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(54) **SPRING LOCK**

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Related U.S. Application Data

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(51) **Int. Cl.**
H05K 7/14 (2006.01)

(52) **U.S. Cl.**
CPC ***H05K 7/1404*** (2013.01); *Y10T 29/49826* (2015.01); *Y10T 403/602* (2015.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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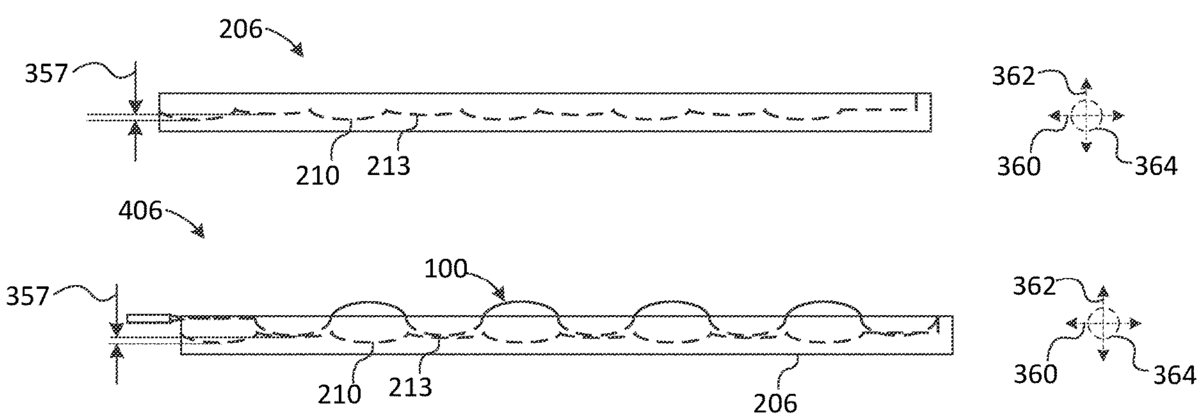
Primary Examiner — Courtney L Smith

(57) **ABSTRACT**

A spring lock includes a sinusoidal spring that has one or more crests and troughs formed along a length of the sinusoidal spring, the length extending along a sliding axis, the one or more crests and troughs forming a sinusoidal spring profile. The spring lock further includes a lock bar that has a track extending along the sliding axis, the track being configured to hold the sinusoidal spring and allow the sinusoidal spring to move along the sliding axis, the track further including one or more depressions and plateaus with the depressions and plateaus forming a lock bar profile, wherein the spring lock is locked when the sinusoidal spring profile and the lock bar profile are out-of-phase and the spring lock is unlocked when the sinusoidal spring profile and the lock bar profile are in-phase.

12 Claims, 10 Drawing Sheets



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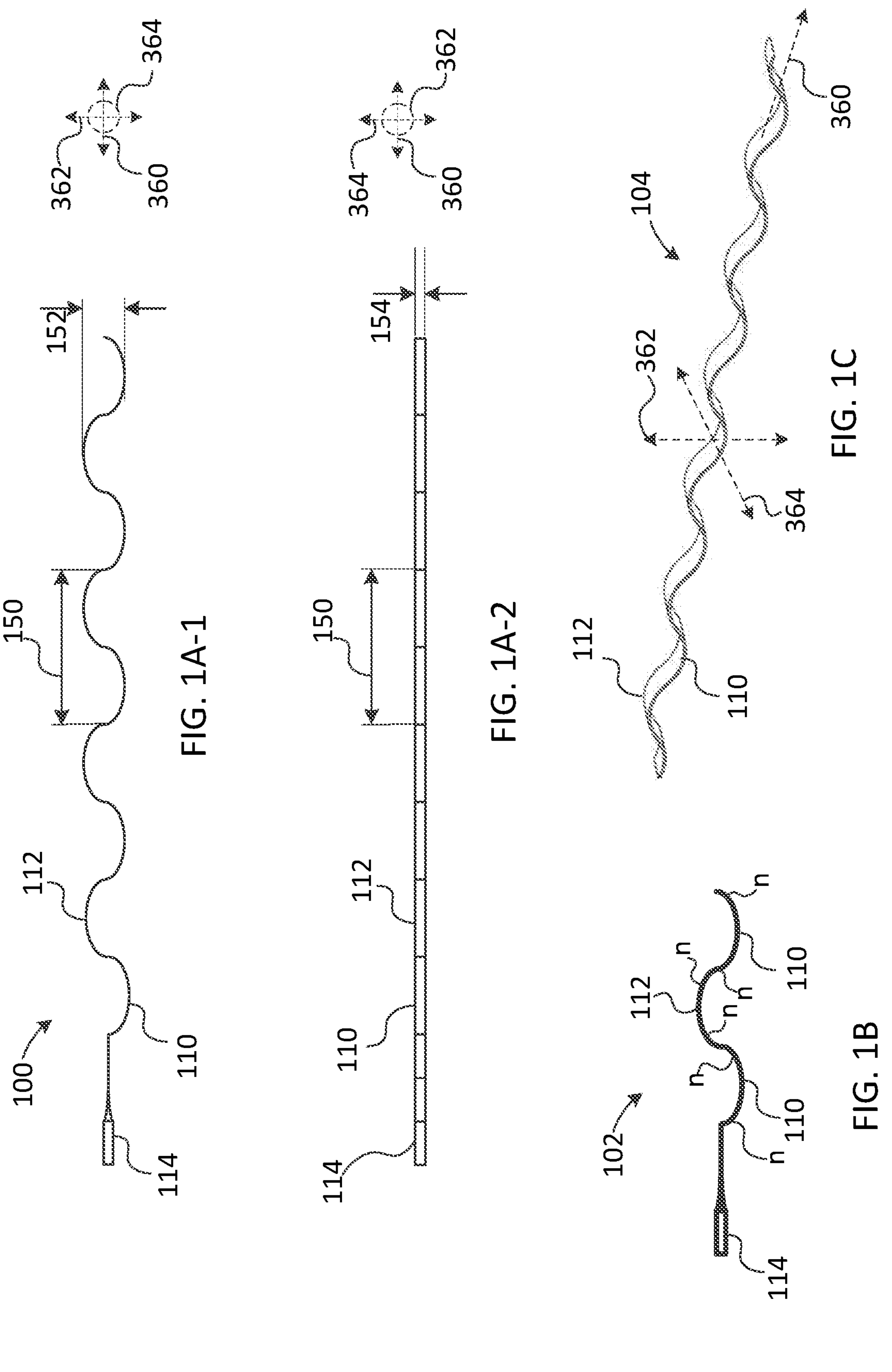


