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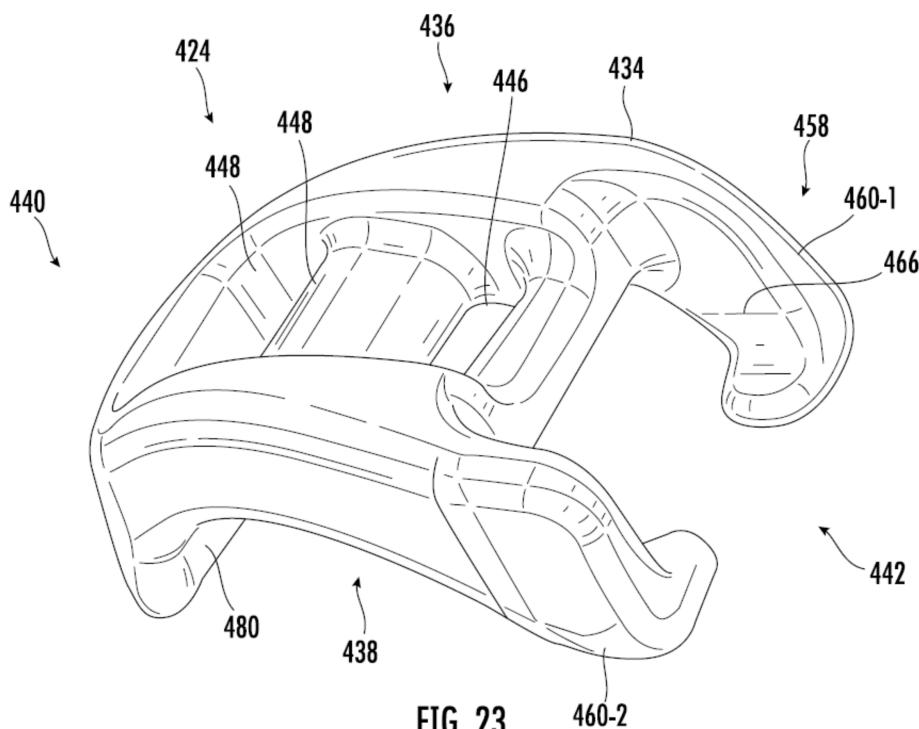
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(57) The buckle (424) includes a body (434) having a top face (436), a bottom face (438), a first longitudinal end (440) and a second longitudinal end (442). The first longitudinal end (440) has a first transverse width and the second longitudinal end (442) has a second transverse width greater than the first transverse width. The buckle further includes a first opening (444) through the

body (434), a second opening (446) through the body (434), and a bar (448) between the first opening (444) and the second opening (446). The buckle (424) may further include a vertical wall (480) and/or a retainer (458) to secure a flexible length to the buckle (424) once connected to the buckle (424).

**FIG. 23****EP 4 740 779 A1**

## Description

### BACKGROUND

**[0001]** Buckles are frequently used to releasably connect the end portions of flexible lengths such as straps, bands, cords, ropes, cables and the like. In some circumstances, a buckle may be used to releasably connect the end portions of a single flexible length so as to form a loop, such as for a waist belt, a harness or the like. In some circumstances, a buckle may be used to releasably connect the end portions of different flexible lengths to form a longer overall flexible length. Many buckles are designed with objectives that may work against one another. On one hand, it is desirable for the buckle to quickly and easily attach and detach the end portions. On the other hand, the buckle should reliably and securely connect the end portions with little chance of accidental disconnection.

### BRIEF DESCRIPTION OF THE DRAWINGS

#### [0002]

Figure 1 is a top view illustrating portions of an example connection system in a disconnected state.

Figure 2 is a sectional view of the connection system of Figure 1 during connection.

Figure 3 is a sectional view of the connection system of Figure 1 later during connection.

Figure 4 is a top view illustrating portions of the connection system of Figure 1 in a connected state.

Figure 5 is a sectional view of the connection system of Figure 4 in the connected state.

Figure 6 is a top view illustrating portions of an example connection system in a disconnected state.

Figure 7 is a sectional view of the connection system of Figure 6 during connection.

Figure 8 is a sectional view of the connection system of Figure 6 later during connection.

Figure 9 is a top view illustrating portions of the connection system of Figure 6 in a connected state.

Figure 10 is a sectional view of the connection system of Figure 4 in the connected state.

Figure 11 is a cross-sectional view of the connection system of Figure 6 in the connected state.

Figure 12 is a top view illustrating portions of an

example connection system in a disconnected state.

Figure 13 is a sectional view of the connection system of Figure 1 during connection.

Figure 14 is a sectional view of the connection system of Figure 12 later during connection.

Figure 15 is a top view illustrating portions of the connection system of Figure 12 in the connected state.

Figure 16 is a sectional view of the connection system of Figure 15 taken along line 16-16 and in the connected state.

Figure 17 is a sectional view of the connection system of Figure 15 taken along line 17-17 and in the connected state.

Figure 18 is a top view illustrating portions of an example connection system in a disconnected state.

Figure 19 is a sectional view of the connection system of Figure 18 during connection.

Figure 20 is a sectional view of the connection system of Figure 18 later during connection.

Figure 21 is a top view illustrating portions of the connection system of Figure 18 in a connected state.

Figure 22 is a cross-sectional view of the connection system of Figure 21 in the connected state.

Figure 23 is a perspective view of an example buckle.

Figure 24 is a front view of the example buckle of Figure 23.

Figure 25 is a rear view of the example buckle of Figure 23.

Figure 26 is a top view of the example buckle of Figure 23.

Figure 27 is a bottom view of the example buckle of Figure 23.

Figure 28 is a right side view of the example buckle of Figure 23.

Figure 29 is a left side view of the example buckle of Figure 23.

Figure 30 is a top view illustrating portions of an example connection system including the example buckle of Figure 23 and in a disconnected state.

Figure 31 is a top view of the example connection system of Figure 30 during connection.

Figure 32 is a side view of the example connection system of Figure 31 during connection.

Figure 33 is a top view of the example connection system of Figure 30 in a connected state.

Figure 34 is a side view of the example connection system of Figure 33 in the connected state.

Figure 35 is a front perspective view illustrating portions of an example harness including the example connection systems of Figure 33.

Figure 36 is a front perspective view illustrating portions of an example harness including the example connection systems of Figure 33.

**[0003]** Throughout the drawings, identical reference numbers designate similar, but not necessarily identical, elements. The figures are not necessarily to scale, and the size of some parts may be exaggerated to more clearly illustrate the example shown. Moreover, the drawings provide examples and/or implementations consistent with the description; however, the description is not limited to the examples and/or implementations provided in the drawings.

#### DETAILED DESCRIPTION OF EXAMPLES

**[0004]** Disclosed are various example buckles that address the competing objectives of (1) providing a quick, easy and intuitive connection and disconnection and (2) providing a secure and robust connection less susceptible to accidental disconnection. The example buckles achieve these objectives with a one-piece, single unit buckle that may be formed from a single integral unitary body or that may be formed from multiple body parts joined to one another, wherein reliance upon additional separate components for secure connection is optional. The example buckles may be used in various applications such as harnesses, belts and the like.

**[0005]** The example buckles comprise a body having a top face, a bottom face, a first longitudinal end and a second longitudinal end. Two openings are formed in the body with a bar separating and extending between the two openings. The bar is configured for use in a connection system, wherein the bar is to be connected to an end portion of a flexible length. For purposes of this disclosure, a "flexible length" may refer to a flexible strap, band, cord, cable or other flexible line. In some implementations, the end portion of the flexible length may be wound or wrapped about the bar and secured to itself by stitching, fusing, adhesives or the like. In some implementations, the end portion of the flexible length may include an additional connection component such as a hook that

releasably connects to the bar or a fastener that is crimped about the bar or otherwise connected to the bar. The flexible length extends from the bar (or from its connector) along a bottom face of the buckle towards and then away from the first longitudinal end of the buckle.

**[0006]** The connection systems in which the buckles are to be used further include a flexible length having a flexible loop. The flexible loop is sized such that an entirety of the buckle may pass through the loop. In some implementations, passing of the buckle through the loop may involve progressive stepwise bending or deformation of different portions of the loop as it is receiving the buckle. In some implementations, the loop may be elastic, wherein the loop may be resiliently stretched during reception of the buckle. The relative shapes and sizes of the buckle and the loop are such that once the buckle has been passed through the loop, the buckle and the loop are connected to one another and resist inadvertent withdrawal and disconnection of the buckle from the loop, especially when under tension. In some implementations, the flexible length having the flexible loop is the same flexible length connected to the bar of buckle. In other implementations, a first flexible length provides a flexible loop and a separate distinct flexible length is connected to the bar of the buckle.

**[0007]** In some implementations, the first longitudinal end has a first transverse width, and the second longitudinal end has a second transverse width greater than the first transverse width. In some implementations, the sides of the buckle may linearly taper from the wider second longitudinal end to the narrower first longitudinal end. In some implementations, the first longitudinal end may be pointed. In some implementations, the first longitudinal end may be rounded. In some implementations, the second longitudinal end may be flat or straight, parallel with the bar. In some implementations, the second longitudinal end may be convex, a polygon or concave.

**[0008]** The narrower width of the first longitudinal end facilitates easier slipping of the loop over the first longitudinal end, making connection and disconnection easier. In addition, the narrower width of the first longitudinal end provides a visual intuitive cue as to which end of the buckle the loop is to initially receive. The wider width of the second longitudinal end overlaps the underlying connected loop to a greater extent than the narrower first longitudinal end, reducing likelihood of the buckle inadvertently passing through the loop and becoming disconnected from the loop.

**[0009]** In some implementations, the buckle comprises a retainer in the form of retention arms on the bottom or underside of the buckle (the same bottom face of the buckle along which the end portion of the flexible length extends from the bar). The retention arms are located and sized so as to form an intermediate open channel into which the flexible loop and/or portions of the flexible length providing the flexible loop may be positioned. Once the flexible loop or portions of the associated

flexible length have been inserted into the channel formed by the retention arms, the retention arms engage the loop and/or flexible length to retain the loop or flexible length within the channel, inhibiting withdrawal from the channel. As result, the flexible loop and size or portions of the associate flexible length are held within the channel against the bottom face of the buckle to resist movement of the loop away from the buckle and to resist inadvertent passing of the buckle back through the loop. The retention arms further inhibit inadvertent rotation of the loop relative to the buckle (such as when the buckle and the loop are not in tension) to maintain the closed end of the loop along the first longitudinal end and about the buckle.

**[0010]** In some implementations, the retention arms may comprise a pair of bars longitudinally extending on both transverse sides of the bottom face of the buckle. In some implementations, the retention arms are located at the second longitudinal end of the buckle. In other implementations, the retention arms extend along a majority if not all of the longitudinal length of the buckle along the bottom face of the buckle, forming a longitudinal channel receiving and retaining portions of the flexible loop. In some implementations, the retention arms comprise inwardly extending portions forming catches or hooks that form a bottom of the channel, wherein the bottom face of the body opposite the hooks from the top of the channel and extends along a top face of the loop and wherein the hooks extend along a bottom face of the loop.

**[0011]** In some implementations, the retainer may be in the form of a single side-ways facing clip. The clip extends downwardly across an underside of the body of the buckle. The clip may be resiliently flexible. In such implementations, the loop and/or flexible length associated with the loop may be slid into the channel formed by the clip.

**[0012]** In some implementations, the body of the buckle is flat or planar. In some implementations, the body of the buckle is shaped such that the bottom face of the buckle is concave. The concave shape of the underside of the buckle may extend from the first opening to the second longitudinal end. The concave shape may form a transversely extending cavity that may receive portions of the loop to further assist in maintaining connection of the loop to the buckle.

**[0013]** In some implementations, the bottom side of the buckle may include a pair of retention rails or guide rails. The rail forming vertical channel into which the loop and such or flexible length may be received. The rails may inhibit inadvertent separation of the loop from the buckle.

**[0014]** In some implementations, the first longitudinal end of the buckle comprises a vertical wall downwardly extending from the bottom face of the buckle. The vertical wall provides a vertical surface facing the second longitudinal end of the buckle. In some implementations, the vertical wall may be perpendicular to the plane of the buckle or the top face of the flexible length. In other implementations, the vertical wall may be downwardly angled or oblique to the plane of the buckle of the top face

of the flexible length. In some implementations, the vertical wall may extend from a first transverse side or edge to a second transverse side or edge. In some implementations, the vertical wall may extend along only a portion of the total transverse width of the buckle.

**[0015]** The vertical wall assists in inhibiting movement of the flexible loop towards and beyond the first longitudinal end of the buckle to assist in retention of the loop about the buckle. After the buckle as an passed through the loop, the closed end the loop may be sandwiched between a top face of the end portion of the flexible length connected to the bar and an underside or bottom face of the buckle, with the closed end of the loop further sandwiched between upwardly bending portions of the top face of the end portion of flexible length connected to the bar and the vertical wall. The vertical wall may further assist in the securement of the loop over, around and onto the buckle by serving as a forward hook about which the closed end of the loop may be initially secured.

**[0016]** For purposes of this disclosure, the term "coupled" shall mean the joining of two members directly or indirectly to one another. Such joining may be stationary in nature or movable in nature. Such joining may be achieved with the two members, or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate member being attached to one another. Such joining may be permanent in nature or alternatively may be removable or releasable in nature.

**[0017]** For purposes of this disclosure, the phrase "configured to" denotes an actual state of configuration that fundamentally ties the stated function/use to the physical characteristics of the feature proceeding the phrase "configured to".

**[0018]** For purposes of this disclosure, the term "releasably" or "removably" with respect to an attachment or coupling of two structures means that the two structures may be repeatedly connected and disconnected to and from one another without material damage to either of the two structures or their functioning.

**[0019]** Figures 1-5 illustrate an example connection system 20 comprising an example buckle 24, a first end portion 26 of a flexible length 28 and a second end portion 30 of flexible length 28 or a different flexible length, the second end portion 30 comprising a loop 32. Figure 1 illustrates connection system 20 in a disconnected state. Figures 2 and 3 illustrate the connection of end portions 26 and 30 through the manipulation of buckle 24 and loop 32. Figures 4 and 5 illustrate connection system 20 in a connected state.

