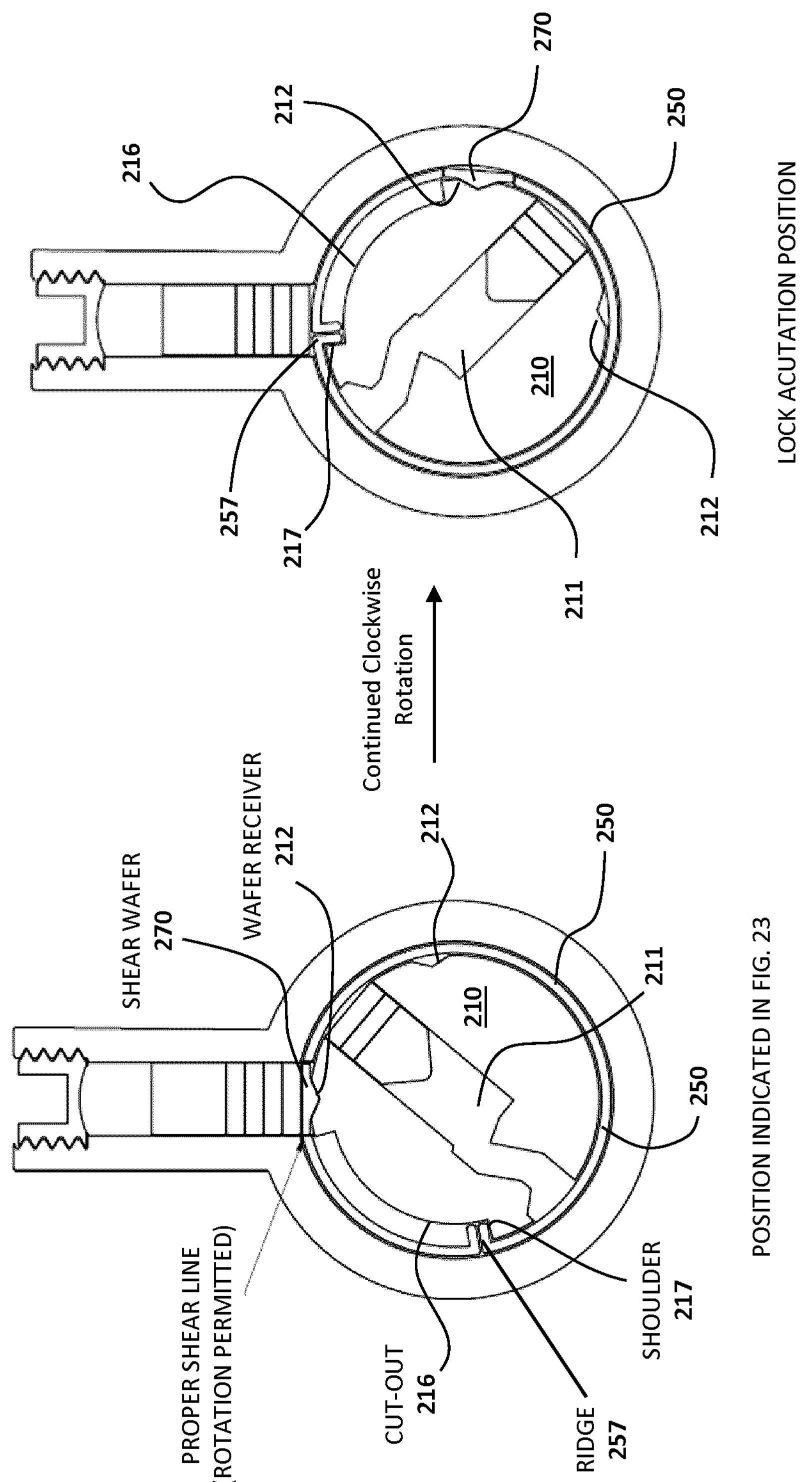

PROPER SHEAR LINE
(ROTATION PERMITTED)
SHEAR WAFER
270
WAFER RECEIVER
212
212
210
211
250
250
CUT-OUT
216
RIDGE
257
SHOULDER
217
POSITION INDICATED IN FIG. 23
Continued Clockwise
Rotation
216
212
270
250
257
217
210
211
212
LOCK ACUTATION POSITION

