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(54) Title: HARSH ENVIRONMENT BUCKLE ASSEMBLIES AND ASSOCIATED SYSTEMS AND METHODS

(57) Abstract: Buckle assemblies for personal restraint systems and associated systems and methods are disclosed herein. In one embodiment, a buckle assembly includes a release actuator that can apply a first force and a second force to release a web connector. The release actuator is slidably coupled to a frame that includes a pair of opposing openings. A pawl is pivotally mounted to the frame via the opposing openings and includes a latch portion positioned to releasably engage the web connector. A biasing member is operably positioned between the release actuator and the pawl, and the release actuator is movable to compress the biasing member and exert the first force against the pawl. The release actuator is also movable to contact the pawl to exert the second force against the pawl. The first and second forces urge the pawl to rotate and disengage the latch portion from the web connector.

## HARSH ENVIRONMENT BUCKLE ASSEMBLIES AND ASSOCIATED SYSTEMS AND METHODS

### TECHNICAL FIELD

**[0001]** The following disclosure relates generally to buckle assemblies for use in personal restraint systems and, more particularly, to buckle assemblies and associated systems and methods that are adapted for use in harsh environments.

### BACKGROUND

**[0002]** A variety of vehicles include restraint systems to help restrain operators or passengers while the vehicles are in motion. Many of these restraint systems have buckles or other components that are releasably fastened together to connect two or more pieces of webbing. For example, seatbelts in most passenger vehicles include a buckle that is attached to a first piece of webbing. To secure a vehicle occupant, a tongue that is connected to a second piece of webbing is releasably engaged by the buckle. In most restraint systems, buckles generally have multiple internal components that are moveable to provide for releasable engagement of the tongue. For example, buttons, latches, springs and other components are often used to provide a releasable engagement mechanism. As with many mechanical devices, the operation of these components may be affected by the environment in which they operate.

**[0003]** Some vehicle types, e.g., off-road recreational utility vehicles (RUVs), are frequently operated in harsh environments that can expose restraint system components to a variety of contaminants. Exposing buckles or other components to mud, sand, water, and/or other contaminants, can affect the operation of the restraint system. In some cases, the contamination can restrict or prevent movement of a release button or other component that is necessary to release the tongue from the buckle. In other cases, contamination can restrict insertion of the tongue into the buckle. Cleaning, repairing or replacing buckles and other components to address such occurrences can require substantial time and expense.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0004]** Figure 1 is an isometric view of a connector joined to a buckle assembly configured in accordance with an embodiment of the present technology.

**[0005]** Figure 2 is an exploded isometric view of the buckle assembly and connector configured in accordance with an embodiment of the present technology.

**[0006]** Figure 3 is an enlarged isometric view of a pawl configured in accordance with an embodiment of the present technology.

**[0007]** Figure 4 is an enlarged isometric view of the several components of the buckle assembly configured in accordance with an embodiment of the present technology.

**[0008]** Figures 5A to 8C are isometric and side cross-sectional views of the connector and several components of the buckle assembly illustrating various stages of operation in accordance with an embodiment of the present technology.

**[0009]** Figure 9 is an enlarged isometric view of a pawl configured in accordance with another embodiment of the present technology.

## DETAILED DESCRIPTION

**[0010]** The following disclosure describes various embodiments of buckle assemblies and associated systems and methods. In some embodiments, a buckle assembly for a personal restraint system includes a release actuator (e.g., a button) that can apply increased force to release a web connector. For example, a buckle assembly configured in accordance with one embodiment of the present technology includes a frame having a pair of opposing openings and a pawl pivotally mounted to the frame via the opposing openings. The pawl includes a latch portion positioned to releasably engage a web connector, and a biasing member is operably positioned between the release actuator and the pawl. The release actuator is movable to a first position to compress the biasing member and exert a first force against the pawl. The release actuator is also movable to a second position to further compress the biasing member and directly contact the pawl to exert a second force against the pawl. The second force can be greater than the first force, and the first and second forces

together urge the pawl to rotate and disengage the latch portion from the web connector.

**[0011]** In several embodiments, buckle assemblies can include an ejector that urges a web connector out of the buckle assembly when the release actuator is operated. The ejector can also operate to engage the latch portion with the web connector. For example, insertion of a web connector into the buckle assembly can drive the ejector against the pawl to rotate the pawl and engage the latch portion with the web connector. In other embodiments, the devices, systems and associated methods can have different configurations, components, and/or procedures. Still other embodiments may eliminate particular components and/or procedures. A person of ordinary skill in the relevant art, therefore, will understand that the present technology, which includes associated devices, systems, and procedures, may include other embodiments with additional elements or steps, and/or may include other embodiments without several of the features or steps shown and described below with reference to Figures 1 to 9.

**[0012]** As discussed above, exposure of personal restraint systems to harsh environments can affect the operation of various components. The present technology includes several embodiments of buckle assemblies and restraint system components that can mitigate the impact of harsh environments and contaminants. Certain details are set forth in the following description and Figures 1 to 9 to provide a thorough understanding of various embodiments of the disclosure. To avoid unnecessarily obscuring the description of the various embodiments of the disclosure, other details describing well-known structures and systems often associated with buckle assemblies, personal restraint systems, and the components or devices associated with the manufacture of buckle assemblies and personal restraint systems are not set forth below. Moreover, many of the details and features shown in the Figures are merely illustrative of particular embodiments of the disclosure. Accordingly, other embodiments can have other details and features without departing from the spirit and scope of the present disclosure. In addition, the various elements and features illustrated in the Figures may not be drawn to scale. Furthermore, various embodiments of the disclosure can include structures other than those illustrated in the Figures and are expressly not limited to the structures shown in the Figures.

**[0013]** Figure 1 is an isometric view of a buckle assembly 100 configured in accordance with an embodiment of the present disclosure. In the illustrated embodiment, the buckle assembly 100 includes a housing 102 having an opening 104. A web connector 106 having a web opening 108 can be inserted into the opening 104 to couple the web connector 106 to the buckle assembly 100. A web (e.g., a seat belt web) or other restraint system component can be coupled to the web connector 106 via the opening 108 in a conventional manner to secure an occupant of a vehicle in his or her seat. For example, a portion of a lap belt (not shown) can be fastened to the connector 106 via the web opening 108.

**[0014]** Figure 2 is an exploded isometric view of the buckle assembly 100 and the connector 106 configured in accordance with an embodiment of the present technology. In the illustrated embodiment of Figure 2, the housing 102 includes an upper portion 202 and a lower portion 204. The upper portion 202 is removably secured to the lower portion 204 via a pair of fasteners (e.g., screws) 206. The buckle assembly 100 also includes a frame 208 having a pair of first openings 210 and a pair of second openings 212. A pawl 214 includes a latch portion 216 and a drive portion 218. As described in more detail below, the pawl 214 can be pivotally coupled to the frame to releasably engage the connector 106 via a latch opening 201.

**[0015]** The buckle assembly 100 also includes a release actuator 220 (e.g., a release button) that can be slidably coupled to the frame 208. The release actuator 220 includes a plurality of guide features 221 and a first biasing member mount 222 (e.g., a first spring mount) that can engage an end portion of a first biasing member 224 (e.g., a first spring). The drive portion 218 includes a second biasing member mount 226 (e.g., a second spring mount) that can engage an opposite end portion of the first spring 224. The first spring 224 can be positioned to extend between the first spring mount 222 and the second spring mount 226, and the first spring 224 can bias the release actuator 220 toward the opening 104. The release actuator 220 slidably straddles the frame 208 and can be actuated to release the connector 106 by depressing the actuator 220 into the opening 104, as described in more detail below. A release actuator insert 228 is positioned between the housing upper portion 202 and the release actuator 220. The insert 228 contacts features on the frame 208 to provide a hard stop when the release actuator 220 is fully depressed into the opening 104. The components of the buckle

assembly 100 can be constructed from a variety of materials. For example, in some embodiments, the frame 108, the latch portion 216 of the pawl 214, and/or other components can be constructed from metal or metal alloys (e.g., steel). Additionally, in several embodiments, the housing 102, the release button 220, the drive portion 218 of the pawl 214, and/or other components can be constructed from a variety of plastics (e.g., high-density polyethylene (HDPE)).

**[0016]** An ejector 230 is slidably coupled to the frame 208 and biased toward the opening 104 by a second biasing member 232 (e.g., a second spring). When the release actuator 220 is actuated to unlatch the connector 106 from the buckle assembly 100, the second spring 232 can urge the ejector 230 to push the connector 106 out of the opening 104. A locking pin 234 can be movably received in the second openings 212 of the frame 208, and can be driven by the guide features 221 of the release actuator 220. The locking pin 234 can also interact with the pawl 214 to prevent inadvertent release of the connector 106.

**[0017]** The buckle assembly 100 can further include a switch 236 having an actuator 238 (e.g., an actuation lever). The pawl 214 can engage the actuator 238 to provide an indication of the status of the buckle assembly (e.g., unlatched or latched). Additionally, a coupling member 240 can couple a tang (not shown) to the frame 208. The tang can be coupled to a piece of webbing or another restraint system component to secure the buckle assembly 100 to an associated vehicle. In some embodiments, the tang and/or the frame can include load absorbing features that can interact with the coupling member 240 and provide for relative motion between the frame 208 and the tang. The relative motion can be used to provide an indication that the buckle assembly 100 has been subjected to a load sufficient to warrant repair or replacement of the buckle assembly 100. In several embodiments, such load absorbing and indicating features can be at least generally similar to those described in U.S. Patent Application No. 62/236,792, filed October 2, 2015, and entitled Load Indicators for Personal Restraint Systems and Associated Systems and Methods, which is incorporated by reference herein in its entirety. The switch 236 can be coupled to a load indicating component, the housing 102, or another component of the buckle assembly 100 such that the actuator 238 is positioned to be actuated via the pawl 214, as discussed in more detail below.