**[0020]** As shown by Figure 1, buckle 24 comprises a body 34 having a top face 36, a bottom face 38 (shown in Figure 5), a first longitudinal end 40 and a second longitudinal end 42. Two openings 44 and 46 are formed in the body 34 with a bar 48 separating and extending between the two openings. The bar 48 is connected to end portion 26 of a flexible length 28. In the example illustrated, end

portion 26 of flexible lengths 28 wraps or winds about bar 48 before being connected back to itself by stitching, adhesives or the like. In other implementations, the end portion 26 of the flexible length 28 may include an additional connection component such as a hook that releasably connects to the bar 48 or a fastener that is crimped about the bar 48 or otherwise connected to the bar 48. The flexible length 28 extends from the bar 48 (or from its connector) along the bottom face 38 of the buckle 24 towards and then away from the first longitudinal end 40 of the buckle 24.

**[0021]** Flexible loop 32 is sized such that an entirety of the buckle 24 may pass through the loop 32. In some implementations, passing of the buckle 24 through the loop 32 may involve progressive stepwise bending or deformation of different portions of the loop as it is receiving the buckle 24. In some implementations, the loop 32 may be elastic, wherein the loop 32 may be resiliently stretched during reception of the buckle. As shown by Figures 4 and 5, the relative shapes and sizes of the buckle 24 and the loop 32 are such that once the buckle 24 has been passed through the loop 32, the buckle 24 and the loop 32 are connected to one another and resist inadvertent withdrawal and disconnection of the buckle 24 from the loop 32, especially when under tension. In some implementations, the flexible length having the flexible loop 32 is the same flexible length connected to the bar of buckle 24. In other implementations, a first flexible length providing flexible loop 32 is separate distinct from the flexible length 28 that is connected to the bar 48 of the buckle 24.

**[0022]** As shown by Figure 1, the first longitudinal end 40 has a first transverse width W1 and the second longitudinal end 42 has a second transverse width W2 greater than the first transverse width W1. In the illustrated example, the sides of the buckle 24 linearly taper from the wider second longitudinal end 42 to the narrower first longitudinal end 40. In other implementations, the first longitudinal end 40 may be pointed. In other implementations, the first longitudinal end 40 may be rounded. In the illustrated example, the second longitudinal end 42 is flat or straight, parallel with the bar 48. In other implementations, the second longitudinal end 42 may be convex, a polygon or concave.

**[0023]** The narrower width of the first longitudinal end 40 facilitates easier slipping of the loop 32 over the first longitudinal end 40, making connection and disconnection easier. In addition, the narrower width of the first longitudinal end 40 provides a visual intuitive cue as to which end of the buckle 24 the loop 32 is to initially receive. The wider width of the second longitudinal end 42 overlaps the underlying connected loop 32 to a greater extent than the narrower first longitudinal end 40, reducing likelihood of the buckle inadvertently passing through the loop 32 and becoming disconnected from the loop 32.

**[0024]** Figures 2-5 illustrate the connection of the loop 32 to the buckle 24. As shown by Figure 2, the closed end

49 of loop 32 is brought over top of end 40 (as indicated by arrow 54). As shown by Figure 3, once the end 40 has passed through the opening 56 of loop 32, the loop 32 may be moved in a direction away from end portion 40, as indicated by arrow 57, and end portion 42 may be lifted through opening 56 as indicated by arrow 58. As should be appreciated, the relative movements of buckle 24 and loop 32 may be done in various different manners. As result, buckle 24 is completely passed through opening 56 into the connected state shown in Figure 4 and 5.

**[0025]** As shown by Figures 4 and 5, in the connected state, loop 32 is entirely below buckle 24. As shown by Figure 5, the closed end 49 of loop 32 is sandwiched between a top face of the end portion 26 of flexible length 28 and an underside or bottom face 38 of buckle 24. To actuate system 20 to a disconnected state, the closed end 49 is moved forwardly (to the left in Figure 4) and shaped such that the closed end 49 of loop 32 may be lifted over end portion 40 to permit buckle 24 to be moved to the left (as seen in Figure 4), withdrawing buckle 24 from opening 56 of loop 32 (generally the reverse of what is shown in Figures 2 and 3).

**[0026]** In the example illustrated, buckle 24 is integrally formed as part of a single unitary body. For example, buckle 24 may be molded as a single piece or part from one or more polymers, metals, fiber composite materials, ceramics or combinations thereof without any fasteners, welds, bonds or other mechanical or chemical connections. In other implementations, buckle 24 may be formed from multiple pieces which are joined to one another. For example, buckle 24 may be molded or otherwise formed as a single piece but for bar 48, wherein bar 48 comprises a separate rod or other piece held in place and secured to the molded body of buckle 24. In other implementations, the outer profile of buckle 24 may have other shapes other than the illustrated trapezoid.

**[0027]** Figures 6-11 illustrate portions of an example connection system 120 comprising an example buckle 124, a first end portion 26 of flexible length 28 and a second end portion 30 of flexible length 28 or a different flexible length, the second end portion comprising loop 32. Figure 6 illustrates connection system 120 in a disconnected state. Figures 7 and 8 illustrate connection of end portions 26 and 30 through the manipulation of buckle 124 and loop 32. Figures 9-11 illustrate connection system 120 in a connected state.

**[0028]** Buckle 124 is similar to buckle 24 except that end portion 140 of buckle 24 is not narrower than end portion 142. In addition, buckle 124 further comprises retainer 158. Those remaining components of buckle 124 which correspond to components of buckle 24 are numbered similarly. In other implementations, end portion 140 may alternatively be narrower than end portion 142 for the benefits described above with respect to buckle 24. Buckle 124 may have the shape shown in Figure 1.

**[0029]** Retainer 158 is configured to extend at least partially along a bottom face of loop 32 and/or the portion

of the flexible length associated with loop 32 so as to retain loop 32 in place, secured to buckle 124. In the example illustrated, retainer 158 comprises a pair of opposing retention arms 160-1 and 160-2 (collectively referred to as arms 160). Retention arms 160 project downwardly from bottom face 38 of buckle 124 and are configured to contact or engage loop 32 to inhibit transverse outward movement of portions of loop 32 relative to buckle 24. In the example illustrated, retention arms 160 are in the form of inwardly projecting tabs or hooks that further inhibit movement of loop 32 in a direction downward away from the bottom face 38 of buckle 124. As shown by Figure 11, retention arm 160-1 extends on a first transverse side of the body 134 at the second longitudinal end 142, the first retention arm 160-1 extending downwardly and inwardly towards a second transverse side of the body. Retention arm 160-2 extends on the second transverse side of the body 134 at the second longitudinal end 142, the second retention arm 160-2 extending downwardly and inwardly towards the first transverse side of the body.

**[0030]** As shown by Figure 7 and 8, movement of loop 32 and buckle 124 to the connected state shown in Figure 9-11 is similar to the movement shown in Figure 2 and 3 except that actuation to the connected state may further involve the movement shown in Figure 8. As shown by Figure 8, once the body 134 of buckle 124 has passed through opening 56 of loop 32, the loop 32 and/or connected portions of flexible length 28 are lifted (as indicated by arrow 163) and inwardly moved or bent so as to position portions of loop 32 and/or flexible length 28 within the bottom opened channel 166 formed by the bottom face 38 of buckle 124 and retention arms 160, inhibiting withdrawal from the channel 166. As result, the flexible loop and/or portions of the associate flexible length are held within the channel 166 against the bottom face 38 of the buckle 124 to resist movement of the loop 32 away from the buckle 124 and to resist inadvertent passing of the buckle 124 back through the loop 32. The retention arms 160 further inhibit inadvertent rotation of the loop 32 relative to the buckle 124 (such as when the buckle 124 and the loop 32 are not in tension) to maintain the closed end 49 of the loop 32 along the first longitudinal end 140 and about the buckle 124. The inwardly extending projections 170 of arms 160 form catches or hooks that form a bottom of the channel 166, wherein the bottom face 38 of the body 134 opposite the hooks form the top of the channel 166 and wherein the hooks or inward projections 170 extends along a bottom face of the loop 32 and form a bottom of the channel 166. In some implementations, the inwardly extending projections 170 may be omitted.

**[0031]** Figures 12-17 illustrates portions of an example connection system 220. Figure 12 illustrates connection system 220 in a disconnected state. Figures 13 and 14 illustrate the connection of end portions 26 and 30 through the manipulation of buckle 224 and loop 32. Figures 14-17 illustrate connection system 120 in a con-

nected state. System 220 is similar to system 120 described above except that system 220 comprises a buckle 224 having a differently shaped body 234 and additionally comprising retention rails 262-1, 262-2, in addition to retention arms 160-1 and 160-2 described above. Those remaining components of system 220 which correspond to components of system 120 are numbered similarly.

**[0032]** Similar to body 34 of buckle 24, body 234 of buckle 224 comprises a narrower end portion 240 and a wider longitudinal end portion 242. End portion 240 becomes narrower (in the transverse direction) by being rounded or curved, having a convex front edge facing away from end portion 242.

**[0033]** End portion 242 has a concave rear edge facing away from end portion 240. The pair of convex and concave front and rear edges provided visual cue as to which end of body 234 that the opening 56 of loop 32 should be initially placed over for connection. In other implementations, end portion 242 may have a straight or convex edge. In other implementations, the curvature (radii) of end portion 240, 242 may be larger or smaller than that shown. In yet other implementations, body 234 may have a shape similar to that shown in figure 1 or other shapes as described above with respect to body 34.

**[0034]** Retention rails 262 project downwardly, away from lower or bottom surface 38 of body 234 adjacent to or proximate to the two opposite transverse sides of body 234. In the example illustrated, rails 262 each project away from bottom face 38 by distance greater than or equal to the thickness of the strap or other line forming loop 32. Retention rails 262 are configured to form a longitudinal channel for containing loop 32 when loop 32 is secured to buckle 224. Retention rails 262 assist in maintaining loop 32 in the connected state by preventing transverse movement of loop 32 when connected. Although each of retention rails 262 is illustrated as a single elongate downwardly projecting bar extending across a majority, if not all of the longitudinal length of body 234, in other implementations, retention rails 262 may have a shorter length or may be composed of multiple spaced individual segments extending in a row. Although each of retention rails 262 is illustrated as having a uniform height along the length, in other implementations, such retention rails 262 and have a varying height along its length. For example, each of retention arm to see may have a greater height proximate to end portion 240. In some other implementations, each of retention rails 262 may have a greater height proximate to end portion 242. As should be appreciated, retention rails 262 may likewise be added to any of the other example buckles described above or hereafter. In some implementations, retention rails 262 may be omitted.

**[0035]** As shown by Figure 13 and 14, movement of loop 32 and buckle 224 to the connected state shown in Figure 14-17 is similar to the movement shown in Figure 2 and 3 except that actuation to the connected state may further involve the movement shown in Figure 14. As

shown by Figure 14, once the body 234 of buckle 224 has passed through opening 56 of loop 32, the loop 32 and/or connected portions of flexible length 28 are positioned between retention rails 262 and further lifted (as indicated by arrow 263) and inwardly moved or bent so as to position portions of loop 32 and/or flexible length 28 within the bottom open channel 166 formed by the bottom face 38 of buckle 124 and retention arms 160, inhibiting withdrawal from the channel 166. As result, the flexible loop and/or portions of the associated flexible length are held within the channel 166 against the bottom face 38 of the buckle 124 to resist movement of the loop 32 away from the buckle 124 and to resist inadvertent passing of the buckle 224 back through the loop 32. The retention arms 160 and rails 262 further inhibit inadvertent rotation of the loop 32 relative to the buckle 124 (such as when the buckle 124 and the loop 32 are not in tension) to maintain the closed end 49 of the loop 32 along the first longitudinal end 140 and about the buckle 224. The inwardly extending projections 170 of arms 160 form catches or hooks that form a bottom of the channel 166, wherein the bottom face 38 of the body 134 opposite the hooks form the top of the channel 166 and wherein the hooks or inward projections 170 extends along a bottom face of the loop 32 and form a bottom of the channel 166. In some implementations, the inwardly extending projections 170 may be omitted.

**[0036]** Figures 18-22 illustrates portions of an example connection system 320. Figure 18 illustrates connection system 320 in a disconnected state. Figures 19 and 20 illustrate connection of end portions 26 and 30 through the manipulation of buckle 324 and loop 32. Figures 20-22 illustrate connection system 320 in a connected state. System 320 is similar to system 120 described above except that system 320 comprises a buckle 324 having a differently shaped body 334 and comprises a retainer 358 in place of retainer 158. Those remaining components of system 320 which correspond to components of system 120 are numbered similarly.

**[0037]** Body is similar to body 134 of buckle 124 described above except that body 234 is widest at a longitudinal midpoint and narrow at both opposite longitudinal ends. In the example illustrated, body 334 has a shape of a diamond. The two pointed ends of body 334 facilitate easier disconnection of loop 32 from buckle 324 from either end. The wider midportion assists in inhibiting accidental withdrawal of buckle 324 from loop 32. In the example illustrated, retainer 358 is located near the widest portion of body 334, near or at the longitudinal midpoint of body 334 to enhance securement and retention of loop 32 once positioned about and below body 334.

**[0038]** In contrast to retainer 158 which comprises a pair of inwardly extending prongs or tabs that form the channel 166, retainer 358 is in the form of a single clip 360 suspended from the bottom face 38 of body 334. In the example illustrated, the clip serving as retainer 158 extends from one transverse side and across substantially

the entirety of body 334 so as to underlie both sides (on opposite sides of the opening 56) of the loop 32. In other implementations, the clip 360 serving as retainer 158 may have a shorter length.

**[0039]** As shown by Figure 22, in the example illustrated, clip 360 forms a channel 366 that has a single sideways facing mouth 367. In the example illustrated, clip 360 further comprises an upwardly extending catch or lip 369 along the mouth to assist in retaining the loop 32 within channel 366. In some implementations, the clip 360 is dimensioned and formed from a material such that clip 360 is resiliently flexible or bendable at its connection end 373 and/or along the length of the arm 375 forming clip 360 to further facilitate opening of mouth 367 and insertion of loop 32. Although clip 360 is illustrated as being centrally located between the two longitudinal ends of body 334, the widest of body 334, in other implementations, clip 360 may be provided at other locations along body 334. Additionally, retainer 358 may be used in lieu of retainer 158 in any of the above-described implementations or as a retainer in the implementation described below with respect to Figures 23-36. In such implementations, retainer 358 may extend across the respective body at or near the widest point along the longitudinal length of the respective body. For example, retainer 358 (clip 360) may be provided on the underside or bottom face the buckle at or near the longitudinal end 142 of each of the above-described buckles 24, 124 and 224.

