US011980252B2

(12) United States Patent
Hipp

(10) Patent No.: US 11,980,252 B2
(45) Date of Patent: May 14, 2024

(54) **DYNAMIC LACING SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/345,728**

(22) Filed: **Jun. 30, 2023**

(65) **Prior Publication Data**

US 2023/0354964 A1 Nov. 9, 2023

Related U.S. Application Data

(63) Continuation of application No. 17/987,076, filed on Nov. 15, 2022, now Pat. No. 11,730,237, which is a continuation of application No. 17/061,623, filed on Oct. 2, 2020, now Pat. No. 11,510,460.

(60) Provisional application No. 62/910,086, filed on Oct. 3, 2019.

(51) **Int. Cl.**
A43C 11/14 (2006.01)

(52) **U.S. Cl.**
CPC *A43C 11/14* (2013.01)

(58) **Field of Classification Search**
CPC A43C 11/14; A43C 11/004; A43C 11/16; A43C 7/08; A43C 1/006
See application file for complete search history.

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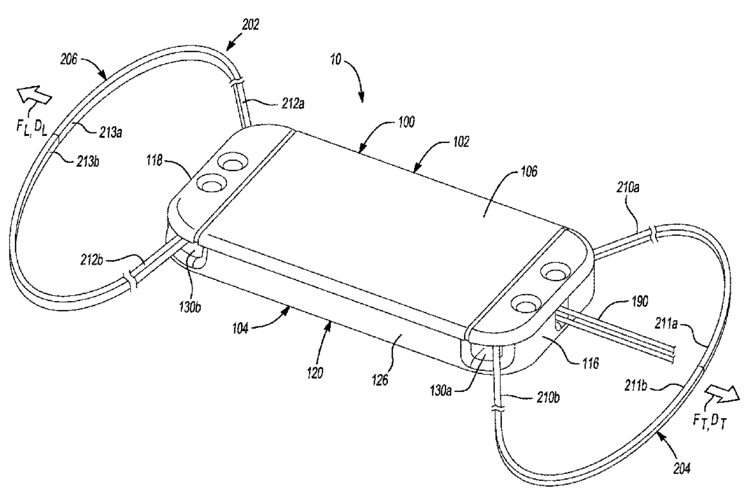
(57) **ABSTRACT**

A cable lock includes a housing having a first engagement surface and a second engagement surface. The cable lock also includes a locking member slideably disposed between the first engagement surface and the second engagement surface and including a first lock element opposing the first engagement surface and a second lock element opposing the second engagement surface. The first lock element includes a first series of teeth and a second series of teeth arranged in parallel with the first series of teeth. The first lock element is operable to engage a first portion of a cable. The second lock element includes a first series of teeth and a second series of teeth arranged in parallel with the first series of teeth of the second lock element. The second lock element is operable to engage a second portion of the cable.

20 Claims, 16 Drawing Sheets



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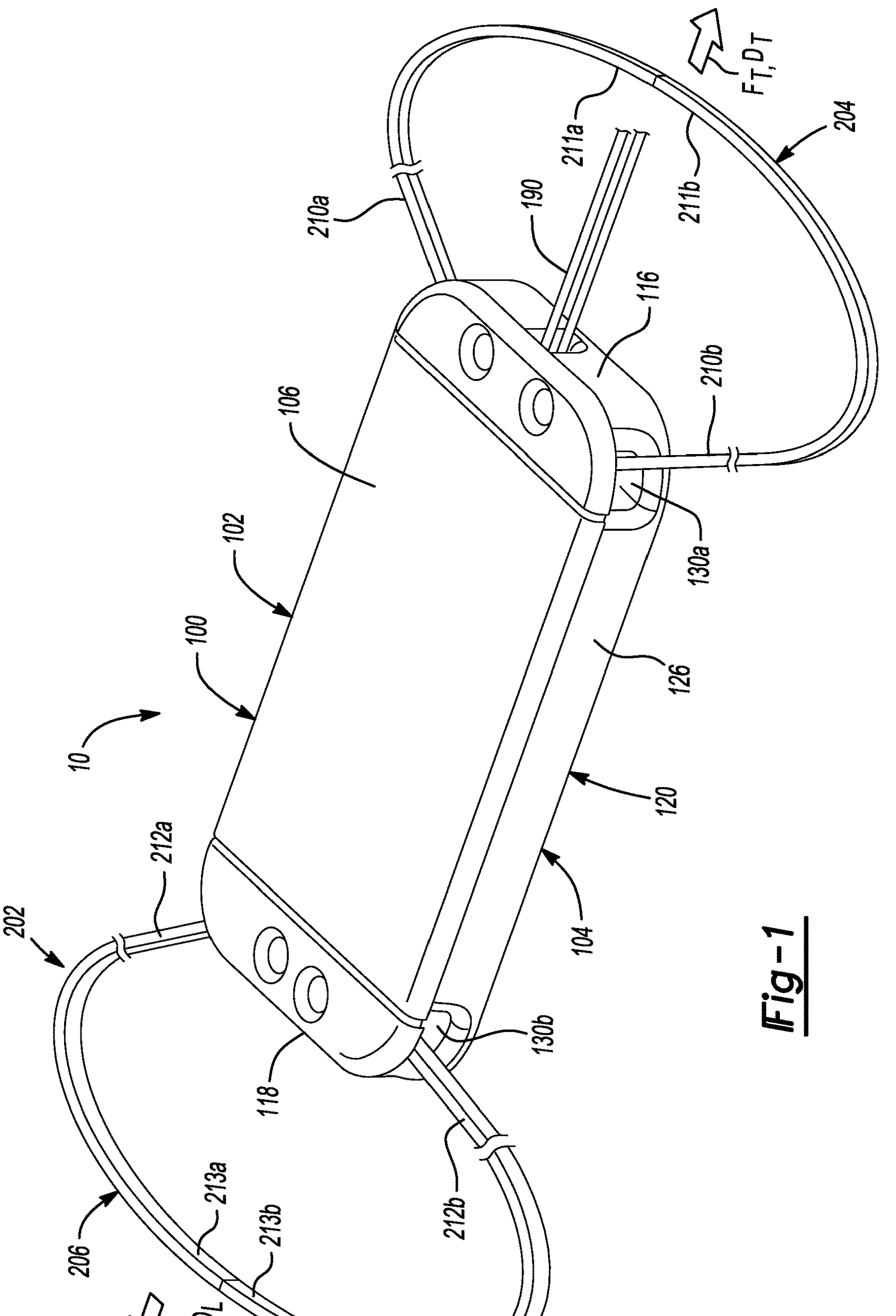

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212b
213a
213b
F_T, D_T
F_L, D_L

Fig-1

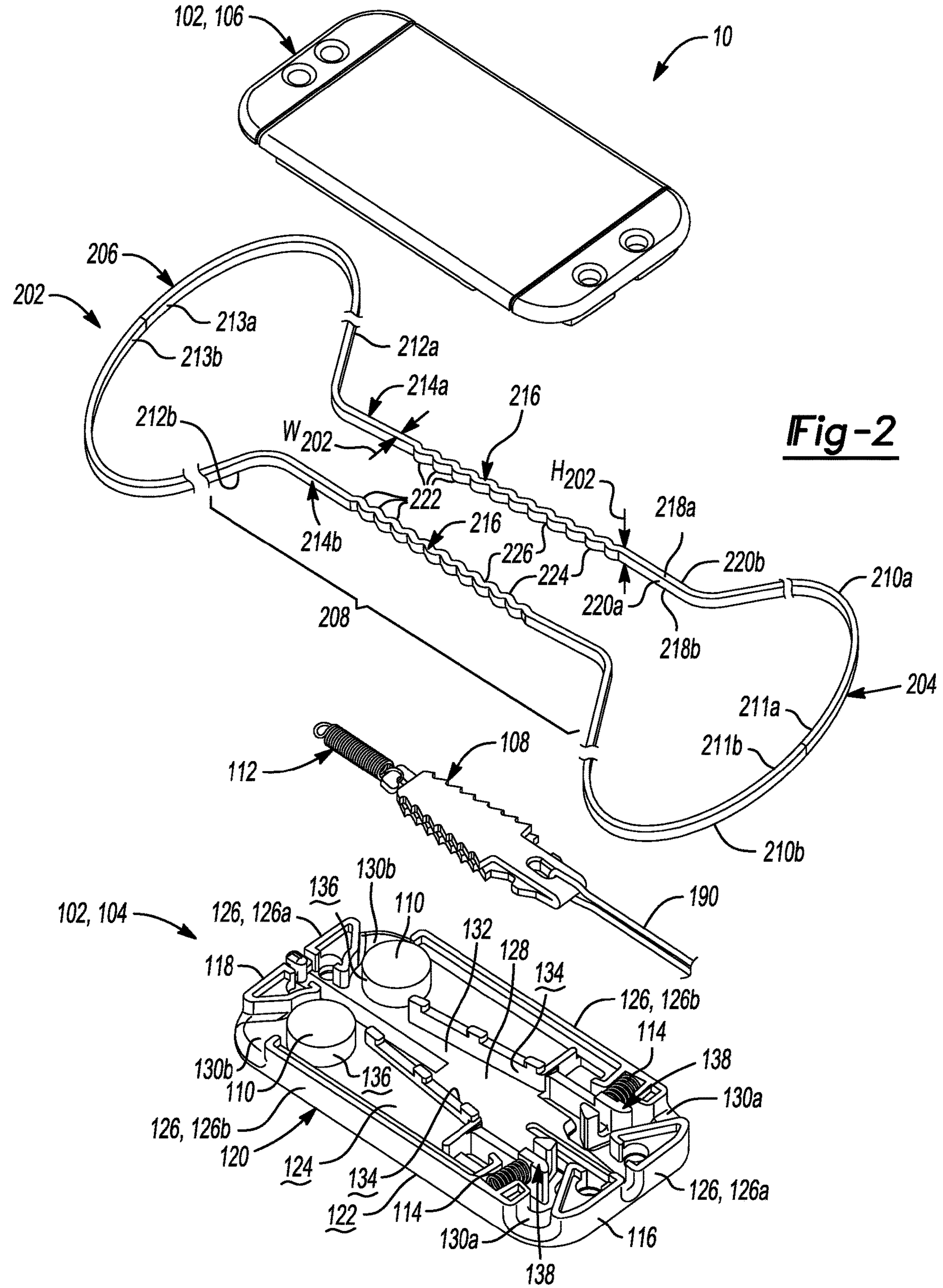
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Fig-2

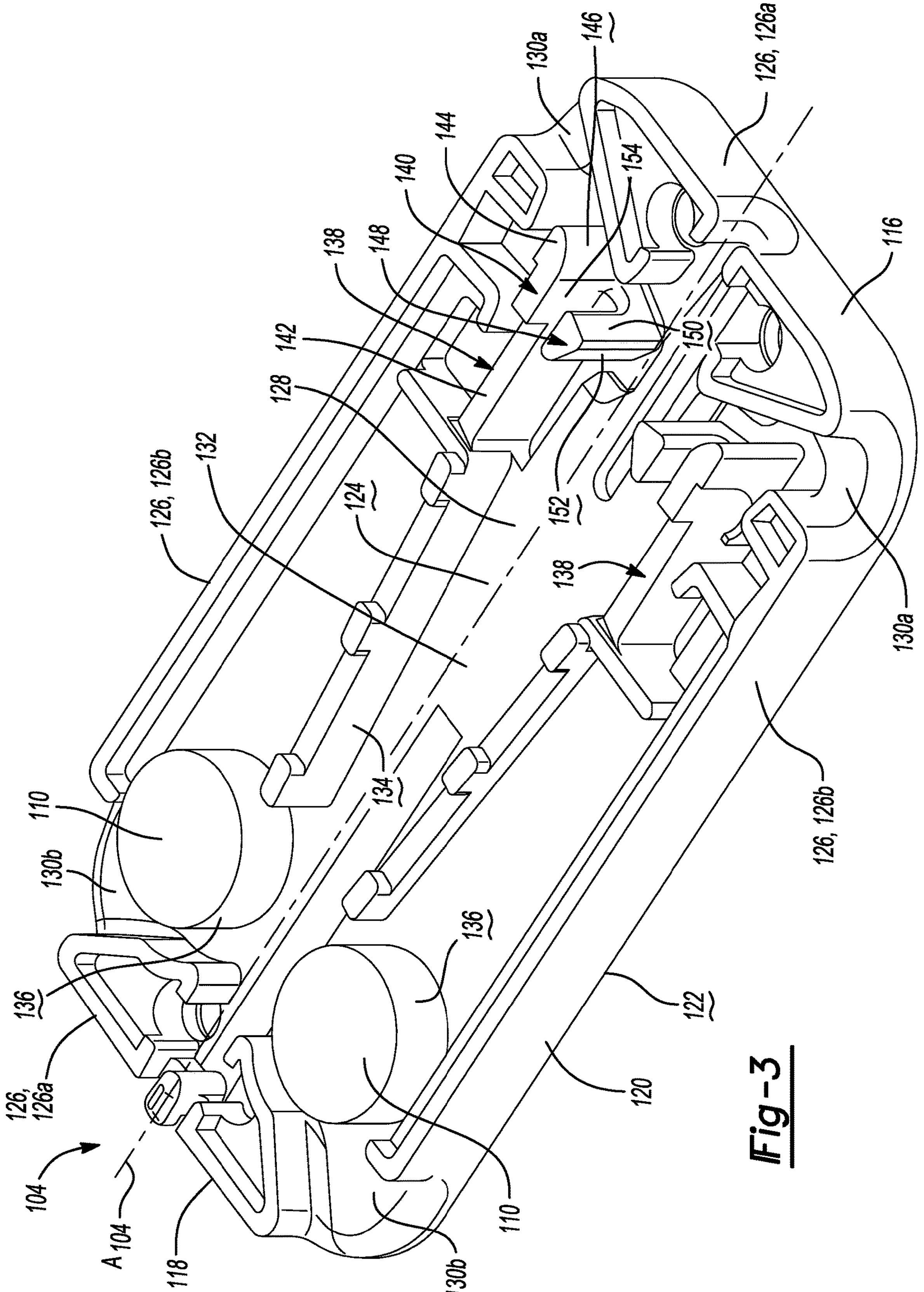
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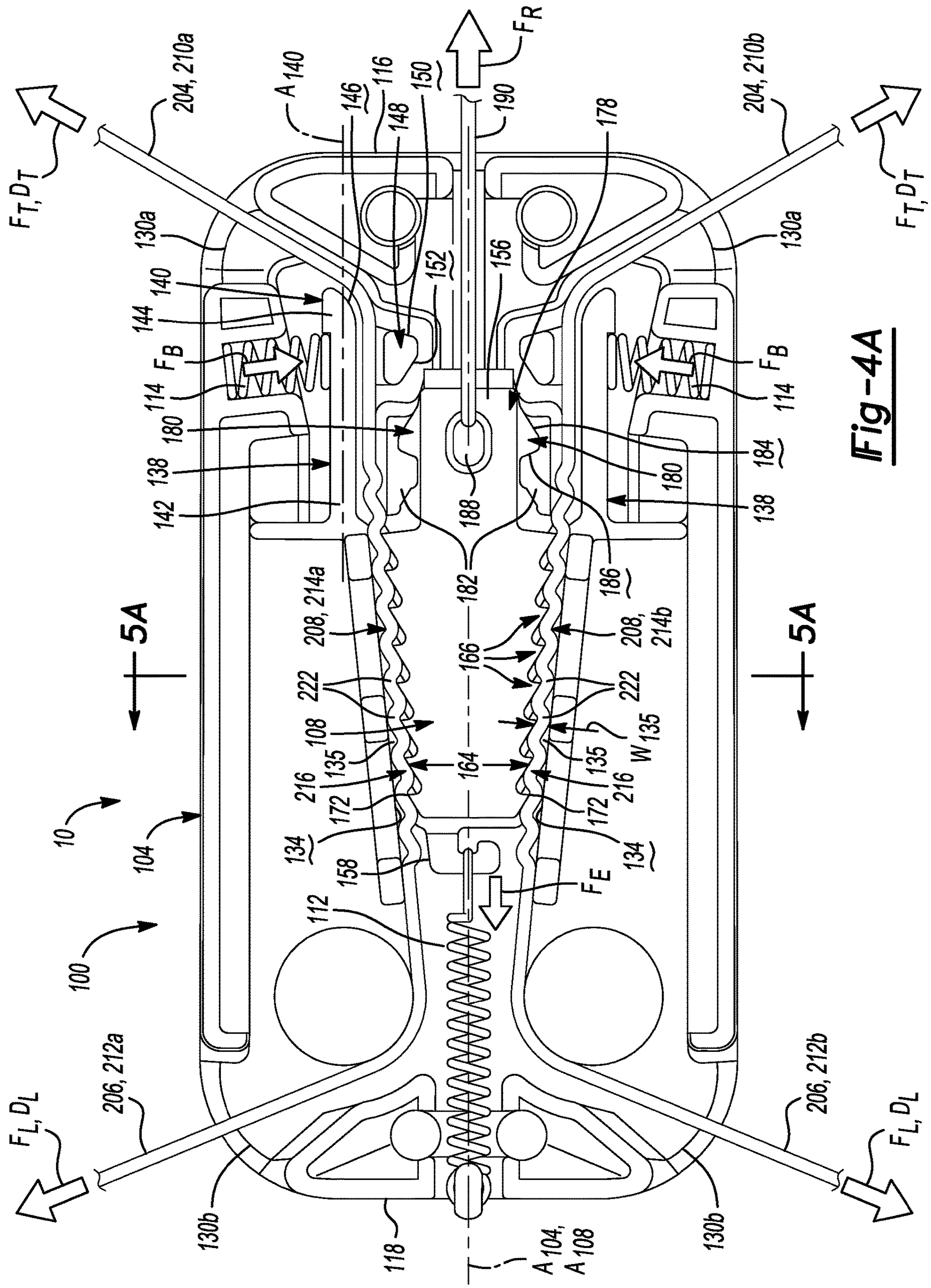
Fig-3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208, 214b
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A_{140}
A_{104}, A_{108}
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F_T, D_T
F_L, D_L
W_{135}
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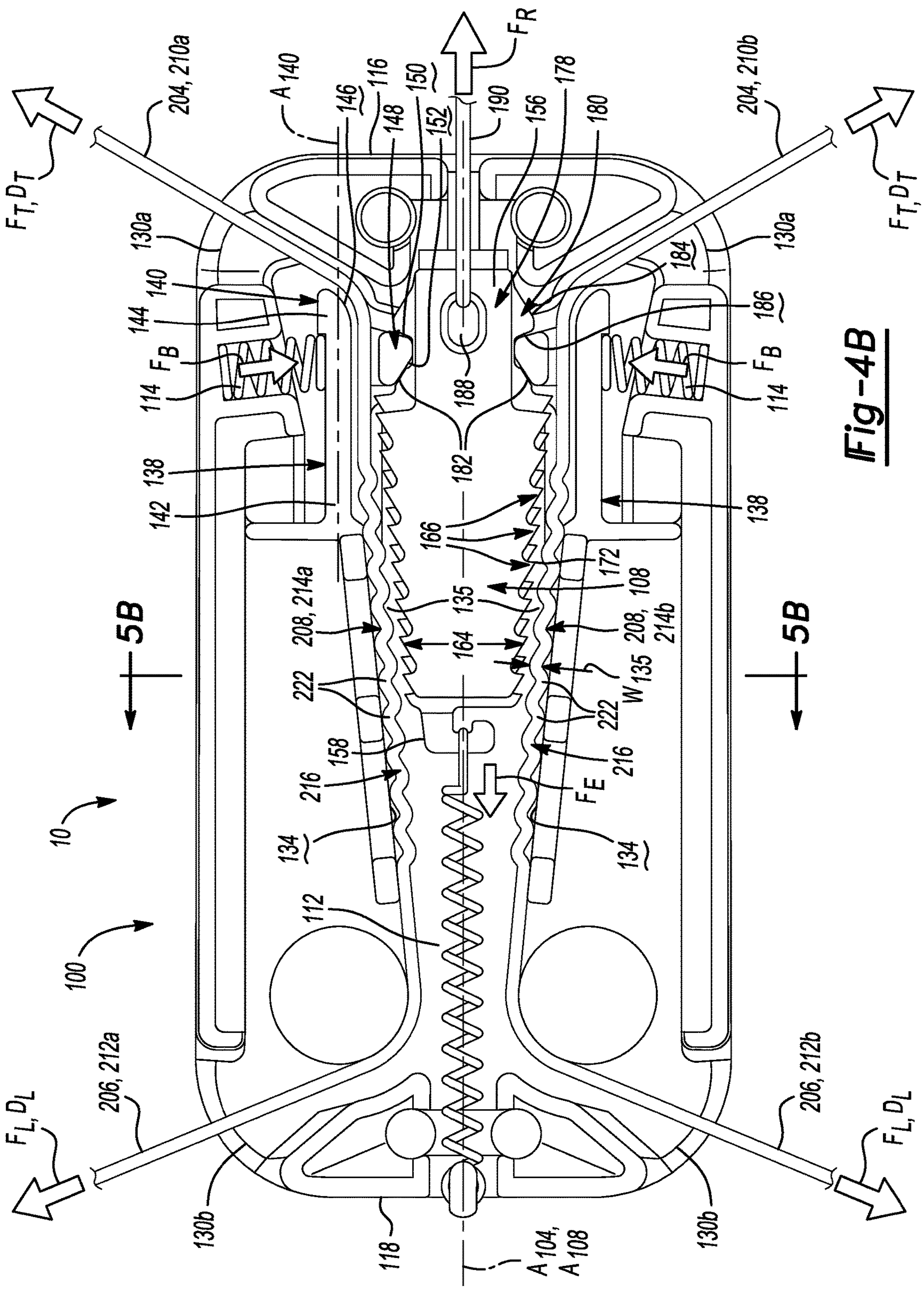
Fig-4A