FIG. 1A-1

FIG. 1A-2

FIG. 1B

FIG. 1C

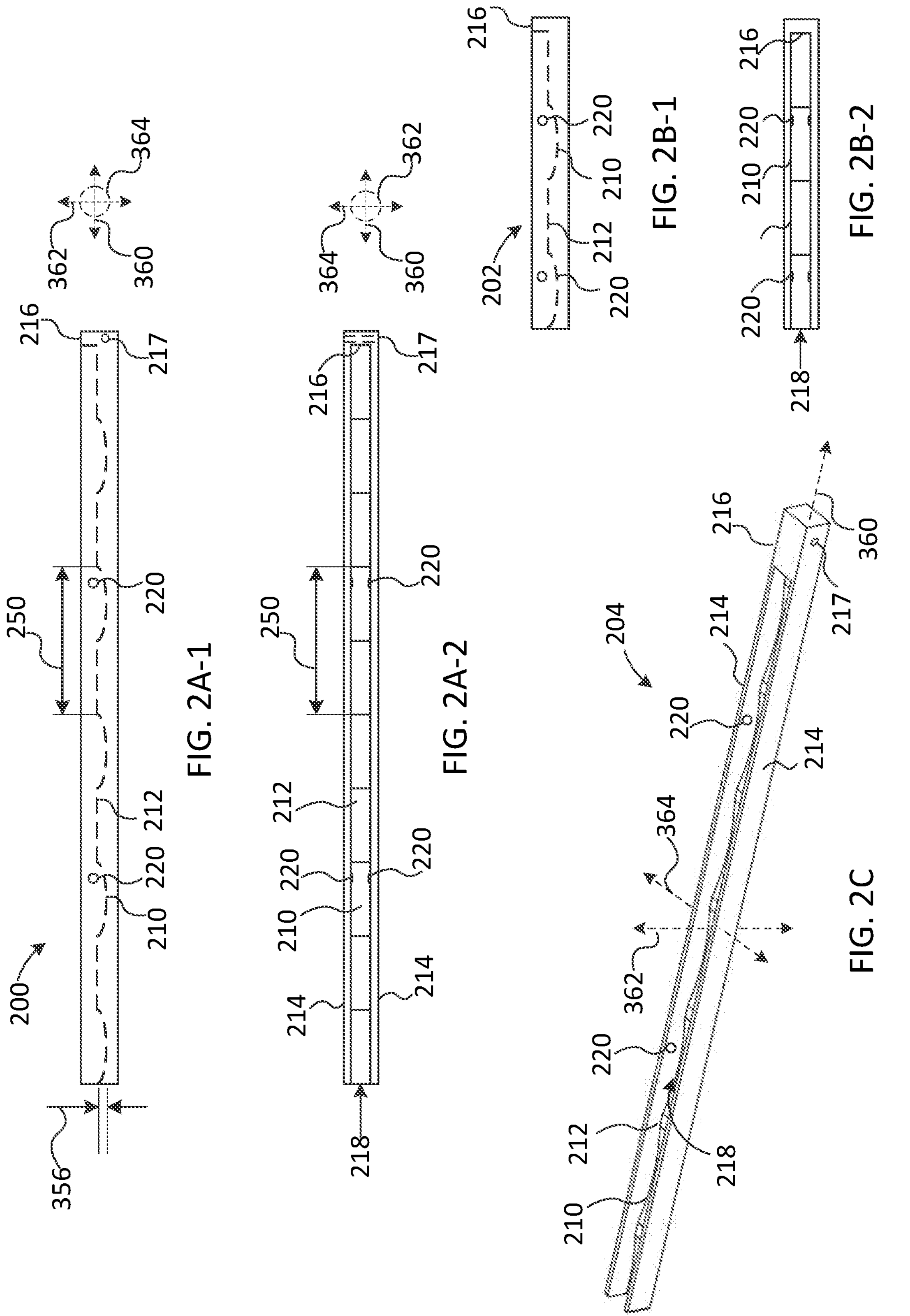


FIG. 2A-1

FIG. 2A-2

FIG. 2B-1

FIG. 2B-2

FIG. 2C

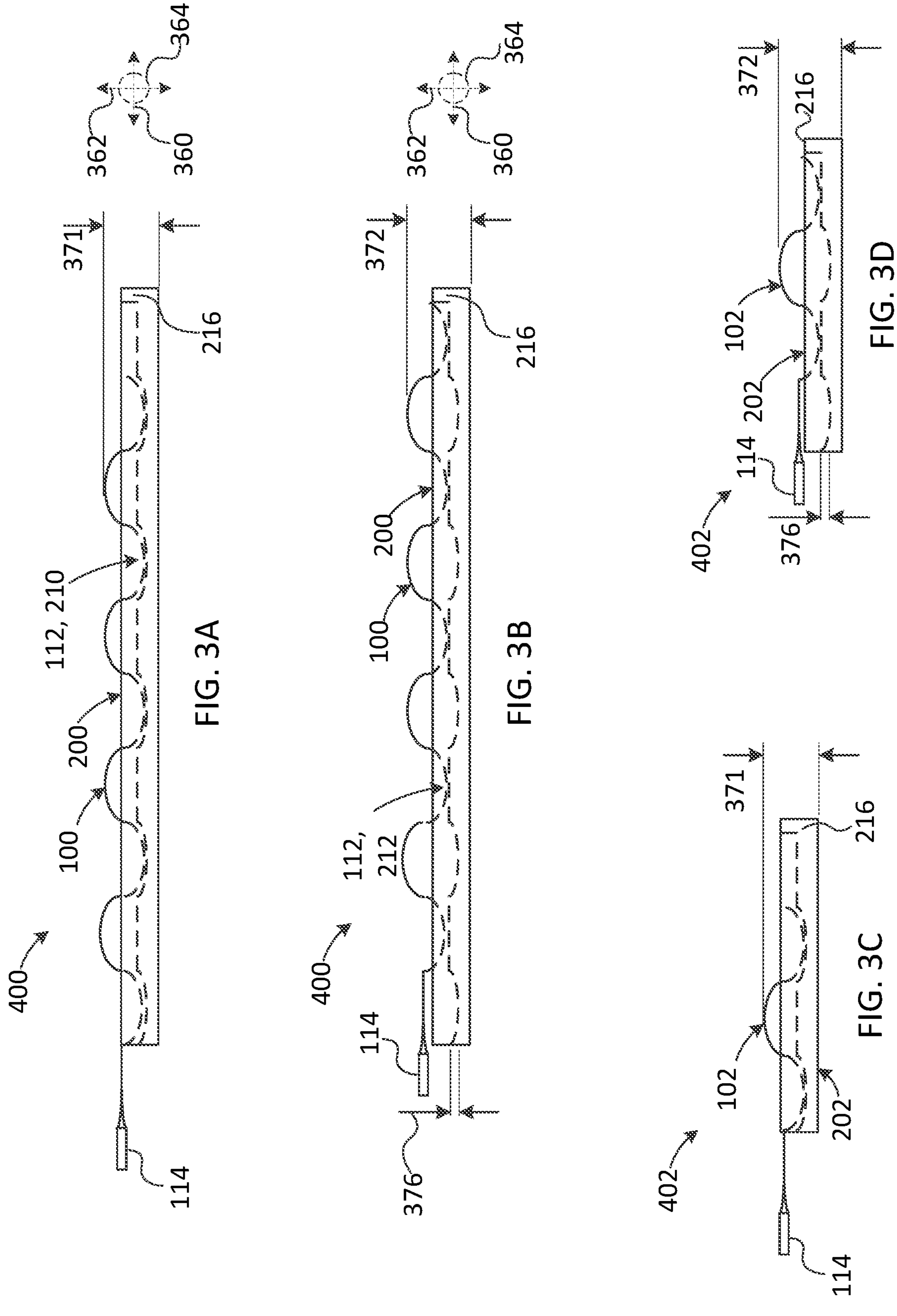


FIG. 3A

FIG. 3B

FIG. 3C

FIG. 3D

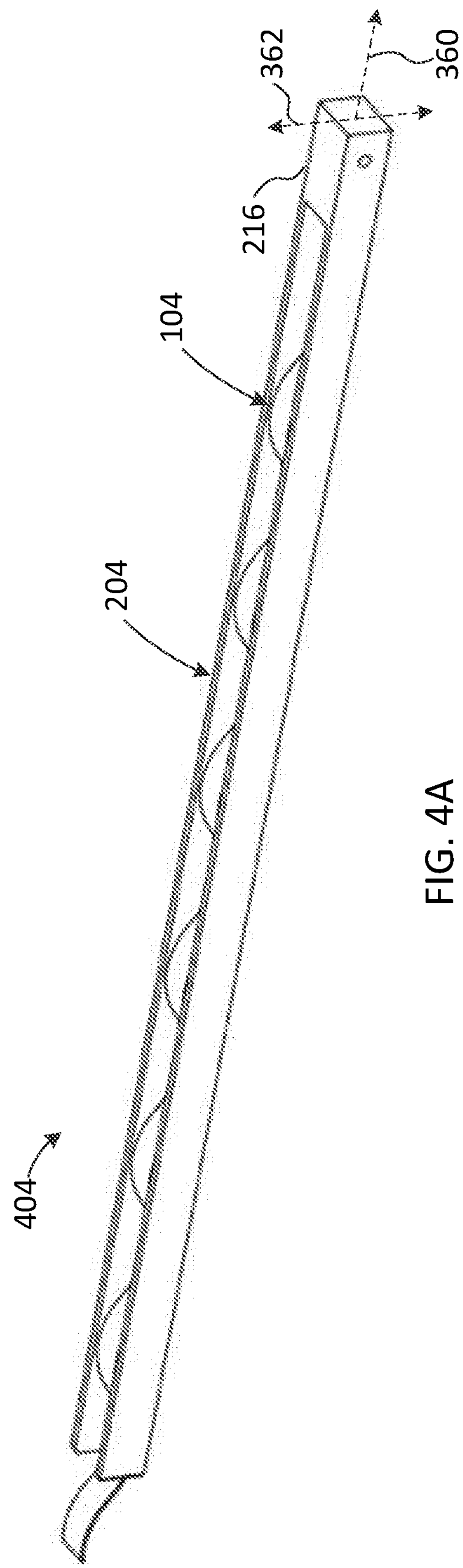


FIG. 4A

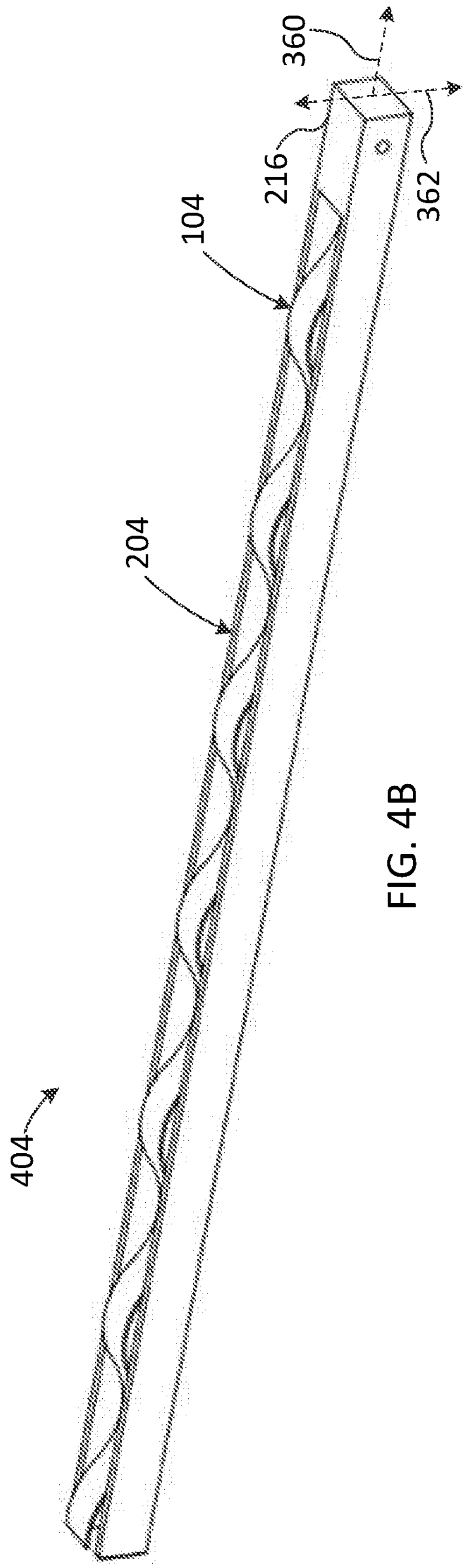