**[0040]** As shown by Figures 19 and 20, loop 32 is secured to buckle 324 in a fashion similar to that described above with respect to buckle 124. As described above, once buckle 324 is passed through opening 56 of loop 32 (as shown in Figure 19), portions of the loop 32 and/or the associated flexible length 28 are lifted (as indicated by arrow 363) and manipulated (at once or in a progressive stepwise manner, the left side of flexible length being inserted followed by insertion of the right side of the flexible length) to position loop 32 and/or associated portions of the flexible length within the channel 166 formed by the clip 360.

**[0041]** Figures 23-29 illustrate an example buckle 424 for use as part of an example connection system 420 (shown in Figure 30-36). Buckle 424 comprises a body 434 having a top face 436 (shown in Figure 27), a bottom face 438 (shown in Figure 26), a first longitudinal end 440 and a second longitudinal end 442. Two openings 444 and 446 are formed in the body 434 with a bar 448 separating and extending between the two openings. As shown in Figure 32, the bar 448 is connected to end portion 26 of a flexible length 28. In the example illustrated, end portion 26 of flexible length 28 wraps or winds about bar 48 before being connected back to itself by stitching, adhesives or the like. In other implementations, the end portion 26 of the flexible length 28 may include an additional connection component such as a hook that releasably connects to the bar 448 or a fastener that is crimped about the bar 448 or otherwise connected to the bar 48. The flexible length 28 extends from the bar 448 (or from its

connector) along the bottom face 438 of the buckle 424 towards and then away from the first longitudinal end 440 of the buckle 424.

**[0042]** Flexible loop 32 of connection system 420 is similar to that of connection systems 20, 120, 220, and 320, described above. Flexible loop 32 is sized such that an entirety of the buckle 424 may pass through the loop 32. In some implementations, passing of the buckle 424 through the loop 32 may involve progressive stepwise bending or deformation of different portions of the loop as it is receiving the buckle 424. In some implementations, the loop 32 may be elastic, wherein the loop 32 may be resiliently stretched during reception of the buckle. As shown by Figure 33, the relative shapes and sizes of the buckle 424 and the loop 32 are such that once the buckle 424 has been passed through the loop 32, the buckle 424 and the loop 32 are connected to one another and resist inadvertent withdrawal and disconnection of the buckle 424 from the loop 32, especially when under tension. In some implementations, the flexible length having the flexible loop 32 is the same flexible length connected to the bar 448 of buckle 424. In other implementations, a first flexible length providing flexible loop 32 is separate and distinct from the flexible length 28 that is connected to the bar 448 of the buckle 424.

**[0043]** As shown by Figure 26, the first longitudinal end 440 has a first transverse width  $W_1$  and the second longitudinal end 442 has a second transverse width  $W_2$  greater than the first transverse width  $W_1$ . In the illustrated example, the sides of the buckle 424 linearly taper from the wider second longitudinal end 442 to the narrower first longitudinal end 440. In other implementations, the first longitudinal end 440 may be pointed. In other implementations, the first longitudinal end 440 may be rounded. In the illustrated example, the second longitudinal end 442 is flat or straight, parallel with the bar 448. In other implementations, the second longitudinal end 442 may be convex, a polygon or concave.

**[0044]** The narrower width of the first longitudinal end 440 facilitates easier slipping of the loop 32 over the first longitudinal end, making connection and disconnection easier. In addition, the narrower width of the first longitudinal end 440 provides a visual intuitive cue as to which end of the buckle 424 the loop 32 is to initially receive. The wider width of the second longitudinal end 442 overlaps the underlying connected loop 32 to a greater extent than the narrower first longitudinal end 440, reducing likelihood of the buckle inadvertently passing through the loop 32 and becoming disconnected from the loop 32.

**[0045]** As shown by Figures 23 and 26, buckle 124 further comprises retainer 458. Retainer 458 is configured to extend at least partially along a bottom face of loop 32 and/or the portion of the flexible length associated with loop 32 so as to retain loop 32 in place, secured to buckle 424. In the example illustrated, retainer 458 comprises a pair of opposing retention arms 460-1 and 460-2 (collectively referred to as arms 460). Retention arms 460 project downwardly from bottom face 438 of buckle 424

and are configured to contact or engage loop 32 to inhibit transverse outward movement of portions of loop 32 relative to buckle 24. In the example illustrated, retention arms 460 are in the form of inwardly projecting tabs or hooks that further inhibit movement of loop 32 in a direction downward away from the bottom face 38 of buckle 124. As shown by Figure 23 and 25, retention arm 460-1 extends on a first transverse side of the body 434 at the second longitudinal end 442, the first retention arm 460-1 extending downwardly and inwardly towards a second transverse side of the body. Retention arm 460-2 extends on the second transverse side of the body 434 at the second longitudinal end 442, the second retention arm 460-2 extending downwardly and inwardly towards the first transverse side of the body. As indicated above, in some implementations, the retainer 458 formed by retention arms 460 may be replaced with a single clip, such as the clip 360 described above with respect to buckle 324.

**[0046]** As shown by Figures 28 and 29, the body of the buckle is shaped such that the bottom face 438 of the buckle is concave. The concave shape of the underside of the buckle may extend from the first opening 444 to the second longitudinal end 442. The concave shape may form a transversely extending cavity that may receive portions of the loop 32 to further assist in maintaining connection of the loop 32 to the buckle 424.

**[0047]** As shown by Figures 25 and 27, the first longitudinal end 440 of the buckle 424 comprises a vertical wall 480 downwardly extending from the bottom face 438 of the buckle 424. The vertical wall 480 provides a vertical surface facing the second longitudinal end 442 of the buckle. In some implementations, the vertical wall 480 may be perpendicular to the plane of the buckle 424 or the top face of the flexible length 28. In other implementations, the vertical wall 480 may be downwardly angled or oblique to the plane of the buckle of the top face of the flexible length. As shown by Figure 7, vertical wall 480 may be concave, having a radius similar to or corresponding to the radius of the closed end 49 of loop 32, the concave profile facing rearwardly towards longitudinal end 442. In some implementations, the vertical wall 480 may extend from a first transverse side or edge to a second transverse side or edge. In some implementations, vertical wall 480 may extend along only a portion of the total transverse width of the buckle 424. The vertical wall 480 assists in inhibiting movement of the flexible loop 32 towards and beyond the first longitudinal end 440 of the buckle to assist in retention of the loop 32 about the buckle 424. After the buckle 424 as an passed through the loop 32, the closed end 49 of the loop 32 may be sandwiched between a top face of the end portion of the flexible length 28 connected to the bar 448 and an underside or bottom face 438 of the buckle 424, with the closed end 49 of the loop 32 further sandwiched between upwardly bending portions of the top face of the end portion of flexible length 28 connected to the bar 448 and the vertical wall 480. The vertical wall 480 may further assist

in the securement of the loop 32 over around and onto the buckle 424 by serving as a forward hook about which the closed end 49 of the loop 32 may be initially secured.

**[0048]** In the example illustrated, buckle 424 is integrally formed as part of a single unitary body. For example, buckle 424 may be molded as a single piece or part from one or more polymers (such as thermoplastics), metals (such as aluminum), ceramics, composite materials and/or fiber composite materials. In other implementations, the buckle 424 may be formed without any fasteners, welds, bonds or other mechanical or chemical connections. In other implementations, buckle 424 may be formed from multiple pieces which are joined to one another. For example, buckle 424 may be molded or otherwise formed as a single piece but for bar 448, wherein bar 448 comprise a separate rod or other piece held in place and secured to the molded body of buckle 424. In other implementations, the outer profile of buckle 424 may have other shapes other than the illustrated trapezoid.

**[0049]** Figures 30-34 illustrate the movement of loop 32 and buckle 424 to the connected state shown in Figures 33 and 34. As shown by Figure 30, the closed end 49 of loop 32 is brought over top of end 440 (as indicated by arrow 454). As shown by Figure 3, once the end 440 has passed through the opening 56 of loop 32, the loop 32 may be moved in a direction away from end 440 (as indicated by arrow 456), and end portion 42 may be lifted through opening 56 (or loop 32 may be lowered over and past end 442). As should be appreciated, the relative movements of buckle 24 and loop 32 may be done in various different manners. As result, buckle 424 is completely passed through opening 56 into the connected state shown in Figure 32.

**[0050]** As shown by Figures 32, in the connected state, loop 32 is entirely below buckle 424. The closed end 49 of loop 32 is sandwiched between a top face of the end portion 26 of flexible length 28 and an underside or bottom face 438 of buckle 424. To actuate system 22 a disconnected state, the closed end 49 is moved forwardly (to the left in Figure 33) and shaped such that the closed end 49 of loop 32 may be lifted over end 440 to permit buckle 424 to be moved to the right (as seen in Figure 31), withdrawing buckle 424 from opening 56 of loop 32 (generally the reverse of what is shown in Figures 31 and 32).

**[0051]** As shown by Figures 33 and 34, once the body 434 of buckle 424 has passed through opening 56 of loop 32, the loop 32 and/or connected portions of flexible length 28 are lifted and inwardly moved or bent so as to position portions of loop 32 and/or flexible length 28 through the opening 467 (shown in Figure 26) between arms 460 and into channel 466 formed by the bottom face 438 of buckle 424 and retention arms 460, inhibiting withdrawal from the channel 466. As result, the flexible loop and/or portions of the associated flexible length are captured and held within the channel 466 against the bottom face 438 of the buckle 424 to resist movement of

the loop 32 away from the buckle 424 and to resist inadvertent passing of the buckle 424 back through the loop 32. The retention arms 460 further inhibit inadvertent rotation of the loop 32 relative to the buckle 424 (such as when the buckle 424 and the loop 32 are not in tension) to maintain the closed end 49 of the loop 32 along the first longitudinal end 440 and about the buckle 424. The inwardly extending projections 470 of arms 460 form catches or hooks that form a bottom of the channel 166, wherein the bottom face 38 of the body 434 opposite the hooks form the top of the channel 466 and wherein the hooks or inward projections 470 extends along a bottom face of the loop 32 and form a bottom of the channel 166. In some implementations, the inwardly extending projections 470 may be omitted.

**[0052]** Figure 35 and Figure 36 illustrate two different examples of a harness 520 having connection systems 420. Each of the example harnesses 520, 520' comprises three primary components: a waist belt 524 (sometimes referred to as a "swami") and a pair of leg loops 526-R and 526-L (collectively referred to as leg loops 526). In some implementations, harness 520 may comprise additional primary components that encircle or wrap about the shoulders and/or chest of the person wearing harness 520. Waist belt 524 is configured to support leg loops 526 from the waist of a person wearing harness 520. Waist belt 524 is further configured to be attached to a tether, rope, cable or other flexible line from which waist belt 524 may be suspended from an upper support to limit an extent to which waist belt 524 and the person wearing harness 520 may fall from the upper support. Waist belt 524 comprises wide band portion 530, narrow extension portions 532-1, 532-2 (collectively referred to as narrow extension portions 532), connector 534, tether support line connectors 536 and gear loops 538).

**[0053]** Wide band portion 530 comprises an elongate band configured to wrap about the waist of the person wearing harness 520. Wide band portion 530 has a width so as to distribute forces along a larger surface area (as compared to a single straight line) to providing enhanced comfort to the person wearing harness 520. Wide band portion 530 has a nonuniform width along its length, being wider along a rear portion 539 and narrower along front-end portions 540-1, 540-2. In some implementations, wide band portion 530 is configured to rest upon the iliac crest of a person's hip bones. In such implementations, wide band portion 530 may have a curved configuration similar to that of a banana.

**[0054]** Narrow extension portions 532-1 and 532-2 extend from front end portions 540-1, 540-2, respectively, of wide band portion 530. Narrow extension portions 532 each have a width less than that of rear portion 539 and, in the example illustrated, less than at least portions of front-end portions 540. In the example illustrated, narrow extension portions 532 comprise straps that are each joined to connector 534. In the example illustrated in which connector 534 comprises a buckle or pair rungs, wherein at least one of narrow extension portions 532 is config-

ured to thread through the rungs or the buckle to provide an adjustable length for waist belt 524.

**[0055]** Connector 534 releasably connects narrow extension portions 532 to secure waist belt 524 about the waist of the person wearing harness 520. In the example illustrated, connector 534 comprises a quick disconnect connector in the form of a side release buckle. In the example illustrated, the side release buckle is joined to narrow extension portions 532-1 to provide narrow extension portions 532-1 with an adjustable length extending between front-end portions 540-1 and connector 534. In other implementations, narrow extension portions 532-1 may be joined to connector 534 with a fixed length between end portions 540-1 and connector 534. In yet other implementations, connector 534 may comprise other forms of a connector.

**[0056]** Tether support line connector 536, sometimes referred to as a belay loop such as shown in Figure 35, provides a connection point for a tether support line, in the form of a rope, cable, strap or the like configured to be suspended from an upper support. Referring to Figure 36, tether support line connector 536 comprises the two loops formed by upper end portions of the narrow extension portions 556 of the leg loops 526, wherein the tether support line is "tied into" the two loops. In some implementations, such loops may be formed from materials such as nylon, polyester, ultra-high molecular weight yarns, liquid crystal polymers such as VECTRAN™, or other fibers.

**[0057]** Gear loops 538 comprise loops extending from wide band portion 30. Gear loops 538 are configured to be attached to various pieces of gear that may be hung from waist belt 524. In some implementations, waist belt 524 may include additional gear loops 538.

**[0058]** Leg loops 526-R and 526-L extend from and are suspended from the right and left front sides, respectively, of waist belt 524. Leg loops 526-R and 526-L are configured to be wrapped about the right and left thighs, respectively, of the person wearing harness 520. Leg loops 526 are substantially identical to one another. Leg loops 526 each comprise wide band portion 550, narrow extension portion 552, connection system 420, narrow extension portion 556 and leg loop riser 558.

**[0059]** Wide band portion 550 comprises a wide band configured to underlie a person's thighs while spreading or distributing forces across a wider surface area to provide enhanced comfort to the thighs of the person wearing harness 520. Wide band portion 550 has a nonuniform width along its length, tapering as it approaches each of narrow extension portions 552 and 556. In such implementations, wide band portion 550 may have a curved configuration similar to that of a banana. Wide band portion has a minimum widest width of 43 mm when used as part of a waist belt and a minimum widest width of 43 mm when employed as part of a leg loop.