**[0018]** Figure 3 is an enlarged isometric view of the pawl 214 configured in accordance with an embodiment of the present technology. In the illustrated embodiment, the latch portion 216 includes a latch arm 302, a locking arm 304, and a pair of opposing tabs 306. The drive portion 218 includes a pair of hooks 308 (only one visible in Figure 3), and a curved body 310 having a slot 312. The drive portion 218 can be coupled to the latch portion 216 via extension of the locking arm 304 through the slot 312, and engagement of the hooks 308 with the tabs 306. The drive portion 218 further includes an actuation arm 314 having the second spring mount 226 and a protrusion with a contact surface 316. The contact surface 316 can engage the actuation lever 238 on the switch 236 (Figure 2).

**[0019]** Figure 4 is an enlarged isometric view of the frame 208, the pawl 214 and the locking pin 234 configured in accordance with an embodiment of the present technology. In the illustrated embodiment, the pawl 214 is rotatably coupled to the frame 208 via engagement of the tabs 306 with the first openings 210. The pawl 214 can rotate about the tabs 306 to move (e.g., rotate) the latch arm 302 in the directions of the arrows  $A_1$  and  $A_2$ . The second openings 212 include upper or vertical portions 402 and lower or horizontal portions 404. Rotation of the pawl 214 about the tabs 306 moves the locking pin 234 in the directions of arrows  $A_1$  and  $A_2$  within the upper portions 402.

**[0020]** Figures 5A to 8C are isometric and side cross-sectional views of the connector 106 and several components of the buckle assembly 100 illustrating various stages of operation in accordance with an embodiment of the present technology. For example, Figures 5A to 5C illustrate components of the buckle assembly 100 in an unlatched position, with the connector 106 spaced apart from the buckle assembly 100. Referring to Figures 5A to 5C together, in the unlatched position, the latch arm 302 is raised and the locking pin 234 is positioned in the upper portions 402 of the second openings 212. The first spring 224 is partially compressed, acting against the second spring mount 226 to urge the pawl 214 in a direction of rotation that drives the contact surface 316 on the drive portion 218 against the actuation lever 238 on the switch 236.

**[0021]** The contact between the contact surface 316 and the lever 238 provides an electrical indication via the switch 236 that the buckle assembly 100 is unlatched. For example, in some embodiments, the switch 236 can be part of an electrical circuit that

is itself part of an electrical system in an associated vehicle. The electrical system can include buzzers, lights, or other components that can be energized depending on the condition of the electrical circuit that includes the switch 236. For example, in some embodiments, contact between the contact surface 316 and the lever 238 can open the switch 236. The associated electrical system can detect that the circuit is open and energize a buzzer and/or light to show that the buckle assembly 100 is unlatched.. In other embodiments, engagement of the lever 238 can close the switch 236 to complete an electrical circuit that initiates the energization of a buzzer and/or light. Additionally, in several embodiments, a variety of electrical or mechanical interlocks can be initiated via operation of the switch 236. For example, in some embodiments, the electrical system of an associated vehicle can limit vehicle operation to a lower rate of speed based on the position of the switch 236 (*i.e.*, open or closed)

**[0022]** When the buckle assembly 100 is in the unlatched position, the compression of the first spring 224 also acts on the first spring mount 222 to bias the release button 220 in the direction of arrow  $A_3$ , *i.e.*, toward the opening 104 (Figure 1). However, the release button 220 is maintained in a partially depressed position by the guide features 221 and the locking pin 234. Specifically, in the unlatched position, the locking pin 234 is positioned in the upper portions 402 of the second openings 212. The upper portions 402 prevent the locking pin 234 from moving in the direction of arrow  $A_3$ , and the locking pin 234 acts on the guide features 221 to similarly prevent movement of the release button 220 in the direction of arrow  $A_3$ . Additionally, in the unlatched position, the second spring 232 urges the ejector 230 toward the opening 104.

**[0023]** Figures 6A and 6B are isometric and side cross-sectional views, respectively, of the buckle assembly 100 in an unlatched position, with the connector 106 partially inserted into the opening 104. Insertion of the connector 106 in the direction of arrow  $A_4$  drives the ejector 230 away from the opening 104 (Figure 1), compressing the second spring 232. Continued insertion of the connector 106 drives the ejector 230 into contact with the latch portion 216 of the pawl 214, as shown in Figures 6A and 6B (second spring 232 not shown in Figure 6A for clarity), and aligns the latch opening 201 with the latch arm 302. The contact between the ejector 230 and



the latch portion 216 urges the pawl 214 to rotate and move the latch arm 302 in the direction of arrow  $A_2$ , toward the latch opening 201.

**[0024]** Figures 7A and 7B are isometric views, and Figure 7C is a side cross-sectional view of the buckle assembly 100 in a latched position, with the connector 106 fully inserted into the opening 104. Comparing Figures 6A and 6B with Figures 7A to 7C, rotation of the pawl 214 in the direction of arrow  $A_2$  drives the latch arm 302 fully into the latch opening 201, and the locking arm 304 drives the locking pin 234 to the lower portions 404 of the second openings 212. With the locking pin 234 in the lower portions 404 of the second openings 212, the upper portions 402 no longer prevent movement of the locking pin 234 and the release button 220 in the direction of arrow  $A_3$ . Accordingly, this enables the first spring 224 to drive the release button 220 in the direction of arrow  $A_3$ . Movement of the release button 220 in the direction of arrow  $A_3$  drives the locking pin 234 in the direction of arrow  $A_3$ , via the guide features 221.

**[0025]** In the fully latched position shown in Figures 7A to 7C, the locking pin 234 prevents inadvertent unlatching of the buckle assembly 100. In particular, referring to Figure 7C, the lower portions 404 of the second openings 212 prevent motion of the locking pin 234 in the direction of arrow  $A_1$ . The locking pin 234 acts on the latch portion 216 to prevent motion of the latch portion 216 in the direction of arrow  $A_1$ , and the latch arm 302 is thereby maintained in the latch opening 201. With the latch arm 302 extending into the latch opening 201, the connector 106 cannot be removed from the buckle assembly 100. Additionally, in the fully latched position, the contact surface 316 on the pawl 214 is spaced apart from the actuation lever 238 of the switch 236. This enables the switch 236 to provide an electrical indication that the buckle assembly 100 is latched, as described above.

**[0026]** Figures 8A and 8B are isometric views, and Figure 8C is a side cross-sectional view of the buckle assembly 100 in a latched position, with the connector 106 fully inserted in the opening 104. In the illustrated embodiment, the release button 220 is partially depressed to initiate unlatching of the buckle assembly 100. In particular, the release button 220 has been moved in the direction of arrow  $A_4$ , driving the locking pin 234 (via the guide features 221) toward the upper portions 402 of the second openings 212. Additionally, depression of the release button 220 has compressed the first spring 224. As the first spring 224 is being compressed, it exerts a first force

against the drive portion 218, urging the pawl 214 to rotate and move the latch arm 302 in the direction of arrow  $A_1$ . In several embodiments, the first force is applied to the pawl 214 at an outer perimeter of the second spring mount 226. As the release button 220 is further depressed, the first spring mount 222 comes into direct contact with the second spring mount 226. The contact of the first spring mount 222 with the second spring mount 226 exerts a second force on the drive portion 218 that also urges the pawl 214 to rotate and move the latch arm 302 in the direction of arrow  $A_1$ .

**[0027]** In some embodiments, the second force can be greater than the first force. For example, in some embodiments, the first force is limited to a maximum value, from compression of the first spring, that occurs when the release actuator 220 is depressed to the position where the first spring mount 222 contacts the second spring mount 226. The second force, however, is not limited. That is, most (if not all) of the force exerted on the release actuator 220 (by, e.g., the user) in the direction of arrow  $A_4$  is transmitted to the pawl 214 via the first force and the second force. Specifically, if the release actuator 220 is depressed to the position in which the first spring mount 222 contacts the second spring mount 226, any additional force applied to the release actuator 220 is transferred to the pawl 214 via the second force acting through the direct physical contact between the first spring mount 222 and the second spring mount 226. Regardless of whether the second force is greater than the first force, the second force provides additional force to rotate the pawl 214. In particular, the sum of the first force and the second force can result in a total force that can be significantly greater than the first force alone, and can help overcome any resistance to rotation of the pawl 214, as described in more detail below.

**[0028]** Depression of the release button 220 also drives the guide features 221 to move the locking pin 234. Specifically, the guide features 221 move the locking pin 234 to the junction of the lower portions 404 and the upper portions 402 of the second openings 212. With the locking pin 234 at the junction of the lower portions 404 and the upper portions 402, the first force and second force on the pawl 214 rotate the pawl, moving the latch arm 302 out of the latch opening 201 and moving the locking pin 234 in the direction of arrow  $A_1$  within the upper portions 402 (as shown in Figures 5A to 5C). With the latch arm 302 withdrawn from the opening 201 in the connector 106, the second spring 232 urges the ejector 230 against the connector 106, ejecting the

connector 106 from the buckle assembly 100 and returning the buckle assembly 100 to the unlatched condition shown in Figures 5A to 5C.

**[0029]** Contaminants (e.g., dirt, moisture, etc.) that enter a buckle assembly can increase the friction on a latch or otherwise restrict the free movement of the latch or other buckle assembly components. This increased friction can prevent the proper operation of the associated buckle assembly. For example, in many existing buckle assemblies, a spring or other compressible component is used to release a latch. To prevent spring damage, many buckle assemblies include release buttons that contact internal components of the associated buckle assembly and “bottom out” before they fully compress their associated springs. Accordingly, the maximum force that can be exerted with such buckle assemblies is limited to that which does not fully compress the spring. This spring force may be insufficient to overcome obstructions or contamination in many existing buckle assemblies.

**[0030]** Buckle assemblies configured in accordance with the present technology can provide for reliable operation in harsh environments. For example, in addition to exerting a first force on the pawl 214 via the first spring 224, the direct contact of the release button 220 with the pawl 214 provides a second force on the pawl 214. The second force is applied via direct physical contact, and is not limited to a force generated via spring pressure. As discussed above, the direct contact can provide for the transfer of all (or most) of the force exerted on the release button 220 to the pawl 214. The direct contact and the transfer of additional force provided by the embodiments disclosed herein can help to reduce the likelihood of obstructed or “jammed” buckle assemblies. Additionally, although the illustrated embodiments include direct physical contact between the release button 220 and the pawl 214 (via the first spring mount 220 and the second spring mount 226), other embodiments can provide for the transfer of all (or most) of the force exerted on the release button 220 to the pawl 214 via indirect contact. For example, one or more intermediate components (e.g., rods, levers, blocks, slides, spacers, or other components) can be positioned between the release button 220 and the pawl 214. The intermediate component(s) can thereby transfer the force from the release button 220 to the pawl 214.