FIG. 4B

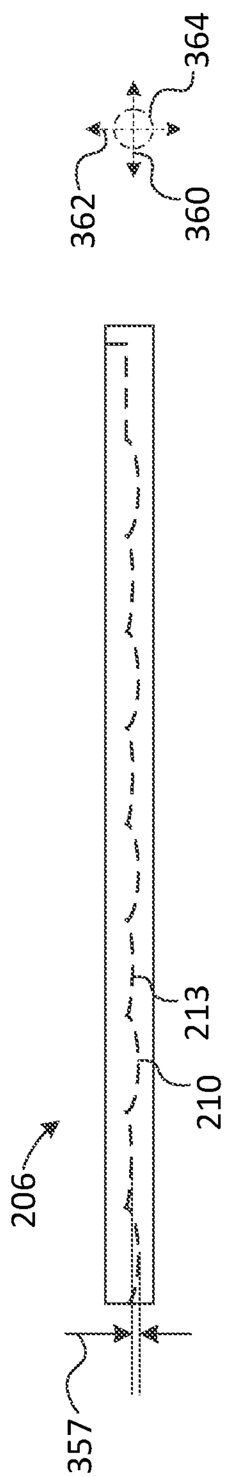


FIG. 5A

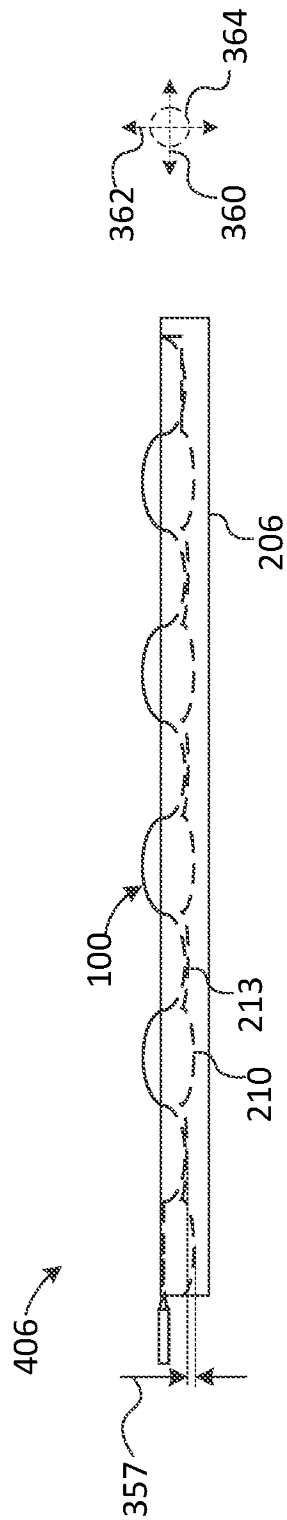


FIG. 5B

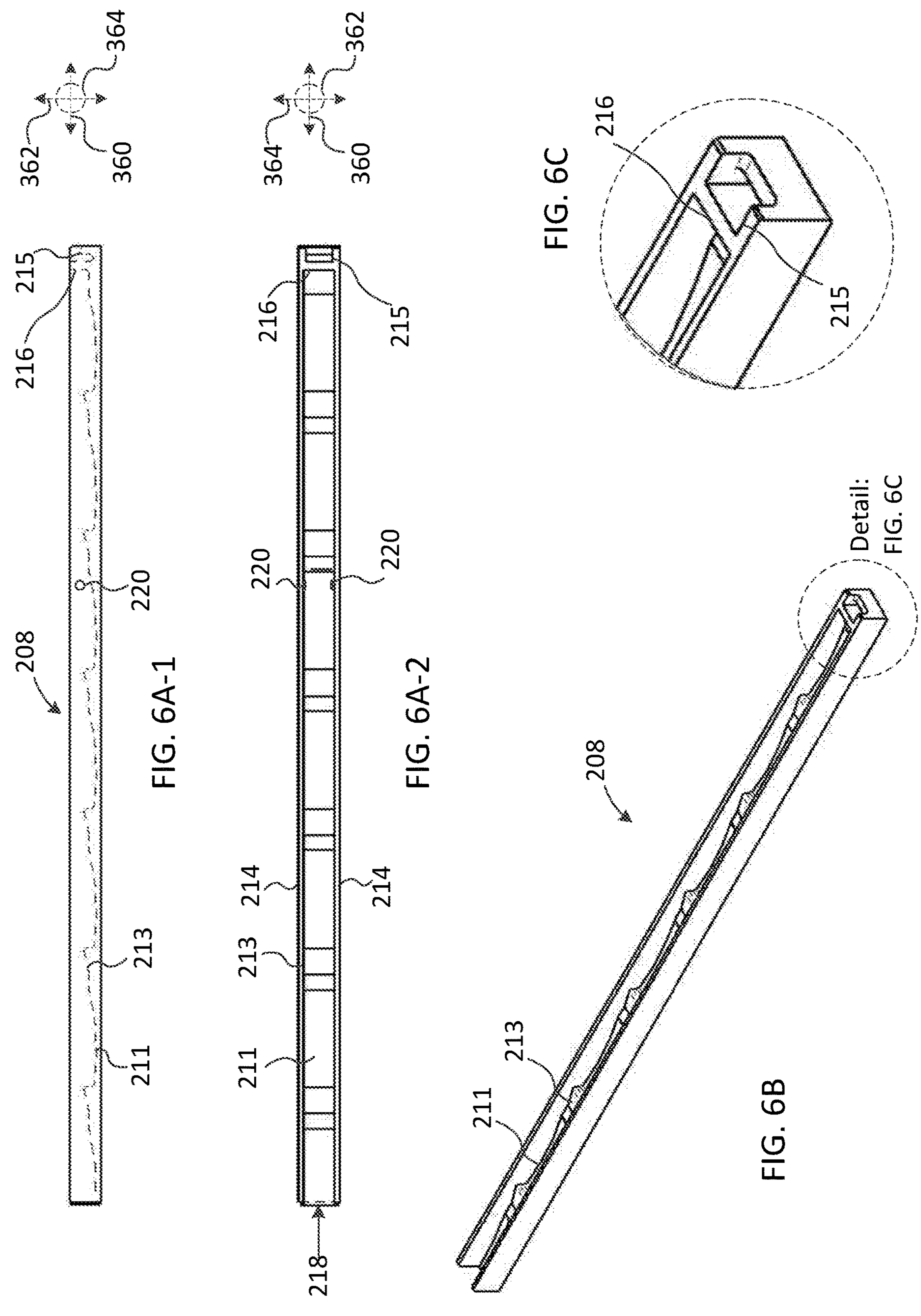


FIG. 6A-1

FIG. 6A-2

FIG. 6B

FIG. 6C

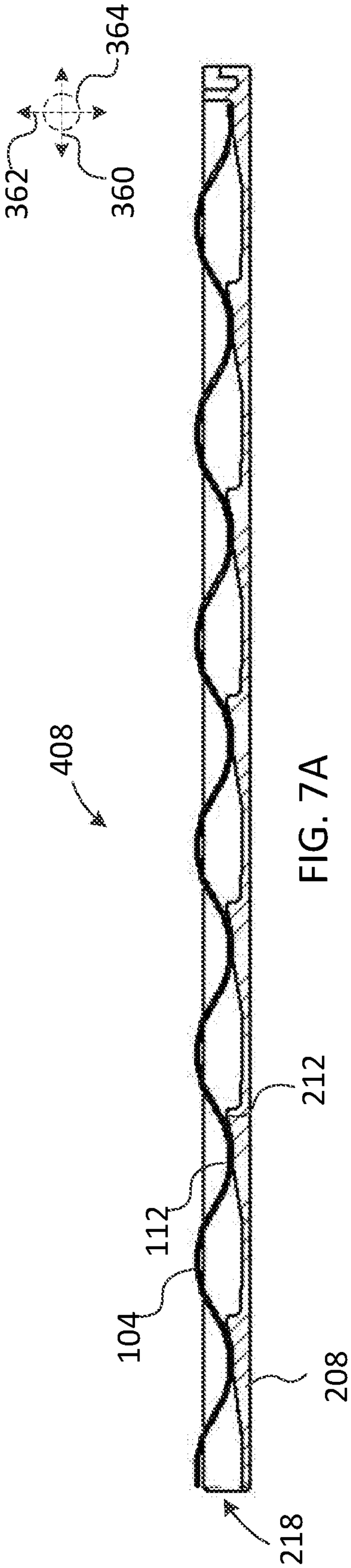
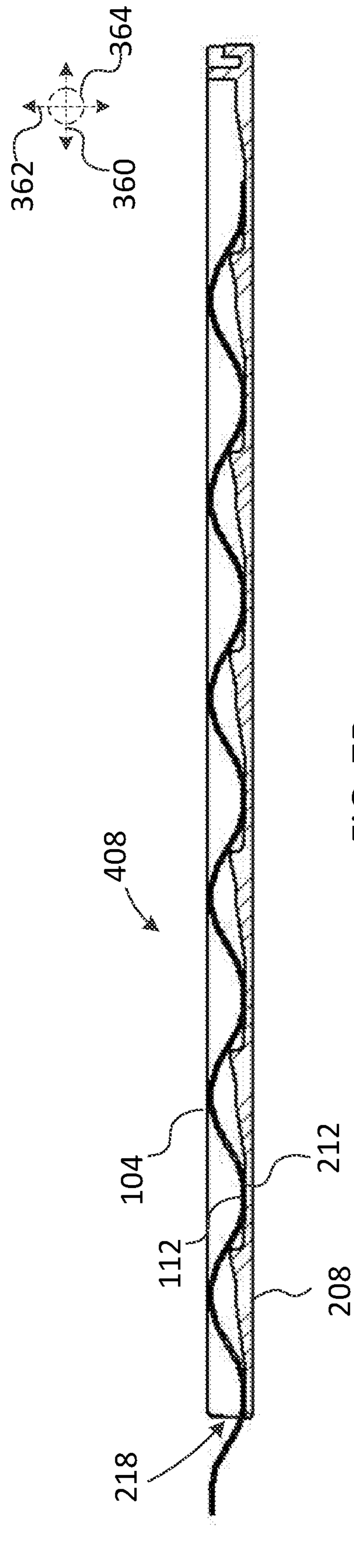