**[0060]** Narrow extension portion 552 extends from wide band portion 550 so as to extend along an inner

thigh of the person wearing harness 520. Narrow extension portion 552 provides a length that may be more flexible, bendable or twistable as compared to wide band portion 550. In the example illustrated, narrow extension portion 552 has a maximum transverse width that is no greater than 75% to of the maximum transverse width of wide band portion 550.

**[0061]** Buckle 424 of connection system 420 releasably connects an end of wide band portion 550 to narrow extension portion 556 so as to complete the loop about the person's thigh.

**[0062]** Narrow extension portion 556 extends from wide band portion 550 and is joined or connected to waist belt 524. Narrow extension portions 556 of leg loops 526 are joined to one another (or are part of a single integral strap, band, cord or the like) that passes through tether support line connector 536 (belay loop 536). Referring to Figure 36, each of narrow extension portions 556 can be further interconnected by a cross piece 537 to form a tie-in point or loop 559. In other implementations, narrow extension portion 556 is connected to waist belt 524 in other fashions.

**[0063]** Leg loop risers 558 comprises straps, cords or the like which each have a first end connected to an underside of respective leg loops 526 (the underside of wide band portion 550), and a second end connected to a rear of waist belt 524 (rear portion 539 of wide band portion 530). Leg loop risers 538 assist in supporting and suspending leg loops 526 from waist belt 524.

**[0064]** Figure 36 is a perspective view harness 520', a variation upon the harness 520 shown in Figure 35. Harness 520' is similar to harness 520 except that narrow extension portions 556 of leg loops 526 are joined to one another (or are part of a single integral strap, band, cord or the like) that passes through tether support line connector 536 (belay loop 536). Each of narrow extension portions 556 is further interconnected by a cross piece 537 to form a tie-in point or loop 559. Those remaining components of harness 520' that correspond to similar components of harness 520 are numbered similarly.

**[0065]** Although the present disclosure has been described with reference to example implementations, workers skilled in the art will recognize that changes may be made in form and detail without departing from the scope of the claimed subject matter. For example, although different example implementations may have been described as including features providing benefits, it is contemplated that the described features may be interchanged with one another or alternatively be combined with one another in the described example implementations or in other alternative implementations. Because the technology of the present disclosure is relatively complex, not all changes in the technology are foreseeable. The present disclosure described with reference to the example implementations and set forth in the following claims is manifestly intended to be as broad as possible. For example, unless specifically otherwise noted, the claims reciting a single particular element also

encompass a plurality of such particular elements. The terms "first", "second", "third" and so on in the claims merely distinguish different elements and, unless otherwise stated, are not to be specifically associated with a particular order or particular numbering of elements in the disclosure.

## Claims

### 1. A buckle (24, 124, 224, 324, 424) comprising:

- a body (34, 134, 234, 334, 434) having a top face (36, 436) a bottom face (38, 438) a first longitudinal end (40, 140, 240, 440) and a second longitudinal end (42, 142, 242), the first longitudinal end (40, 140, 440) having a first transverse width and the second longitudinal end (42, 142, 442) having a second transverse width greater than the first transverse width,

#### **characterized in that**

the buckle comprises

- a first opening (44, 444) through the body (34, 134, 234, 334, 434);
- a second opening (46, 446) through the body (34, 134, 234, 334, 434);
- a bar (48, 448) between the first opening (44, 444) and the second opening (46, 446).

### 2. The buckle (24, 124, 224, 324, 424) of claim 1, wherein the bottom face (38, 438) is concave at least from the first opening (44, 444) to the second longitudinal end (42, 142, 242).

### 3. The buckle (24, 124, 224, 324, 424) of claim 2, wherein the body (34, 134, 234, 334, 434) comprises a vertical wall (480) extending downwardly at the first longitudinal end (40, 140, 440).

### 4. The buckle (24, 124, 224, 324, 424) of claim 3, wherein the body (34, 134, 234, 334, 434) comprises:

a first retention arm (160-1, 460-1) on a first transverse side of the body (34, 134, 234, 334, 434) at the second longitudinal end (42, 142, 442), the first retention arm (160-1, 460-1) extending downwardly and inwardly towards a second transverse side of the body (34, 134, 234, 334, 434); and  
a second retention arm (160-2, 460-2) on the second transverse side of the body (34, 134, 234, 334, 434) at the second longitudinal end (42, 142, 242), the second retention arm (160-2, 460-2) extending downwardly and inwardly towards the first transverse side of the body (34, 134, 234, 334, 434).

### 5. The buckle (24, 124, 224, 324, 424) of claim 1 further comprising a clip (360) on a bottom face (38, 438) of the body (34, 134, 234, 334, 434).

### 6. The buckle (24, 124, 224, 324, 424) of claim 1, wherein the body (34, 134, 234, 334, 434) is integrally formed as a single unitary body (34, 134, 234, 334, 434).

### 7. The buckle (24, 124, 224, 324, 424) of claim 1, wherein a first longitudinal end (40, 140, 440) of a flexible length extending along the bottom face (38, 438) of the buckle (24, 124, 224, 324, 424) and secured to the bar (48, 448); and

a second longitudinal end (42, 142, 442) of the flexible length or a different flexible length, the second longitudinal end (42, 142, 442) having a loop (32), receiving the buckle (24, 124, 224, 324, 424) and wrapping about the first longitudinal end (40, 140, 440) below the buckle (24, 124, 224, 324, 424).

### 8. The buckle (24, 124, 224, 324, 424) of claim 7, wherein, wherein the flexible length comprises the second longitudinal end (42, 142, 242).

### 9. The buckle (24, 124, 224, 324, 424) of claim 8, wherein the bottom face (38, 438) is concave at least from the first opening (44, 444) to the second longitudinal end (42, 142, 242).

### 10. The buckle (24, 124, 224, 324, 424) of claim 9, wherein the body (34, 134, 234, 334, 434) comprises a vertical wall (480) extending downwardly at the first longitudinal end (40, 140, 440).

### 11. The buckle (24, 124, 224, 324, 424) of claim 10, wherein the body comprises:

a first retention arm (160-1, 460-1) on a first transverse side of the body (34, 134, 234, 334, 434) at the second longitudinal end (42, 142, 242), the first retention arm (160-1, 460-1) extending downwardly and inwardly towards a second transverse side of the body (34, 134, 234, 334, 434); and

a second retention arm (160-2, 460-2) on the second transverse side of the body (34, 134, 234, 334, 434) at the second longitudinal end (42, 142, 242), the second retention arm (160-2, 460-2) extending downwardly and inwardly towards the first transverse side of the body (34, 134, 234, 334, 434).

### 12. The buckle (24, 124, 224, 324, 424) of claim 9, wherein the body comprises:

a first retention arm (160-1, 460-1) on a first transverse side of the body (34, 134, 234,

334, 434) at the second longitudinal end (42, 142, 242), the first retention arm (160-1, 460-1) extending downwardly and inwardly towards a second transverse side of the body (34, 134, 234, 334, 434); and 5  
a second retention arm (160-2, 460-2) on the second transverse side of the body (34, 134, 234, 334, 434) at the second longitudinal end (42, 142, 242), the second retention arm (160-2, 460-2) extending downwardly and inwardly to- 10  
wards the first transverse side of the body (34, 134, 234, 334, 434).

13. The buckle (24, 124, 224, 324, 424) of claim 8, wherein the body (34, 134, 234, 334, 434) is inte- 15  
grally formed as a single unitary body (34, 134, 234, 334, 434).
14. The buckle (24, 124, 224, 324, 424) of claim 12, wherein the flexible length comprises the second 20  
longitudinal end (42, 142, 242).

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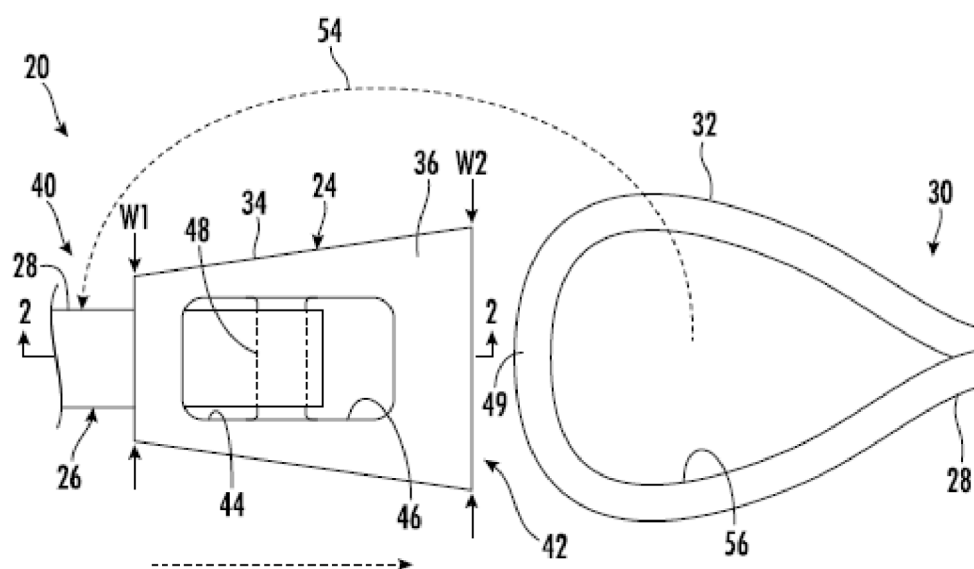