**[0031]** In several of the embodiments described above, the direct contact between the release button 220 and the pawl 214 provides for a transfer of additional force to the

pawl 214 to release the connector 106 from the buckle assembly 100. In other embodiments, the first biasing member 224 can be designed to provide for a direct transfer of additional force. For example, in some embodiments, the first biasing member 224 can be designed and positioned to fully compress and transfer all (or most) of the force exerted on the release button 220 to the pawl 214. Specifically, rather than direct contact between the release button 220 and the pawl 214, the first biasing member 224 can reach a fully compressed position (e.g., a solid height position) prior to contact between the release button 220 and the pawl 214. In such embodiments, the first biasing member 224 can effectively become a "solid" member (with adjacent coils of the biasing member in contact with one another) to transfer forces from the release button 220 to the pawl 214. In several such embodiments, the first biasing member 224 can be selected based on axial rigidity or other criteria. For example, the first biasing member 224 can be selected based on one or more factors that help reduce the likelihood of buckling or axial bending during complete compression.

**[0032]** Existing buckle assemblies often include switches that register their condition (e.g., latched or unlatched) based on the insertion of a connector. That is, the switches are positioned to be actuated by the insertion of a connector tongue into the buckle assembly and full engagement of the tongue with the buckle assembly. In general, insertion of a tongue corresponds with latching, and these existing switches can thereby provide an indication that the connector is fully engaged in most situations (e.g., by activation of a buzzer or other electrical component by the switch). However, when contaminants or other issues prevent a latch from moving into position, these existing buckle assemblies and switches can provide a false indication. That is, insertion of a tongue into these existing buckle assemblies can provide an indication that the buckle assembly is latched, even when contaminants have prevented the latch from moving into the latched position.

**[0033]** Buckle assemblies configured in accordance with the present technology can provide more reliable indications of their condition. In particular, the buckle assemblies disclosed herein include the switch 236 positioned to be actuated via movement of the pawl 214, and not merely by insertion of the connector 106. Specifically, referring to Figures 4 and 5A, actuation of the switch 236 requires rotation

of the pawl 214 and corresponding movement of the latch arm 302 in the direction of arrow  $A_2$ . Accordingly, the buckle assemblies disclosed herein include condition indicating systems that provide enhanced reliability.

**[0034]** Moreover, the positioning of the switch 236 can provide for enhanced reliability of the buckle assembly 100 by reducing the exposure of the switch 236 to contaminants. For example, the buckle assembly 100 can be mounted in a vehicle with the lower portion 204 of the housing 102 positioned toward an associated seat, and the upper portion 202 of the housing 102 thereby being above the lower portion 204. In the illustrated embodiment of Figures 2 and 5A, the switch 236 is positioned within the upper portion 202, adjacent the actuation arm 314. With the upper portion 202 of the housing 102 being above the lower portion 204, contamination that enters the buckle assembly 100 will generally settle in the lower portion 204. Accordingly, the switch 236 will be exposed to less contaminants and will be less susceptible to interference or failure.

**[0035]** Figure 9 is an enlarged isometric view of a pawl 902 configured in accordance with an embodiment of the present technology. The pawl 902 includes several components that are at least generally similar to those of the pawl 214 that was described above with reference to Figure 3. For example, in the illustrated embodiment, the pawl 902 includes a latch portion 904 and a drive portion 906. The latch portion 904 includes a latch arm 908, an engagement arm 910, and a pair of opposing tabs 912. The drive portion 906 includes a pair of hooks 914 (only one visible in Figure 9), a pair of locking arms 916, and a curved body 918 having a slot 920. The drive portion 906 can be coupled to the latch portion 904 via extension of the engagement arm 910 through the slot 920, and engagement of the hooks 914 with the tabs 912. The drive portion 906 further includes an actuation arm 922 having a second spring mount 924 and a protrusion with a contact surface 926. Similar to the pawl 214, the contact surface 926 can engage the actuation lever 238 on the switch 236 (Figure 2).

**[0036]** In several embodiments, the pawl 902 can be included in the buckle assembly 100 in place of the pawl 214. In such embodiments, several aspects of the operation of the buckle assembly 100 and the pawl 214 can be at least generally similar to that described above with respect to the buckle assembly 100 and the pawl 214. For

example, with reference to Figures 4, 8A–C and 9, incorporation of the pawl 902 into the buckle assembly 100 can provide for unlatching of the buckle assembly 100 via depression of the release button 220. In particular, the release button 220 can compress the first spring 224 and exert a first force against the drive portion 906, urging the pawl 902 to rotate and move the latch arm 908 in the direction of arrow A1. Additionally, the first spring mount 222 can directly contact the second spring mount 924, exerting a second force on the drive portion 904 that also urges the pawl 902 to rotate and move the latch arm 908 in the direction of arrow A1.

**[0037]** Operation of the pawl 914 can also differ in several aspects from that of operation of the pawl 214. As discussed above with respect to operation of the pawl 214, the locking arm 304 of the latch portion 216 can move the locking pin 234. In contrast, with reference to Figures 4, 8A–C and 9, incorporation of the pawl 902 into the buckle assembly 100 can include movement of the locking pin 234 via the drive portion 906. In particular, rotation of the pawl 902 in the direction of arrow A<sub>2</sub> drives the locking arms 916 of the drive portion 906 against locking pin 234, moving the locking pin 234 to the lower portions 404 of the second openings 212.

**[0038]** Buckle assemblies and restraint system components configured in accordance with the present technology can be designed and constructed to conform to a variety of regulations and standards. For example, the buckle assemblies and restraint system components disclosed herein can conform with Standard No. 209 (49 C.F.R. § 571.209), SAE Standard J386 (Society of Automotive Engineers, Standard J386), UNECE Regulation No. 16 (United Nations Economic Commission for Europe, Technical Prescriptions for Wheeled Vehicles, Addendum 15, Regulation No. 16), and/or other regulations and standards.

**[0039]** From the foregoing, it will be appreciated that specific embodiments have been described herein for purposes of illustration, but that various modifications may be made without deviating from the spirit and scope of the present technology. Those skilled in the art will recognize that numerous modifications or alterations can be made to the components or systems disclosed herein. Moreover, certain aspects of the present technology described in the context of particular embodiments may be combined or eliminated in other embodiments. Further, while advantages associated with certain embodiments have been described in the context of those embodiments,

other embodiments may also exhibit such advantages, and not all embodiments need necessarily exhibit such advantages to fall within the scope of the present technology. Accordingly, the inventions are not limited except as by the appended claims.

## CLAIMS

I/We claim:

1. A buckle assembly for releasably engaging a web connector, the buckle assembly comprising:

a frame having a pair of opposing openings;

a pawl pivotally mounted to the frame via the opposing openings, wherein the pawl includes a latch portion positioned to releasably engage the web connector;

a release actuator operably mounted to the frame; and

a biasing member operably positioned between the release actuator and the pawl, wherein the release actuator is movable to a first position to compress the biasing member against the pawl to urge the pawl to rotate and disengage the latch portion from the web connector, and wherein the release actuator is movable to a second position to further compress the biasing member and to contact the pawl to further urge the pawl to rotate and disengage the latch portion from the web connector.

2. The buckle assembly of claim 1, further comprising an ejector slidably coupled to the frame, wherein the ejector is movable via the web connector to urge the pawl to rotate and engage the latch portion with the web connector.

3. The buckle assembly of claim 1 wherein the pawl rotates in a first direction to disengage the latch portion, wherein the buckle assembly further comprises an ejector slidably coupled to the frame and positioned to be engaged by a tongue of the web connector, wherein insertion of the tongue into the buckle assembly drives the ejector against the pawl to rotate the pawl in a second direction that engages the latch portion with the tongue.



4. The buckle assembly of claim 1 wherein the latch portion includes a locking arm, wherein the pawl further includes a drive portion, and wherein the drive portion includes:

- a curved body having a slot, wherein the arm extends through the slot;
- a hook shaped to engage the latch portion; and
- a biasing member mount extending from the body, wherein the biasing member is positioned between the release actuator and the biasing member mount.

5. The buckle assembly of claim 1 wherein the pawl includes a first biasing member mount, wherein the release actuator includes a second biasing member mount, wherein the biasing member extends between the first biasing member mount and the second biasing member mount, and wherein the release actuator urges the pawl to rotate via direct physical contact between the first biasing member mount and the second biasing member mount.

6. The buckle assembly of claim 1, further comprising a switch configured to provide an indication of engagement of the web connector by the buckle assembly, wherein rotation of the pawl to disengage the latch portion from the web connector includes rotation of the pawl to contact the switch.

7. The buckle assembly of claim 6 wherein the pawl further includes a drive portion, wherein the drive portion is coupled to the latch portion, wherein the biasing member is operably positioned between the drive portion and the release actuator, and wherein rotation of the pawl to contact the switch includes contact between the drive portion and the switch.

8. The buckle assembly of claim 7 wherein the biasing member is a first biasing member, wherein the buckle assembly further comprises a second biasing member, and wherein the second biasing member biases the ejector to move the web connector out of the buckle assembly.

9. A personal restraint system, comprising:  
a web connector;  
a buckle assembly for releasably engaging the web connector, the buckle assembly including –  
a frame;  
a pawl rotatably coupled to the frame, wherein the pawl includes a latch portion configured to engage the web connector;  
a release actuator movably coupled to the frame; and  
a biasing member operably coupled between the release actuator and the pawl, wherein movement of the release actuator to a first position exerts a first force on the pawl via the biasing member, wherein movement of the release actuator to a second position brings the release actuator into contact with the pawl and exerts a second force on the pawl, and wherein the first force and the second force together urge the pawl to rotate in a direction that disengages the latch portion from the web connector.