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204, 210a
204, 210b
206, 212a
206, 212b
208, 214a
208, 214b
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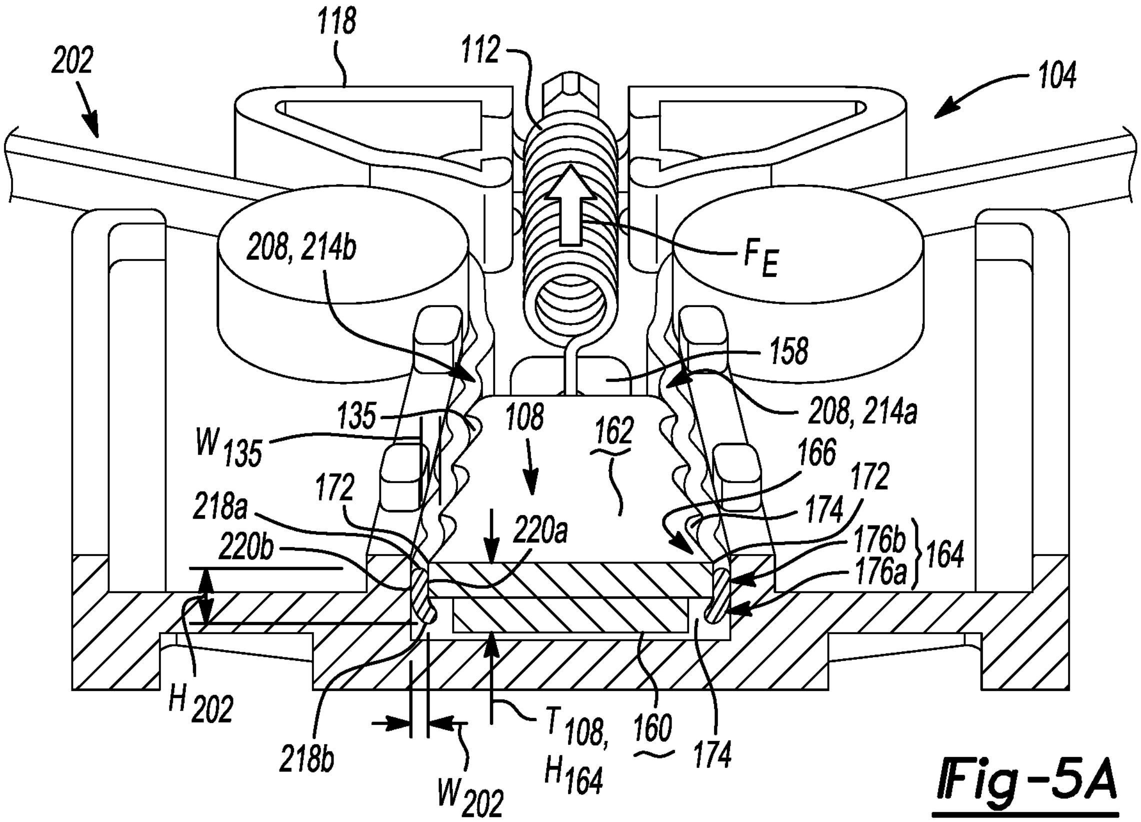
A_{104}, A_{108}

Fig-4B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H_{164}
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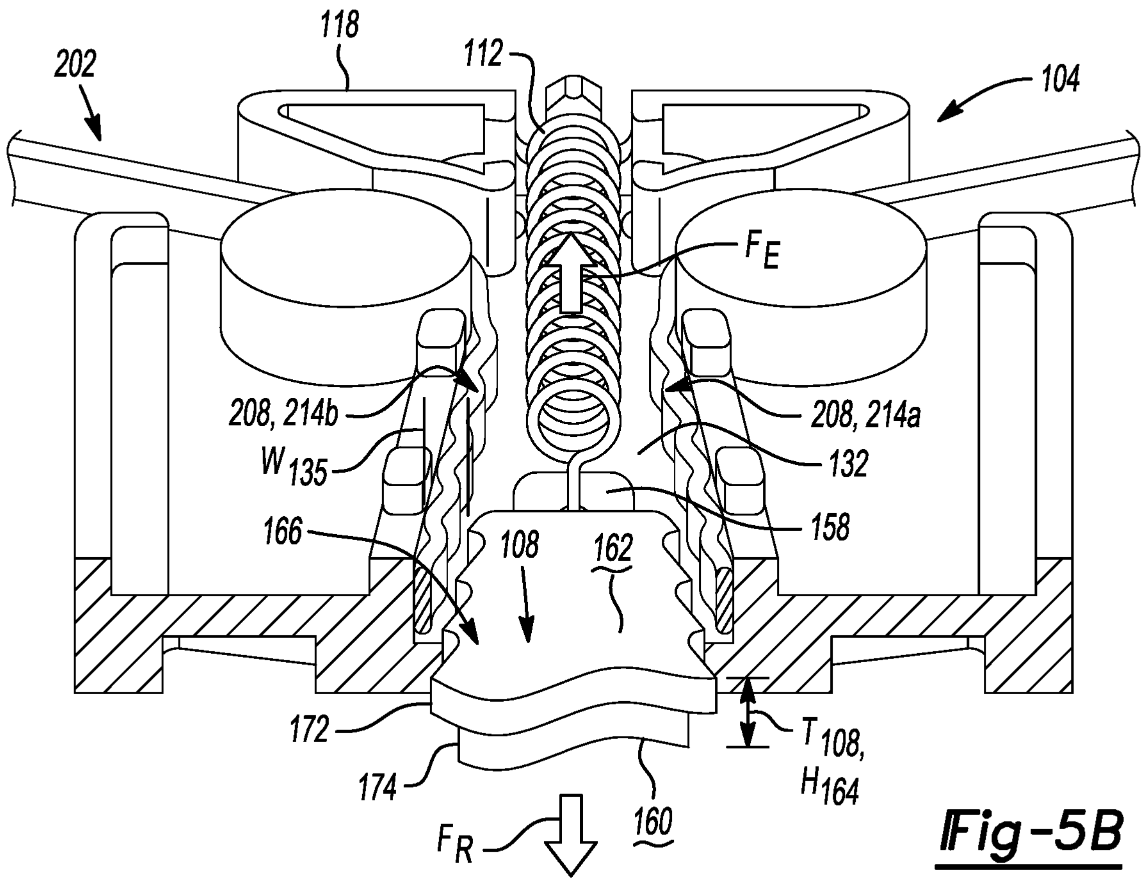
W_{202}

Fig-5A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F_R

Fig-5B

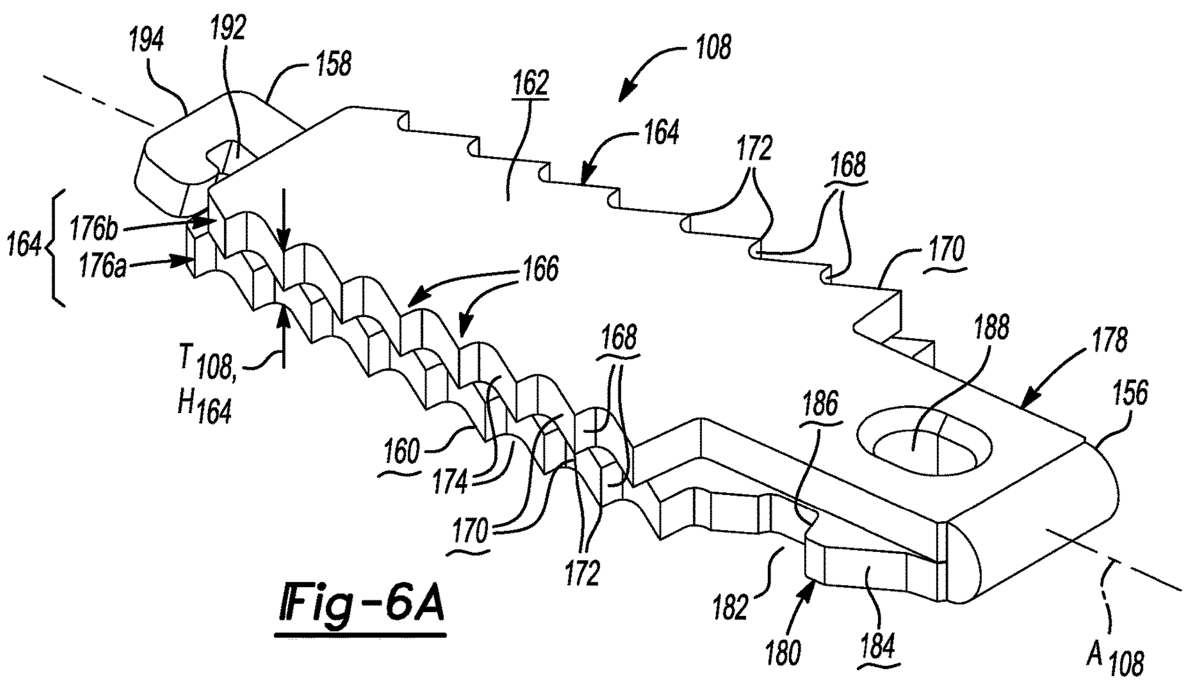
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Fig-6A

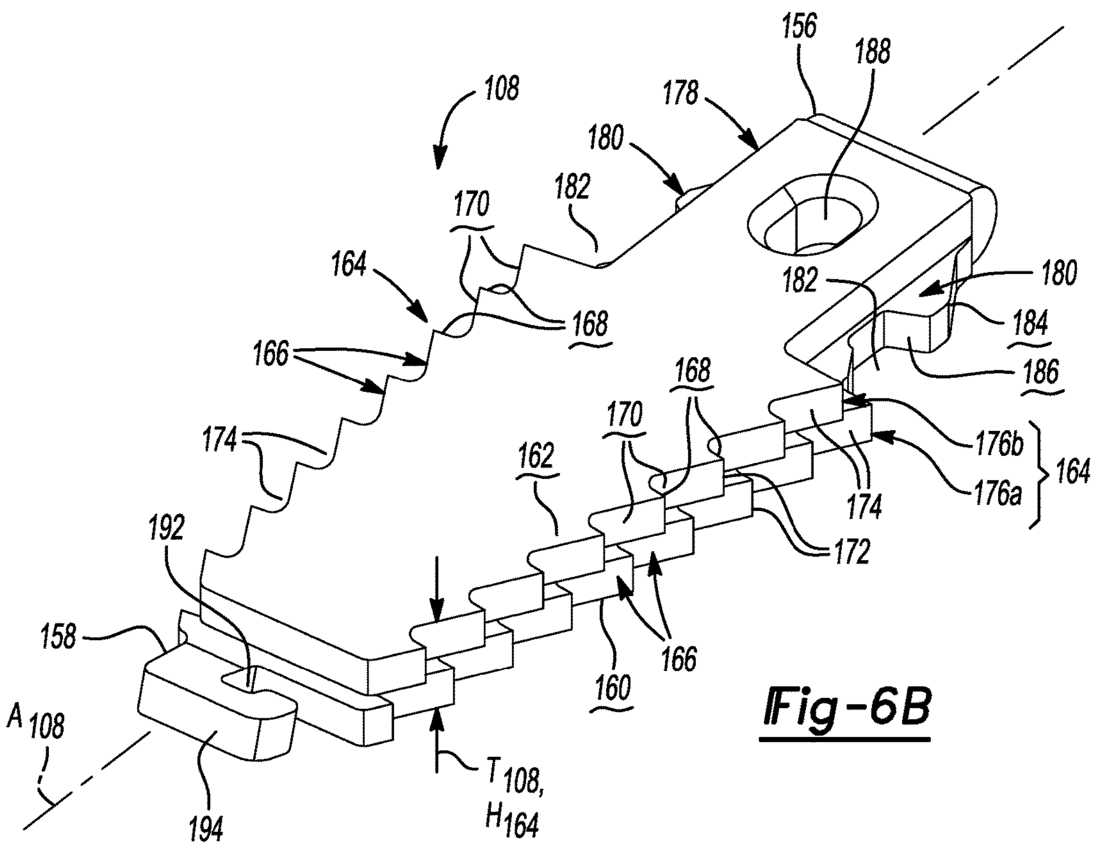
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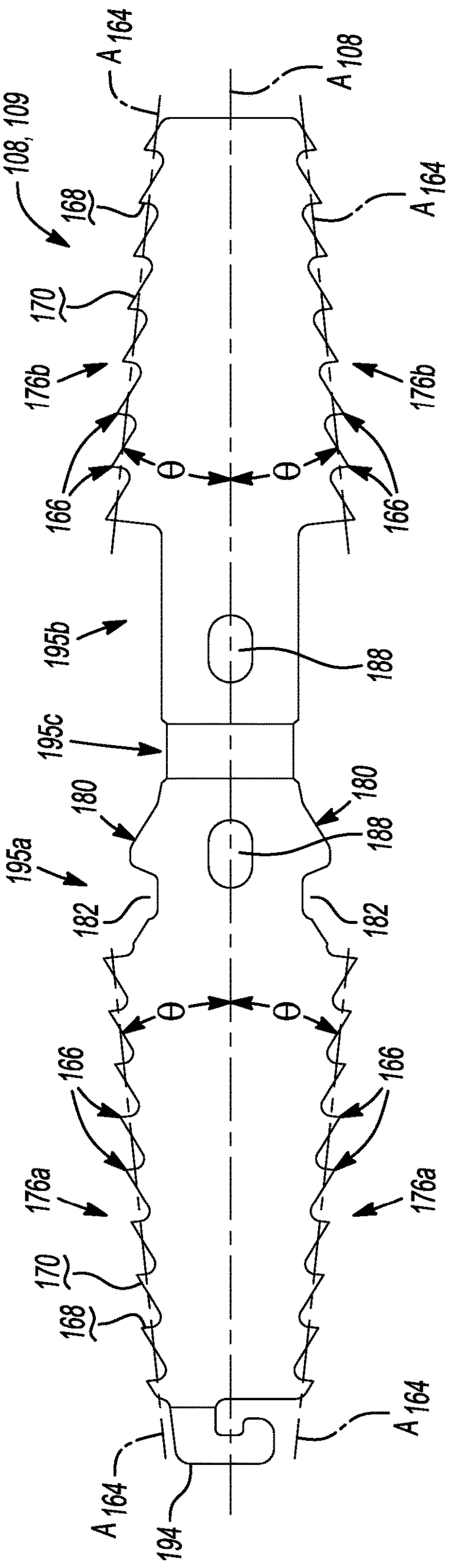
Fig-6B