364
362
360
408
212
112
104
208
218

FIG. 7A


364
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212
112
208
218

FIG. 7B

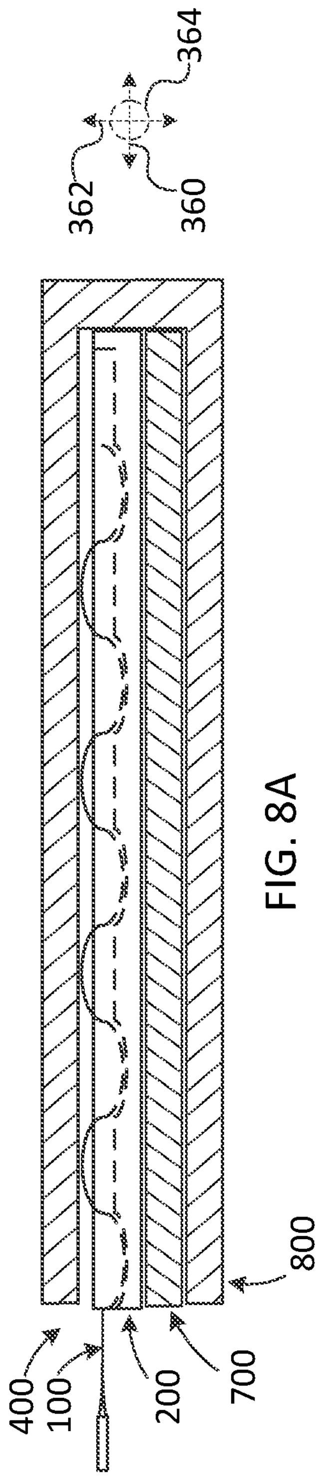

FIG. 8A

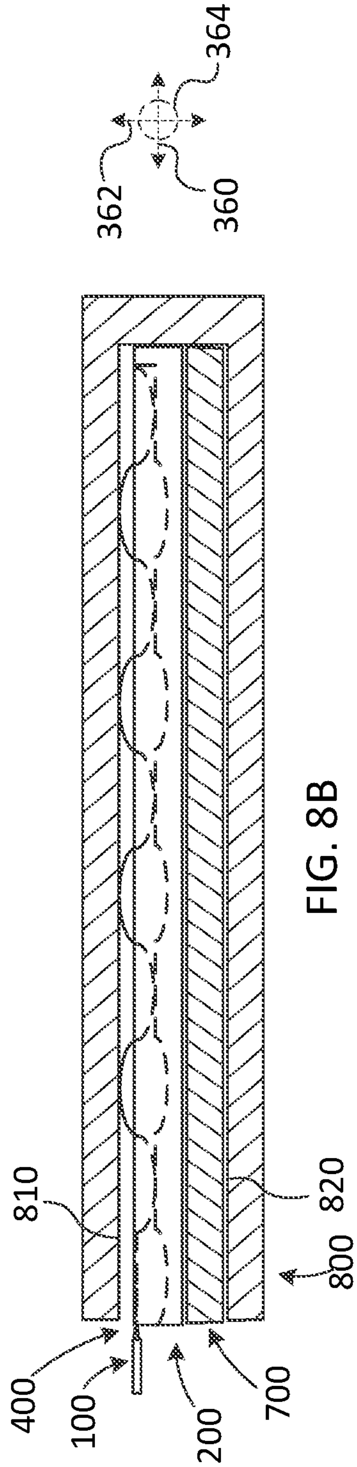

FIG. 8B

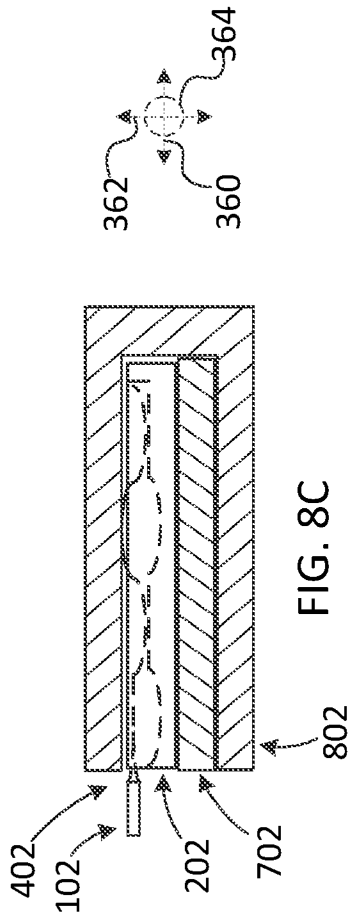

FIG. 8C

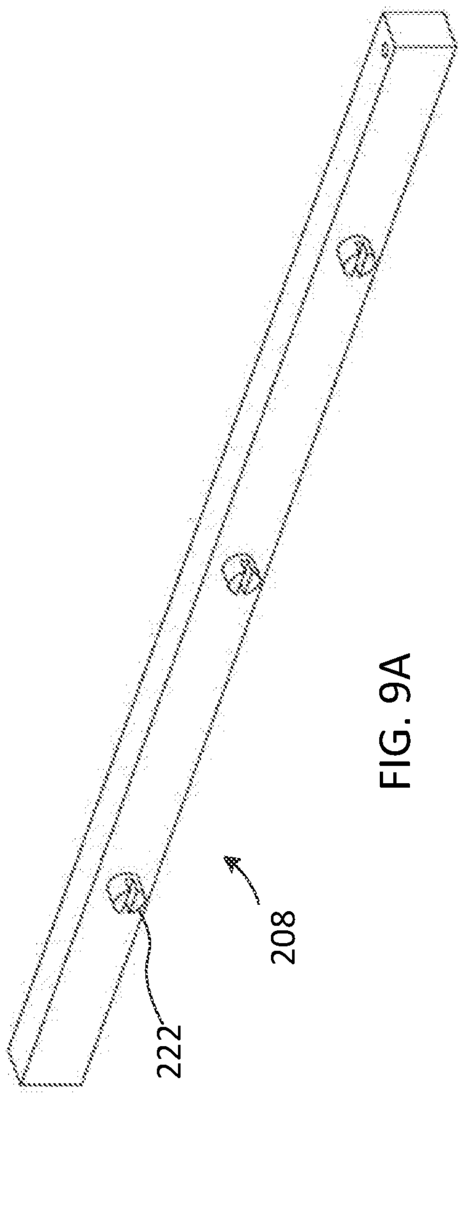

FIG. 9A

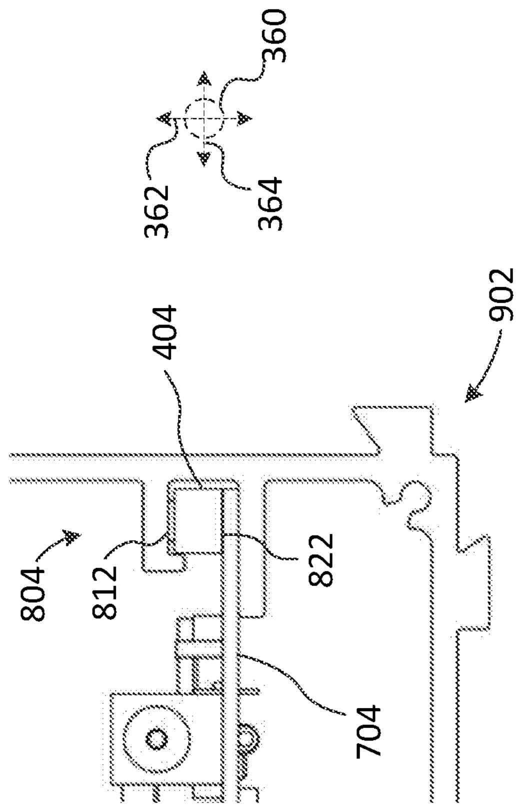

FIG. 9B

FIG. 10A

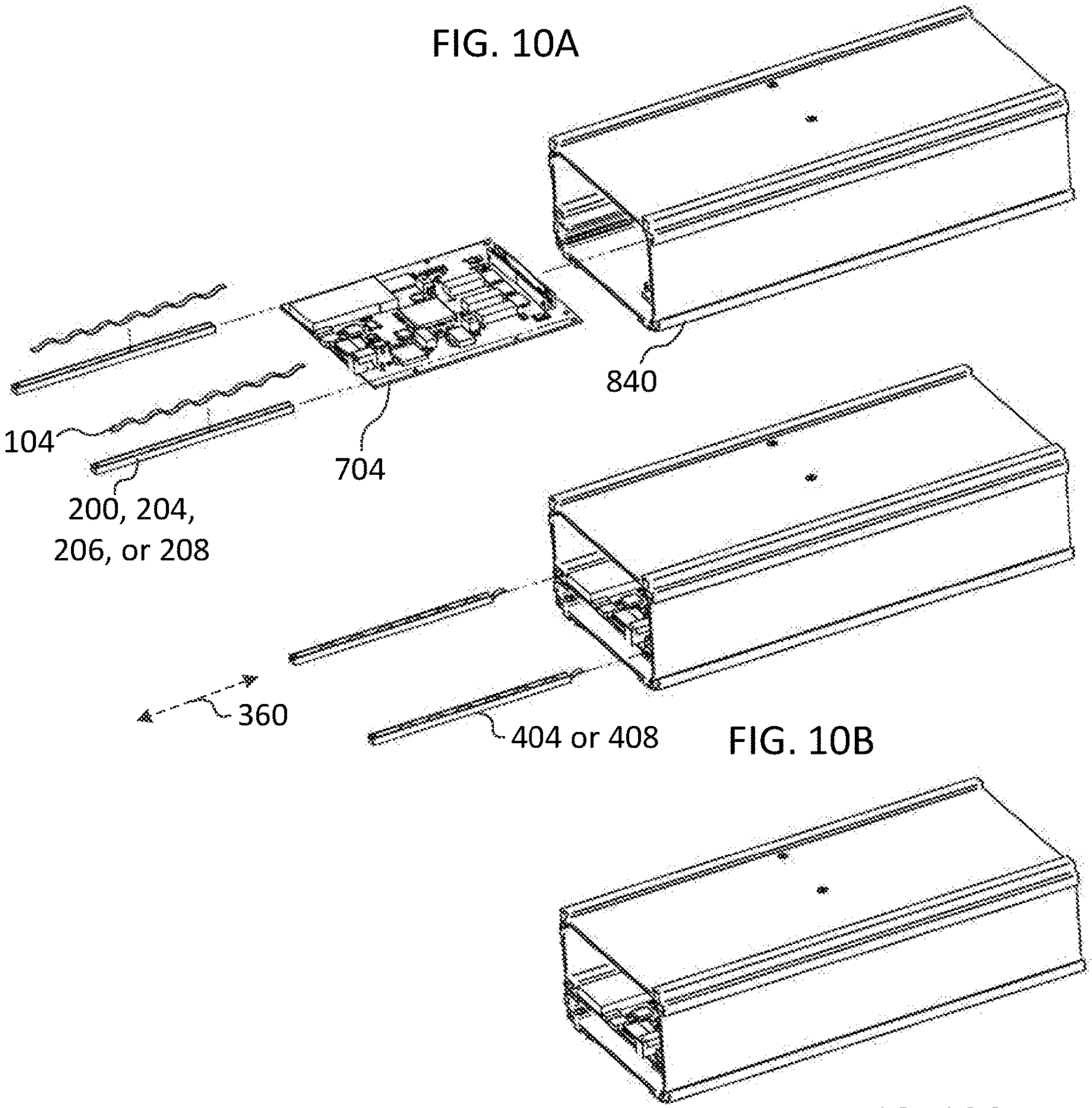

FIG. 10B

FIG. 10C

SPRING LOCK

RELATED APPLICATIONS

This patent application is a continuation of U.S. patent application Ser. No. 13/887,128, filed May 3, 2013 and entitled SPRING LOCK, which is incorporated herein by reference in its entirety.