10. The personal restraint system of claim 9 wherein the biasing member is a first biasing member, and wherein the buckle assembly further includes:  
an ejector slidably coupled to the frame; and  
a second biasing member positioned to bias the ejector in a direction that moves the web connector out of the buckle assembly, wherein insertion of the web connector into the buckle assembly moves the ejector to compress the second biasing member, wherein the direction is a first direction, and wherein the ejector is movable to contact the pawl and exert a third force on the pawl to rotate the pawl in a second direction, opposite to the first direction, that engages the latch portion with the web connector.

11. The personal restraint system of claim 9 wherein the pawl further includes a drive portion coupled to the latch portion, and wherein the first force and the second force are applied to the pawl via the drive portion.

12. The personal restraint system of claim 11 wherein the drive portion includes a slot and the latch portion includes a locking arm, and wherein the drive portion is secured to the latch portion via extension of the locking arm through the slot.

13. The personal restraint system of claim 9 wherein the pawl further includes a drive portion having a biasing member mount, wherein the first force is applied via contact between the biasing member and the drive portion at an outer perimeter of the biasing member mount, and wherein the second force is applied via contact between the release actuator and the biasing member mount.

14. The personal restraint system of claim 9 wherein the buckle assembly further includes a switch, wherein the pawl further includes a drive portion coupled to the latch portion, and wherein the switch is positioned to be actuated via the drive portion.

15. The personal restraint system of claim 14 wherein the buckle assembly further includes a housing having an upper portion and a lower portion, wherein the web connector is received in the lower portion, and wherein the switch is positioned within the upper portion.

16. A buckle assembly, comprising:  
a frame;  
a pawl having a latch portion, wherein the pawl is movably coupled to the frame and operable to releasably engage the latch portion with a web connector;  
a release button slidably coupled to the frame; and  
a biasing member operably coupled between the release button and the pawl and positioned to exert a force against the pawl to rotate the pawl in a direction that disengages the latch portion from the web connector,

wherein the release button is operable to compress the biasing member to a solid height position to increase the force on the pawl.

17. The buckle assembly of claim 16 wherein the biasing member is a coil spring having a plurality of coils, and wherein the solid height position includes compression to bring individual coils into contact with adjacent coils.

18. The buckle assembly of claim 16 wherein the pawl further includes a drive portion coupled to the latch portion, and wherein the buckle assembly further comprises a switch operable to provide an indication of a condition of the buckle assembly, wherein rotation of the pawl to disengage the latch portion from the web connector includes the drive portion contacting the switch.

19. The buckle assembly of claim 18, further comprising a housing having an upper portion and a lower portion, wherein the latch portion releasably engages the web connector within a space that is at least partially enclosed by the lower portion, and wherein the switch is positioned within a space that is at least partially enclosed by the upper portion.

20. The buckle assembly of claim 16 wherein the direction is a first direction, the buckle assembly further comprising an ejector slidably coupled to the frame, wherein the ejector is movable via the connector to engage the pawl and rotate the pawl in a second direction that engages the latch portion with the web connector.