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A 108
108, 109
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195c
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176a
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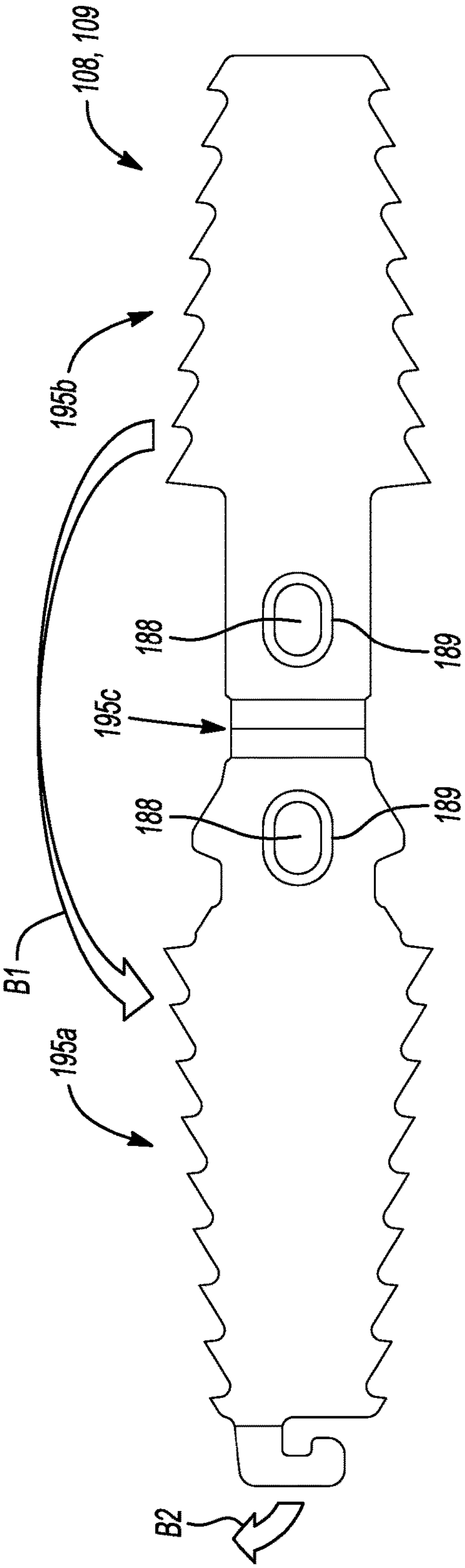
Fig-7A



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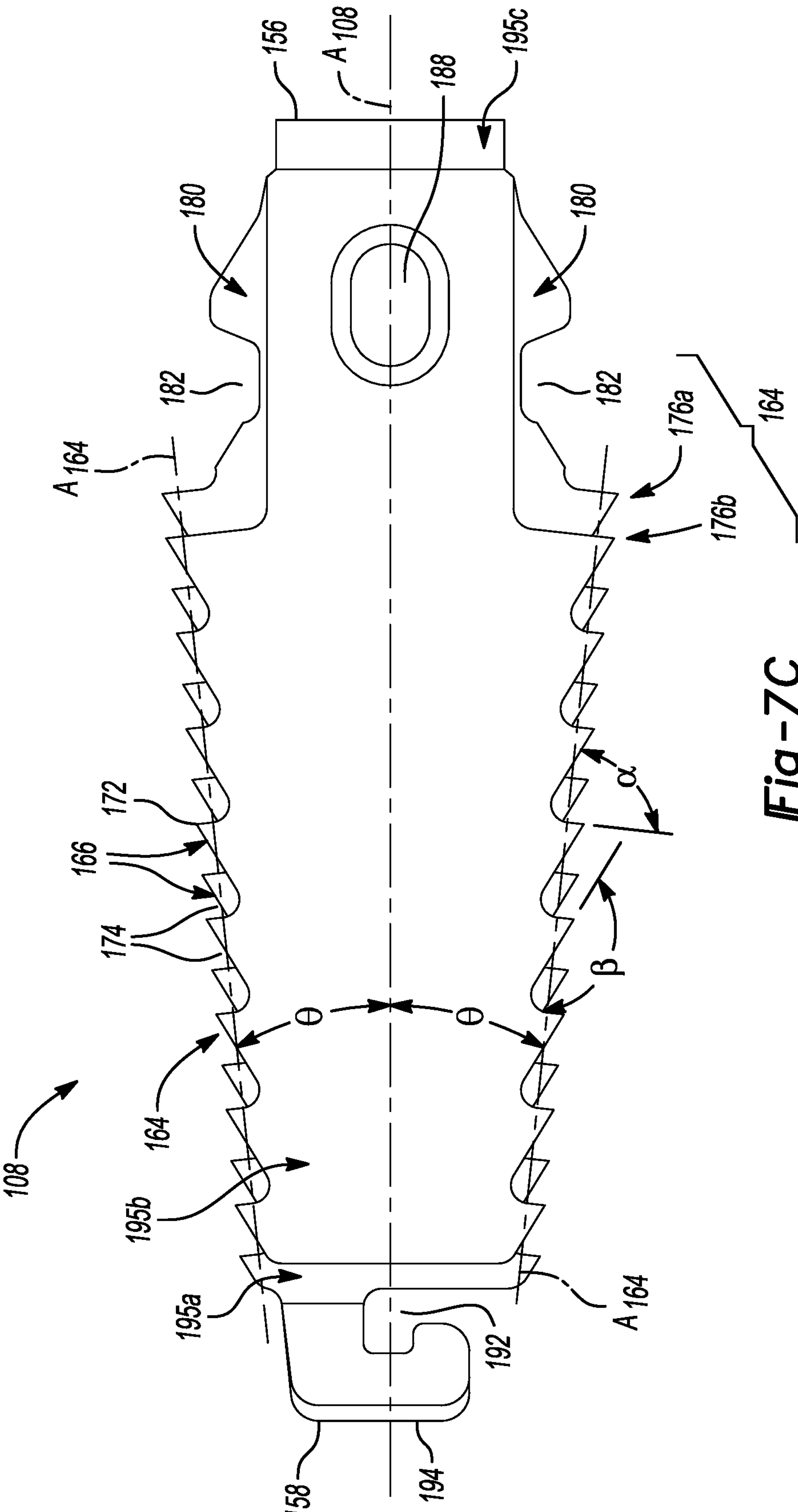
B2

Fig-7B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A_{164}
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Fig-7C

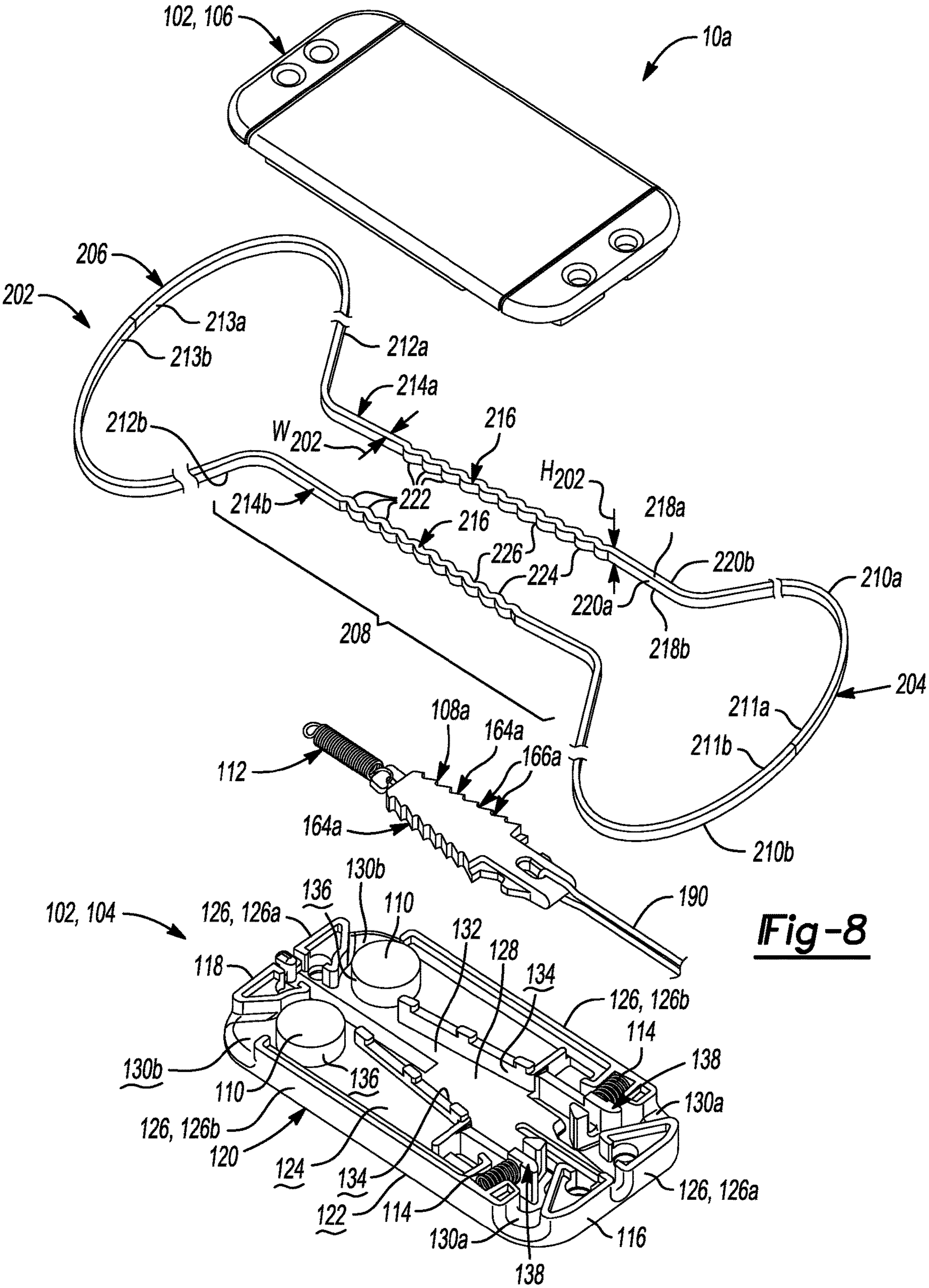
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Fig-8

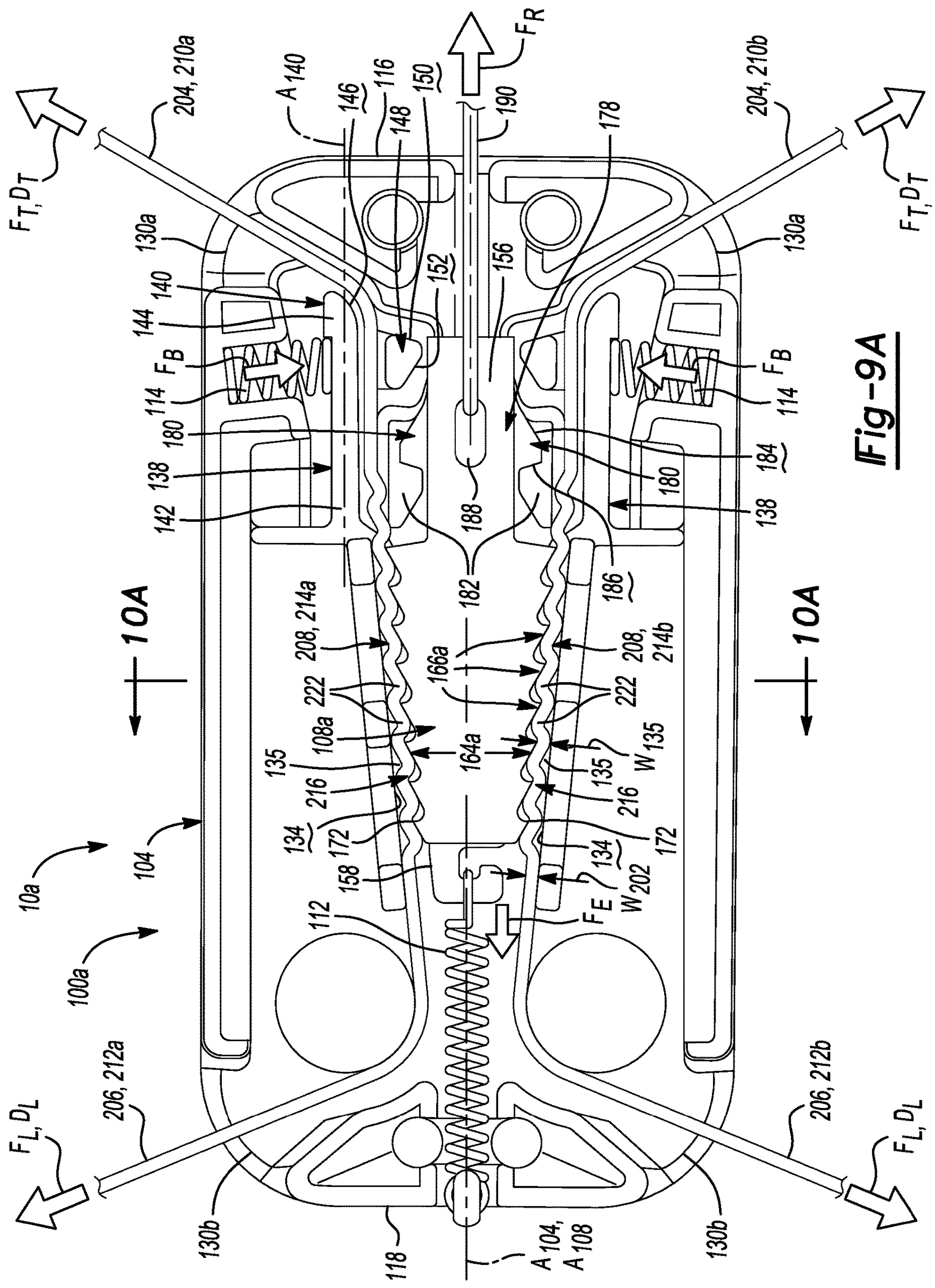
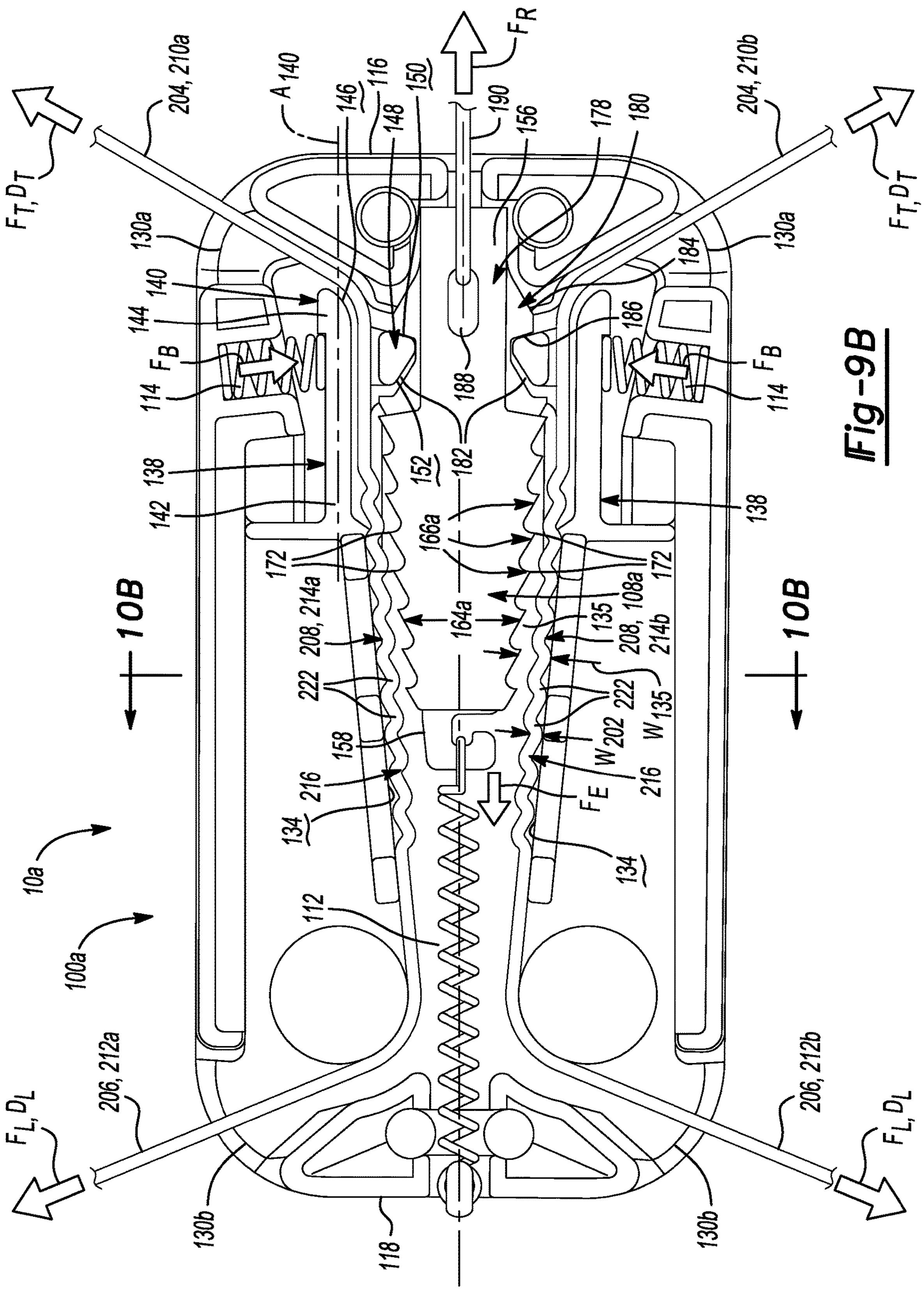