FIG. 1

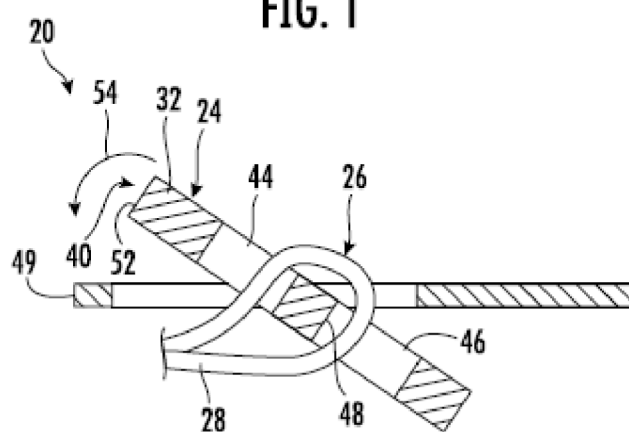


FIG. 2

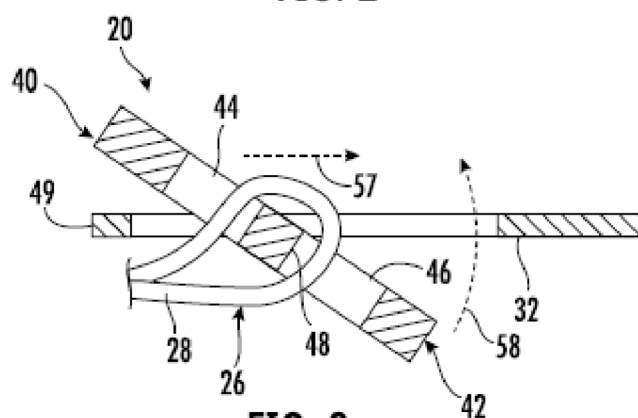


FIG. 3

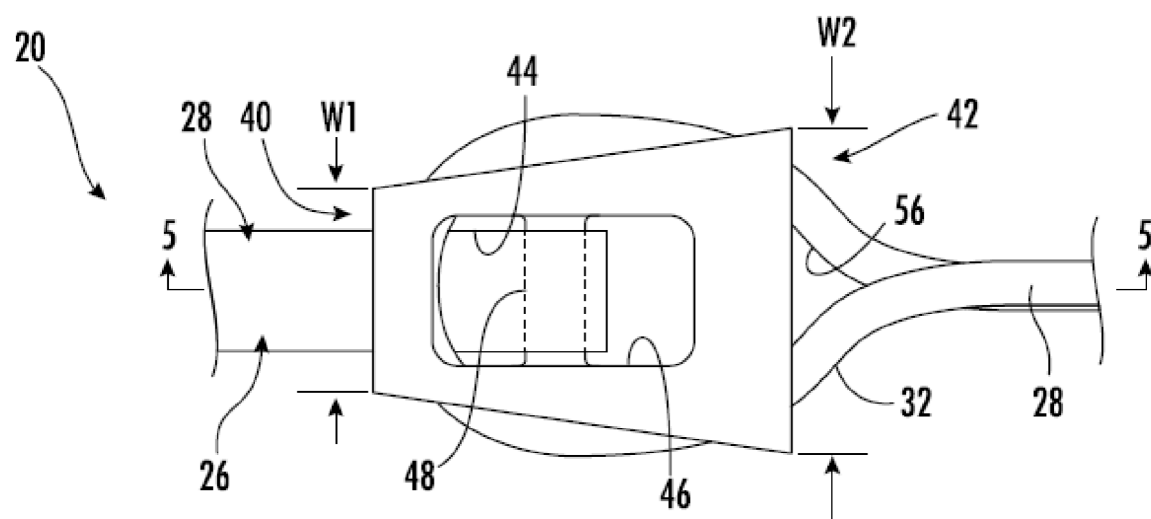


FIG. 4

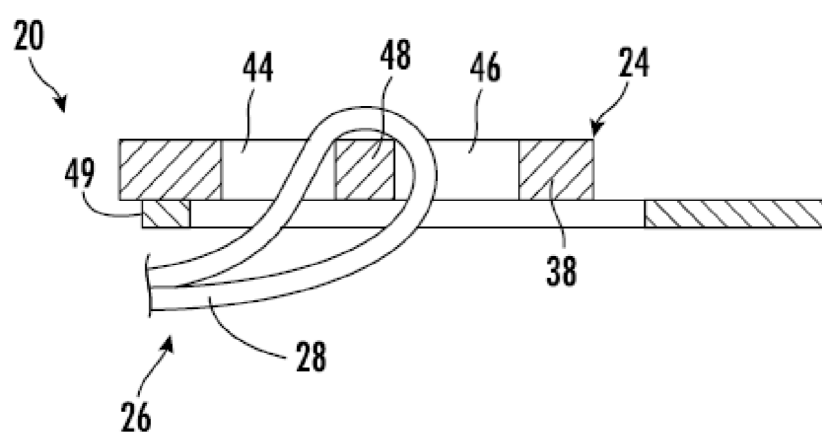


FIG. 5

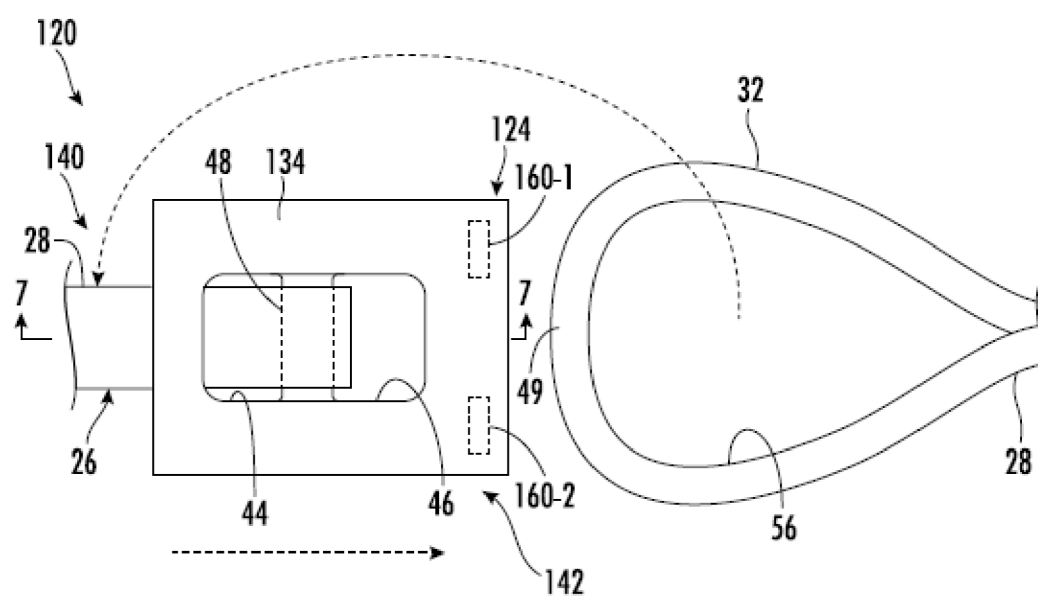


FIG. 6

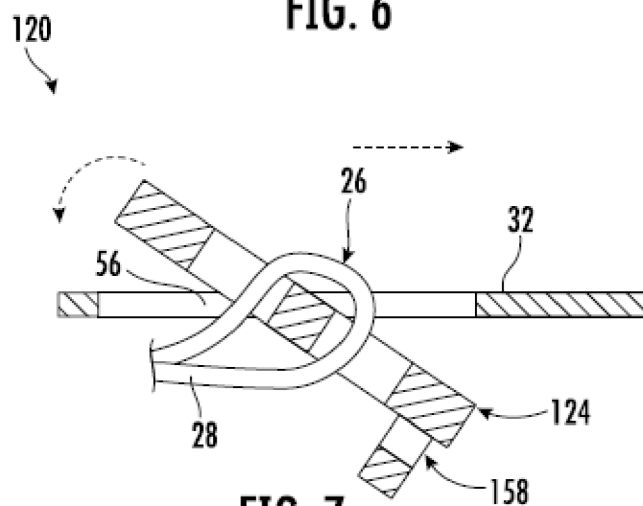


FIG. 7

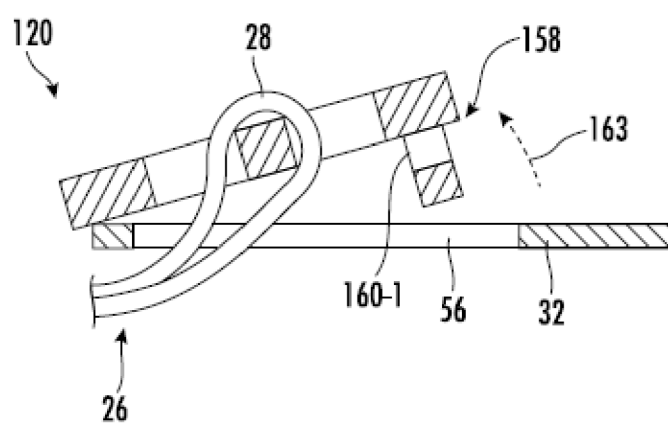


FIG. 8

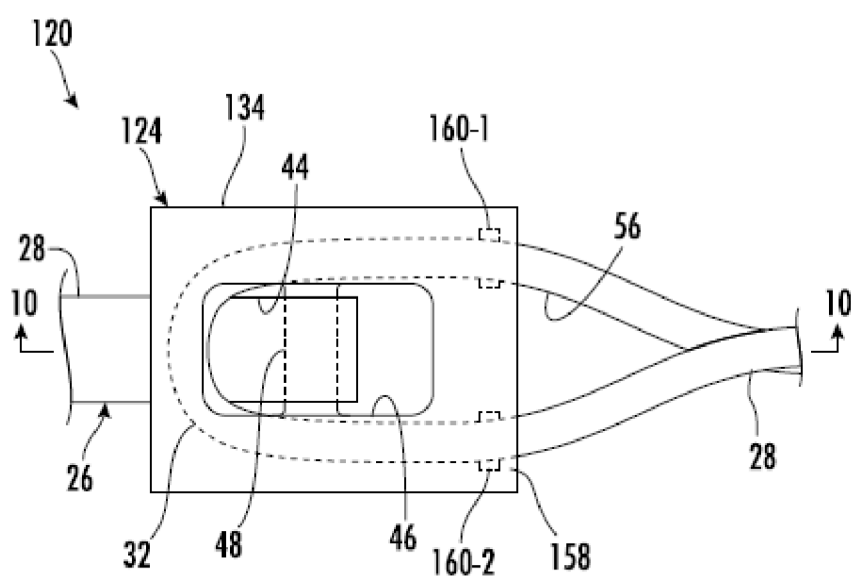


FIG. 9

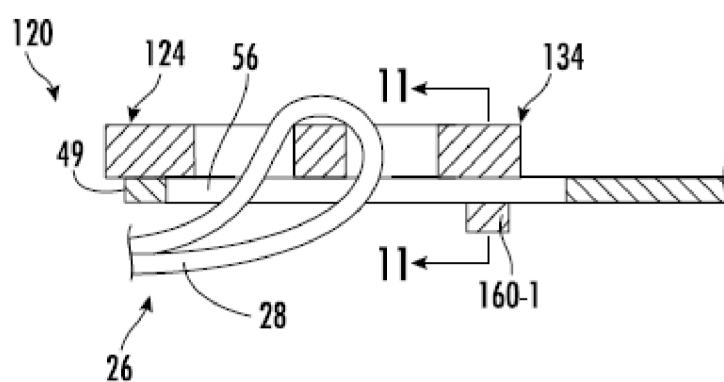


FIG. 10

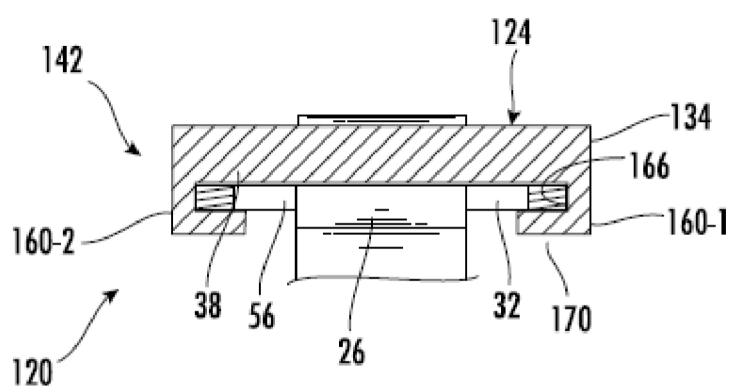


FIG. 11

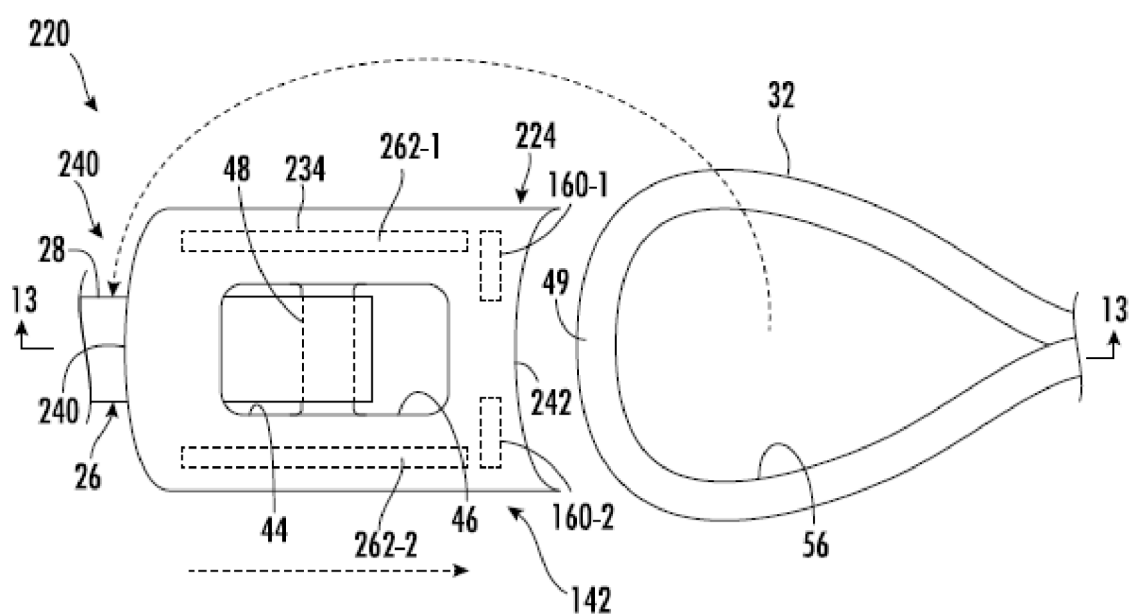


FIG. 12

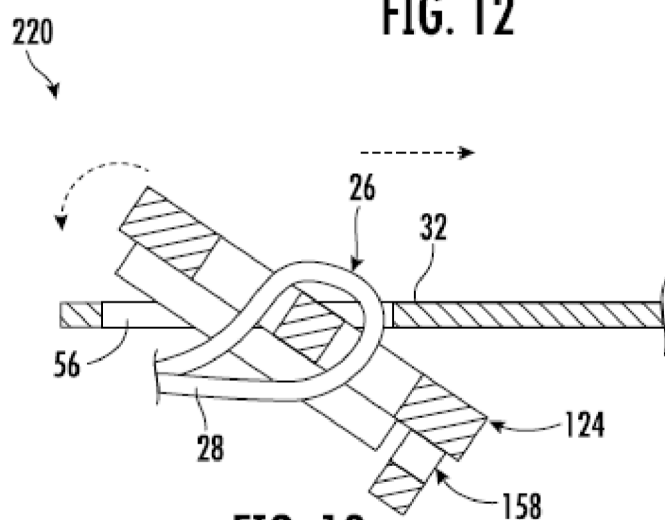


FIG. 13

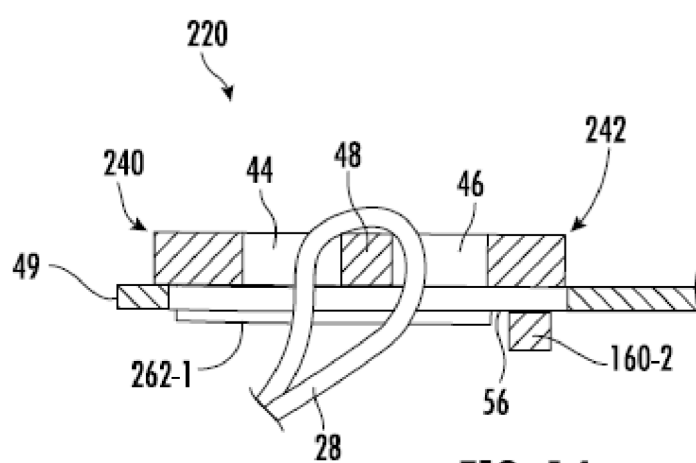


FIG. 14

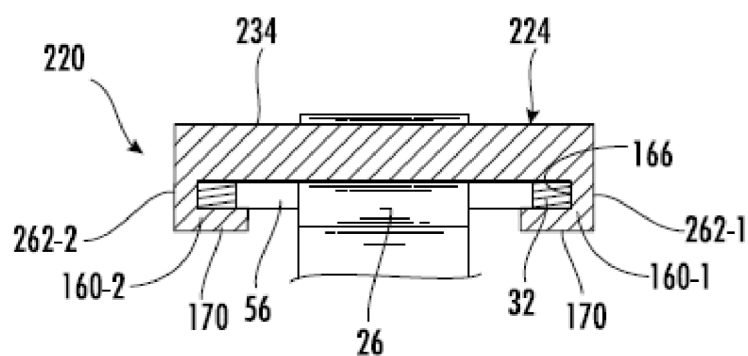
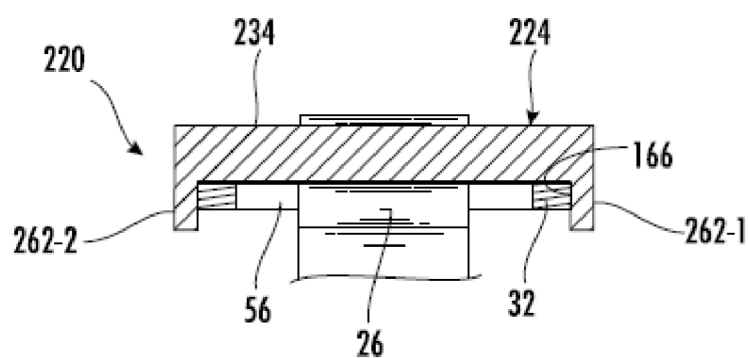
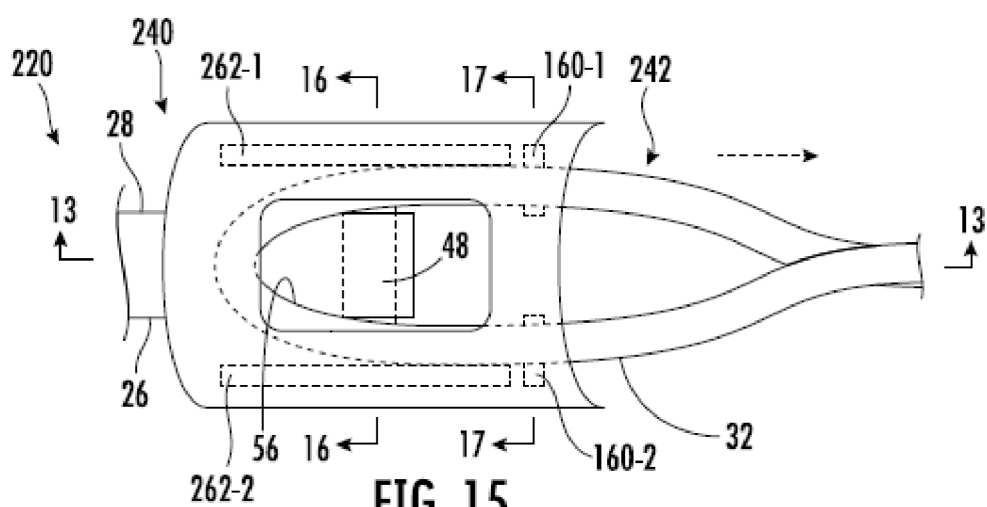