GOVERNMENT SPONSORED RESEARCH

The invention was made, at least in part, with support from the U.S. Government under Grant No. N00173-12-D-2004-0001, which was awarded by the Naval Research Laboratory (NRL). The U.S. Government has certain rights in the invention.

TECHNICAL FIELD

The present disclosure relates to a spring lock.

SUMMARY

Applicants have identified the need for a low-cost, easy to use, circuit board (PCB) retention system that requires few or no tools to secure a PCB to a computer housing or chassis. The present disclosure in aspects and embodiments addresses these various needs and problems by providing a spring locking mechanism.

In embodiments, the spring lock includes a sinusoidal spring comprising: one or more crests and troughs formed along a length of the sinusoidal spring, the length extending along a sliding axis, the one or more crests and troughs forming a sinusoidal spring profile; and a lock bar comprising a track extending along the sliding axis, the track configured to hold the sinusoidal spring and allow the sinusoidal spring to move along the sliding axis, the track comprising one or more depressions and plateaus, the depressions and plateaus forming a lock bar profile. The spring lock is locked when the sinusoidal spring profile and the lock bar profile are out-of-phase and the spring lock is unlocked when the sinusoidal spring profile and the lock bar profile are in-phase.

In embodiments, the sinusoidal spring profile and the lock bar profile are regular and symmetric about a locking axis, the locking axis being perpendicular to the sliding axis. In another embodiment, the sinusoidal spring profile and the lock bar profile are non-symmetric about the locking axis, the locking axis being perpendicular to the sliding axis. In yet another embodiment, the sinusoidal spring profile and the lock bar profile are non-symmetric about the sliding axis.

In embodiments, the track comprises walls defining a track width, the track width being slightly larger than a sinusoidal spring width. In another embodiment, the walls comprise one or more protrusions configured to retain the sinusoidal spring along a locking axis while allowing the sinusoidal spring to move along the sliding axis, the locking axis being perpendicular to the sliding axis.

In embodiments, the lock bar further comprises an anchoring block at one end of the lock bar, the anchoring block restricting the sinusoidal spring motion along the sliding axis. The lock bar may further comprise a removal component.

In embodiments, the one or more depressions form at least one primary sinusoidal depression and the one or more plateaus form at least one primary sinusoidal plateau. In another embodiment, the at least two primary sinusoidal depressions form a primary sinusoidal depression period; the at least two primary sinusoidal plateaus form a primary sinusoidal plateau period, and the primary sinusoidal depression period and the primary sinusoidal plateau period are substantial equal to the sinusoidal spring period.

In embodiments, the primary sinusoidal depression period is out-of-phase with the primary sinusoidal plateau period or the at least two primary sinusoidal plateaus comprise at least two secondary sinusoidal depressions.

In another embodiment, the one or more depressions form a primary sinusoidal depression and a secondary sinusoidal depression, the primary and secondary sinusoidal depressions configured to restrict the sinusoidal spring and lock bar from involuntarily shifting from a locked position to an unlocked position. A secondary sinusoidal depression surface may be configured to restrict motion of the sinusoidal spring relative to the lock bar.

Also disclosed is a method for securing a component between an upper static surface and a lower static surface, the method including: providing a sinusoidal spring having a sinusoidal spring period along a sliding axis, a sinusoidal amplitude along a locking axis, and a width along a lateral axis, the sliding axis, locking axis and lateral axis are all perpendicular to one another and providing a lock bar comprising a track along the sliding axis, the track configured to allow the sinusoidal spring to move along the sliding axis between an unlocked and a locked position. The method further includes placing the sinusoidal spring, lock bar, and flat component between the upper static surface and the lower static surface and moving the sinusoidal spring, relative to the lock bar, along the sliding axis from the unlocked to the locked position.

In another method, a shortest distance between the upper static surface and the lower static surface is greater than or equal to a combined unlocked profile thickness of the sinusoidal spring, lock bar, and flat component when the sinusoidal spring and the lock bar are in the unlocked position and is less than a combined locked profile thickness of the sinusoidal spring, lock bar, and flat component when the sinusoidal spring and the lock bar are in the locked position.

In another embodiment, a spring lock includes a sinusoidal spring having one or more crests or troughs along a locking axis, the crests or troughs forming a sinusoidal spring profile, a length along a sliding axis, and a width along a lateral axis, wherein the sliding axis, locking axis and lateral axis are all perpendicular to one another. The spring lock further includes a lock bar that has a track along the sliding axis, the track comprising one or more depressions or plateaus, the depressions or plateaus forming a lock bar profile; wherein the sinusoidal spring profile and the lock bar profile are configured to be in-phase or out-of-phase with respect to each other.

In embodiments, the spring lock is configured to allow the sinusoidal spring to move along the sliding axis to change the spring lock between the unlocked and locked positions. In other embodiments, the lock bar is configured to restrict motion of the sinusoidal spring along the lateral axis. A lock bar may further comprise an anchoring block at one end of the lock bar, the anchoring block configured to restrict the sinusoidal spring motion along one direction of the sliding axis.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1A-1** and **1A-2** illustrate an elevation and plan view of a sinusoidal spring;

FIG. **1**B illustrates an elevation view of a sinusoidal spring;

FIG. **1**C illustrates an isometric view of a sinusoidal spring;

FIGS. **2**A-**1** and **2**A-**2** illustrate an elevation and plan view of a lock bar;

FIGS. **2**B-**1** and **2**B-**2** illustrate an elevation view of a lock bar;

FIG. **2**C illustrates an isometric view of a lock bar;

FIG. **3**A illustrates a spring lock in an "unlocked" configuration;

FIG. **3**B illustrates the spring lock shown in FIG. **3**A in a "locked" configuration;

FIG. **3**C illustrates another spring lock in an "unlocked" configuration;

FIG. **3**D illustrates the spring lock shown in FIG. **3**C in a "locked" configuration;

FIG. **4**A illustrates another spring lock in an "unlocked" configuration;

FIG. **4**B illustrates the spring lock shown in FIG. **4**A in a "locked" configuration;

FIG. **5**A illustrates another lock bar with a secondary sinusoidal depression period;

FIG. **5**B illustrates a spring lock with the lock bar shown in FIG. **5**A;

FIGS. **6**A-**1** and **6**A-**2** illustrate an elevation and plan view of another lock bar;

FIG. **6**B illustrates an isometric view of the lock bar shown in FIG. **6**A;

FIG. **6**C illustrates an isometric detail view of a removal component;

FIG. **7**A illustrates an elevation view of another spring lock in a "locked" configuration;

FIG. **7**B illustrates an elevation view of the spring lock of FIG. **7**A in an unlocked configuration;

FIG. **8**A illustrates a sinusoidal spring lock in an "unlocked" configuration;

FIG. **8**B illustrates the sinusoidal spring lock shown in FIG. **8**A in a "locked" configuration;

FIG. **8**C illustrates another spring lock in a "locked" configuration;

FIG. **9**A illustrates a lock bar with retaining posts;

FIG. **9**B illustrates an end view of a spring lock in use with a circuit board in a computer housing; and

FIGS. **10**A, **10**B, and **10**C illustrate an assembly drawing of a circuit board being inserted into a housing and secured with a spring lock.

DETAILED DESCRIPTION

The present disclosure covers apparatuses and associated methods for a spring lock. In the following description, numerous specific details are provided for a thorough understanding of specific preferred embodiments. However, embodiments can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In some cases, well-known structures, materials, or operations are not shown or described in detail in order to avoid obscuring aspects of the preferred embodiments. Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in a variety of alternative embodiments. Thus, the following more detailed description of the embodiments of the present invention, as illustrated in some aspects in the drawings, is not intended to limit the scope of the invention, but is merely representative of the various embodiments of the invention.

In this specification and the claims that follow, singular forms such as "a," "an," and "the" include plural forms unless the content clearly dictates otherwise. All ranges disclosed herein include, unless specifically indicated, all endpoints and intermediate values. In addition, "optional," "optionally," or "or" refer, for example, to instances in which subsequently described circumstance may or may not occur, and include instances in which the circumstance occurs and instances in which the circumstance does not occur. The terms "one or more" and "at least one" refer, for example, to instances in which one of the subsequently described circumstances occurs, and to instances in which more than one of the subsequently described circumstances occurs.

FIGS. **1**A-**1** and **1**A-**2** illustrate an elevation (shown on top) and a plan view (shown on bottom) of one embodiment of a sinusoidal spring **100**. In embodiments, the sinusoidal spring **100** has a sinusoidal spring period **150** along a sliding axis **360**, a peak-to-peak or sinusoidal amplitude **152** along the locking axis **362**, and a width **154** along a lateral axis **364**. The sliding, locking, and lateral axis are all perpendicular to one another and their relations is illustrated to the right of the sinusoidal spring **100** in FIGS. **1**A-**1** and **1**A-**2**. In embodiments, the sinusoidal spring period **150** and sinusoidal amplitude **152** may be on the order of a few inches, an inch, or fractions of an inch. For example, the sinusoidal spring period **150** may be ¼, ½, 1, 2, 4, 8, 12, or more inches and the sinusoidal amplitude **152** may be ¼, ½, 1, 2, 4, 8, 12, or more inches.

The sinusoidal spring **100** may further comprise one or more crests **112** and troughs **110**. In the illustrated embodiment, the sinusoidal spring has four crests **112** and five troughs **110**. More or fewer crests **112** or troughs **110** may be included depending on the overall length of the sinusoidal spring **100** and length of the sinusoidal spring period **150**.