Fig-9A



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W_{135}
W_{202}
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Fig-9B

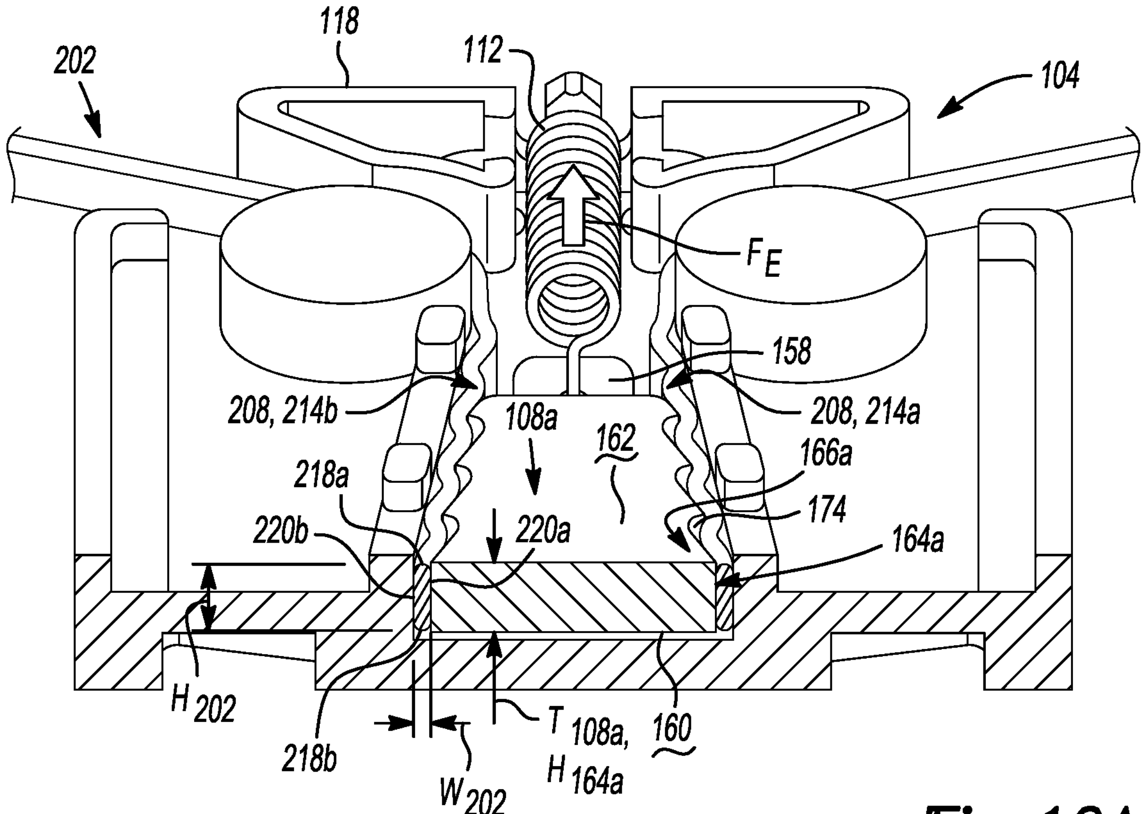

Fig-10A

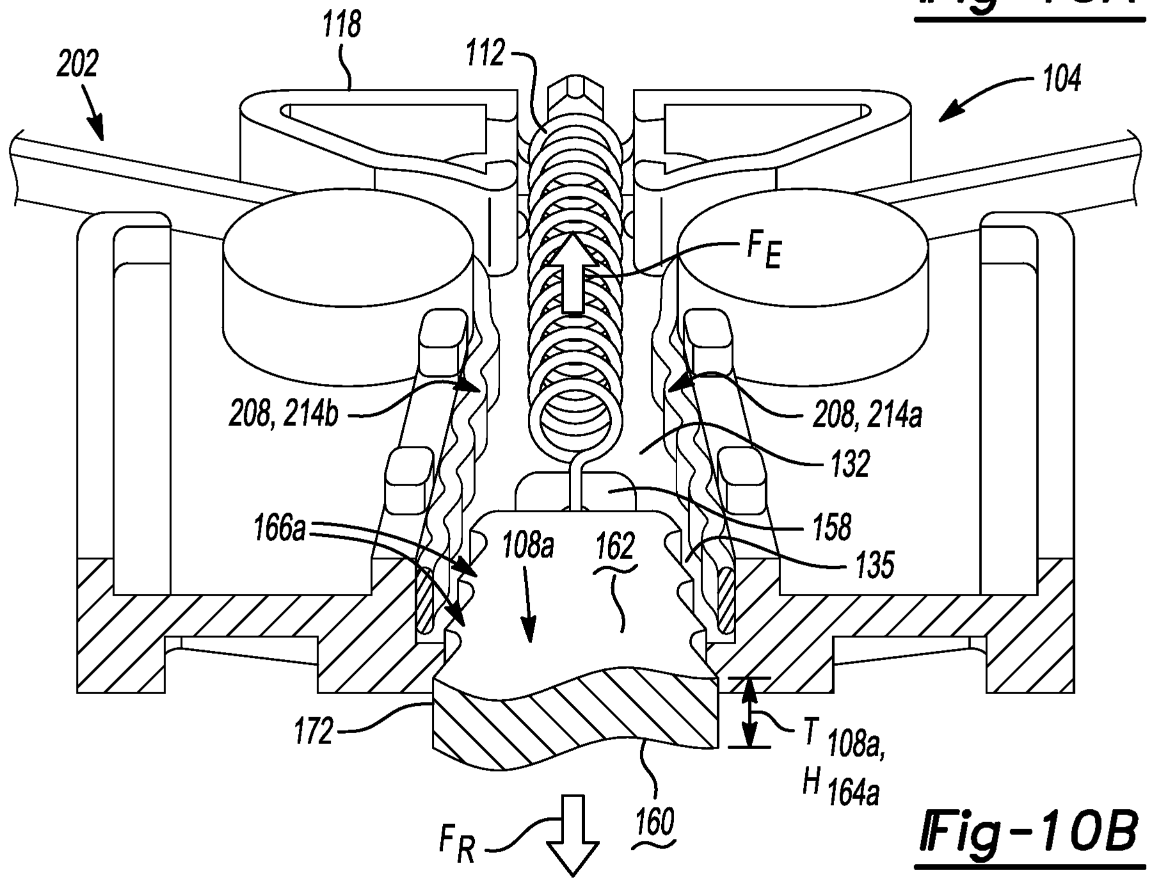

Fig-10B

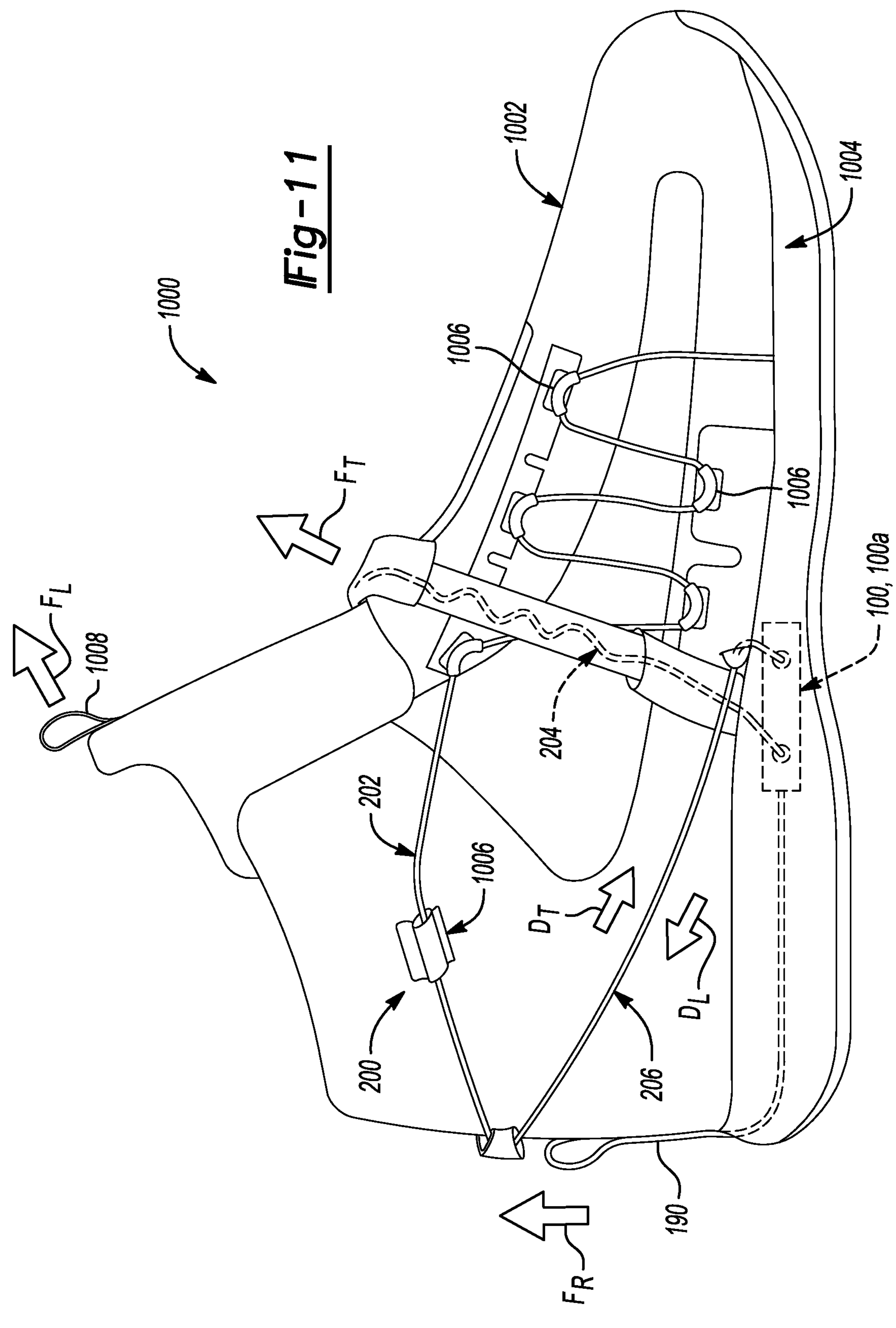
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Fig-11