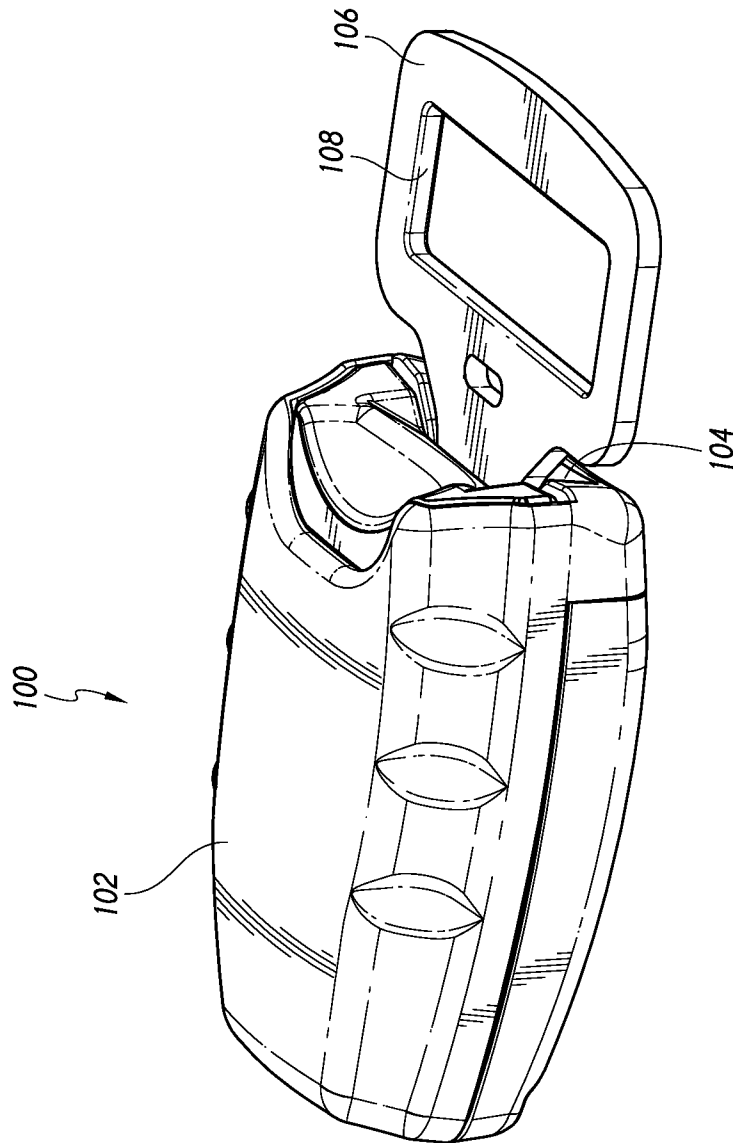


FIG. 1

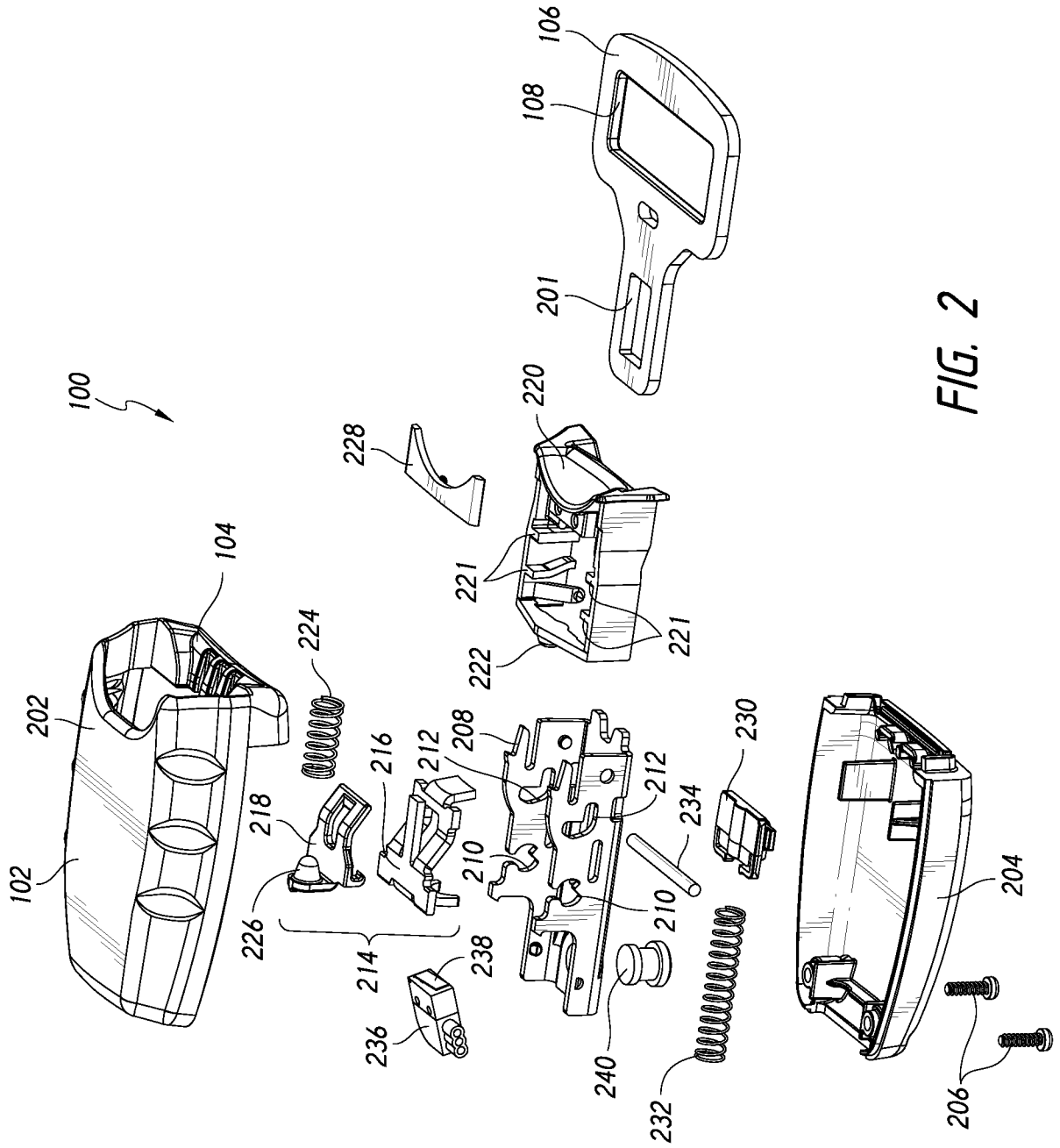


FIG. 2

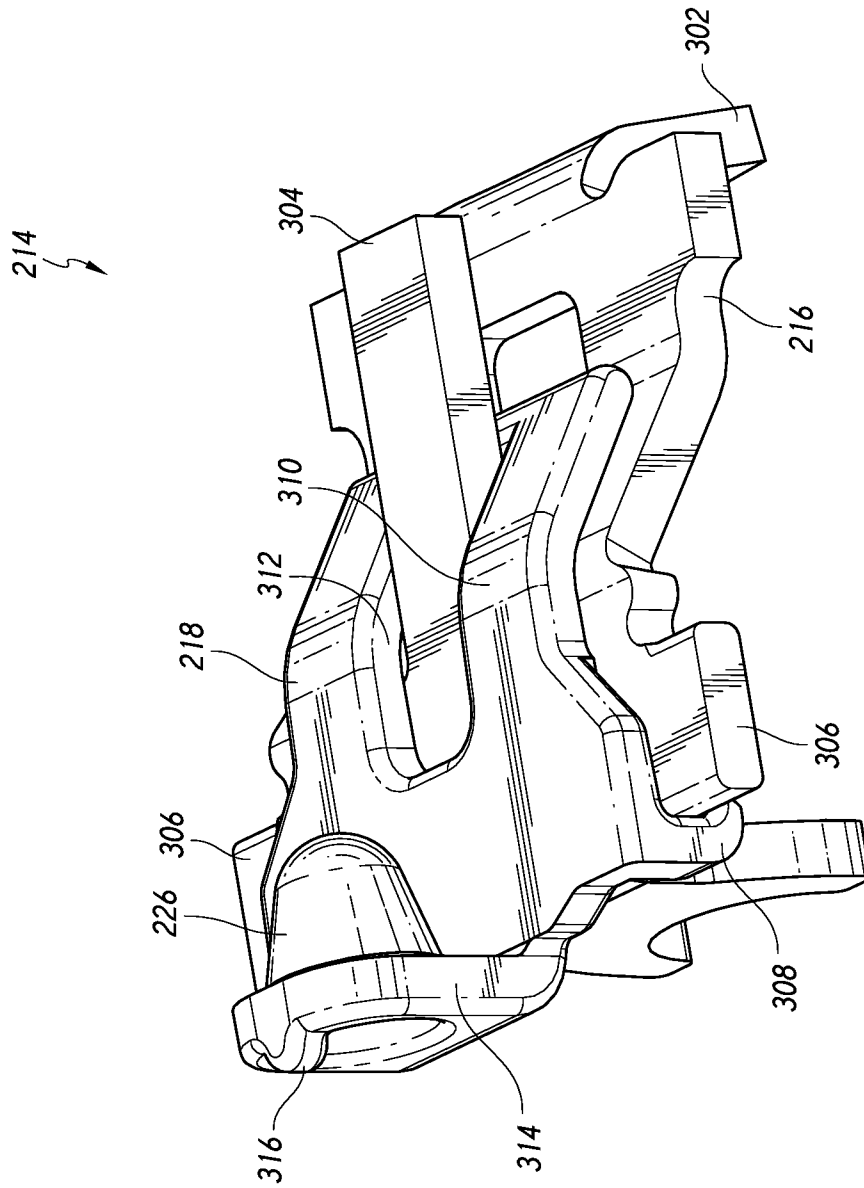


FIG. 3

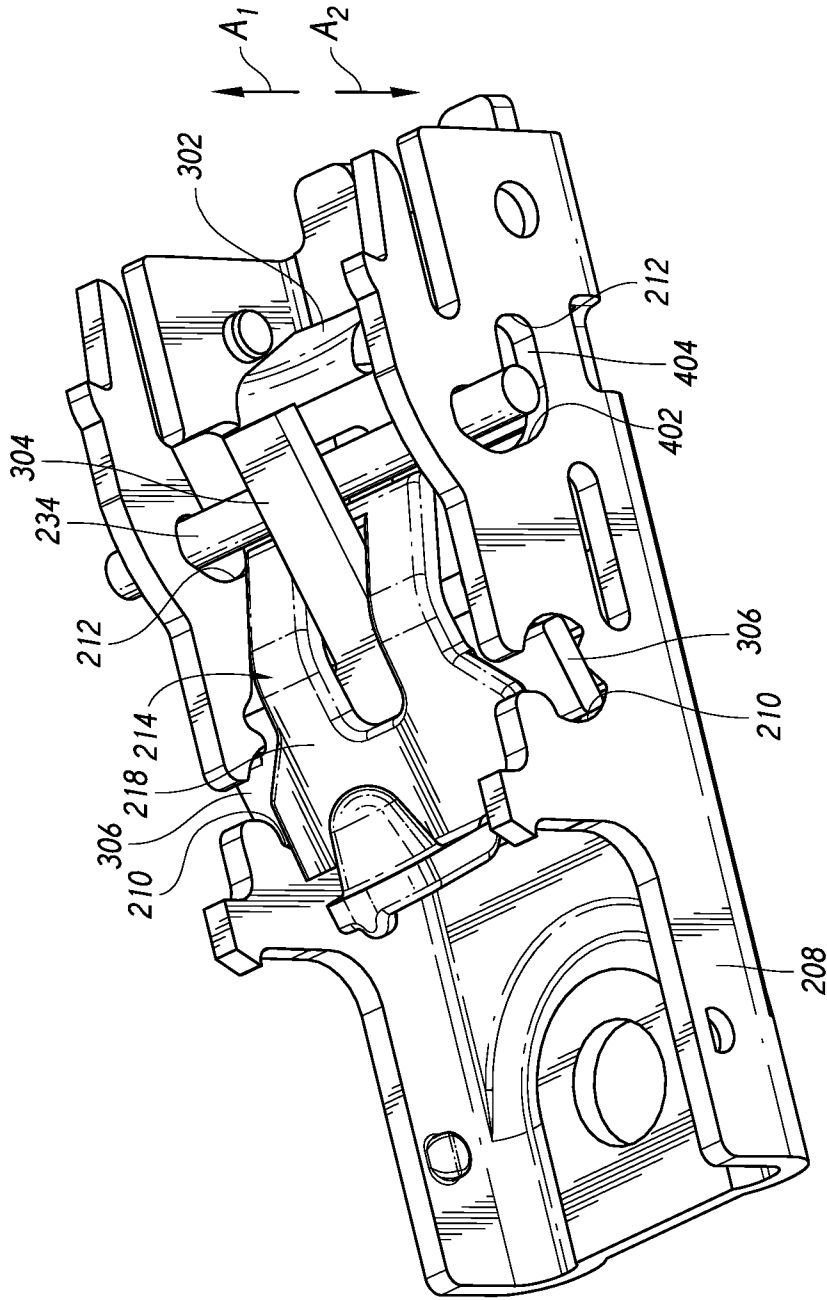


FIG. 4



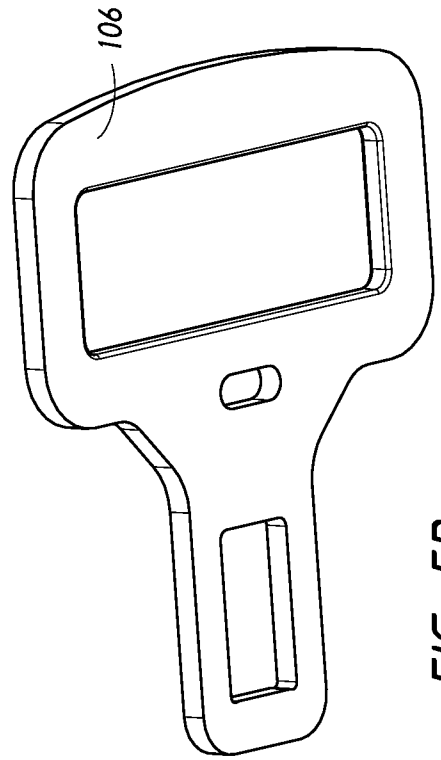
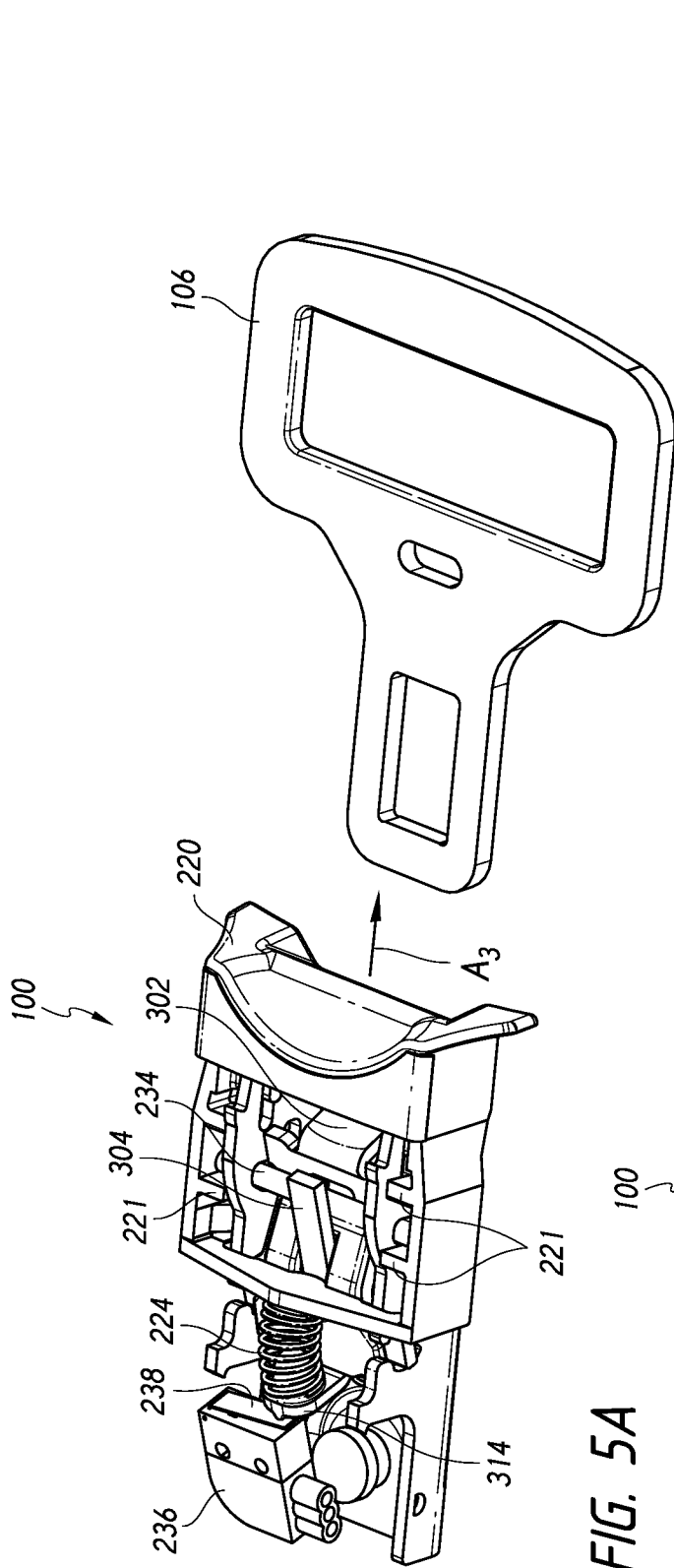