In this disclosure, the term "sinusoidal spring" refers to a spring with crests or troughs as opposed to other types of springs such as helical, conical, torsional, or clock springs. A sinusoidal spring need not be in the shape of a true sinusoid, may be nonsymmetrical, or may not have an irregular pattern. A sinusoidal spring may only have one or more sets of crests or troughs. For example, a sinusoidal spring may have as few as one crest and two troughs or two crests and one trough. The crests and troughs may be any suitable shape or profile.

The sinusoidal spring **100** may be made from any suitable flexible material such as spring steel, phosphor-bronze, Mylar (biaxially-oriented polyethylene terephthalate), aluminum, copper, epoxy impregnated carbon fiber, or resilient plastics. The material may be selected based on the desired mechanical properties such as stiffness or locking force, chemical properties such as corrosion resistance, or heat transfer properties.

The sinusoidal spring **100** may further include a handle **114**. The handle **114** may be used to slide the sinusoidal spring **100** without tools along the sliding axis **360** between an unlocked and locked position, as will be described below. The handle **114** may be made from the same material as the sinusoidal spring **100** or may be made from another suitable material, such as rigid plastic, e.g., acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC), acrylic, or other polymers, etc.

The sinusoidal spring width **154** may be on the order of an inch or a fraction of an inch. For example, the sinusoidal spring width **154** may be ¼, ½, 1, 2, 4, 8, 12, or more inches. Similarly, the sinusoidal spring width **154** may be equal, greater than, or less than the sinusoidal spring thickness.

FIGS. **1A-1** and **1A-2** illustrate the sinusoidal spring **100** thickness as being thin relative to the width **154**, i.e., the sinusoidal spring **100** thickness is less than the width **154**. In other embodiments, the sinusoidal spring **100** may have a different cross-section (e.g., square, rectangular, or round). The sinusoidal spring **100** may be a wire of various gauge (AWG) thickness. For example, in embodiments, the sinusoidal spring **100** may be anywhere from 16 AWG (0.0641 inches in diameter) to 8 AWG (0.1285 inches in diameter).

FIG. **1**B illustrates another sinusoidal spring **102** with two troughs **110** and one crest **112**. Sinusoidal spring **102** is thicker and has six nodes (n), two nodes for each trough **110** or crest **112**. Increasing the number of nodes, increasing the thickness, width **354**, or selecting a material with a higher Young's modulus of elasticity may increase the sinusoidal spring stiffness or locking force for a given compression.

FIG. **1**C illustrates in an isometric view of another sinusoidal spring **104**. FIG. **1**C further illustrates the relationship between the sliding axis **360**, locking axis **362**, and lateral axis **364**.

FIGS. **2A-1**, **2A-2**, **2**B, and **2**C illustrate various embodiments of a lock bar **200**, **202**, and **204**, respectively. FIGS. **2A-1** and **2A-2** illustrate an elevation (top) and plan view (bottom) of a lock bar **200**. In embodiments, the lock bar **200**, **202**, or **204** comprises a slotted track **218** with primary sinusoidal depressions **210** and a primary sinusoidal plateau **212** along the sliding axis **360**. The primary sinusoidal depressions **210** and primary sinusoidal plateaus **212** may be 180 degrees out of phase to each other. Two walls or guides **214** define the width of the slotted track **218**. The width of the slotted track **218** may be wider than the width **154** of the sinusoidal spring **100**, **102**, or **104**. The slotted track **218** is configured to allow the sinusoidal spring **100**, **102**, or **104** to move along the sliding axis **360** but constrain the sinusoidal spring **100**, **102**, or **104** along the lateral axis **364** between the two walls or guides **214**.

In other embodiments, the slotted track **218** may be configured to hold more than one sinusoidal spring **100**, **102**, or **104**. Additionally, two or more sinusoidal springs may move or operate independently from one another. Two or more sinusoidal springs **100**, **102**, or **104** in a slotted track **218** may provide a greater locking force than a single sinusoidal spring **100**, **102**, or **104**.

In embodiments, the primary sinusoidal depression period **250** may be equal to the sinusoidal spring period **150**. The primary sinusoidal depressions **210** have a depression depth **356** as measured relative to the primary sinusoidal plateau **212**.

The lock bar **200** may also comprise a header **216** and an anchoring hole **217**. In this embodiment, the header **216** may restrict movement of the sinusoidal spring along one direction of the sliding axis **360**.

FIGS. **2**B-**1** and **2**B-**2** illustrate another lock bar **202**. Lock bar **202** also has a slotted track **218** and a header **216**. Lock bar **202** has only two primary sinusoidal depressions **210** and one primary sinusoidal plateau **212** to match the two troughs **110** and one crest **112** of sinusoidal spring **102** (shown in FIG. **1**B). The number, size (e.g., period or amplitude), or profile of the primary sinusoidal depressions **210** and primary sinusoidal plateaus **212** may match the number, size, or profile of troughs **110** and crests **112**.

FIG. **2**C illustrates in an isometric view another lock bar **204** with the slotted track **218**, two walls or guides **214**, primary sinusoidal depressions **210**, primary sinusoidal plateaus **212**, header **216**, and anchoring hole **217**. FIG. **1**C further illustrates the relationship between the sliding axis **360**, locking axis **362**, and lateral axis **364**. The lock bar **204** illustrates shorter primary sinusoidal plateaus **212** as compared to lock bars **200** or **202**. The primary sinusoidal plateaus **212** may be shorter or longer to adjust the desired sliding distance of a sinusoidal spring between an unlocked and a locked position, as described below.

Referring to FIGS. **2A-1**, **2A-2**, **2**B, and **2**C, the lock bar **200**, **202**, or **204** may further include protrusions **220** configured to retain a sinusoidal spring **100**, **102**, or **104** in the slotted track **218**. FIGS. **2A-1**, **2A-2**, **2**B, and **2**C each show two sets of protrusions **220**. In embodiments, more or fewer protrusions may be included with a lock bar. The protrusions **220** may extend from the walls or guides **214** of the slotted track **218**. In the illustrated figures, the protrusions **220** are shown as symmetrical pairs. In embodiments, two or more protrusions **220** may be staggered along the length of the walls or guides **214**.

The protrusions **220** may allow an operator to "snap" a sinusoidal spring **100**, **102**, or **104** into the slotted track **218** such that the sinusoidal spring **100**, **102**, or **104** is retained in the slotted track **218** by the protrusions **220**. The protrusions may further allow the sinusoidal spring **100**, **102**, or **104** to move freely along the sliding axis **360** at least half a wavelength from a "locked" to an "unlocked" position or from an "unlocked" to a "locked" position. The protrusions **220** may be configured to secure the sinusoidal spring **100**, **102**, or **104** along the locking axis **362** yet allow the sinusoidal spring **100**, **102**, or **104** to move relative to the lock bar at least half a wavelength along the sliding axis **360**.

A lock bar **200**, **202**, or **204** may be made of any suitable material such as plastic, e.g., acrylonitrile butadiene styrene (ABS), polyvinyl chloride (PVC), acrylic, or other polymers, etc. A lock bar **200**, **202**, or **204** may be made of metal, e.g., copper, aluminum, titanium, or steel, etc. A lock bar **200**, **202**, or **204** may be made of wood. The lock bar may be manufactured on a 3-D printer, injection molded, or milled etc.

FIG. **3**A-**3**D are elevation drawings illustrating embodiments of a spring lock **400** and **402**. In embodiments, the spring lock may comprise a sinusoidal spring **100** and a lock bar **200**. The sinusoidal spring **100**, **102**, and lock bar **200** and **202** may be the embodiments illustrated in FIGS. **1A-1**, **1A-2**, **1**B, **2A-1**, **2A-2**, and **2**B. As shown in FIGS. **3**A and **3**C, the sinusoidal spring **100** or **102**, may rest inside the primary sinusoidal depression **210** of the lock bar **200** or **202**. In this configuration, the sinusoidal spring **100** or **102** and lock bar **200** or **202** are "in phase" or in a relaxed, "unlocked" position. As shown in FIGS. **3**B and **3**D, the sinusoidal spring **100** or **102**, may rest on top of the slotted track (not labeled) of the lock bar **200** or **202**, i.e., the troughs **112** of the sinusoidal spring **100** or **102** rest on top of the primary periodic plateaus **212** of the lock bar. In this sense, the sinusoidal spring **100** or **102** and lock bar **200** or **202** are "out of phase" or in the "locked" position. Therefore, in embodiments, a "locked" spring lock may be one that has a sinusoidal spring period out of phase with a lock bar's primary sinusoidal depressions and an "unlocked" spring lock is one that has a sinusoidal spring period in phase with a lock bar's sinusoidal depressions.

In other embodiments, a "locked" spring lock may be one that has a sinusoidal spring positioned on top of a slotted track or on top of one or more plateaus of a lock bar. Additionally, an "unlocked" spring lock may be one that has a sinusoidal spring positioned inside a slotted track or inside the depressions of a lock bar.

Referring back to FIGS. **1A-1**, **1A-2**, **1**B, **1**C, **2A-1**, **2A-2**, **2**B, **2**C, **3**A-**3**D, and **4**A-**4**B, in embodiments, the sinusoidal spring **100**, **102**, or **104** and lock bar **200**, **202**, or **204**, have regular, symmetric, or repeating patterns of crests **110**, troughs **112**, primary sinusoidal depressions **210**, and primary sinusoidal plateaus **212**. In other embodiments, the crests **110**, troughs **112**, depressions **210**, or plateaus **212** need not be regular, symmetric, nor repeating. Instead, the features or profile of a "sinusoidal" spring or lock bar may be arranged in any arbitrary manner that is matched by the mating component.

The lock bar **200** or **202** may be configured to allow the sinusoidal spring **100** or **102** to move along the sliding axis **360** between an "unlocked" (FIGS. **3**A and **3**C) and "locked" (FIGS. **3**B and **3**D) position, while restricting relative motion along the lateral axis **364** because of the wall or guides **214**, or the locking axis **362** because of the protrusions **220**. In the depicted embodiments, the sinusoidal spring **100** or **102**, with the aid of the handle **114**, moves along the sliding axis **360** towards the header **216** to change from an "unlocked" to a "locked" position. In other embodiments, the spring lock **400** or **402** may alternate from a "locked" to an "unlocked" configuration or from an "unlocked" to a "locked" configuration by moving the sinusoidal spring **100** or **102** along the sliding axis **360** away from the header **216**. In still other embodiments, the sinusoidal spring **100** or **102** may be fixed in its position relative to external components (not shown) and the lock bar **200** or **202** may move relative to the sinusoidal spring **100** or **102** such that the spring lock **400** or **402** changes from a "locked" or "unlocked" configuration to an "unlocked" or "locked" configuration. In these last embodiments, a handle or an anchoring hole (depicted as **217** in FIGS. **2**A-**1**, **2**A-**2**, and **2**C) may be used to move the lock bar **200** or **202** along the sliding axis **360**.