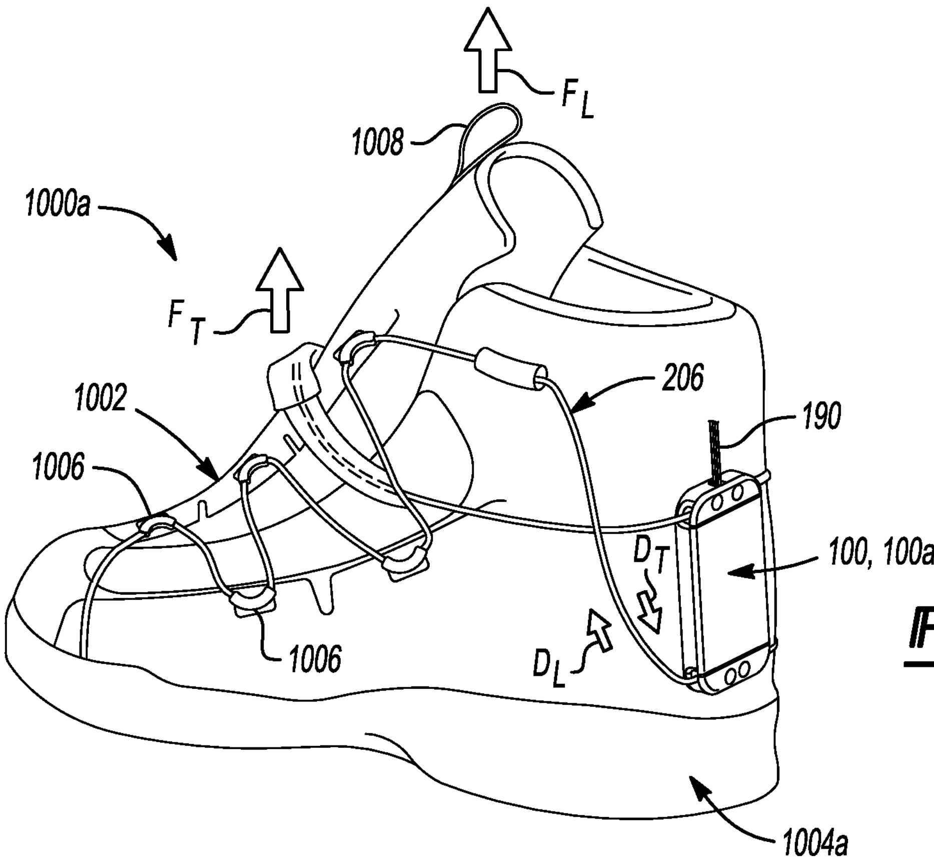

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Fig-12

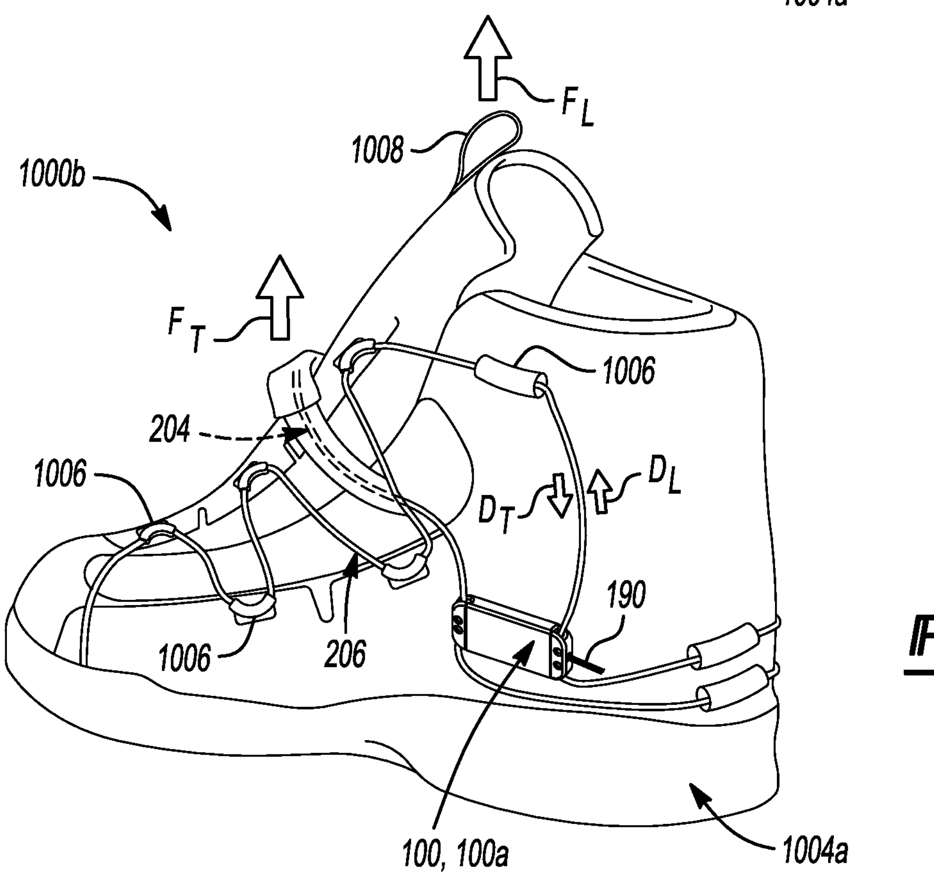

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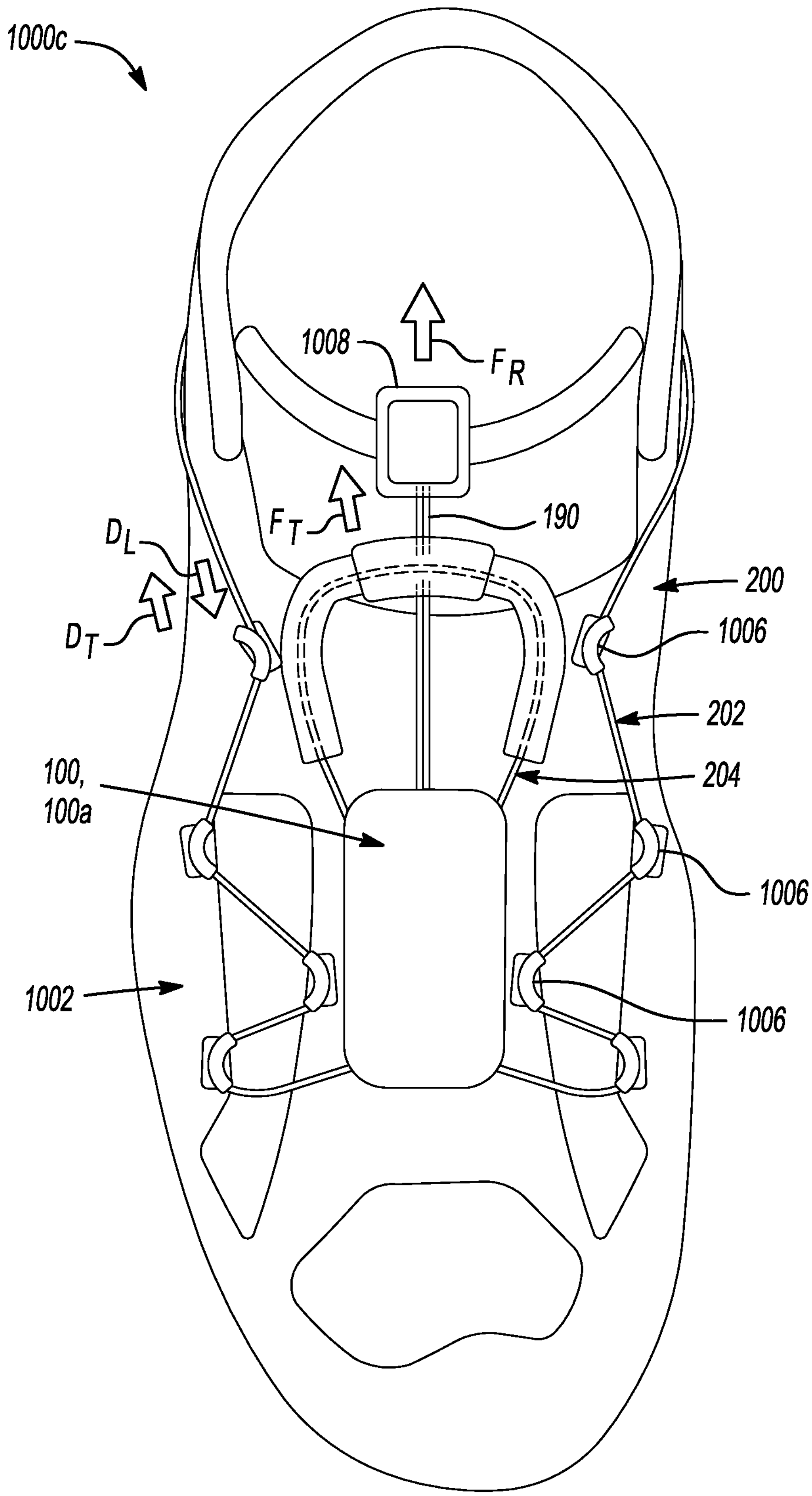
Fig-13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100a
1006
1002
1006

Fig-14

DYNAMIC LACING SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. application Ser. No. 17/987,076, filed Nov. 15, 2022, which is a continuation of U.S. application Ser. No. 17/061,623, filed Oct. 2, 2020, which claims priority under 35 U.S.C. § 119(e) to Provisional U.S. Patent Application No. 62/910,086, filed Oct. 3, 2019, the disclosures of which are hereby incorporated by reference in their entireties.

FIELD

The present disclosure relates generally to articles of footwear having a dynamic lacing system for moving footwear between a tightened state and a loosened state.

BACKGROUND

This section provides background information related to the present disclosure which is not necessarily prior art.

Articles of footwear conventionally include an upper and a sole structure. The upper may be formed from any suitable material(s) to receive, secure and support a foot on the sole structure. A bottom portion of the upper, proximate to a bottom surface of the foot, attaches to the sole structure. Sole structures generally include a layered arrangement extending between an outsole providing abrasion-resistance and traction with a ground surface and a midsole disposed between the outsole and the upper for providing cushioning for the foot.

The upper may cooperate with laces, straps, or other fasteners to adjust the fit of the upper around the foot. For instance, laces may be tightened to close the upper around the foot and tied once a desired fit of the upper around the foot is attained. Care is required to ensure that the upper is not too loose or too tight around the foot each time the laces are tied. Moreover, the laces may loosen or become untied during wear of the footwear. While fasteners such as hook and loop fasteners are easier and quicker to operate than traditional laces, these fasteners have a propensity to wear out over time and require more attention to attain a desired tension when securing the upper to the foot.

Known automated tightening systems typically include a tightening mechanism, such as rotatable knob, that can be manipulated to apply tension to one or more cables that interact with the upper for closing the upper around that foot. While these automated tightening systems can incrementally increase the magnitude of tension of the one or more cables to achieve the desired fit of the upper around the foot, they require a time-consuming task of manipulating the tightening mechanism to properly tension the cables for securing the upper around the foot. Further, when it is desired to remove the footwear from the foot, the wearer is often required to simultaneously depress a release mechanism and pull the upper away from the foot to release the tension of the cables. Thus, known automated tightening systems lack suitable provisions for both quickly adjusting the tension of the cables to close the upper around the foot and quickly releasing the tension applied to the cables so that the upper can be quickly loosened for removing the footwear from the foot. Moreover, the tightening mechanism employed by these known automated tightening systems is required to be incorporated onto an exterior of the upper so that the tightening mechanism is accessible to the wearer for adjusting the fit of the upper around the foot, thereby detracting from the general appearance and aesthetics of the footwear.

DRAWINGS

The drawings described herein are for illustrative purposes only of selected configurations and are not intended to limit the scope of the present disclosure.

FIG. **1** is a perspective view of a cable lock and cable according to the principles of the present disclosure;

FIG. **2** is an exploded view of the lock system of FIG. **1** showing a housing and a locking member of the cable lock;

FIG. **3** is a perspective view of the housing of the lock system of FIG. **1**;

FIG. **4**A is a top view of the lock system of FIG. **1**, showing the housing having a lid removed to expose the locking member slidably disposed within the housing when the locking member is in a locked position;

FIG. **4**B is a top view of the lock system of FIG. **1** showing the housing having the lid removed to expose the locking member slidably disposed within the housing when the locking member is in an unlocked position;

FIG. **5**A is a cross-sectional view of the lock system of FIG. **1** taken along section line **5**A-**5**A of FIG. **4**A, and showing an interface between the locking member, the cable, and the housing when the locking member is in the locked position;

FIG. **5**B is a cross-sectional view of the lock system of FIG. **1** taken along section line **5**B-**5**B of FIG. **4**B, and showing an interface between the locking member, the cable, and the housing when the locking member is in the locked position;

FIGS. **6**A and **6**B are perspective views of the locking member of the lock system of FIG. **1**;

FIGS. **7**A-**7**C illustrate steps for forming the locking member of FIGS. **6**A and **6**B;

FIG. **8** is an exploded view of another cable lock according to the principles of the present disclosure;

FIG. **9**A is a top view of the lock system of FIG. **8**, showing the housing having a lid removed to expose the locking member slidably disposed within the housing when the locking member is in a locked position;

FIG. **9**B is a top view of the lock system of FIG. **8** showing the housing having the lid removed to expose the locking member slidably disposed within the housing when the locking member is in an unlocked position;

FIG. **10**A is a cross-sectional view of the lock system of FIG. **8** taken along section line **10**A-**10**A of FIG. **9**A, and showing an interface between the locking member, the cable, and the housing when the locking member is in the locked position;

FIG. **10**B is a cross-sectional view of the lock system of FIG. **8** taken along section line **10**B-**10**B of FIG. **9**B, and showing an interface between the locking member, the cable, and the housing when the locking member is in the locked position;

FIG. **11** is a side perspective view of an article of footwear incorporating a lock system of the present disclosure in a sole structure of the article of footwear

FIG. **12** is a rear perspective view of an article of footwear incorporating a lock system of the present disclosure at a heel region of the article of footwear;

FIG. **13** is a rear perspective view of an article of footwear incorporating a lock system of the present disclosure at a medial side region of the article of footwear; and

FIG. **14** is a top view of an article of footwear incorporating a lock system of the present disclosure on a tongue portion of the article of footwear.

Corresponding reference numerals indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION

Example configurations will now be described more fully with reference to the accompanying drawings. Example configurations are provided so that this disclosure will be thorough, and will fully convey the scope of the disclosure to those of ordinary skill in the art. Specific details are set forth such as examples of specific components, devices, and methods, to provide a thorough understanding of configurations of the present disclosure. It will be apparent to those of ordinary skill in the art that specific details need not be employed, that example configurations may be embodied in many different forms, and that the specific details and the example configurations should not be construed to limit the scope of the disclosure.

The terminology used herein is for the purpose of describing particular exemplary configurations only and is not intended to be limiting. As used herein, the singular articles "a," "an," and "the" may be intended to include the plural forms as well, unless the context clearly indicates otherwise. The terms "comprises," "comprising," "including," and "having," are inclusive and therefore specify the presence of features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof. The method steps, processes, and operations described herein are not to be construed as necessarily requiring their performance in the particular order discussed or illustrated, unless specifically identified as an order of performance. Additional or alternative steps may be employed.

When an element or layer is referred to as being "on," "engaged to," "connected to," "attached to," or "coupled to" another element or layer, it may be directly on, engaged, connected, attached, or coupled to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly engaged to," "directly connected to," "directly attached to," or "directly coupled to" another element or layer, there may be no intervening elements or layers present. Other words used to describe the relationship between elements should be interpreted in a like fashion (e.g., "between" versus "directly between," "adjacent" versus "directly adjacent," etc.). As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

The terms first, second, third, etc. may be used herein to describe various elements, components, regions, layers and/or sections. These elements, components, regions, layers and/or sections should not be limited by these terms. These terms may be only used to distinguish one element, component, region, layer or section from another region, layer or section. Terms such as "first," "second," and other numerical terms do not imply a sequence or order unless clearly indicated by the context. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the example configurations.

One aspect of the disclosure provides a cable lock. The cable lock includes a housing having a first engagement surface and a second engagement surface spaced apart from the first engagement surface. The cable lock also includes a locking member slideably disposed between the first engagement surface and the second engagement surface and having a first lock element opposing the first engagement surface to define a first locking channel and a second lock element opposing the second engagement surface to define a second locking channel. The first lock element (i) includes a first series of teeth and a second series of teeth arranged in parallel with the first series of teeth and (ii) is operable to engage a first portion of a cable disposed within the first locking channel. The second lock element (i) includes a first series of teeth and a second series of teeth arranged in parallel with the first series of teeth of the second lock element and (ii) is operable to engage a second portion of the cable disposed within the second locking channel.

Implementations of the disclosure may include one or more of the following optional features. In some implementations, the locking member includes a bottom surface and a top surface formed on an opposite side of the locking member from the bottom surface, the first series of teeth of the first lock element and the second lock element extending adjacent to the bottom surface and the second series of teeth of the first lock element and the second lock element extending adjacent to the top surface. The first series of teeth of the first lock element and the second lock element may be staggered from the second series of teeth of the first lock element and the second lock element, respectively. The first series of teeth of the first lock element and the second lock element may include a first series of recesses formed between adjacent ones of the teeth of the first series of teeth, each of the teeth of the second series of teeth of the first lock element and the second lock element being aligned with one of the recesses of the first series of recesses. The second series of teeth of the first lock element and the second lock element may include a second series of recesses formed between adjacent ones of the teeth of the second series of teeth, each of the teeth of the first series of teeth of the first lock element and the second lock element being aligned with one of the recesses of the second series of recesses.

In some examples, each of the first lock element and the second lock element is formed at an oblique angle relative to a longitudinal axis of the locking member. The oblique angle may range from 2 degrees to 12 degrees. Additionally or alternatively, the oblique angle may range from 4 degrees to 8 degrees or the oblique angle may be 6 degrees. The first lock element may be parallel to the first engagement surface and the second lock element may be parallel to the second engagement surface.

In some configurations, the cable has an inner side and an outer side formed on an opposite side of the cable from the inner side, a distance from the inner side to the outer side defining a width of the cable. Here, the inner side may face the first lock element and the second lock element, and the outer side may face the first engagement surface and the second engagement surface. The cable may have a top end and a bottom end disposed on an opposite end of the cable from the top end. A distance from the top end of the cable to the bottom end of the cable defining a height of the cable, the height being less than a height of the first lock element and the second lock element. The height of the cable may be greater than the width of the cable. The inner side may be substantially straight from the top end to the bottom end and the outer side may be substantially straight from the top end to the bottom end.

In some implementations, the cable lock includes a biasing spring operable to apply a biasing force and to bias the locking member toward a locked state. The cable lock may also include a release cord attached to the locking member and operable to move the locking member from the locked state to an unlocked state when a tensile force exceeding the biasing force of the biasing spring is applied to the release cord in an unlocking direction. Here, the release cord may be attached to the locking member at an opposite end of the locking member than the biasing spring. An article of footwear may include the cable lock described above.

Another aspect of the disclosure provides a locking member for a cable lock. The locking member includes a first lock element extending along a direction from a first end of the locking member to a second end of the locking member. The first lock element includes a first series of teeth and a second series of teeth in parallel with the first series of teeth. The locking member also includes a second lock element extending along the direction from the first end of the locking member to the second end of the locking member and formed on an opposite side of the locking member from the first lock element. The second lock element includes a third series of teeth and a fourth series of teeth in parallel with the third series of teeth.

This aspect of the disclosure may include one or more of the following optional features. In some examples, the locking member includes a bottom surface and a top surface formed on an opposite side of the locking member from the bottom surface, the first series of teeth and the third series of teeth extending adjacent to the bottom surface, and the second series of teeth and the fourth series of teeth extending adjacent to the top surface. The first series of teeth may be staggered from the second series of teeth, and the third series of teeth may be staggered from the fourth series of teeth. The first series of teeth may define a first series of recesses, the teeth of the second series of teeth being aligned with the first series of recesses. The third series of teeth may define a second series of recesses, the teeth of the fourth series of teeth being aligned with the second series of recesses.

In some configurations, each of the first lock element and the second lock element is formed at an oblique angle to a longitudinal axis of the locking member. Here, the oblique angle may range from 2 degrees to 12 degrees. Optionally, the oblique angle may range from 4 degrees to 8 degrees or the oblique angle may be 6 degrees. An article of footwear may include the locking member as described above.

Yet another aspect of the disclosure proves a method of forming a locking member. The method includes forming a locking member blank having a first thickness. The locking member blank includes (i) a first portion including a first lock element and a second lock element formed on an opposite side of the first portion from the first lock element, (ii) a second portion including a third lock element and a fourth lock element formed on an opposite side of the second portion from the third lock element, and (iii) an intermediate portion connecting the first portion and the second portion. The method also includes bending the locking member blank along the intermediate portion to fold the first portion upon the second portion. The first lock element and the third lock element are arranged in parallel with each other and the second lock element and the fourth lock element are arranged in parallel with each other.

Implementations of this aspect of the disclosure may include one or more of the following optional features. In some implementations, forming the locking member blank includes forming each of the first lock element, the second lock element, the third lock element, and the fourth lock element with a series of teeth, each of the series of teeth defining a corresponding series of recesses disposed between adjacent ones of the teeth. Here, bending the locking member blank may include aligning the series of teeth of the first lock element with the series of recesses of the third lock element and aligning the series of teeth of the second lock element with the series of recesses of the fourth lock element.

In some examples, the method includes deburring the locking member blank. The locking member blank may be formed of a metal. Optionally, the locking member blank may be formed of an aluminum alloy. Forming the locking member blank may include stamping the locking member blank in a progressive die.

With reference to FIGS. **1** and **2**, a fastening system **10** including a cable lock **100** and a cable **202** is shown. Generally, the cable lock **100** is configured to interface with the cable **202** to adjust and secure a fit of an article when worn by a user. For example, the cable lock **100** and the cable **202** may be incorporated as part of a tensioning system **200** in an article of footwear **1000** (FIGS. **11-14**) for dynamically adjusting and securing the fit of the article of footwear on the foot of the wearer. In other examples, the cable lock **100** and the cable **202** may be used with other articles, such as vests, helmets, or other articles where a dynamically-adjustable fit is desirable.

Referring to FIG. **2**, the cable lock **100** includes an enclosure **102** having a housing **104** and a cover **106**, and a lock or locking member **108** disposed within the enclosure **102** configured to selectively engage the cable **202**. The cable lock **100** further includes a first biasing member **112** configured to bias the locking member **108** towards an engaged or locked position, and a pair of second biasing members **114** configured to cooperate with the housing **104** to retain the locking member **108** in a disengaged or unlocked position, as described below with respect to FIGS. **4**B and **5**B.