FIG. 5A

FIG. 5B

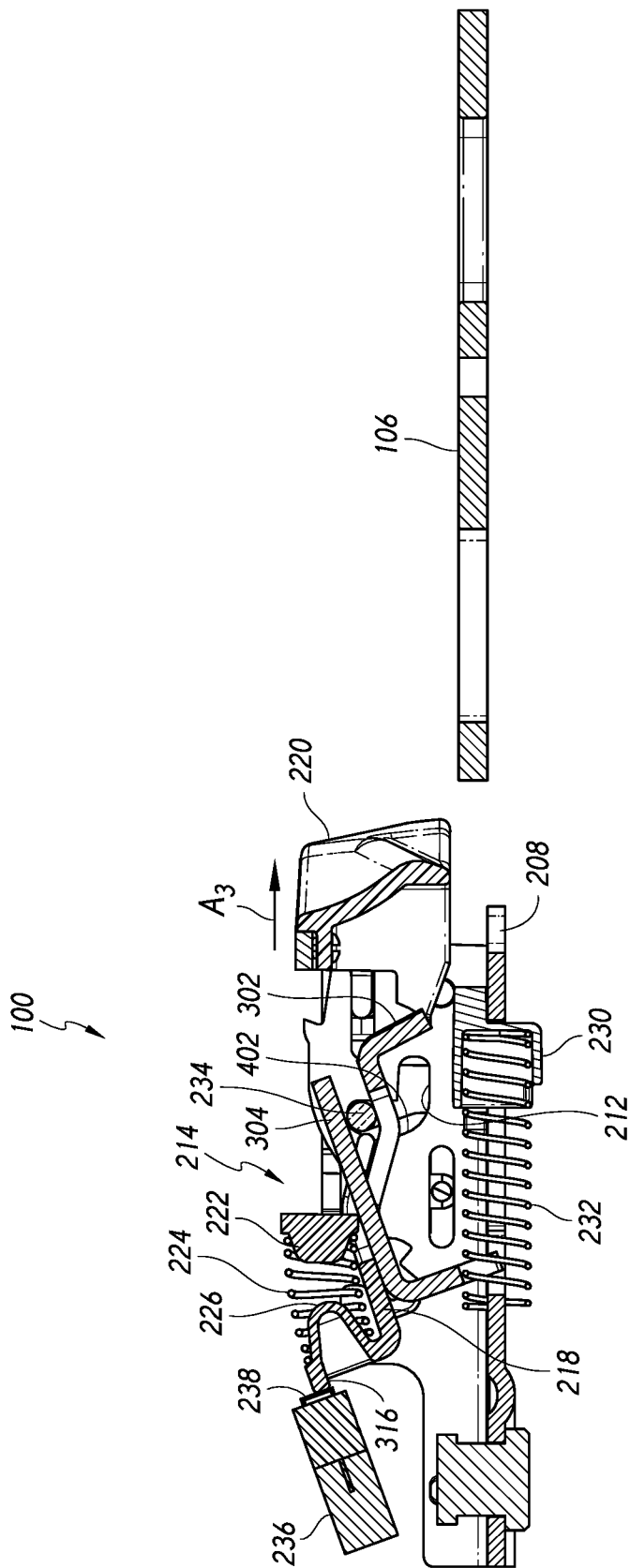


FIG. 5C

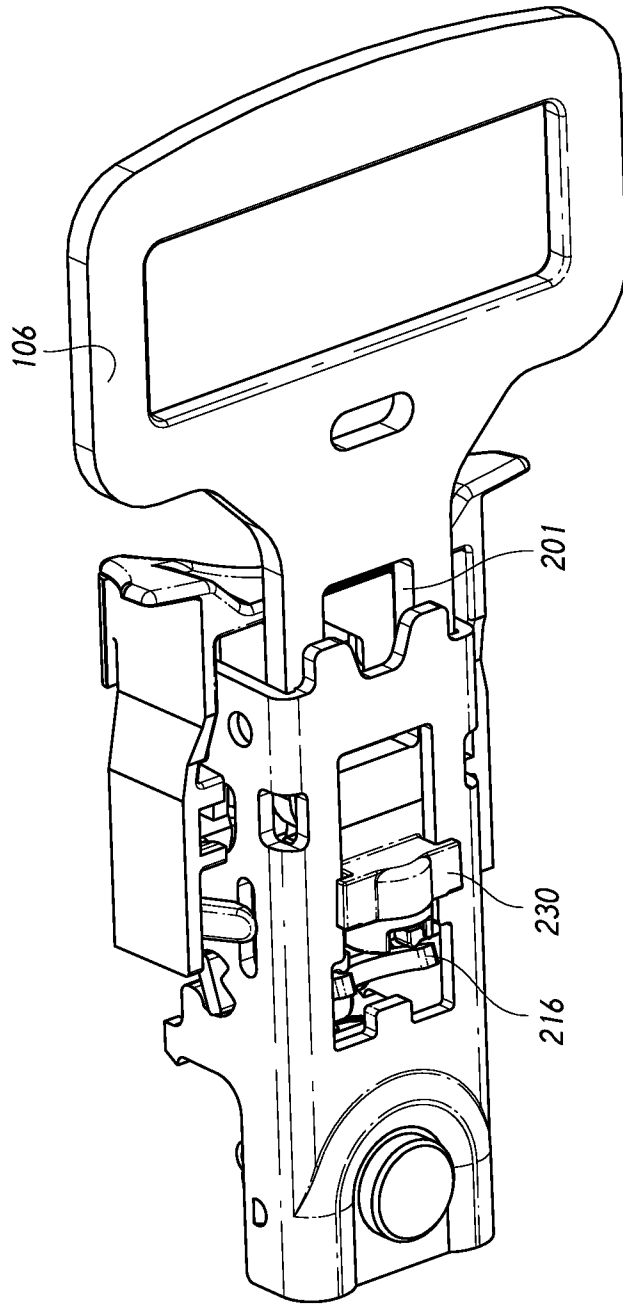


FIG. 6A

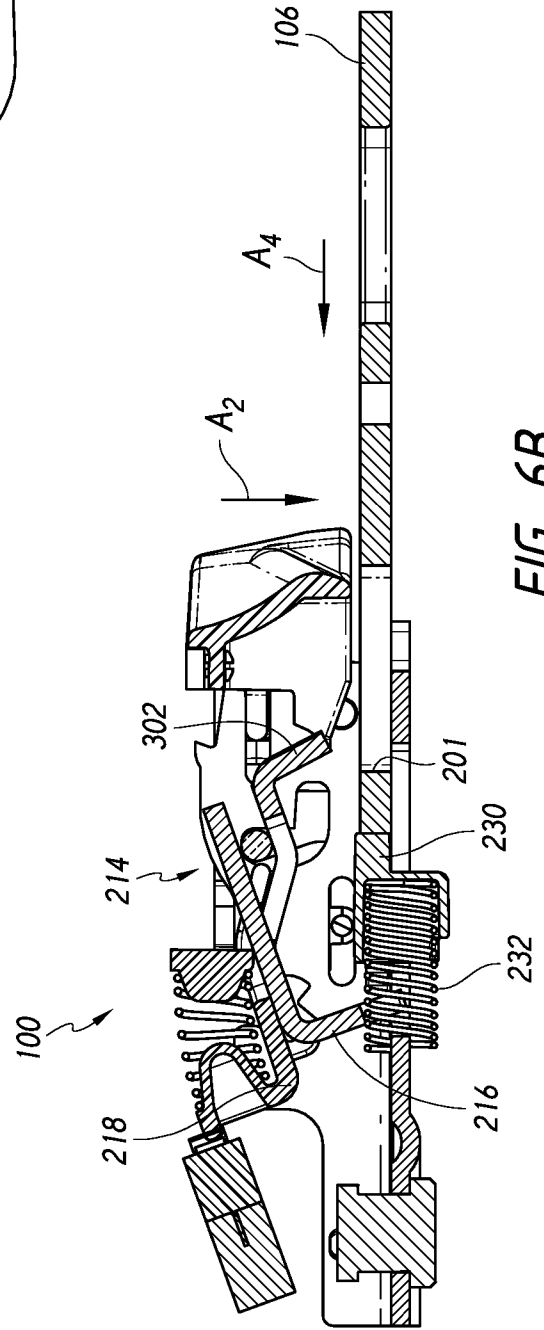


FIG. 6B

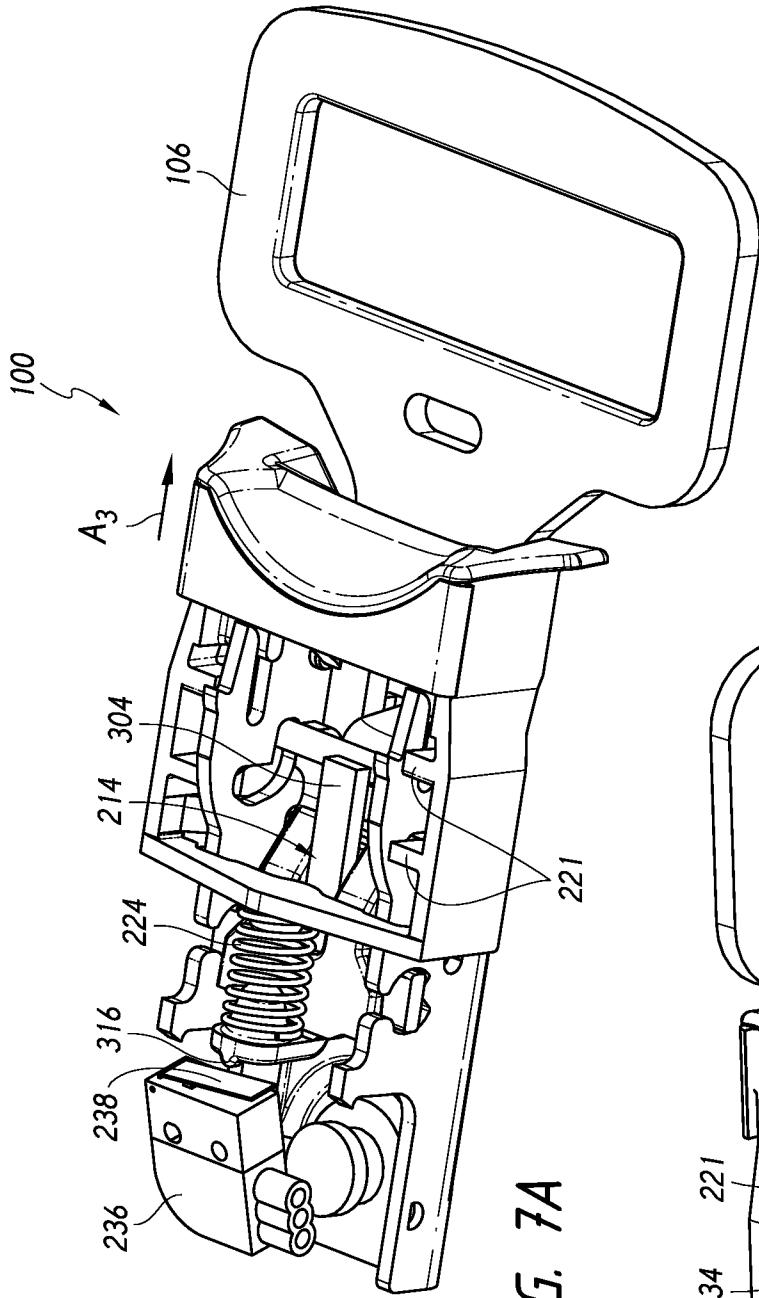


FIG. 7A

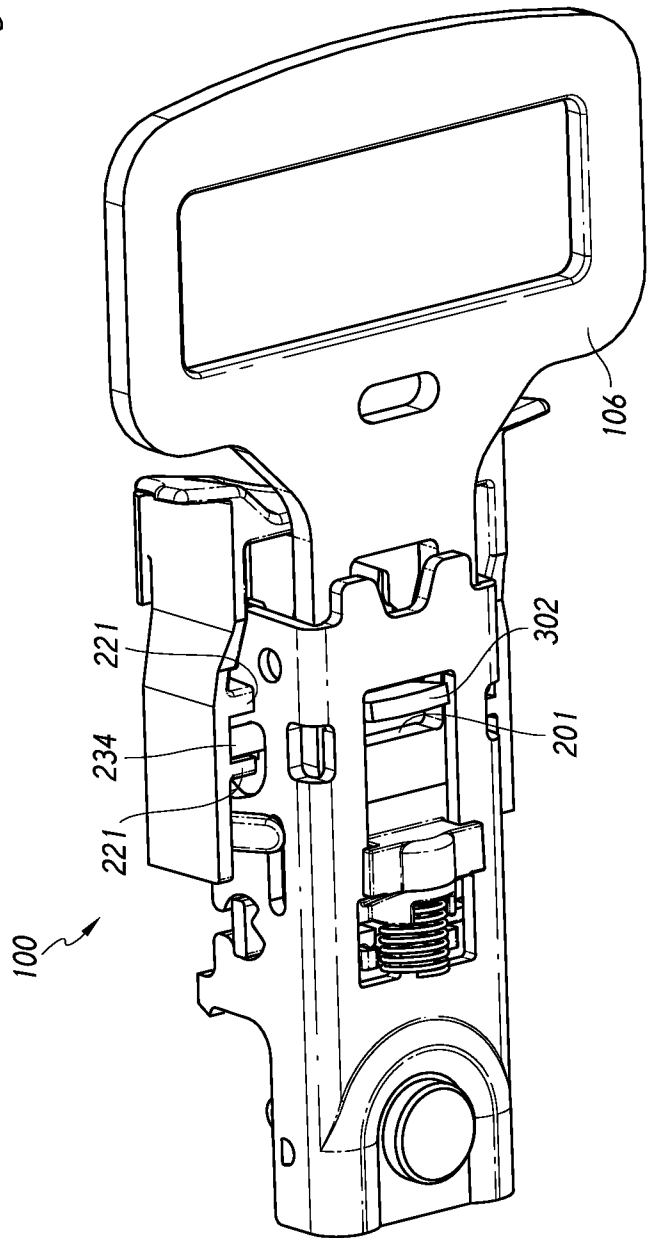


FIG. 7B

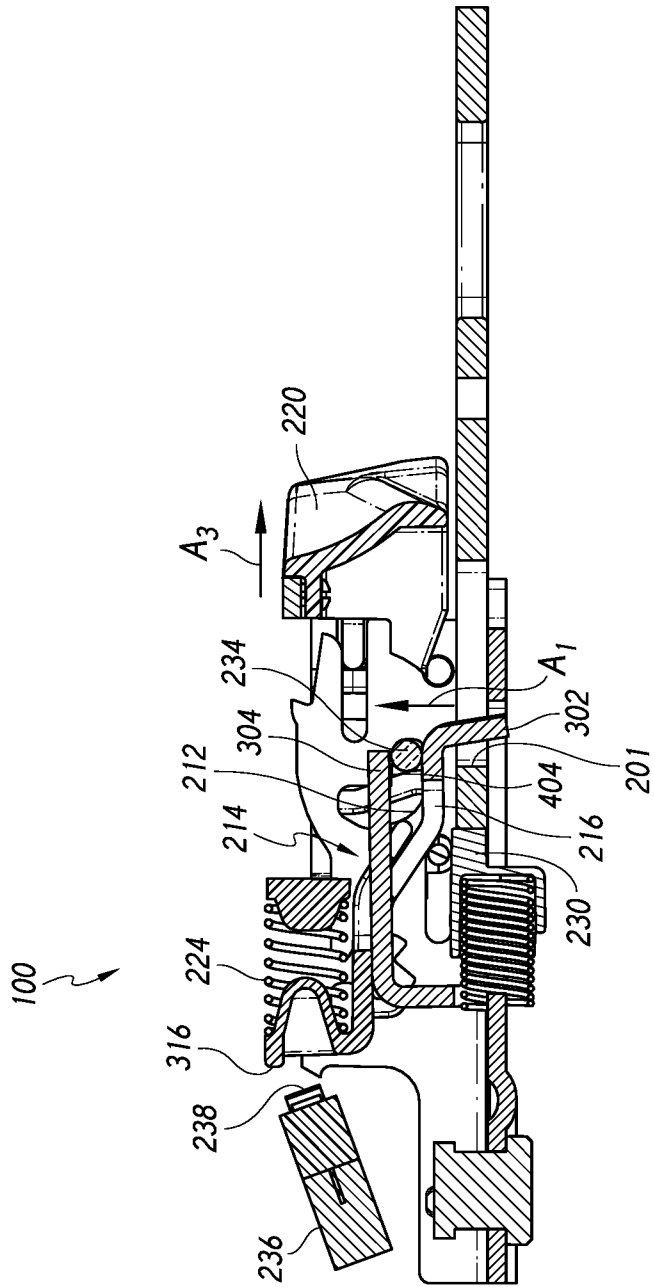


FIG. 7C

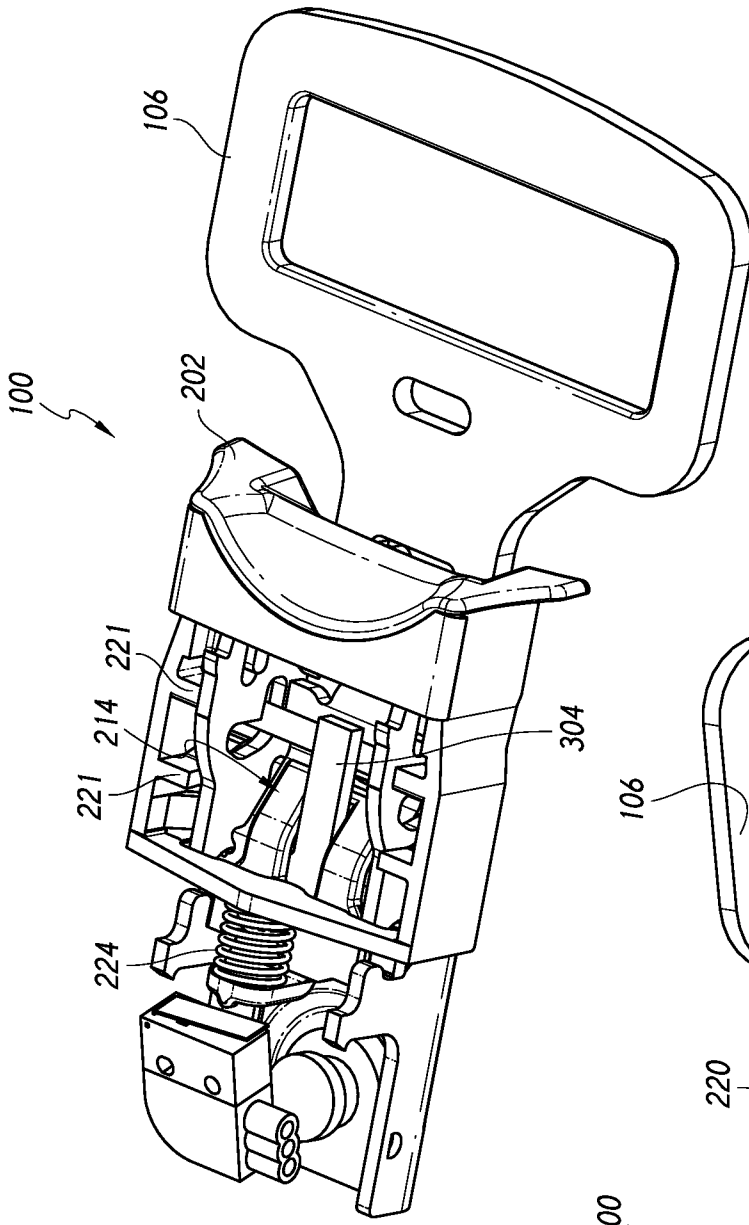


FIG. 8A

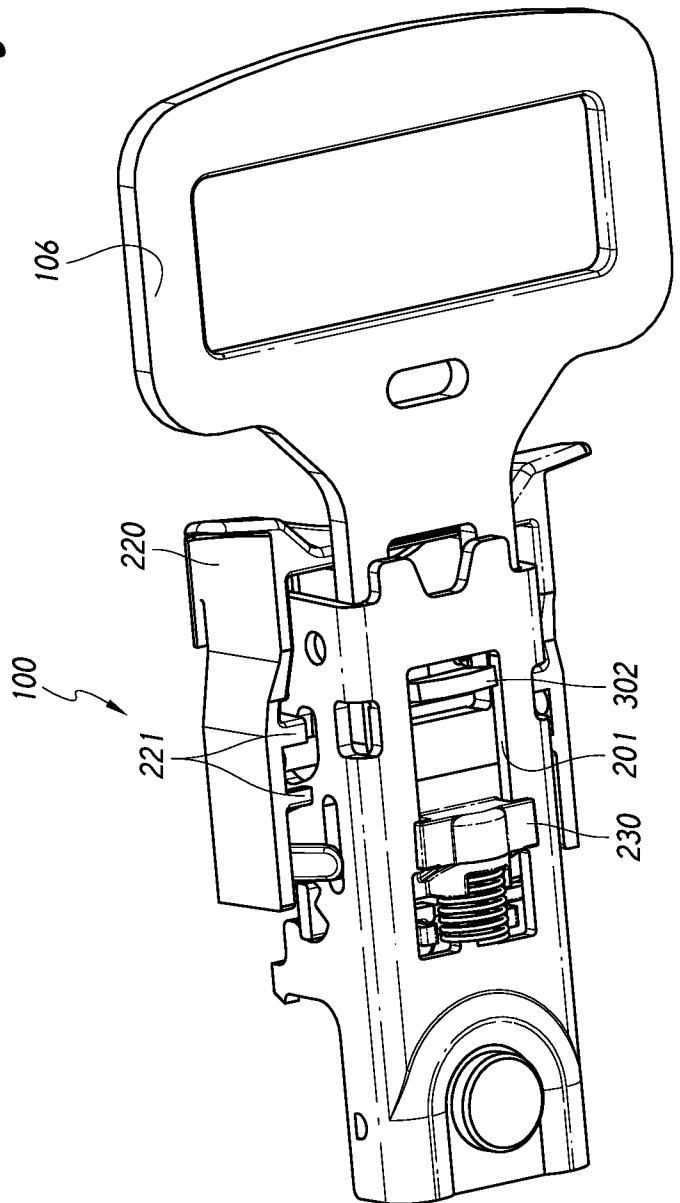


FIG. 8B

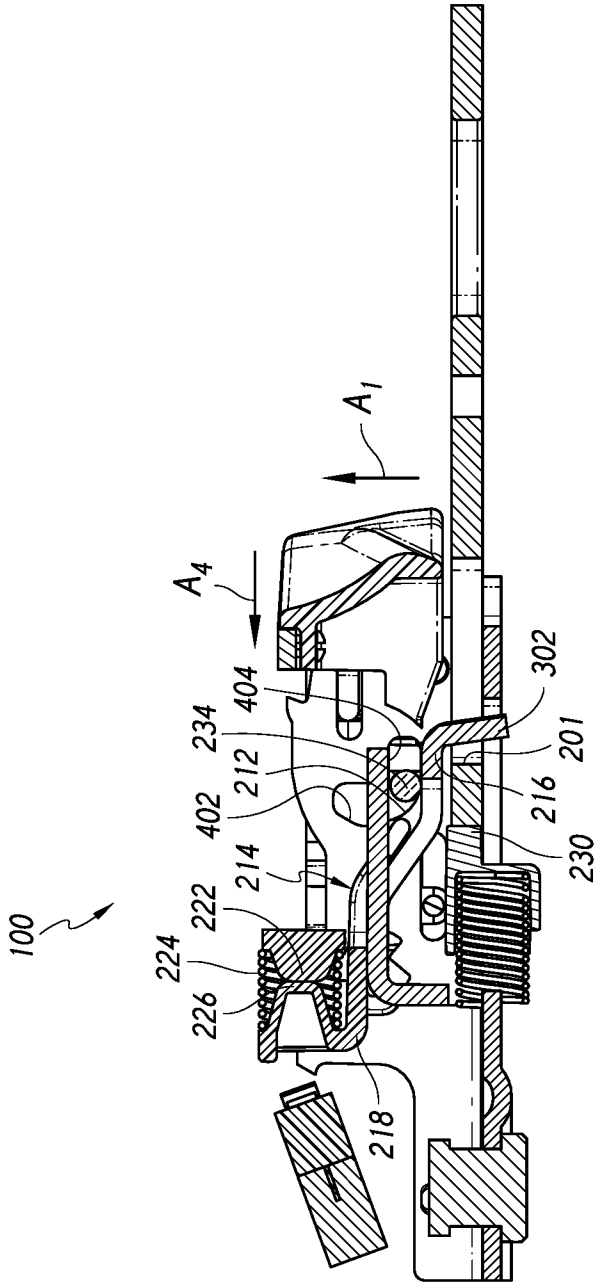


FIG. 8C

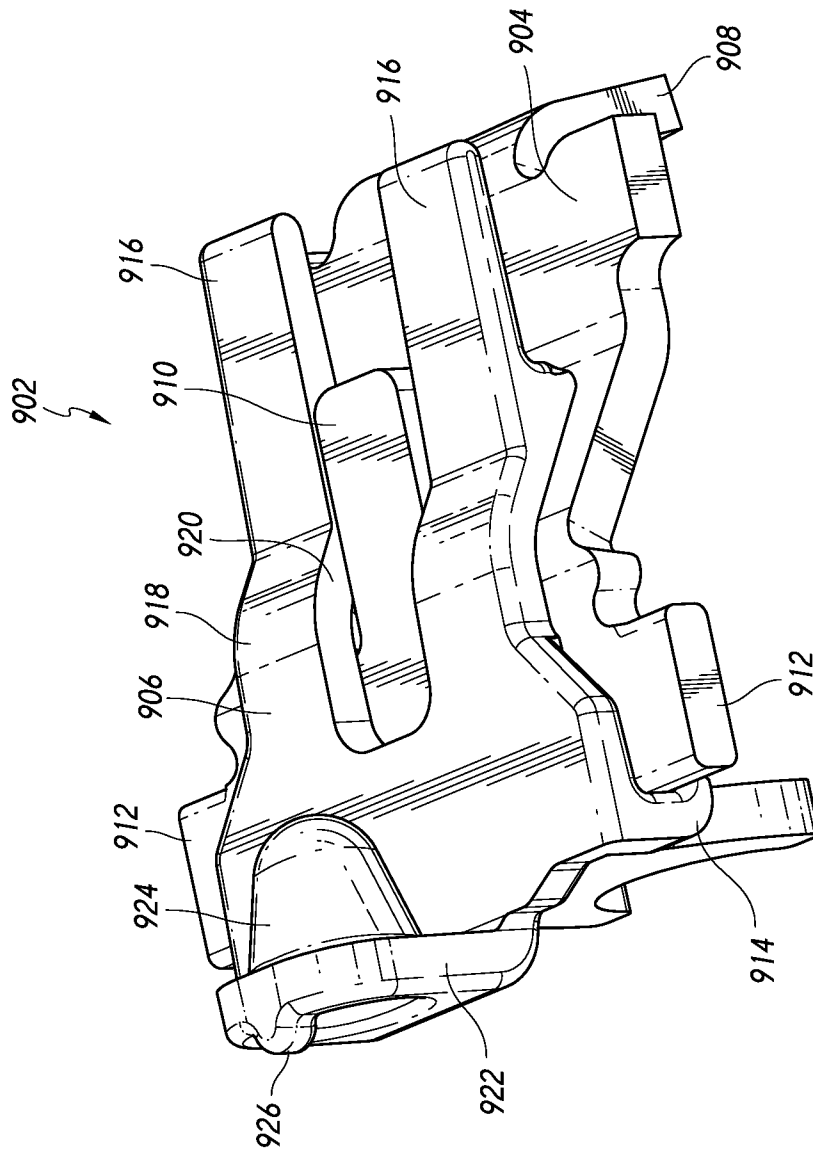


FIG. 9



INTERNATIONAL SEARCH REPORT		International application No. PCT/US16/64599
<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC: A41F 3/04( 2006.01);A44B 19/00( 2006.01)  CPC: 024/593.100 According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) CPC : 024/593.100  Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched  Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) US-PGPUB, USPAT, USOCR: pawl, buckle, latch, frame, ejector, restraint, tongue, blast, tongue, actuate, bias, switch.		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,428,103 A (WIER) 31 January 1984 (31.01.1984), see entire documents.	4, 6-8, 12, 14-15 and 18-19
X	US 2006/0090313 AI (MUROMACHI) 04 May 2006 (04.05.2006), see entire documents.	1-3, 5, 9-11, 13, 16-17, and 20
A	US 4,454,634 A (HAGLUND et al) 19 June 1984 (19.06.1984), see entire documents.	4, 6-8, 12, 14-15 and 18-19
A	US 4,562,625 A (DOTY et al) 07 January 1986 (07.01.1986), see entire documents.	4, 6-8, 12, 14-15 and 18-19
A	US 4,574,911 A (NORTH) 11 March 1986 (11.03.1986), see entire documents.	4, 6-8, 12, 14-15 and 18-19
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents:		
"A" document defining the general state of the art which is not considered to be of particular relevance  "E" earlier application or patent published on or after the international filing date  "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)  "O" document referring to an oral disclosure, use, exhibition or other means  "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention  "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art  "&" document member of the same patent family	
Date of the actual completion of the international search 06 January 2017 (06.01.2017)		Date of mailing of the international search report <b>12 JAN 2017</b>
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-8300		Authorized officer  John Nguyen  Telephone No. 571-272-6952