FIGS. **4**A and **4**B illustrate in an isometric view another embodiment of a spring lock **404** in an "unlocked" (FIG. **4**A) and "locked" (FIG. **4**B) position. As the sinusoidal spring **104** slides along the sliding axis **360** towards the header **216**, the sinusoidal spring **104** moves from resting inside the primary sinusoidal depressions (not labeled) to being on top of the primary sinusoidal plateaus (not labeled). Like the other embodiments, by shifting the sinusoidal spring **104** half a wavelength relative to the lock bar **204**, the thickness of the spring lock **404** along the locking axis **362** subsequently changes.

Referring now to FIGS. **5**A and **5**B, a lock bar **206** may comprise one or more secondary sinusoidal depressions **213**. In embodiments, the secondary sinusoidal depressions **213** may restrict movement of the sinusoidal spring **100** along the sliding axis **360** when the spring lock is in the "locked" configuration. The sinusoidal spring **100** may rest inside the secondary sinusoidal depressions **213** in the "locked" configuration, similar to how the sinusoidal spring **100** rests inside the primary sinusoidal depressions **210** in the "unlocked" configuration. The secondary sinusoidal depressions **213** may better secure a sinusoidal spring **100** even though the depression depth **357**, and thus the maximum sinusoidal spring compression distance, is less than the depression distance **356** of spring locks **400** or **402** (shown in FIGS. **3**B and **3**D). The restriction in movement of the sinusoidal spring **100** relative to the lock bar **206** may prevent an inadvertent shift from a "locked" configuration to an "unlocked" configuration.

FIGS. **5**A and **5**B illustrate the primary sinusoidal depressions **210** and the secondary sinusoidal depressions **213** as smooth curves, somewhat matching the profile of the sinusoidal spring **100**. The sinusoidal depressions **210** or **213** may comprise any suitable shape. For example, the sinusoidal depressions **210** or **213** may individually be v-shaped, flat with end ridges, or saw-toothed shaped. The shapes may be modified to increase or decrease surface friction between the sinusoidal spring **100** and the lock bar **206**. Additionally, the surface of the secondary sinusoidal depressions **213** may be modified or coated with a coating to change the frictional force between a sinusoidal spring **100** and the lock bar **206** with the spring lock **406** in the "locked" position. For example, increased surface friction may better restrict motion of the sinusoidal spring **100** relative to the lock bar **206** or otherwise secure the sinusoidal spring **100** in the "locked" position.

FIGS. **6**A-**1** and **6**A-**2** illustrate an elevation (top) and plan (bottom) view of another embodiment of a lock bar **206** with primary sinusoidal depressions **211** and primary sinusoidal plateaus **213** along the sliding axis **313**. The primary sinusoidal depressions **211** and primary sinusoidal plateaus **213** are shaped differently than the previously illustrated embodiments. The primary sinusoidal depressions **211** and primary sinusoidal plateaus are designed to better secure a sinusoidal spring (not shown) in a "locked" configuration with the lock bar **206**. The lock bar **206** may include other similar features as lock bars **200**, **202**, or **204**. For example, lock bar **206** also includes a sliding track **218** and walls or guides **214**. Lock bar **206** may also include protrusions **220** and a header **216**.

The lock bar **206** may include a removal component **215** with the detail illustrated in FIG. **6**C, similar to the anchoring hole **217** (shown in FIGS. **2**A-**1**, **2**A-**2**, and **2**C). The removal component **215** may be configured to accept a removal tool (not shown) to push or pull the lock bar along the sliding axis **360**.

FIGS. **7**A and **7**B are elevation drawings illustrating embodiments of a spring lock **408**. In embodiments, the spring lock **408** may comprise a sinusoidal spring **104** and a lock bar **208**. As shown in FIG. **7**A, the sinusoidal spring **104**, may rest in or on top of the slotted track **218** of the lock bar **208**, i.e., the troughs **112** of the sinusoidal spring **104** rest on top of the primary sinusoidal or periodic plateaus **212** of the lock bar **208**. In this configuration, the sinusoidal spring **104** and lock bar **208** are "out of phase" or in the "locked" position. As shown in FIG. **7**B, the sinusoidal spring **100** may rest down inside or within the slotted track **118** of the lock bar **208**, i.e., the troughs **112** of the sinusoidal spring **104** rest on top of the primary sinusoidal or periodic depressions **210** of the lock bar **208**. In this configuration, the sinusoidal spring **100** and lock bar **208** are "in phase" or in a relaxed, "unlocked" position.

The spring locks in FIGS. **3**A-**3**D, **4**A, **4**B, **5**B, **7**A, and **7**B are illustrated in "unlocked" or "locked" positions but the sinusoidal springs **100**, **102**, or **104**, and the lock bars **200**, **202**, **204**, **206**, or **208** are not constrained along the locking axis by upper or lower anchored or static surfaces. Therefore, the sinusoidal springs in the above-mentioned illustrations do not exert a "locking" force against the illustrated lock bars.

FIGS. **8**A-**8**C illustrate a spring lock **400** or **402** used to lock a planar component **700** inside a channel **800**. In FIG. **8**A, the spring lock **400** and planar component **700** are positioned inside the channel **800** such that the sinusoidal spring **100** does not impart a significant, or no force, on the lock bar **200** along the locking axis **362**. As described above, the sinusoidal spring **100** rests inside the slotted track (not labeled) of the lock bar **200**, i.e., the troughs (not labeled) of the sinusoidal spring **100** rest in the primary periodic depressions (not labeled) of the lock bar **200**. In this position, the sinusoidal spring **100** and lock bar **200** are "in phase" or in a relaxed, "unlocked" position. In this configuration, the spring lock **400** (including the sinusoidal spring **100** and the lock bar **200**) and planar component **700** may slide in or out of the channel **800** along the sliding axis **360** without significant force being applied along the sliding axis **360** to the spring lock **400** or planar component **700**.

In FIG. **8**B, the sinusoidal spring **100** has been repositioned relative to the lock bar **200** such that the sinusoidal spring **100** is on top of the primary periodic plateaus (not labeled) of the lock bar **200**. In this position, the sinusoidal spring **100** and lock bar **200** are "out of phase" or in the "locked" position. The sinusoidal spring **100** is compressed along the locking axis **362** and exerts a force against the upper surface **810** of the channel **800** and the primary periodic plateaus (not labeled) of the lock bar **200** such that the sinusoidal spring **100** compresses the lock bar **200** and planar surface **700** against the bottom surface **820** of the channel **800**. The sinusoidal spring **100** may apply even pressure against the lock bar **200** at each point where the sinusoidal spring **100** touches the lock bar **200** or along the entire length of the lock bar **200**. The compressive force of the planar surface **700** against the bottom surface **820** of the channel **800** is such that the planar component **700** is secured or "locked" into the channel **800**. The compressive force applied in the "locked" configuration may prevent the lock bar **200** or planar surface **700** from slipping out of the channel **800** when subjected to vibrational movement.

In FIGS. **3**A-**3**D, the change in elevation of the sinusoidal spring **100** or **102** between an "unlocked" and "locked" position may be equal to a depression depth **376**. In an "unlocked" position, the spring lock **400** or **402** is thinner along the locking axis **362**. In the "locked" configuration, the spring lock **400** or **402** has a greater thickness along the locking axis **362**. Therefore, by shifting the sinusoidal spring **100** or **102** half a wavelength relative to the lock bar **200** or **202**, the thickness of the spring lock **400** or **402** along the locking axis **362** subsequently changes.

The change in thickness of the spring lock **400** or **402** between the configurations illustrated in FIG. **3**A or **3**C and the configurations illustrated in FIG. **3**B or **3**D may be the maximum compression distance of the sinusoidal spring **100** or **102** between an "unlocked" and a "locked" position. The "unlocked" spring lock height **371** in FIGS. **3**A and **3**C is the overall height of the spring lock **400** or **402** in an "unlocked" and unconstrained configuration. The spring lock height **372** in FIGS. **3**B and **3**D is the overall height of the spring lock **400** or **402** in a "locked" and unconstrained configuration. The spring lock **400** or **402** in FIGS. **3**B and **3**D is "unconstrained" because the spring lock **400** is not compressed in a channel by upper or lower static surfaces. The maximum difference in height between the "unlocked" spring lock height **371** and the "locked" spring lock height **372** is equal to the depression depth **376**. Thus, the depression depth **376** may also be equal to the maximum sinusoidal spring compression distance in a "locked" configuration.

The compressive or locking force of the sinusoidal spring **100** or **102** against the lock bar **200** or **202**, and thus the compressive or locking force of the spring lock **400** or **402**, is a function of the number of nodes (labeled "n" in FIG. **1**B), thickness, width **354**, and Young's modulus, or other material properties of the sinusoidal spring **100**, **102**, or **104**. The compressive or locking force of a spring lock is also a function of the sinusoidal spring compression distance. Thus, for a given sinusoidal spring with fixed properties of number of nodes, thickness, width, and Young's modulus, increasing the sinusoidal spring compression distance or the depression depth **376** may increase the compressive or locking force of a spring lock.

Referring again to FIGS. **8**A-**8**C, there may be more or fewer "touch points" between a sinusoidal spring **100** or **102** and a lock bar **200** or **202** to secure the planar surface **700** or **702** inside the channel **800** or **802**. For example, the sinusoidal spring **100** depicted in FIG. **8**B provides four "touch points" against the top surface **810** of the channel **800** and five "touch points" against the primary periodic plateaus (not labeled) of the lock bar **200**. The combined touch points may provide the necessary frictional force necessary to "lock" the spring lock **400** and the planar component **700** inside the channel **800** such that the spring lock **400** and planar component **700** are not free to slide (without an external force applied) along the sliding axis **360** out of the channel **800**. As a further illustration, only two "touch points" are provided between sinusoidal spring **102** and the lock bar **202** depicted in FIG. **8**C.