With reference to FIGS. **1** and **2**, the housing **104** defines a length extending between a first end **116** and a second end **118**. The housing **104** includes a base portion **120** having an outer surface **122** and a cable-receiving inner surface **124** formed on an opposite side of the base portion **120** from the outer surface **122**. A peripheral wall **126** extends from the inner surface **124** and cooperates with the base portion **120** and the cover **106** to define a main cavity **128** of the enclosure **102**, configured to receive the cable **202** and the locking member **108**. In the illustrated example, the peripheral wall **126** includes a pair of end walls **126*a*** at each of the first end **116** and the second end **118**, and an opposing pair of sidewalls **126*b*** extending between the end walls **126*a*** to define a substantially rectangular housing **104**.

The peripheral wall **126** may include a plurality of cable openings **130*a***, **130*b*** formed therethrough for providing communication between the main cavity **128** and an exterior of the enclosure **102**. In the illustrated example, the openings **130*a***, **130*b*** include a first pair of openings **130*a*** proximate to the first end **116** for receiving a first end of the cable **202**, and a second pair of openings **130*b*** proximate to the second end **118** for receiving a second end of the cable **202**. Although the openings **130*a***, **130*b*** of the illustrated example are shown as being formed through corners of the enclosure **102**, the openings **130*a***, **130*b*** may be formed entirely in the end walls **126*a*** or entirely in the sidewalls **126*b***.

With continued reference to the cable lock **100**, the housing **104** includes a locking chamber **132** defined by an opposing pair of locking or engagement surfaces **134** that converge toward one another such that the locking chamber **132** is associated with a wedge-shaped configuration tapering from the first end **116** toward the second end **118** of the housing **104**. Accordingly, the engagement surfaces **134** are defined by corresponding sidewalls of the housing **104** converging toward one another and extending in a direction from the inner surface **124** of the base portion **120** to the cover **106** to define the locking chamber **132**. As described in greater detail below, the engagement surfaces **134** cooperate with the locking member **108** to secure the cable **202**.

The housing **104** includes cable guides **110** extending from the inner surface **124** of the base portion **120**. The cable guides **110** each include a guide surface **136** along which the cable **202** may pass from the locking chamber **132** to either one of the openings **130***b* at the second end **118**. In the illustrated example, the cable guides **110** are fixed members, formed integrally with the base portion **120**. However, in other examples, the cable guides **110** may be formed separately from the housing **104** and/or may be rotatable.

With reference to FIG. **3**, the housing **104** includes a pair of retention features **138** configured to selectively engage the locking member **108** and to secure the locking member **108** in the unlocked position, as shown in FIGS. **4**B and **5**B. The housing **104** may include two retention features **138** disposed on opposite sides of the housing **104**, whereby the retention features **138** are biased inward toward the locking member **108**. The retention features **138** are configured to be biased by the second biasing members **114**. In the illustrated example, the retention features **138** each include a flexible tab **140** integrally formed with the housing **104** such that the retention features **138** act as living hinges movable between an engaged state and a disengaged state for allowing the locking member **108** to pass therebetween. Accordingly, each tab **140** extends along a longitudinal axis A_{140} from a fixed first end **142** to a detached distal end **144**. As shown, the distal ends **144** of each tab **140** may partially define a path of the cable **202** between the locking chamber **132** and the openings **130***a* at the first end **116** of the housing **104**. Accordingly, the distal end **144** may include a convex inner guide surface **146** along which the cable **202** passes between the locking chamber **132** and a respective one of the first openings **130***a*.

Each of the retention features **138** further includes a projection **148** extending laterally into the locking chamber **132** from the distal end **144** of the tab **140**. A width of the projection **148** may taper along a direction from the first end **116** to the second end **118**, such that the projection **148** includes a retention surface **150** facing the first end **116** of the housing **104** and a biasing surface **152** formed on the opposite side of the projection **148** from the retention surface **150**. Each of the retention surface **150** and the biasing surface **152** may be formed at an oblique angle with respect to a longitudinal axis A_{104} of the housing **104**. However, an angle of the retention surface **150** with respect to the longitudinal axis A_{104} may be greater than the angle of the biasing surface **152**, such that the retention surface **150** is configured to provide greater resistance to movement of the locking member **108** towards the second end **118** (i.e. the locked state) than towards the first end **116** (i.e. the unlocked state). In the illustrated example, the projection **148** is spaced apart from the distal end **144** of the tab **140**, and cooperates with the distal end **144** to define a track **154** or passage for guiding the cable **202** from the locking chamber **132** to one of the first openings **130***a*.

With reference to FIGS. **4**A and **4**B, the cable lock **100** includes a pair of the second biasing members **114** configured to bias the distal ends **144** of the tabs **140** and, consequently, the projections **148** of the retention features **138**, inwards toward the locking chamber **132**. In the illustrated example, the biasing members **114** are compression springs that apply a continuous biasing force FB to the distal ends **144** of the tabs **140**. In other examples, the biasing force FB may be applied by other types of biasing members **114**, such as tension springs, coil springs, or by forming the first end **142** of the tab **140** as a resilient living hinge.

The locking member **108** is configured to be slideably received within the locking chamber **132** of the housing **104**. As provided above, the locking member **108** is operable between a locked state and an unlocked state to selectively secure the cable **202** relative to the housing **104**. Referring to FIGS. **6**A and **6**B, the locking member **108** extends along a longitudinal axis A_{108} from a first end **156** to a second end **158** disposed at the opposite end from the first end **156**. The locking member **108** further includes a bottom surface **160** configured to interface with the inner surface **124** of the base portion **120** and a top surface **162** formed on an opposite side of the locking member **108** from the bottom surface **160**. A distance between the bottom surface **160** and the top surface **162** defines a thickness T_{108}.

With reference to FIGS. **6**A-**7**B, a pair of lock elements **164** are formed between the bottom surface **160** and the top surface **162** on opposite sides of the locking member **108**. The lock elements **164** each extend along a respective longitudinal axis A_{164} from the first end **156** and the second end **158** of the locking member **108**. As shown, the longitudinal axis A_{164} of each of the lock elements **164** is formed at an oblique angle θ relative to the longitudinal axis A_{108} of the locking member **108**. Thus, in some examples, the lock elements **164** converge toward one another along a direction from the first end **156** to the second end **158**, such that the lock elements **164** are parallel to and oppose respective ones of the engagement surfaces **134** of the housing **104** when the locking member **108** is disposed within the locking chamber **132**.

The angle θ of the lock elements **164** is selected such that the cable **202** will transfer a sufficient portion of the tightening force F_T (as shown in FIG. **4**A) upon the lock elements **164** when the tightening force F_T is applied to the cable **202** to overcome an engaging force F_E of the first biasing element **112**. Thus, application of the tightening force F_T to the cable **202** will cause the locking member **108** to move along the longitudinal axis A_{104} of the housing **104**, away from the first biasing element **112**. If the angle θ is too great, the locking elements **164** may cause the cable **202** to bind within the housing **104**. However, too small of an angle θ will allow the cable **202** to pass freely along the locking elements **164** without imparting the necessary portion of the tightening force F_T to the locking element **108**. The angle θ may range from 2 degrees to 12 degrees, and more particularly, from 4 degrees to 8 degrees. In a particular example, the angle θ is 6 degrees.

In FIGS. **6**A-**7**A, the lock elements **164** include a plurality of outwardly-protruding teeth **166** configured to permit movement by the cable **202** towards the first end **116** of the housing **104** while restricting movement by the cable **202** towards the second end **118** of the housing **104** by gripping the cable **202** when the locking member **108** is in the locked state. In the illustrated example, each of the teeth **166** includes a locking surface **168** facing the first end **156** of the locking member **108** and a trailing surface **170** facing the second end **158** of the locking member **108**. As best shown in FIGS. **6**A and **6**B, the locking surface **168** and the trailing surface **170** of each tooth **166** intersect with each other to form a tip **172** of the tooth **166**, while opposing (i.e., facing each other) locking and trailing surfaces **168**, **170** of adjacent ones of the teeth **166** cooperate to define recesses **174** between the adjacent teeth **166**.

Referring to FIG. 7C, each of the locking surface **168** and the trailing surface **170** may be formed at an angle with respect to a longitudinal axis A_{164} of the lock element **164**. As shown, an angle α of the locking surface **168** with respect to the longitudinal axis A_{164} of the lock element **164** may be perpendicular or acute, such that the locking surface **168** will engage the cable **202** to prevent movement of the cable **202** in the loosening direction D_L when the locking member **108** is in the locked position (FIGS. **4**A and **5**A). An angle β of the trailing surfaces **170** with respect to the longitudinal axis A_{164} of the lock element **164** is obtuse, such that the cable **202** is able to slide over the trailing surfaces **170** in the tightening direction D_T regardless of whether the locking member **108** is in the locked position (FIGS. **4**A and **5**A) or the unlocked position (FIGS. **4**B and **5**B).

As discussed above, each of the lock elements **164** extends along a longitudinal axis A_{164} parallel to the respective engagement surface **134** of the housing **104**. As shown in FIGS. **4**A-**5**B, the tips **172** of the teeth **166** face the engagement surfaces **134**, where a space between the tips **172** of the teeth **166** and the engagement surfaces **134** defines a pair of locking channels **135**. Accordingly, the widths W_{135} of the locking channels **135** are defined by the distance between the engagement surfaces **134** and the tips **172** of the teeth **166**. As such, the widths W_{135} of the locking channels **135** are variable as the locking member **108** moves between the locked state (FIGS. **4**A and **5**A) and the unlocked state (FIGS. **4**B and **5**B). Particularly, in the locked state, the cable lock **100** is configured so that the widths W_{135} of the locking channels **135** are slightly less than a width W_{202} of the cable **202** to compress the cable **202** between the teeth **166** and the engagement surface **134**. Movement of the locking member **108** may be limited in the direction towards the second end **118** of the housing **104** so that a minimum width W_{135} is maintained. For example, a minimum width of one (1) millimeter may be suitable for a cable **202** having a width W_{202} greater than one (1) millimeter.

As shown in FIGS. **6**A and **6**B, each of the lock elements **164** includes a lower first series **176***a* of the teeth **166** and an upper second series **176***b* of the teeth **166**. In the illustrated example, the first series **176***a* extends along a lower portion of each lock element **164** adjacent to the bottom surface **160** and the second series **176***b* extends along an upper portion of the lock element **164** adjacent to the top surface **162**, such that the first series **176***a* and the second series **176***b* are in a stacked arrangement along each lock element **164**. Accordingly, although the first series **176***a* and the second series **176***b* may be described as extending in parallel, the first series **176***a* and the second series **176***b* are not necessarily parallel to each other geometrically. For example, the first series **176***a* and the second series **176***b* may be in parallel in a functional sense, but be arranged at an oblique angle relative to one another.

In the illustrated example, the first series **176***a* and the second series **176***b* are immediately adjacent to each other. Accordingly, the first series **176***a* and the second series **176***b* cooperate to define a height H_{164} of the lock element **164**, which is the same as the thickness T_{108} of the locking member **108**. However, in other examples, the first series **176***a* and the second series **176***b* may be spaced apart from each other and/or the respective surfaces **160**, **162** of the locking member **108**.

As shown in FIGS. **6**A and **6**B, the teeth **166** of the first series **176***a* of each lock element **164** are offset or staggered from the teeth **166** of the second series **176***b* of the respective lock element **164** in a direction extending along a length of the locking member **108**, such that the tips **172** of the teeth **166** of the first series **176***a* are aligned with the recesses **174** of the second series **176***b* along a direction from the bottom surface **160** to the top surface **162**. Likewise, the tips **172** of the teeth **166** of the second series **176***b* are aligned with the recesses **174** of the first series **176***a* along the direction from the bottom surface **160** to the top surface **162**. Accordingly, the teeth **166** of one of the series **176***a*, **176***b* overhang the recesses of the other one of the series **176***a*, **176***b*, and vice versa. As discussed in greater detail below, this staggered configuration of teeth **166** and recesses **174** advantageously restricts movement of the cable **202** along the direction from the bottom surface **160** to the top surface **162**, as the exposed edges of the teeth **166** between the bottom surface **160** and the top surface **162** cooperate to engage or grip the cable **202**.

With continued reference to FIGS. **6**A and **6**B, the first end **156** of the locking member **108** may include a tab portion **178** having flared protuberances **180** extending outwardly therefrom, and a pair of detents **182** formed between the protuberances **180** and the lock elements **164**. Generally, the protuberances **180** include a biasing surface **184** facing toward the first end **156** of the locking member **108** and a retention surface **186** facing in an opposite direction from the biasing surface **184**. The retention surface **186** defines a portion of the detent **182**. The biasing surfaces **184** of the protuberances **180** are configured to interface with the biasing surfaces **152** of the retention features **138** to spread the projections **148** apart from each other as the protuberances **180** pass between the projections **148** when the locking member **108** is moved towards the first end **116** of the housing **104**. The retention surfaces **186** of the protuberances **180** are configured to interface with the retention surfaces **150** of the retention features **138** to secure the locking member **108** in the unlocked state, as shown in FIG. **4**B.

The locking member **108** may include a first aperture **188** at the first end **156** formed through the thickness T_{108} of the locking member **108**. Particularly, the first aperture **188** is formed through the tab portion **178** of the locking member **108** for attaching a release cord **190** of the cable lock **100**. A second aperture **192** is formed through the second end **158** of the locking member **108**, and is configured for attaching the first biasing member **112** to the locking member **108**. In the illustrated example, the second aperture **192** is formed through a hook **194** disposed at the second end **158** of the locking member **108**.

Referring now to FIGS. **7**A-**7**C, steps for forming the locking member **108** are illustrated. Initially, as illustrated in FIG. **7**A, the locking member **108** is formed as a locking member blank **109**. The blank **109** includes a flat piece of material defining the features of the locking member **108** described above. In an initial stage, the blank **109** includes a first portion **195***a* formed at a first end of the blank **109**, a second portion **195***b* formed at a second end of the blank **109**, and an intermediate neck portion **195***c* disposed between and connecting the first portion **195***a* and the second portion **195***b*. The first portion **195***a* of the blank **109** includes the first series **176***a* of the teeth **166**, the protuberances **180** and detents **182**, a first portion of the first aperture **188**, and the hook **194**. The second portion **195***b* of the blank **109** includes the second series **176***b* of the teeth **166** and a second portion of the first aperture **188**.

The blank **109** may be formed by cutting or stamping the blank **109** from a sheet of material. In some examples, the blank **109** is formed using a progressive die, where the features (e.g., teeth **166**, protuberances **180**) are progressively formed in a series of stamping operations. The material of the blank is selected to impart desired characteristics of durability, machinability, and malleability. For example, suitable materials are capable of withstanding the bending steps associated with forming the locking member without cracking, but have a hardness sufficient to minimize degradation of the features **166**, **180** over a period of use. Aluminum alloys, such as AL5052, are examples of suitable materials.

A thickness of the material will be half of the finished thickness T_{108} of the locking member **108**, such that the thickness T_{108} of the locking member **108** is obtained when the first portion **195***a* is folded onto the second portion **195***b*. Following formation of the blank **109**, the blank **109** may be processed through a deburring and finishing step, where the blank **109** is treated to improve surface finish and remove excess material. Suitable processes for deburring and finishing may include abrasive and/or chemical processes, such as sandblasting, vibratory or tumbling finishing, sanding, filing, chemical treatments, or the like.

In another step, shown in FIG. **7**B, the locking member blank **109** may be processed through one or more operations to transition the locking member blank **109** to the locking member **108**. For example, the blank **109** may be processed through one or more machining processes to apply chamfers or rounded edges. As shown in FIG. **7**B, peripheral edges **189** of the first aperture **188** may be machined to provide a transition between the bottom and top surfaces **160**, **162** and the first aperture **188**. The transition may be embodied as a radius or chamfer.

The blank **109** may also be processed through one or more bending steps to transition the blank **109** from a flat piece of material to the folded locking member **108**. In one bending step B**1**, the first portion **195***a* of the blank **109** and the second portion **195***b* of the blank **109** are folded over upon each other by bending the blank **109** along the intermediate neck portion **195***c*. As discussed above, when the first portion **195***a* is folded over onto the second portion **195***b*, the first series **176***a* of teeth **166** formed on the first portion **195***a* are staggered or offset relative to the second series **176***b* of teeth **166** formed on the second portion **195***b*, as illustrated in FIG. **7**C. Accordingly, the recesses **174** of the first portion **195***a* overlap the teeth **166** of the second portion **195***b*, and vice versa. Furthermore, the first portion of the first aperture **188** formed in the first portion **195***a* of the blank **109** is aligned with the second portion of the first aperture **188** formed in the second portion **195***b* of the blank **109** to define the continuous aperture **188** extending through the thickness T_{108} of the locking member **108**.

In another bending step B**2**, the hook **194** formed on the first portion **195***a* of the blank **109** may be bent away from the bottom surface **160** of the locking member **108**. Accordingly, the second end **158** of the locking member **108**, which is formed by a distal end of the hook **194**, is positioned between the bottom surface **160** and the top surface **162**.