FIG. 17

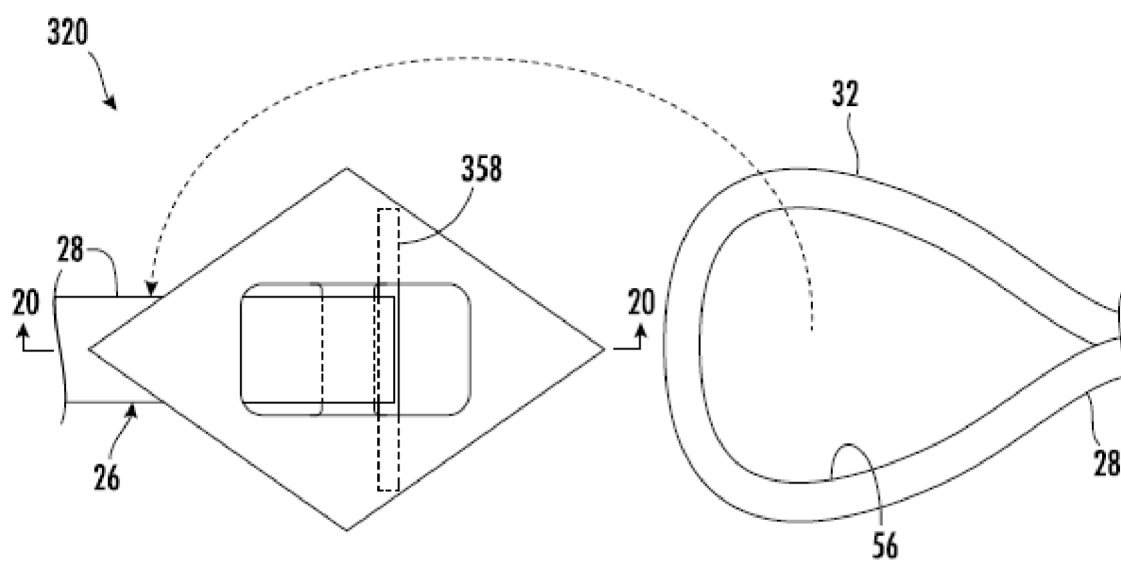


FIG. 18

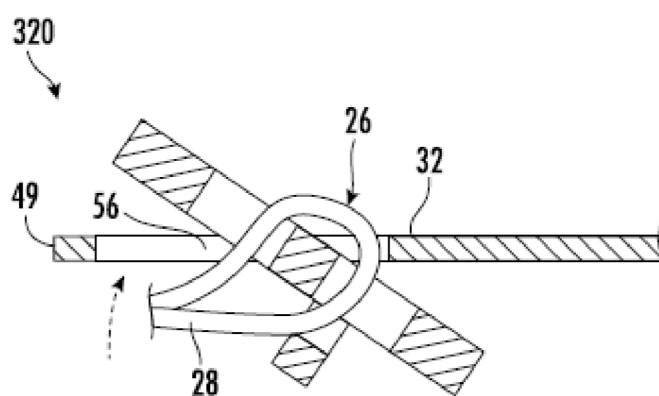


FIG. 19

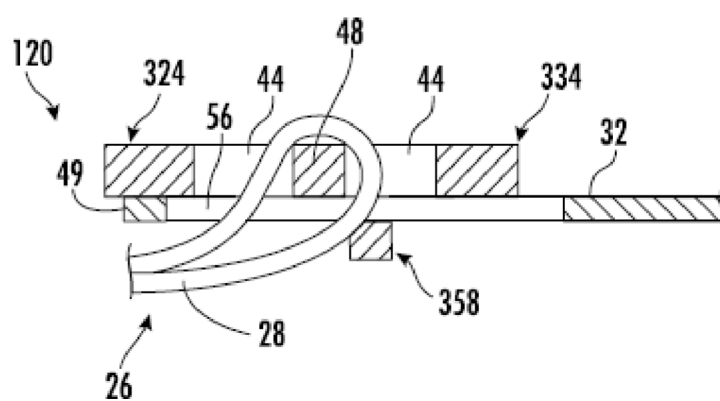


FIG. 20

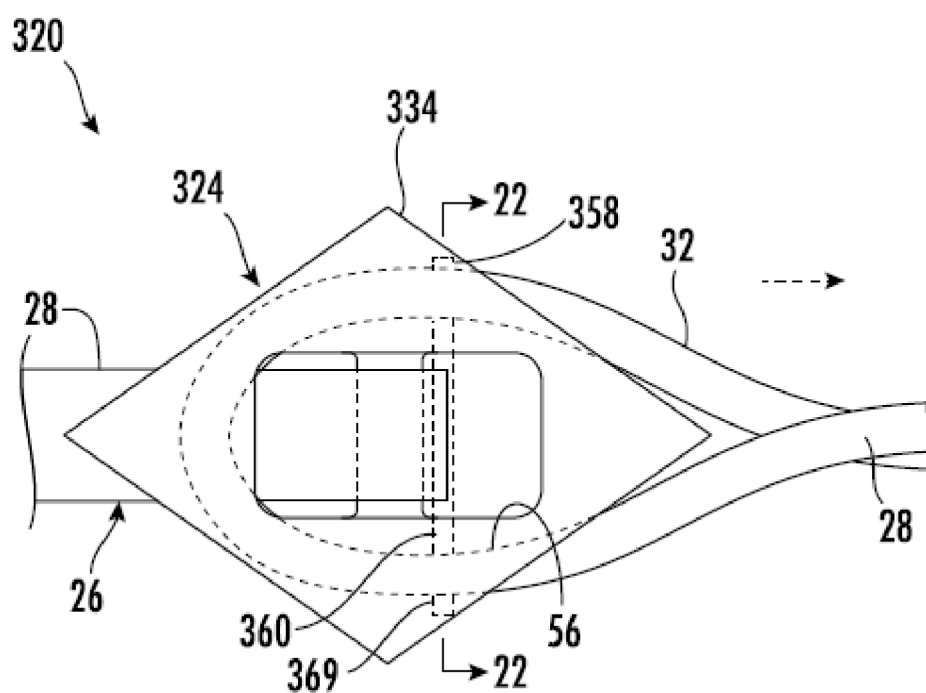


FIG. 21

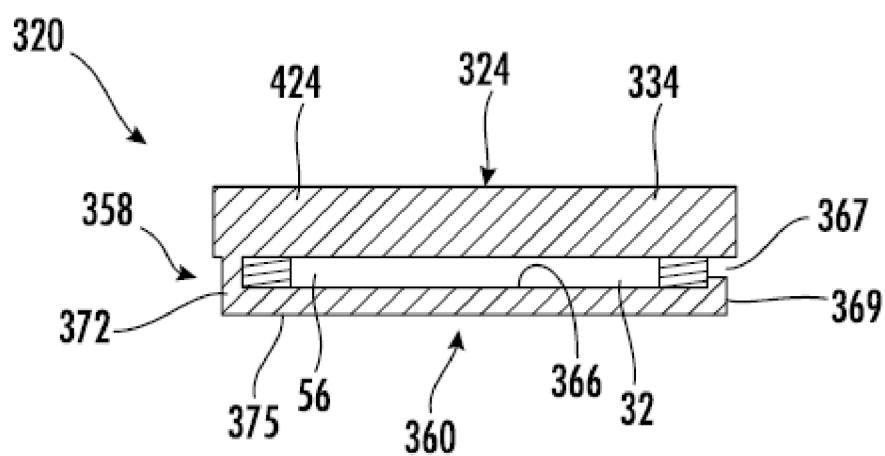
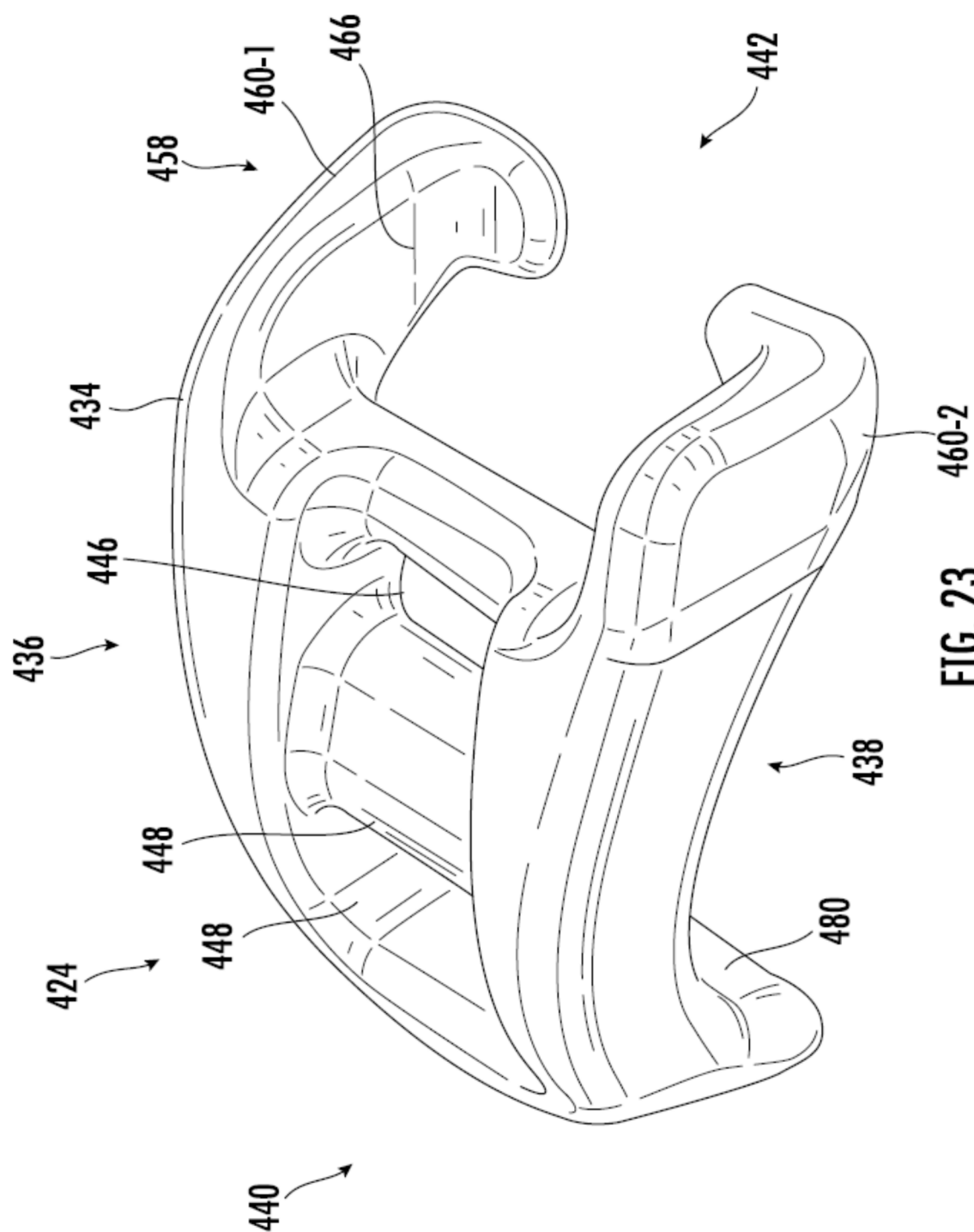
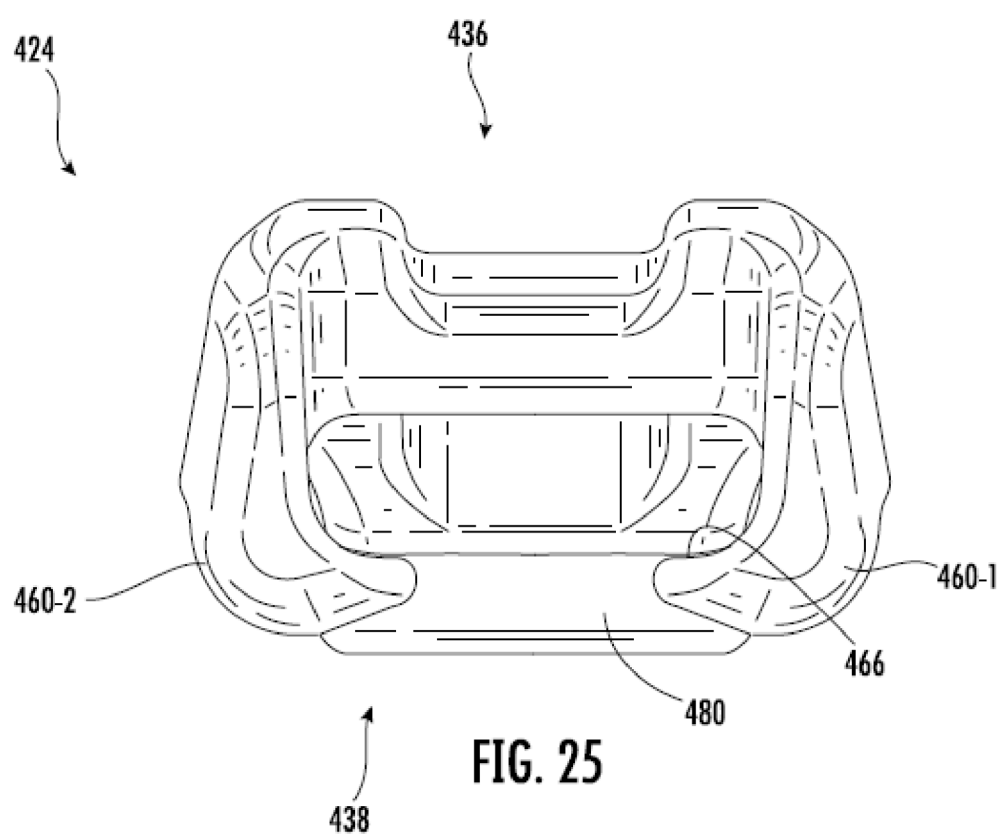
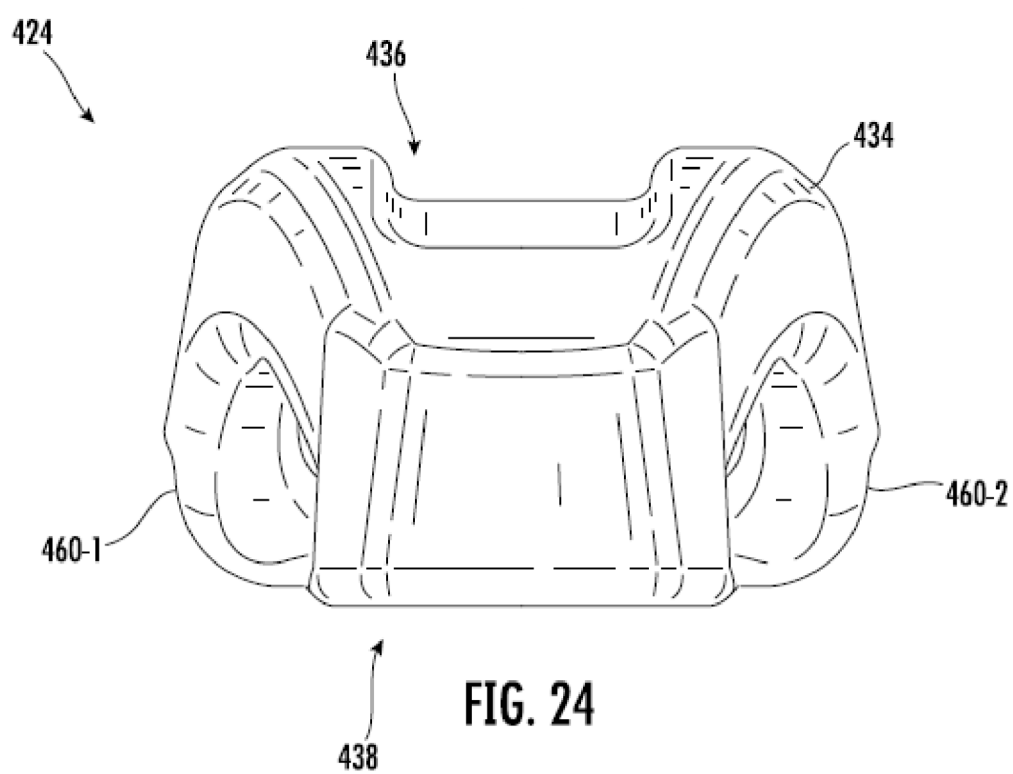