The increased number of touch points between the sinusoidal spring **100** and the lock bar **200** as compared to the sinusoidal spring **102** and the lock bar **202** means that there may be greater locking friction along the sliding axis **360** for spring lock **400** as compared to spring lock **402**. Increasing the number of touch points increases the potential locking force along the sliding axis **360** between the sinusoidal spring **100** or **102** and the lock bar **200** or **202** and thus the overall lock force of the spring lock **400** or **402** to lock a planar component **700** or **702** inside a channel **800** or **802**.

The compressive force of the spring may be modified to increase or decrease the "locking" force of the spring lock **400** or **402** inside the channel **800** or **802**. As described previously, increasing the number of nodes (illustrated in FIG. **1**B), increasing the thickness or width **354** of the sinusoidal spring **100** or **102**, or selecting a material for the sinusoidal spring **100** or **102** with a higher Young's modulus of elasticity may increase the sinusoidal spring stiffness or locking force for a given compression.

A lock bar may include other features to secure a lock bar to a planar surface. For example, FIG. **9**A is a schematic drawing illustrating a bottom view of one embodiment of a lock bar **208**. In this embodiment, the lock bar **208**, which may be similar to the lock bars shown in FIG. **2**A-**1**, **2**A-**2**, **2**B, **2**C, **5**A-**5**B, or **6**A-**6**B, has retaining posts **222** on the bottom side of the lock bar **208**. Retaining posts **222** may allow a user to insert a planar surface (not shown) with a spring lock attached to it into a channel or computer chassis (not shown) in a single operation. The retaining posts may also constrain movement of the spring lock relative to a planar component in the sliding axis **360** and lateral axis **364**.

FIG. **9**B is an end view schematic drawing illustrating a spring lock **404** in use with a circuit board **704** in a computer housing **902**. In this illustration, the spring lock **404** is placed with a circuit board **704** between the walls **812** and **822** of a channel **804** in a computer housing **902**. FIG. **9**B shows a view of the front or back of the spring lock with the lateral axis **364** of the spring lock running left to right in the figure.

One could, for example, position a spring lock **404** in the unlocked position against a planar component **704** (e.g., a circuit board, metal plate, wood plate, etc.) inside a channel **804**. The combined thickness of the spring lock **404** in an "unlocked" position and planar component **704** may be as great as the distance between the upper surface **812** and lower surface **822** of the channel **804**. The unconstrained thickness of the spring lock **404** in a "locked" position and planar component **704** may be greater than the distance between the upper surface **812** and lower surface **822** of the channel **804**. The lock bar **404** or the sinusoidal spring (not labeled) could be manually adjusted to the "locked" configuration, thus applying a spring force to the planar component **704** and the upper and lower walls **812** and **822** of the channel **804**. The spring force applied to the planar component **704** and channel walls **812** and **822** along the locking axis **362** may establish a good thermal contact between the planar component **704** with the walls **812** and **822** (but more especially **822**) of the channel **802**. The spring lock **404** may be used in maintaining a circuit board within operational temperature boundaries or to secure an electrical component inside a housing to prevent the component from breaking connections with other cables or components in a system.

FIGS. **10A-10C** illustrate an assembly drawing of a circuit board **704** being inserted into a computer housing or chassis **840**. The circuit board **704** may be slid into channels (not labeled) into the chassis **840**. A pair of spring locks **404** or **408** may then be slid into the same channels until the sinusoidal spring **104** presses against a header (not shown) at the end of the channel to move the sinusoidal spring **104** relative to the lock bar **200**, **204**, **206**, or **208**, such that the spring lock **404** or **408** is in the "locked" position.

In an alternative method, the spring lock **404** may be attached to the circuit board **704** before the circuit board **704** and the spring lock **404** are slid into the chassis **840** in a single operation. As the circuit board **704** is slid all the way into the chassis **840**, a header (not shown) at the end of the chassis channel presses the sinusoidal spring **104** along the sliding axis **360** such that the spring lock is in the "locked" configuration. The circuit board **704** may remain "locked" in the computer chassis **840** until a removal tool (not shown) is used to pull the lock bar **200**, **204**, **206**, or **208** out of the channel (not labeled), using the removal component **215** (shown in FIGS. **6A-1**, **6A-2**, **6B**, and **6C**) or the anchoring hole **217** (shown in FIGS. **2C**, **4A**, and **4B**).

One operational aspect of a spring lock is positioning the spring lock in contact with the object or objects that need to be secured or clamped. Anchored or static surfaces may refer to the walls of a channel or adjustable jaws of a clamping device. Compressing a sinusoidal spring translates to applying a spring force to both the static surface and the secured object or planar surface. The spring force applied to the secured object assures a more uniform and effective mechanical and thermal contact between the secured object and the static surfaces.

The figures of the present application illustrate a planar surface or circuit board and a computer housing or chassis. Other suitable applications of a spring lock include woodworking clamps or work piece retention in factory automation. Many processes in factory automation include applying a constant force to objects to keep them from shifting or moving. The force is typically applied via electromechanical devices that require considerable amounts of energy and are inefficient. In woodworking, maintaining strong mechanical contact is useful in temporarily securing two wood pieces together while a glue bond cures or until one can permanently secure the pieces together with nails or screws. For circuit boards, good thermal contact may be important in allowing heat to transfer out of the circuit board in order to maintain the circuit board within operational temperatures.

It will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications. Also, various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art, and are also intended to be encompassed by the following claims.

What is claimed is:

1. A spring lock comprising:

a sinusoidal spring comprising one or more crests and troughs formed along a length of the sinusoidal spring, the length extending along a sliding axis, the one or more crests and troughs forming a sinusoidal-spring profile; and

a monolithic, homogenous lock bar comprising:

a track extending along the sliding axis and comprising:

at least two primary sinusoidal depressions forming a primary sinusoidal depression period, and

at least two primary sinusoidal plateaus forming a primary sinusoidal plateau period, the at least two primary sinusoidal plateaus each comprising a secondary sinusoidal depression such that there are at least two secondary sinusoidal depressions,

wherein the at least two primary sinusoidal depressions and the at least two primary sinusoidal plateaus with their secondary sinusoidal depressions form a lock-bar profile; and

first and second walls extending contiguously upward from either side of the track and generally perpendicular to the track; the first wall, track, and second wall forming a contiguous U-shape configured to hold the sinusoidal spring on the track and between the first and second wall,

wherein:

the spring lock is locked when the sinusoidal-spring profile and the lock-bar profile are out-of-phase and the spring lock is unlocked when the sinusoidal-spring profile and the lock bar profile are in-phase.

2. The spring lock of claim **1**, wherein the at least two secondary sinusoidal depressions are configured to restrict the sinusoidal spring and monolithic, homogenous lock bar from involuntarily shifting from a locked position to an unlocked position.

3. The spring lock of claim **2**, wherein a surface of the secondary sinusoidal depression is configured to restrict motion of the sinusoidal spring relative to the monolithic, homogenous lock bar.

4. The spring lock of claim **1**, wherein the sinusoidal-spring profile and the lock-bar profile are regular and symmetric about a locking axis, the locking axis being perpendicular to the sliding axis.

5. The spring lock of claim **1**, wherein the sinusoidal-spring profile and the lock-bar profile are non-symmetric about the locking axis, the locking axis being perpendicular to the sliding axis.

6. The spring lock of claim **1**, wherein the sinusoidal spring profile and the lock bar profile are non-symmetric about the sliding axis.

7. The spring lock of claim **1**, wherein the first and second walls comprise one or more protrusions extending from the first and second walls and the one or more protrusions are configured to retain the sinusoidal spring along a locking axis while allowing the sinusoidal spring to move along the sliding axis, the locking axis being perpendicular to the sliding axis.

8. The spring lock of claim **1**, wherein the lock bar further comprises an anchoring block at one end of the lock bar, the anchoring block restricting the sinusoidal spring motion along the sliding axis.

9. The spring lock of claim **1**, wherein the lock bar further comprises a removal component.

10. The spring lock of claim **1**, wherein the primary sinusoidal depression period is out-of-phase with the primary sinusoidal plateau period.

11. A method for securing a flat component between an upper static surface and a lower static surface, the method comprising:

providing a sinusoidal spring comprising one or more crests and troughs formed along a length of the sinusoidal spring, the length extending along a sliding axis, the one or more crests and troughs forming a sinusoidal-spring profile;

providing a monolithic, homogenous lock bar comprising:

a track extending along the sliding axis and comprising:

at least two primary sinusoidal depressions forming a primary sinusoidal depression period, and

at least two primary sinusoidal plateaus forming a primary sinusoidal plateau period, the at least two primary sinusoidal plateaus each comprising a secondary sinusoidal depression such that there are at least two secondary sinusoidal depressions,

wherein the at least two primary sinusoidal depressions and the at least two primary sinusoidal plateaus with their secondary sinusoidal depressions form a lock-bar profile; and

first and second walls extending contiguously upward from either side of the track and generally perpendicular to the track; the first wall, track, and second wall forming a contiguous U-shape configured to hold the sinusoidal spring on the track and between the first and second wall,

wherein:

the spring lock is locked when the sinusoidal-spring profile and the lock-bar profile are out-of-phase and the spring lock is unlocked when the sinusoidal-spring profile and the lock bar profile are in-phase;

placing the sinusoidal spring, the monolithic, homogenous lock bar, and the flat component between the upper static surface and the lower static surface; and

moving the sinusoidal spring, relative to the monolithic, homogenous lock bar, along the sliding axis from the unlocked to the locked position.

12. The method of claim 11, wherein a shortest distance between the upper static surface and the lower static surface:

is greater than or equal to a combined unlocked profile thickness of the sinusoidal spring, the monolithic, homogenous lock bar, and the flat component when the sinusoidal spring and the monolithic, homogenous lock bar are in the unlocked position; and

is less than a combined locked profile thickness of the sinusoidal spring, the monolithic, homogenous lock bar, and the flat component when the sinusoidal spring and the monolithic, homogenous lock bar are in the locked position.

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