Referring back to FIGS. **4**A-**5**B, the locking member **108** includes the first biasing member **112** attached to the second end **158** and a release cord **190** attached to the first end **156**. As shown, the first biasing member **112** is a tension spring having a first end attached to the second end **158** of the locking member **108** and a second end attached to the second end **118** of the housing **104**. Accordingly, the first biasing member **112** is configured to apply a continuous engaging force F_E to the locking member **108** to bias the locking member **108** towards the locked state. In some examples, the second end **158** of the locking member **108** is substantially centered between the bottom surface **160** and the top surface **162**, such that an engaging force F_E applied to the second end **158** of the locking member **108** by the first biasing member **112** is also centered between the bottom surface **160** and the top surface **162**. Thus, the biasing force F_E extends substantially parallel to the longitudinal axis A_{108} of the locking member **108**.

Conversely, the release cord **190** is attached to the tab portion **178** at the first end **156** of the locking member **108** and is configured to transmit a selectively-applied release force F_R to the first end **156** of the locking member **108**. As discussed above and below and illustrated in FIGS. **4**B and **5**B, when the release force F_R is greater than the engaging force F_E, the locking member **108** will move from the locked state towards the unlocked state.

Referring now to FIG. **2**, the cable **202** includes a control portion **204** extending from the first openings **130***a* formed proximate to the first end **116**, a fastening portion **206** extending from the second openings **130***b*, and a locking portion **208** extending between the control portion **204** and the fastening portions **206**. The control portion **204** is configured to have a tightening force F_T applied thereto to move the cable **202** in the tightening direction D_T. When incorporated into the article of footwear **1000**, the control portion **204** may be arranged on the article of footwear **1000** so that it can be easily grasped by a user to pull the cable **202** in the tightening direction D_T. The fastening portion **206** is configured to cooperate with a tracking system to tighten the article of footwear **1000** when the tightening force F_T is applied to the control portion **204**. Conversely, the fastening portion **206** is also configured to have a loosening force F_L applied thereto to move the cable **202** in a loosening direction D_L. The locking portion **208** is disposed within the housing **104** and is configured to interface with the locking member **108** to secure the position of the cable **202** relative to the housing **104**.

In some examples, each of the control portion **204** and the fastening portion **206** may be referred to as including a first segment **210***a*, **212***a* and a second segment **210***b*, **212***b*. For example, as shown in FIGS. **1** and **2**, the control portion **204** may include a first control segment **210***a* extending from one of the first openings **130***a* to a first terminal end **211***a* and a second control segment **210***b* extending from the other one of the first openings **130***a* to a second terminal end **211***b*. Like the control portion **204**, the fastening portion **206** may include a first fastening segment **212***a* extending from one of the second openings **130***b* to first terminal end **213***a* and a second fastening segment **212***b* extending from the other of the first openings **130***a* to a second terminal end **213***b*.

The first segments **210***a*, **212***a* may be connected to the respective second segments **210***b*, **212***b* such that each of the control portion **204** and the fastening portion **206** form continuous lengths of the cable **202** extending between the openings **130***a*, **130***b*. For example, the terminal ends **211***a*, **211***b* of the segments **210***a*, **210***b* of the control portion **204** and/or the terminal ends **213***a*, **213***b* of the segments **212***a*, **212***b* of the fastening portion **206** may be connected to each other to form a continuous loop. Alternatively, at least one of the control portion **204** and the fastening portion **206** may include separated first segments **210***a*, **212***a* and second segments **210***b*, **212***b*. For example, the terminal ends **211***a*, **211***b* of the control portion **204** and/or the terminal ends **213***a*, **213***b* of the fastening portion **206** be separated from each other and independently attached to the article of footwear **1000**.

The locking portion **208** may also include first locking segment **214***a* and a second locking segment **214***b*. The first control segment **210***a* is connected to the first fastening segment **212***a* by a first locking segment **214***a*, and the second control segment **210***b* is connected to the second fastening segment **212***b* by the second locking segment **214***b*. Each of the first locking segment **214***a* and the second locking segment **214***b* are formed into lock elements **216** that interface with the lock elements **164** of the locking member **108** to secure a position of the cable **202** within the housing **104**. As described in greater detail below, the lock elements **216** of the cable **202** are formed into the segments **214***a*, **214***b* by the teeth **166** and recesses **174** of the lock elements **164** of the locking member **108** when in the locked position. FIG. **2** illustrates the resulting structure of the segments **214***a*, **214***b* when engaged by the teeth **166** and recesses **174**.

While an overall length of the cable **202** remains constant, effective lengths of the control portion **204** and the fastening portion **206** of the cable **202** depend upon the position of the cable **202** with respect to the cable lock **100**. For example, when the control portion **204** is pulled and the cable **202** moves in the tightening direction D_T through the cable lock **100**, the effective length of the control portion **204** will increase and the effective length of the fastening portion **206** will decrease. Conversely, when the fastening portion **206** is pulled and the cable **202** moves in the loosening direction D_L through the cable lock **100**, the effective length of the fastening portion **206** will increase to loosen the article of footwear **1000** and the effective length of the control portion **204** will decrease. As provided above, the locking portion **208** refers to the portion of the cable **202** that is contained within the cable lock **100**, regardless of the position of the cable **202**. Accordingly, the effective lengths of the control portion **204**, the fastening portion **206**, and the locking portion **208** are not fixed sections of the cable **202** itself, but depend on the position of the cable **202** with respect to the cable lock **100**.

With reference to FIGS. **2**, **5**A, and **5**B, at least a portion of the cable **202** may be embodied as a "flat" cable, where a height H_{202} of the cable **202** is greater than a width W_{202} of the cable **202**. Here, the cable **202** includes a top end **218***a* and a bottom end **218***b* formed on an opposite end of the cable **202** from the top end **218***a*. The cable **202** further includes an inner side **220***a* and an outer side **220***b* formed on an opposite side of the cable **202** from the inner side **220***a*. A distance between the ends **218***a*, **218***b* defines the height H_{202} of the cable **202**, while the distance between the sides **220***a*, **220***b* defines the width W_{202} of the cable **202**.

In the illustrated example, the sides **220***a*, **220***b* of the cable **202** are substantially straight from the top end **218***a* to the bottom end **218***b*, thereby providing the cable **202** with the substantially flat shape. Although the entire cable **202** is illustrated as embodying a substantially flat shape—having a height H_{202} greater than a width W_{202}—in some examples one or more of the portions **204**, **206**, **208** may have a rounded or circular cross-sectional shape, while others of the portions **204**, **206**, **208**. For example, the locking portion **208** may be formed with the flat shape, while the control portion **204** and the fastening portion **206** are rounded or circular.

Forming the cable **202**, or at least the locking portion **208** of the cable **202**, to have a relatively flat shape with a height H_{202} greater than a width W_{202} offers several benefits. For example, proper tracking of the flat cable **202** is more easily maintained through the housing **104**, and particularly through the locking channels **135**, as the sides **220***a*, **220***b* of the cable **202** are maintained in facing contact with the engagement surfaces **134** and the lock elements **164**. Additionally, minimizing the width W_{202} of the cable **202** consequently minimizes the distance that the locking member **108** must be moved to move the cable lock **100** to the unlocked state, as the width W_{135} of the locking channel **135** need only be greater than the width W_{202} of the cable **202** to allow movement of the cable **202** through the cable lock **100**.

In the illustrated example, the lock elements **216** of the cable **202** include a plurality of undulations **222** formed along the length of the locking portion **208** of the cable **202** by the teeth **166** and the recesses **174**. Here, a thickness or width W_{202} of the cable **202** is substantially constant along the length of the locking portion **208** such that the cable **202** has a wave-like profile. Accordingly, opposite sides **220***a*, **220***b* of the cable **202** are substantially parallel to each other. Here, the cable **202** has a beaded profile including a series of alternating wider portions and narrower portions, whereby the wider portions are caused by the teeth **166** splaying the cable **202** at the wider portions, thereby securing a position of the cable **202** relative to the housing **104** when the cable lock **100** is in the locked position. Particularly, the undulations **222** form an alternating series of peaks **224** and valleys **226** along the lock elements **216**, which cooperate with the teeth **166** of the locking member **108** to secure the cable **202**.

With continued reference to FIGS. **5**A and **5**B, at least the locking portion **208** of the cable **202** is formed with a height H_{202} that is less than the height H_{164} of lock elements **164**, whereby the top and bottom ends **218***a*, **218***b* of the cable **202** are respectively spaced inwardly from the top surface **162** and the bottom surface **160** of the locking member **108**. By forming the cable **202**, or at least the locking portion **208** of the cable **202**, with a height H_{202} that is less than the height of the lock elements **164**, the ends **218***a*, **218***b* of the cable **202** are maintained within the locking chamber **132** and are less susceptible to rubbing against the inner surface **124** or the cover **106**.

In addition to forming the cable **202** with lesser height H_{202} than the lock elements **164**, a vertical position of the locking portion **208** is maintained within locking chamber **132** by the offset between the first series **176***a* and the second series **176***b*. For example, as shown in FIG. **5**A, where the tips **172** of the upper second series **176***b* of teeth **166** overhang the recesses **174** of the lower first series **176***a* of teeth **166**, an exposed lower edge of each tooth **166** of the upper second series **176***b* will grip an intermediate portion of the inner side **220***a* of the cable **202** to restrict movement of the cable **202** towards the top surface **162** of the lock member **108**. Likewise, exposed upper edges of the teeth **166** of the lower first series **176***a* will grip the intermediate portion of the inner side **220***a* of the cable **202** to restrict movement of the cable **202** towards the bottom surface **160** of the lock member **108**.

The cable **202** may be may be formed from one or more fibers. For instance, the fibers may include polyethylene fibers. Additionally or alternatively, the cable **202** may be formed from a molded monofilament polymer and/or a woven steel with or without other lubrication coating. In some examples, the cable **202** includes multiple strands of material woven together.

FIGS. **4**A and **5**A provide views of the cable lock **100** with the cover **106** removed to show the locking member **108** disposed within the locking chamber **132** of the housing **104** while in the locked state. In some examples, the locking member **108** is biased into the locked state by the first biasing member **112**. For instance, FIGS. **4**A and **5**A show the first biasing member **112** exerting the engaging force F_E upon the locking member **108** to urge the second end **158** of the locking member **108** toward the second end **118** of the housing **104**, and thereby bias the locking member **108** into the locked state. While in the locked state, the locking member **108** restricts movement of the cable **202** relative to the housing **104** by pinching the locking segments **214***a*, **214***b* of the cable **202** between the engagement surfaces **134** of the housing **104** and the lock elements **164** of the locking member **108**. Accordingly, the locked state of the locking member **108** restricts the cable **202** from moving in the loosening direction D_L when the loosening force F_L is applied to the fastening portion **206**. In the example shown, the locking member **108** permits movement of the cable **202** when the tightening force F_T is applied to the cable **202**, as this direction causes the cable **202** to apply a force on the locking member **108** due to the wedge shape of the locking member **108**, thereby moving the locking member **108** toward the unlocked state. The locking member **108** automatically returns to the locked state once the force applied to the cable **202** is released due to the forces imparted on the locking member **108** by the biasing member **112**.

FIGS. **4**B and **5**B provide views of the cable lock **100** with the cover **106** removed to show the locking member **108** disposed within the locking chamber **132** of the housing **104** while in the unlocked position. In some examples, the release cord **190** attached to the tab portion **178** of the locking member **108** applies the release force F_R upon the locking member **108** to move the locking member **108** away from the engagement surfaces **134**. Here, the release force F_R is sufficient to overcome the engaging force F_E of the first biasing member **112** to permit the locking member **108** to move relative to the housing **104** such that the engagement of the locking segments **214***a*, **214***b* of the cable **202** between the lock elements **164** and the engagement surfaces **134** is released. In some examples, the engaging force F_E causes the locking member **108** to transition back to the locked position when the release force F_R applied by the release cord **190** is removed.

While in the unlocked state, the locking member **108** permits movement of the cable **202** relative to the housing **104** by allowing the locking segments **214***a*, **214***b* of the cable **202** to freely move between the respective lock elements **164** and the engagement surfaces **134**. The unlocked state of the locking member **108** permits movement of the cable **202** in both the tightening direction D_T and the loosening direction D_L when the pulling forces F_T, F_L are applied to respective ones of the control portion **204** and the fastening portion **206**. Movement of the cable **202** in the tightening direction D_T causes the effective length of the fastening portion **206** to decrease to move the article of footwear **1000** into the tightened state around the foot, while movement of the cable **202** in the loosening direction D_L allows an effective length of the fastening portion **206** to transition the article of footwear **1000** from the tightened state to the loosened state such that the foot can be removed.

In some examples, a sufficient magnitude and/or duration of the release force F_R applied to the release cord **190** causes the release cord **190** to apply the release force F_R upon the locking member **108** in a direction opposite the direction of the engaging force F_E such that the locking member **108** moves away from the engagement surfaces **134** relative to the housing **104** and toward the first end **116** of the housing **104**. At least one of the retention features **138** of the housing **104** may engage the detent **182** of the locking member **108** when release force F_R moves the locking member **108** a predetermined distance away from the engagement surfaces **134** of the housing **104**, as shown in FIG. **4**B. Here, engagement between the detents **182** of the locking member **108** and the at least one retention feature **138** of the housing **104** maintains the locking member **108** in the unlocked position once the release force F_R is released. The engaging force F_E of the first biasing member **112** and the forces exerted by the pair of second biasing members **114** on the retention features **138** lock the projections **148** of the retentions features **138** into engagement with the detents **182** of the locking member **108** after the locking member **108** moves the predetermined distance and the release force F_R is no longer applied.

In some scenarios, a release force F_R associated with a first magnitude may be applied to the release cord **190** to move the locking member **108** away from the engagement surfaces **134** by a distance less than the predetermined distance such that the retention features **138** do not engage. In these scenarios, the release force F_R associated with the first magnitude can be maintained when it is desirable to move the cable **202** in the loosening direction D_L (e.g., by applying the loosening force F_L to the fastening portion **206**) or the tightening direction D_T (e.g., by applying the tightening force F_T to the control portion **204**) for adjusting the fit of the article of footwear **1000** around the foot. Once the desired fit of the article of footwear **1000** around the foot is achieved, the release force F_R can be released to cause the locking member **108** to transition back to the locked position so that movement of the cable **202** is restricted in the loosening direction D_L and the desired fit can be sustained. It should be noted that even when the locking member **108** is in the locked position, the cable **202** can be moved in the tightening direction D_T. As such, once the loosening force F_L is released and a desired fit is achieved, the locking member **108** automatically retains the desired fit by locking a position of the cable **202** relative to the housing **104**.

In other scenarios, a release force F_R associated with a second magnitude greater than the first magnitude can be applied to the release cord **190** to move the locking member **108** the predetermined distance away from the engagement surfaces **134** to cause the corresponding retention features **138** to engage the detents **182**. Engagement of the retention features **138** is facilitated by providing the projections **148** of the retention features **138** with the tapered biasing surface **152** that opposes the locking member **108** to allow the locking member **108** to more easily move the retention features **138** against the biasing force FB imparted thereon by the second biasing members **114** when the release cord **190** is pulled the predetermined distance. In these scenarios, engagement between the corresponding retention features **138** and the detents **182** maintains the locking member **108** in the unlocked position when the release force F_R is released.

The locking member **108** is returned to the locked position when a tightening force F_T is applied to the control portion **204**. Namely, when the tightening force F_T is applied to control portion **204**, the first control segment **210***a* and the second control segment **210***b* are placed in tension, which exerts a force on the second biasing members **114** via the distal ends **144** of the tab **140** of the retention features **138**, as the first control segment **210***a* and the second control segment **210***b* pass through the first openings **130***a*. In so doing, the distal ends **144** of the retention features **138** compress the second biasing members **114** and cause the projections **148** of the retention features **138** to move away from one another. As a result, the retention features **138** disengage the detents **182** of the locking member **108**, allowing the first biasing member **112** to return the locking member **108** to the locked position.

With particular reference to FIGS. **8**-**10**B, a lock device **100***a* and the cable **202** of a tensioning system **10***a* are shown. In view of the substantial similarity in structure and function of the components associated with the tensioning system **10***a* with respect to the tensioning system **10**, like reference numerals are used hereinafter and in the drawings to identify like components while like reference numerals containing letter extensions are used to identify those components that have been modified.

In the example of FIGS. **8-10**B, the housing **104** and the cable **202** are the same as described above with respect to FIGS. **1-7**C. Here, the locking member **108***a* is formed as a unitary body. Accordingly, instead of being formed in a multi-step process where a first portion and a second portion are folded over upon each other, as described above, the locking member **108***a* may be formed in a single step by stamping or cutting the locking member **108***a* from a piece of material having a thickness corresponding to the desired thickness T_{108a} of the locking member **108**.

By forming the locking member **108***a* in a single-step process, each of the lock elements **164***a* is formed with a single series of teeth **166***a*. Accordingly, each of the teeth **166***a* may extend continuously along a direction from the bottom surface **160** of the locking member **108***a* to the top surface **162** of the locking member **108***a* to define a height H_{164a} of each of the lock elements **164***a*. In the illustrated example, the height H_{164a} of each of the lock elements **164** is the same as the thickness T_{108a} of the locking member, such that each of the teeth **166***a* extends continuously from the bottom surface **160** to the top surface **162**. As with the previous example, the height H_{164a} of the lock elements **164***a* is greater than the height H_{202} of the cable **202**. Accordingly, the top end **218***a* and the bottom end **218***b* of the cable **202** are spaced inwardly from the top surface **162** and the bottom surface **160** of the locking member **108***a*.