FIG. 22





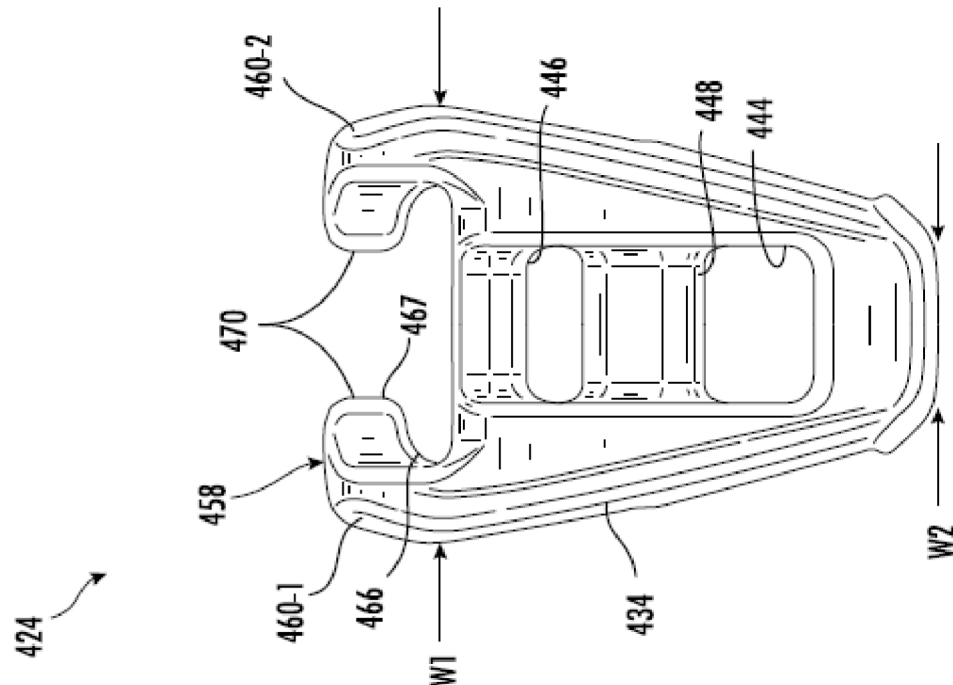


FIG. 26

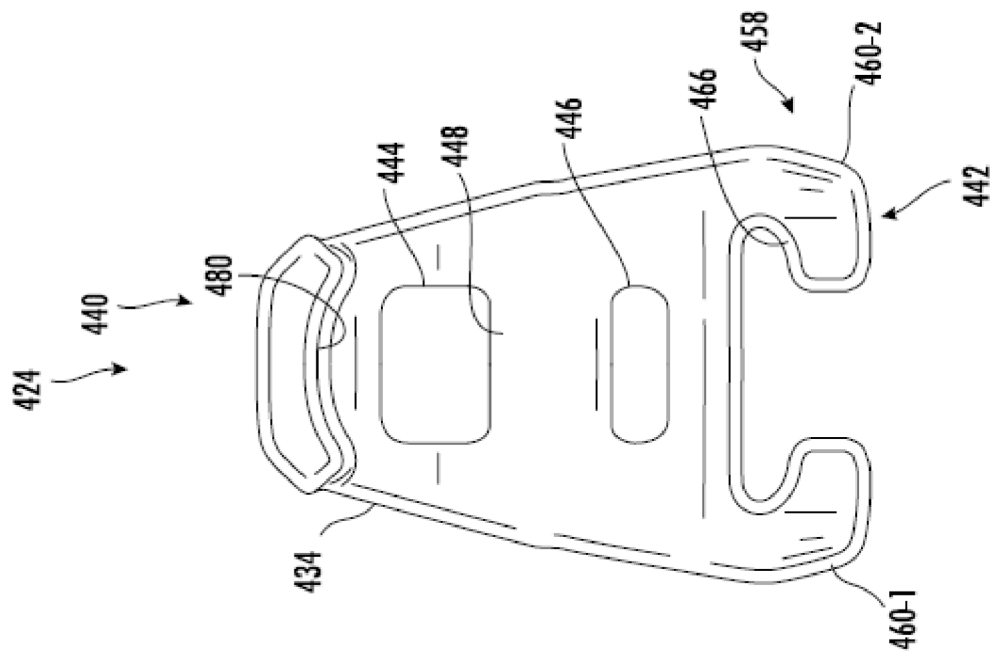
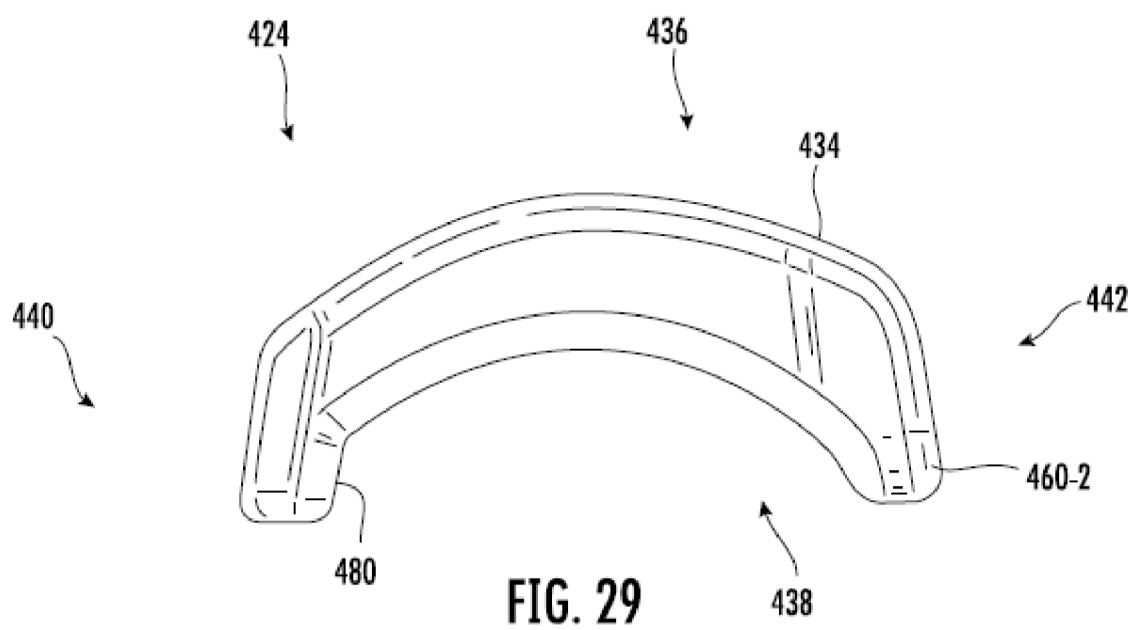
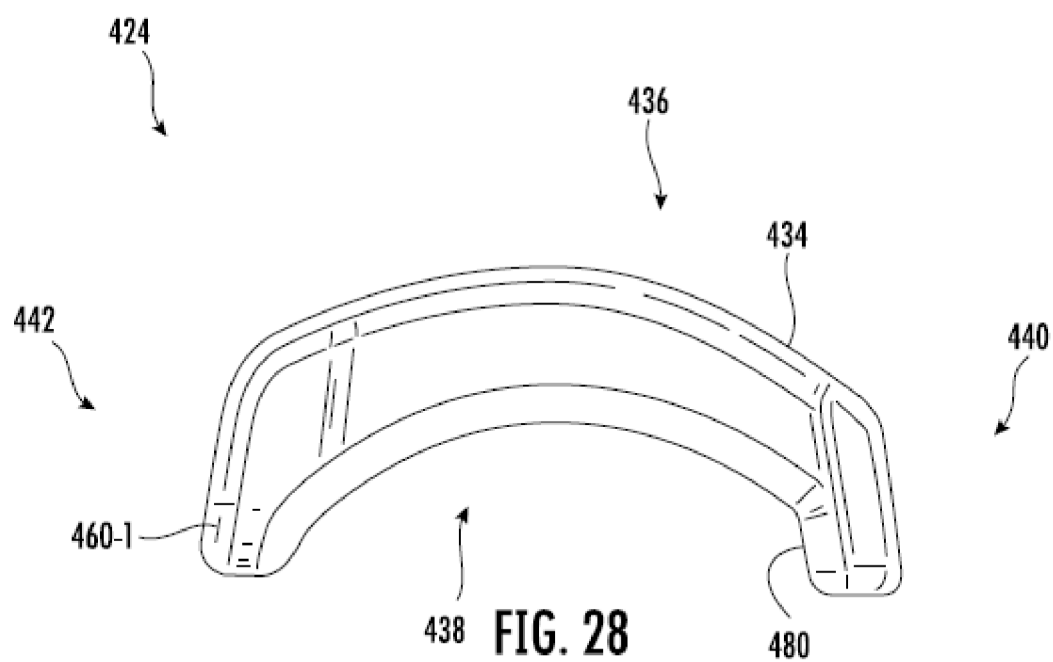
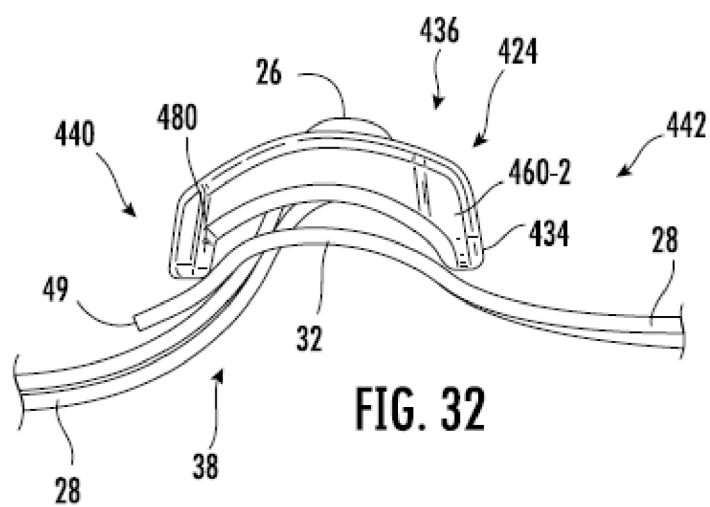
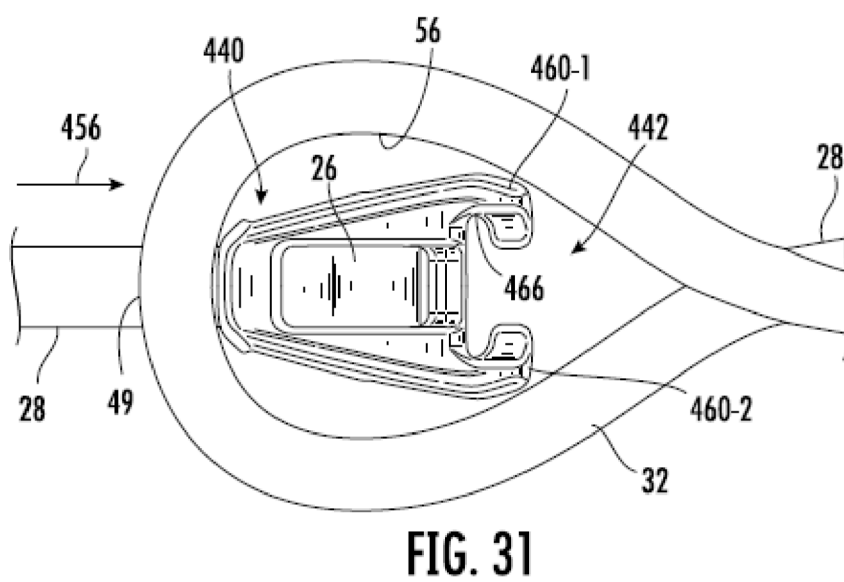
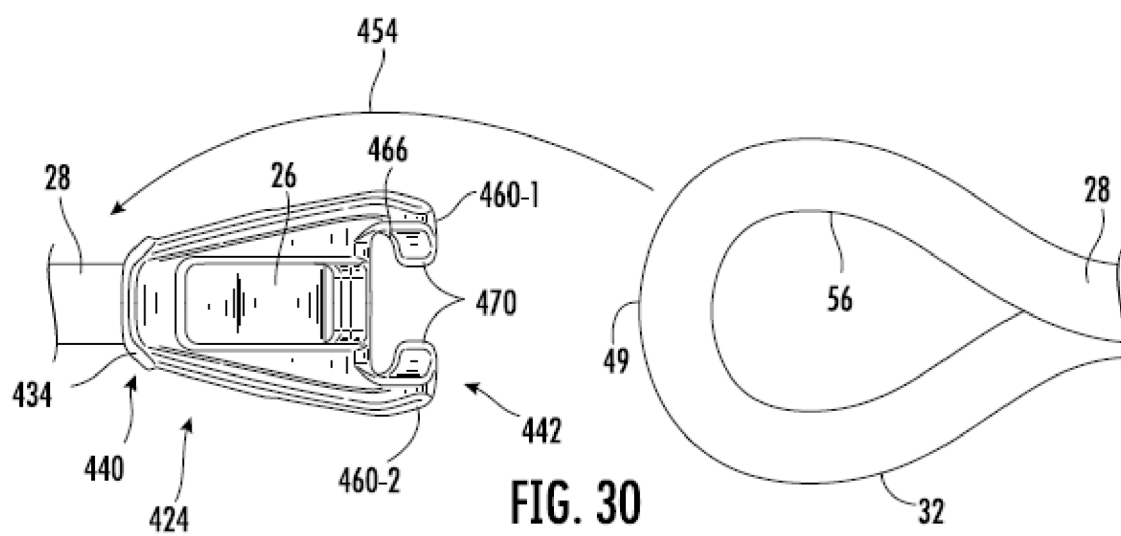
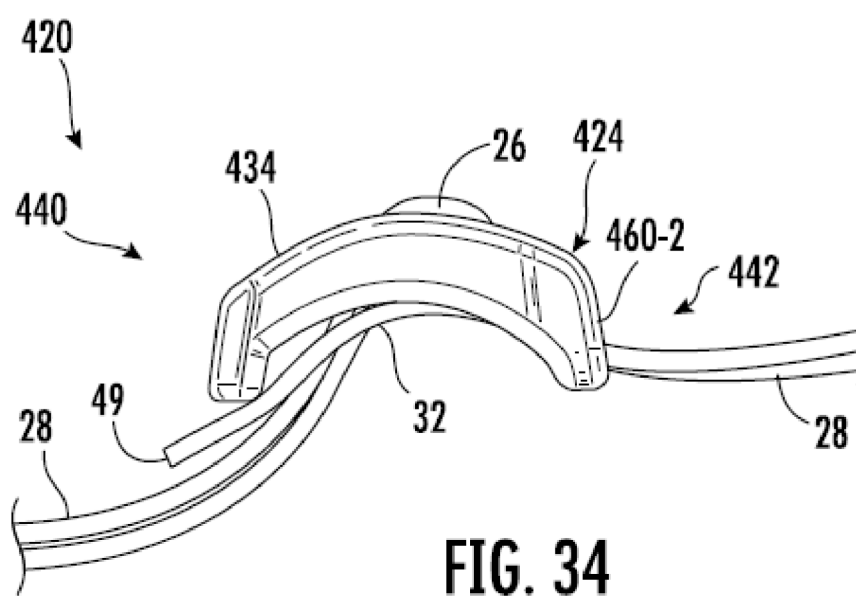
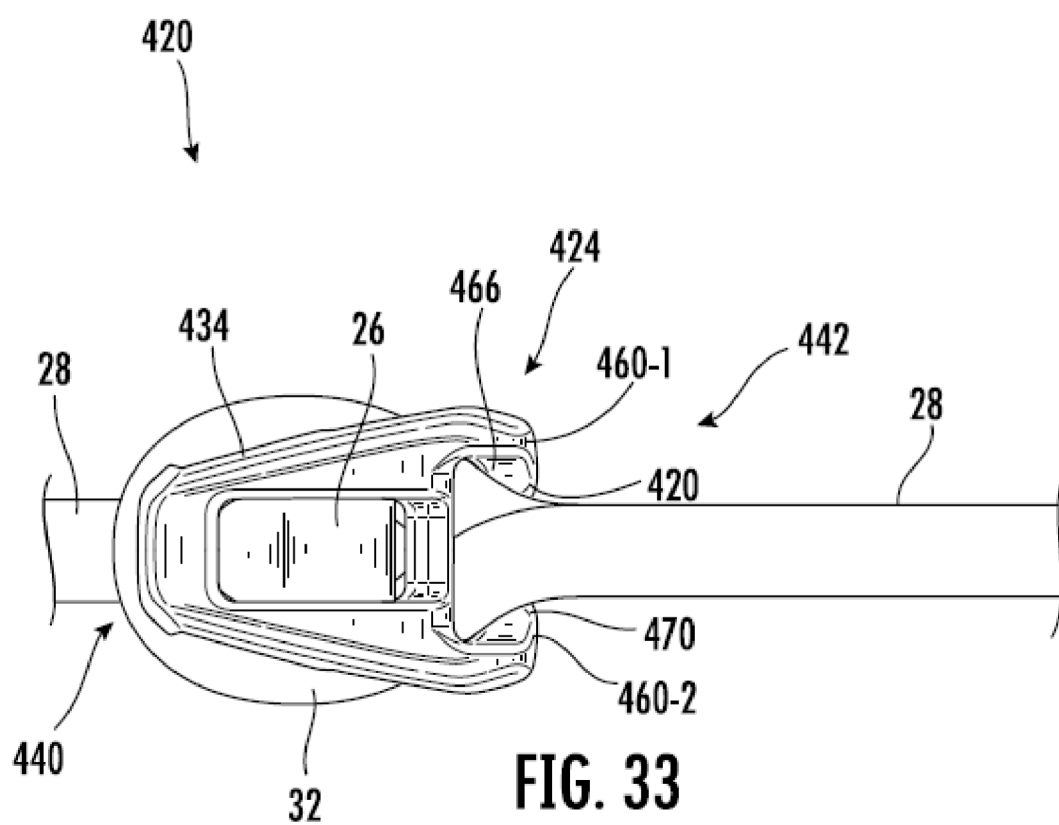