Fig. 24

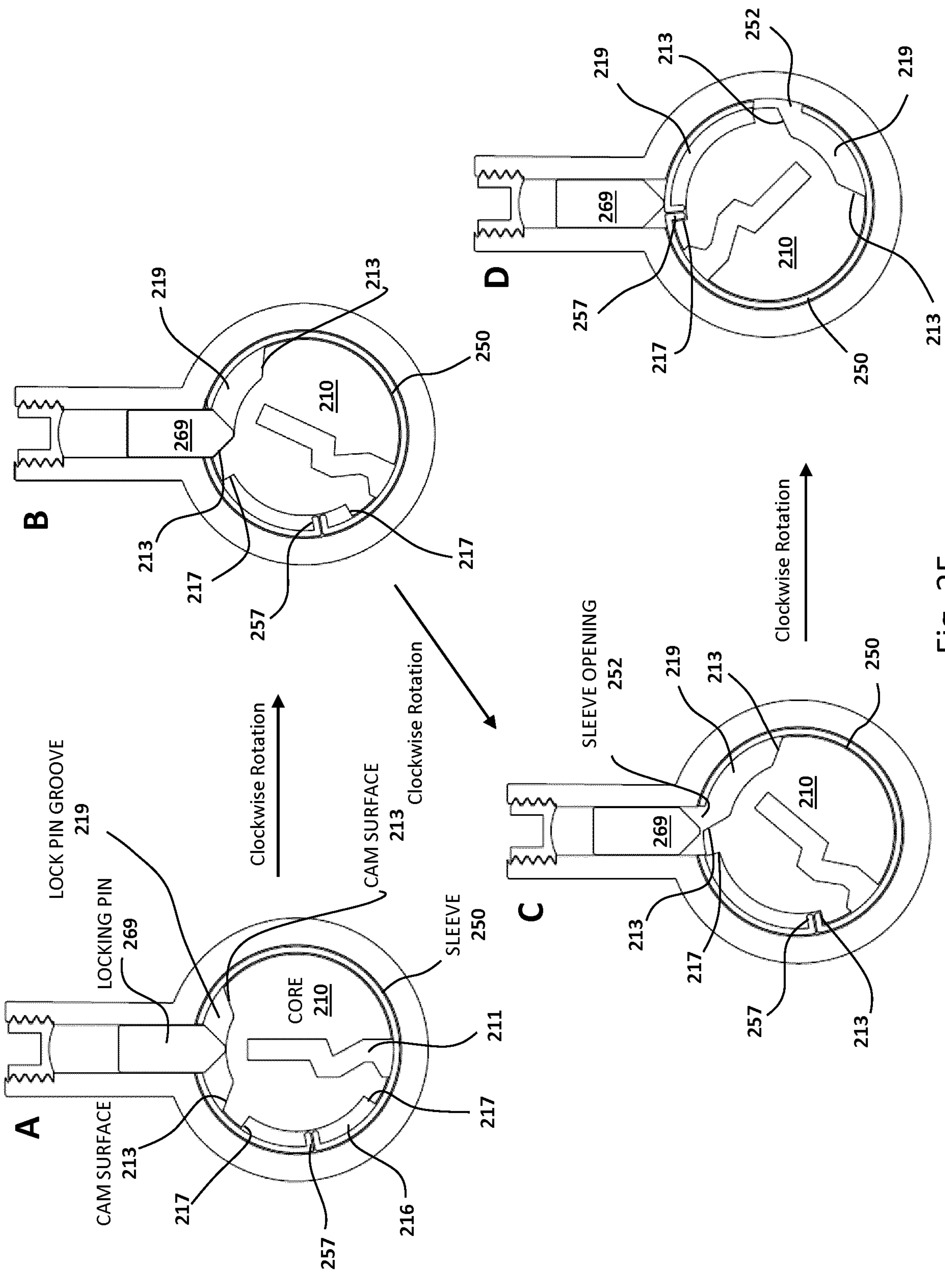

A
B
C
D
LOCK PIN GROOVE
219
LOCKING PIN
269
CAM SURFACE
213
CORE
210
SLEEVE
250
211
216
217
257
Clockwise Rotation
SLEEVE OPENING
252

Fig. 25

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2021/050535

A. CLASSIFICATION OF SUBJECT MATTER
IPC: ***E05B 15/00*** (2006.01) , ***E05B 27/00*** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: E05B 15/00; E05B 27/00.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Databases: Orbit
Keywords : lock, housing, core, receiver, pin, protrud+, groove, key, keyway, sleeve, bore, stack+, shear, wafer, channel, depression, pick-resistant.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US5964111 (LAMBERT) 12 October 1999 (12-10-1999)	1, 2, 11-16
A	US9181728 B2 (FARAG et al.) 10 November 2015 (10-11-2015)	1-29
A	US6978647 B2 (EDWARDS, Jr. et al.) 27 December 2005 (27-12-2005)	1-29
A	US3802234 (GERLACH) 09 April 1974 (09-04-1974)	1-29
A	US3494158 (BAUER) 10 February 1970 (10-02-1970)	1-29
A	US2370862 (JOHNSTONE) 06 March 1945 (06-03-1945)	1-29

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D"	document cited by the applicant in the international application	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E"	earlier application or patent but published on or after the international filing date	"&"	document member of the same patent family
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
23 June 2021 (23-06-2021)	13 July 2021 (13-07-2021)

Name and mailing address of the ISA/CA	Authorized officer
Canadian Intellectual Property Office Place du Portage I, C114 - 1st Floor, Box PCT 50 Victoria Street Gatineau, Quebec K1A 0C9 Facsimile No.: 819-953-2476	Ciprian Galasiu (819) 639-5781

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2021/050535

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
US5964111A	12 October 1999 (12-10-1999)	None	
US9181728B2	10 November 2015 (10-11-2015)	US2014150506A1 US9181728B2 AU2013355351A1 AU2013355351B2 CA2893138A1 CN104919122A MX2015006883A MX359076B WO2014089141A1	05 June 2014 (05-06-2014) 10 November 2015 (10-11-2015) 18 June 2015 (18-06-2015) 05 April 2018 (05-04-2018) 12 June 2014 (12-06-2014) 16 September 2015 (16-09-2015) 07 April 2016 (07-04-2016) 13 September 2018 (13-09-2018) 12 June 2014 (12-06-2014)
US6978647B2	27 December 2005 (27-12-2005)	US2003037582A1 US6978647B2 US2004159136A1 US7225651B2 US2006032280A1	27 February 2003 (27-02-2003) 27 December 2005 (27-12-2005) 19 August 2004 (19-08-2004) 05 June 2007 (05-06-2007) 16 February 2006 (16-02-2006)
US3802234A	09 April 1974 (09-04-1974)	US3802234A CA970988A	09 April 1974 (09-04-1974) 15 July 1975 (15-07-1975)
US3494158A	10 February 1970 (10-02-1970)	None	
US2370862A	06 March 1945 (06-03-1945)	None	