With reference to FIGS. **11-14**, examples of the article of footwear **1000-1000***c* incorporating the lock device **100** and tensioning system **200** are shown. Each of the articles of footwear includes an upper **1002** and a sole structure **1004**, **1004***a* attached to the bottom of the upper. In the example of FIG. **11**, the lock device **100**, **100***a* is disposed within the sole structure **1004**, such that the cable **202** and the release cord **190** are routed through the sole structure **1004** to exterior surfaces of the upper **1002**. The cable lock **100** may be disposed at other locations without departing from the scope of the present disclosure. For instance, the location of the cable lock **100** may be under the foot and may shift from the midfoot region to either one of the forefoot region or the heel region. In other configurations, shown in FIGS. **12-14**, the cable lock **100** may be disposed upon exterior surfaces of the upper **1002** at any suitable location, such as along the heel region of the upper **1002**, as shown in FIGS. **12** and **13**, or over the top of the foot (e.g., above the instep) on the upper **1002** or a tongue portion as shown in FIG. **14**. In other configurations, the cable lock **100** may be disposed within the interior void of the upper **1002** and between the inner surface of a strobel and a drop-in midsole.

Each of the control portion **204** and the fastening portion **206** are routed along the upper **1002** by a series of cable guides or conduits **1006**, which are arranged along the upper **1002** to distribute the tightening force F_T along the upper **1002** when the tightening force F_T is applied to the control portion **204**. The routing of the control portion **204**, the fastening portion **206**, and the release cord **190** may be adapted to accommodate a change in location for the cable lock **100** so that the upper **1002** may be moved between the loosened state and the tightened state. The passages enclosing the second end of the release cord **190** may be disposed at a lateral side or a medial side of the upper **1002**, or any other suitable location.

As discussed above, the cable lock **100**, **100***a* is operable between a locked state restricting movement of the cable **202** in the loosening direction D_L and an unlocked state permitting movement of the cable **202** in both the loosening direction D_L and the tightening direction D_T. In some implementations, the cable lock **100**, **100***a* permits movement of the cable **202** in the tightening direction D_T when the cable lock **100**, **100***a* is in the locked state. This arrangement allows the cable **202** to move in the tightening direction D_T each time the tightening force F_T is applied to the control portion **204** while restricting movement in either the tightening direction D_T or the loosening direction D_L when the tightening force F_T is released. In doing so, the article of footwear **1000-1000***c* can be incrementally tightened around the foot until a desired fit is achieved. In these implementations, the cable lock **100**, **100***a* must transition from the locked state to the unlocked state to permit the cable **202** to move in the loosening direction D_L when the loosening force F_L is applied to the fastening portion **206**. In other words, the cable **202** is restricted from moving in the loosening direction D_L when the loosening force F_L is applied to the fastening portion **206** unless the cable lock **100** is in the unlocked state.

The cable **202** is movable in the tightening direction D_T when a tightening force F_T is applied to the control portion **204** to pull the control portion **204** away from the upper **1100** to tighten the cable guides **412**, and thereby move the upper **1100** into the tightened state. For example, once a foot is received by article of footwear **1000-100***c* and supported upon the sole structure **1004**, **1004***a*, the upper **1002** may be automatically tightened to secure the fit around the foot by applying the tightening force F_T to the control portion **204** without the need of having to manually tie shoe laces or manually fasten other fasteners to tighten the upper **1002**. Here, the movement of the cable **202** in the tightening direction D_T causes an effective length of the control portion **204** to increase and an effective length of the fastening portion **206** to decrease. The decrease in the effective length of the fastening portion **206** is operative to tighten the upper **1002** around the foot such that the foot is secured within the article of footwear **1000-1000***c* while supported upon the sole structure **1004**, **1004***a*. Namely, decreasing the effective length of the fastening portion **206** exerts a tensioning force on the cable guides **1006**, thereby causing the cable guides **1006** to be drawn towards each other and tighten the upper **1002** around the foot.

In some examples, a desired fit of the interior void **1102** around the foot is adjustable based upon a magnitude of the tightening force F_T applied to the control portion **204**. For instance, increasing the magnitude of the tightening force F_T may move the cable **202** further in the tightening direction D_T such that the tightening of the cable guides **1006** along the upper **1002** increases to achieve a tighter fit around the foot. Additionally or alternatively, the fit of the article of footwear **1000-1000***c* around the foot may be adjustable based upon a duration of the tightening force F_T applied to the control portion **204**. For instance, tightening forces F_T applied to the control portion **204** for longer durations may result in the cable **202** moving a further distance in the tightening direction D_T to achieve a tighter fit of the interior void **1102** around the foot.

In the illustrated example, the cable **202** may be indirectly caused to move in the loosening direction D_L by pulling a loosening grip **1008** attached to a tongue portion of the upper

1002. For example, the when the loosening force F_L is applied to the loosening grip 1008, the tongue portion is pulled in a direction away from the upper 1002 to expand an interior cavity of the upper 1002. As a result of the tongue portion being pulled away from the upper 1002, the cable guides 1006 are pulled apart from each other, and the effective length of the fastening portion 206 is caused to increase. When the loosening force F_L is released from the loosening grip 1008, the upper 1002 may move to a relaxed state, whereby the increased effective length of the fastening portion 206 allows the upper 1002 to be expanded for donning or doffing of the footwear 1000. In other examples, the loosening force F_L may be applied directly to the fastening portion 206 to increase the effective length of the fastening portion 206. For example, the fastening portion 206 may include one or more pull tabs that can be grasped by the user for applying the loosening force F_L.

Accordingly, the footwear 1000 may be donned and doffed without having to untie shoe laces or unfasten one or more fasteners to loosen the upper 1002. Particularly, as the cable 202 moves in the loosening direction D_L, an effective length of the fastening portion 206 of the cable 202 is increased as the effective length of the control portion 204 is decreased. Here, the increase to the effective length of the fastening portion 206 allows the cable guides 1006 to move away from each other to facilitate a transition of the upper 1002 from the tightened state to the loosened state such that the foot can be removed.

The following Clauses provide exemplary configurations for an article of footwear, a cable lock, and a method in accordance with the principles of the present disclosure.

Clause 1: A cable lock comprising a housing including a first engagement surface and a second engagement surface spaced apart from the first engagement surface, and a locking member slideably disposed between the first engagement surface and the second engagement surface and including a first lock element opposing the first engagement surface to define a first locking channel and a second lock element opposing the second engagement surface to define a second locking channel, the first lock element (i) including a first series of teeth and a second series of teeth arranged in parallel with the first series of teeth and (ii) operable to engage a first portion of a cable disposed within the first locking channel and the second lock element (i) including a first series of teeth and a second series of teeth arranged in parallel with the first series of teeth of the second lock element and (ii) operable to engage a second portion of the cable disposed within the second locking channel.

Clause 2: The lock system of Clause 1, wherein the locking member includes a bottom surface and a top surface formed on an opposite side of the locking member from the bottom surface, the first series of teeth of the first lock element and the second lock element extending adjacent to the bottom surface and the second series of teeth of the first lock element and the second lock element extending adjacent to the top surface.

Clause 3: The lock system of any of the preceding Clauses, wherein the first series of teeth of the first lock element and the second lock element are staggered from the second series of teeth of the first lock element and the second lock element, respectively.

Clause 4: The lock system of any of the preceding Clauses, wherein the first series of teeth of the first lock element and the second lock element include a first series of recesses formed between adjacent ones of the teeth of the first series of teeth, each of the teeth of the second series of teeth of the first lock element and the second lock element being aligned with one of the recesses of the first series of recesses.

Clause 5: The lock system of Clause 4, wherein the second series of teeth of the first lock element and the second lock element include a second series of recesses formed between adjacent ones of the teeth of the second series of teeth, each of the teeth of the first series of teeth being aligned with one of the recesses of the second series of recesses.

Clause 6: The lock system of any of the preceding Clauses, wherein each of the first lock element and the second lock element is formed at an oblique angle relative to a longitudinal axis of the locking member.

Clause 7: The lock system of Clause 6, wherein the oblique angle ranges from 2 degrees to 12 degrees.

Clause 8: The lock system of Clause 6, wherein the oblique angle ranges from 4 degrees to 8 degrees.

Clause 9: The lock system of Clause 6, wherein the oblique angle is 6 degrees.

Clause 10: The lock system of Clause 6, wherein the first lock element is parallel to the first engagement surface and the second lock element is parallel to the second engagement surface.

Clause 11: The lock system of any of the preceding Clauses, wherein the cable has an inner side and an outer side formed on an opposite side of the cable from the inner side, a distance from the inner side to the outer side defining a width of the cable.

Clause 12: The lock system of Clause 11, wherein the inner side faces the first lock element and the second lock element, and the outer side faces the first engagement surface and the second engagement surface.

Clause 13: The lock system of Clause 12, wherein the cable has a top end and a bottom end disposed on an opposite end of the cable from the top end, a distance from the top end to the bottom end defining a height of the cable, the height of the cable being less than a height of the first lock element and the second lock element.

Clause 14: The lock system of Clause 13, wherein the height of the cable is greater than the width of the cable.

Clause 15: The lock system of Clause 13, wherein the inner side is substantially straight from the top end to the bottom end and the outer side is substantially straight from the top end to the bottom end.

Clause 16: The lock system of any of the preceding Clauses, further comprising a biasing spring operable to apply a biasing force and to bias the locking member toward a locked state.

Clause 17: The lock system of Clause 16, further comprising a release cord attached to the locking member and operable to move the locking member from the locked state to an unlocked state when a tensile force exceeding the biasing force of the biasing spring is applied to the release cord in an unlocking direction.

Clause 18: The lock system of Clause 17, wherein the release cord is attached to the locking member at an opposite end of the locking member than the biasing spring.

Clause 19: An article of footwear including the lock system of any of the preceding Clauses.

Clause 20: A locking member for a cable lock, the locking member comprising a first lock element extending along a direction from a first end of the locking member to a second end of the locking member, the first lock element including a first series of teeth and a second series of teeth in parallel with the first series of teeth, and a second lock element extending along the direction from the first end of the locking member to the second end of the locking member and formed on an opposite side of the locking member from the first lock element, the second lock element including a third series of teeth and a fourth series of teeth in parallel with the third series of teeth.

Clause 21: The locking member of Clause 20, further comprising a bottom surface and a top surface formed on an opposite side of the locking member from the bottom surface, the first series of teeth and the third series of teeth extending adjacent to the bottom surface, and the second series of teeth and the fourth series of teeth extending adjacent to the top surface.

Clause 22: The locking member of any of the preceding Clauses, wherein the first series of teeth is staggered from the second series of teeth, and the third series of teeth is staggered from the fourth series of teeth.

Clause 23: The locking member of any of the preceding Clauses, wherein the first series of teeth defines a first series of recesses, the teeth of the second series of teeth being aligned with the first series of recesses.

Clause 24: The locking member of any of the preceding Clauses, wherein the third series of teeth defines a second series of recesses, the teeth of the fourth series of teeth being aligned with the second series of recesses.

Clause 25: The locking member of any of the preceding Clauses, wherein each of the first lock element and the second lock element is formed at an oblique angle to a longitudinal axis of the locking member.

Clause 26: The locking member of Clause 25, wherein the oblique angle ranges from 2 degrees to 12 degrees.

Clause 27: The locking member of Clause 25, wherein the oblique angle ranges from 4 degrees to 8 degrees.

Clause 28: The locking member of Clause 25, wherein the oblique angle is 6 degrees.

Clause 29: An article of footwear including the locking member of any of the preceding Clauses.

Clause 30: A method of forming a locking member, the method comprising forming a locking member blank having a first thickness, the locking member blank including (i) a first portion including a first lock element and a second lock element formed on an opposite side of the first portion from the first lock element, (ii) a second portion including a third lock element and a fourth lock element formed on an opposite side of the second portion from the third lock element, and (iii) an intermediate portion connecting the first portion and the second portion, and bending the locking member blank along the intermediate portion to fold the first portion upon the second portion, the first lock element and the third lock element being arranged in parallel with each other, and the second lock element and the fourth lock element being arranged in parallel with each other.

Clause 31: The method of Clause 30, wherein forming the locking member blank includes forming each of the first lock element, the second lock element, the third lock element, and the fourth lock element with a series of teeth, each of the series of teeth defining a corresponding series of recesses disposed between adjacent ones of the teeth.

Clause 32: The method of Clause 31, wherein bending the locking member blank includes aligning the series of teeth of the first lock element with the series of recesses of the third lock element and aligning the series of teeth of the second lock element with the series of recesses of the fourth lock element.

Clause 33: The method of any of the preceding Clauses, further comprising deburring the locking member blank.

Clause 34: The method of any of the preceding Clauses, wherein the locking member blank is formed of a metal.

Clause 35: The method of any of the preceding Clauses, wherein the locking member blank is formed of an aluminum alloy.

Clause 36: The method of any of the preceding Clauses, wherein forming the locking member blank includes stamping the locking member blank in a progressive die.

The foregoing description has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular configuration are generally not limited to that particular configuration, but, where applicable, are interchangeable and can be used in a selected configuration, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

What is claimed is:

1. A lock system comprising:

a cable lock including:

a housing having a first engagement surface and a second engagement surface spaced apart from the first engagement surface;

a locking member slideably disposed between the first engagement surface and the second engagement surface;

one or more lock elements, forming a portion of the locking member, opposing at least one of the first engagement surface or the second engagement surface to define a locking channel, the one or more lock elements including a set of teeth and a set of recesses separating adjacent teeth; and

a cable including one or more lock segments having a series of undulations aligned with teeth of the set of teeth, wherein the cable has a substantially flat shape having a height and a width, wherein the height of the cable is greater than the width of the cable.

2. The lock system of claim **1**, wherein the one or more lock elements includes a first lock element including a first series of teeth and a first series of recesses separating adjacent teeth of the first series of teeth, and a second lock element including a second series of teeth and a second series of recesses separating adjacent teeth of the second series of teeth.

3. The lock system of claim **1**, wherein the cable has a rectangular cross-section.

4. The lock system of claim **2**, wherein the first lock element further includes a third series of teeth and a third series of recesses separating adjacent teeth of the third series of teeth, the third series of teeth arranged in parallel with the first series of teeth, and wherein teeth of the first series of teeth are aligned with respective recesses of the third series of recesses and teeth of the third series of teeth are aligned with respective recesses of the first series of recesses.

5. The lock system of claim **2**, wherein the second lock element includes a fourth series of teeth and a fourth series of recesses separating adjacent teeth of the fourth series of teeth, the fourth series of teeth arranged in parallel with the second series of teeth.

6. The lock system of claim **5**, wherein teeth of the second series of teeth are staggered from teeth of the fourth series of teeth.

7. The lock system of claim **5**, wherein teeth of the second series of teeth are aligned with respective recesses of the fourth series of recesses and teeth of the fourth series of teeth are aligned with respective recesses of the second series of recesses.

8. The lock system of claim **1**, wherein the series of undulations define a series of peaks and valleys alternating along a length of the respective lock segment, teeth of the set of teeth being received within respective valleys of the series of peaks and valleys in a locked state to restrict movement of the cable relative to the housing.

9. The lock system of claim **1**, wherein the cable further includes:

a first side extending along the height of the cable;

a second side, opposite the first side, extending along the width of the cable;

a first end; and

a second end opposite the first end,

wherein the first side and the second side are substantially straight from the first end to the second end.

10. The lock system of claim **9**, wherein the cable lock further includes:

one or more cable guides extending from an inner surface of the housing, wherein the first side of the cable directly contacts the one or more cable guides.

11. The lock system of claim **9**, wherein the series of undulations are formed in the first side.

12. The lock system of claim **9**, wherein the first side of the cable is maintained in facing contact with the one or more lock elements, and wherein the second side of the cable is maintained in facing contact with the each of the first engagement surface and the second engagement surface.

13. The lock system of claim **1**, wherein the housing comprises a first sidewall and a second sidewall, and wherein the height of the cable is substantially perpendicular to each of the first sidewall and the second sidewall.

14. An article of footwear including the lock system of claim **1**.

15. A lock system comprising:

a cable lock including:

a housing having a first engagement surface and a second engagement surface spaced apart from the first engagement surface;

a locking member slideably disposed between the first engagement surface and the second engagement surface;

one or more lock elements, forming a portion of the locking member, opposing at least one of the first engagement surface or the second engagement surface to define a locking channel, the one or more lock elements including a set of teeth and a set of recesses separating adjacent teeth; and

a substantially flat cable including one or more lock segments having a series of undulations aligned with teeth of the set of teeth.

16. The lock system of claim **15**, wherein one or more lock elements include a first lock element and a second element, and wherein the first lock element and the second lock element respectively splay a first lock segment and a second lock segment to create alternating wider portions and narrower portions along a length of the first lock segment and the second lock segment in a locked state.

17. The lock system of claim **15**, wherein the one or more lock segments include a series of peaks and valleys alternating along a length of the one or more lock segments, teeth of the set of teeth being received within respective valleys of the series of peaks and valleys in a locked state to restrict movement of the cable relative to the housing.

18. The lock system of claim **15**, wherein the cable further includes: a first side extending along a height of the cable; a second side, opposite the first side, extending along a width of the cable; a first end; and a second end opposite the first end, wherein the first side and the second side are substantially straight from the first end to the second end.

19. The lock system of claim **18**, wherein the height of the cable is substantially perpendicular to a side wall of the housing.

20. An article of footwear including the lock system of claim **15**.

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