FIG. 27







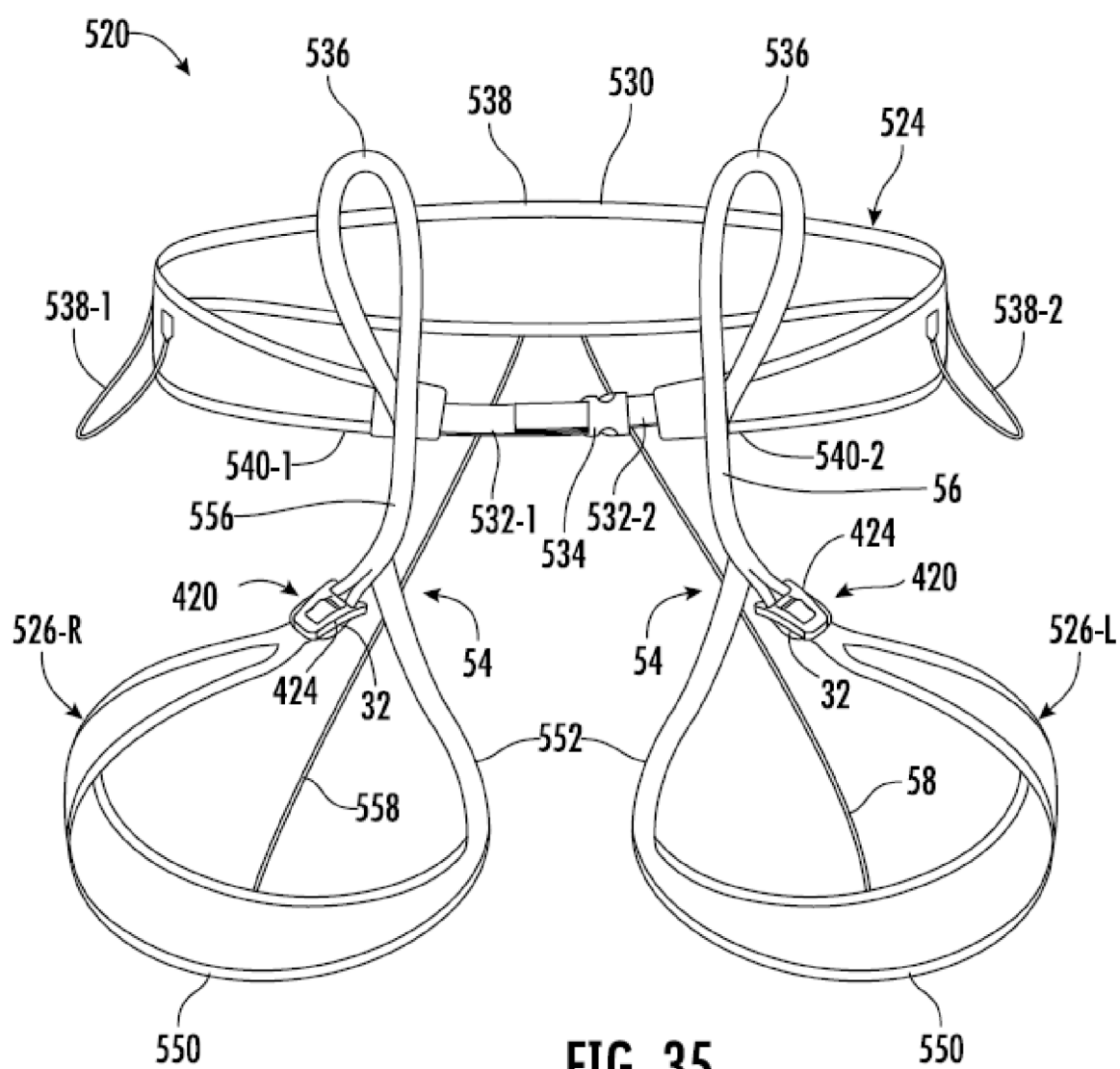


FIG. 35

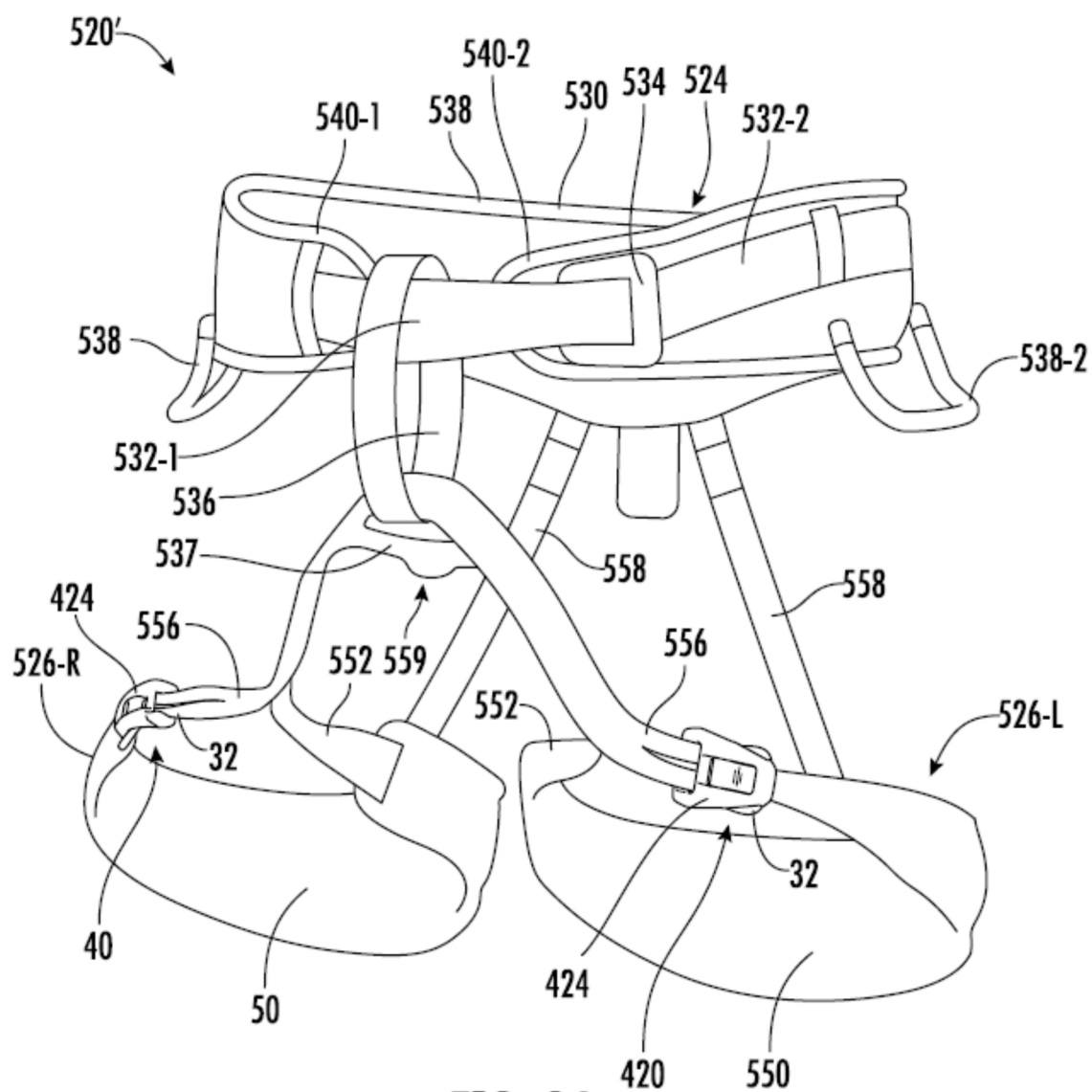


FIG. 36



## EUROPEAN SEARCH REPORT

Application Number

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| The Hague                                                                                                                                                                                                                                                                             |                                                                                                                                                          | 6 March 2026                     | Thielgen, Robert                        |
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| T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                                                                                                                                          |                                  |                                         |

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