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(54) FALL INDICATOR FOR FALL PROTECTION SYSTEMS

(57) Apparatus and associated methods relate to fall arrester having a break-away fall indicator with an aperture aligned with an aperture of the fall arrester that supports a safety lanyard during a fall event. In an illustrative embodiment, the fall indicator may couple to a brake lever with a rivet, which may be a standard rivet, for example. The brake lever may be a component of a rope grab device. A lanyard may be secured through the aperture of the fall indicator and fall arrester with a carabiner, for example. When the fall arrester is subjected to a predetermined fall arresting force, the fall indicator may decouple from the brake lever, for example, by shearing. Upon being shed from its location, the fall indicator may advantageously indicate and alert persons (visually) that the fall protection safety harness has been subjected to a fall arresting force.

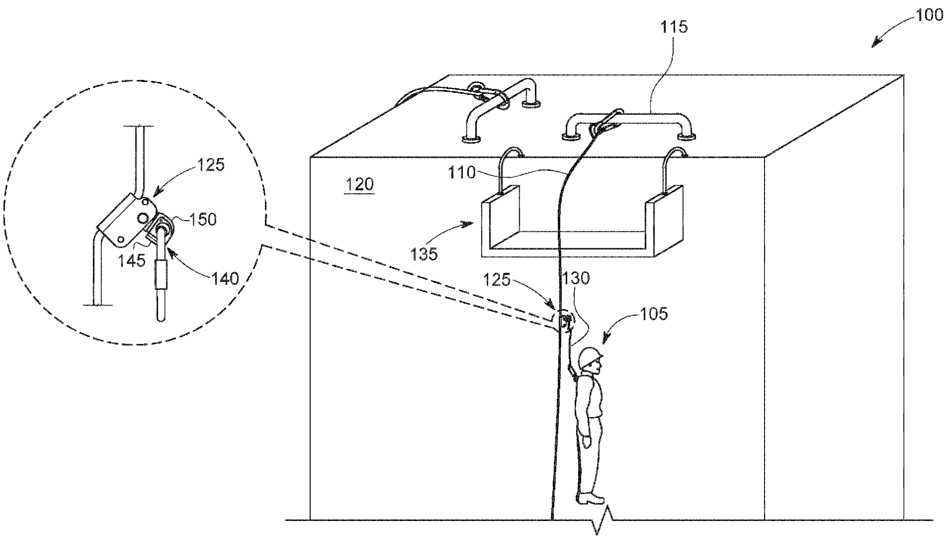

FIG. 1

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Description

TECHNICAL FIELD

[0001] Various embodiments relate generally to fall-protection system indicators that disclose whether a fall protection system has been subjected to a fall arresting force.

BACKGROUND

[0002] Many occupations require workers to operate at great heights. Examples of these occupations include bridge inspectors, high-rise construction operators, and skyscraper window washers. Therefore, fall protection safety systems are frequently used in today's industrial world to provide safety to those people working at dangerous heights above the ground. Individuals who work in such occupations may use safety equipment such as fall protection safety harnesses or fall arresters. Fall protection safety equipment may, in some examples, be fixed to a structure on one end and fastened to an individual's belt for example on the other end. When an individual moves, some fall arresters may slide up or down around a rope that passes through the harness. In an event of a fall, a brake incorporated in the fall arrester may become activated, thus preventing the individual from falling and suffering from injuries. In some countries, government safety regulations may require that fall protection safety harnesses be inspected and repaired.

SUMMARY

[0003] Apparatus and associated methods relate to fall arrester having a break-away fall indicator with an aperture aligned with an aperture of the fall arrester that supports a safety lanyard during a fall event. In an illustrative embodiment, the fall indicator may couple to a brake lever with a rivet, which may be a standard rivet, for example. The brake lever may be a component of a rope grab device. A lanyard may be secured through the aperture of the fall indicator and fall arrester with a carabiner, for example. When the fall arrester is subjected to a predetermined fall arresting force, the fall indicator may decouple from the brake lever, for example, by shearing. Upon being shed from its location, the fall indicator may advantageously indicate and alert persons (visually) that the fall protection safety harness has been subjected to a fall arresting force.

[0004] Various embodiments may achieve one or more advantages. For example, where the fall indicator has been detached from its location, the indicator may make easily recognizable the fact that that the fall protection safety harness has been involved in a fall arresting fall, which may advantageously alert users that the safety integrity of the fall harness may have been compromised. Because of its elegant design and relatively low cost, various embodiments of the fall indicator can be flexibly implemented in other fall protection safety systems, such as a ladder climbing system, horizontal or vertical safety systems, for example. Some embodiments of a fall indicator may be versatile, in that they may be configured to be installed in various types of fall arresting equipment. A fall indicator may beneficially allow an inspector to identify which fall arresters have been subject to falling forces and to quickly scan the affected fall arrester for metal or other material fatigue. Various parts may be replaced if a fall indicator signals that the part was involved in a fall incident, thus allowing repair persons to identify affected parts and reuse unaffected parts. Some embodiments may beneficially allow for easy service and unobtrusive design.

[0005] The details of various embodiments are set forth in the accompanying drawings and the description below. Other features and advantages will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006]

FIG. 1 depicts a perspective view of an exemplary safety harness deployment scenario, along with a zoomed-in side-elevation view of an exemplary fall arrester implementing an exemplary fall indicator.

FIG. 2 depicts a perspective view of an exemplary fall arrester implementing an exemplary fall indicator.

FIG. 3 depicts an exploded view of an exemplary fall arrester system implementing an exemplary fall indicator.

FIGs. 4A, 4B, 4C, 4D, 4E, 4F, and 4G depict various views illustrating exemplary stages of a fall arrest system subject to a fall event.

FIGs. 5A, 5B, 5C, and 5D depict various views of an exemplary fall arrester implementing an exemplary fall indicator.

FIGs. 6A, 6B, and 6C depict various views (perspective, exploded, and cross-sectional, respectively) of an exemplary fall arrester implementing an exemplary fall indicator.

FIGs. 7A, 7B, 7C, 7D, and 7E depict perspective views of an exemplary fall arrester implementing an exemplary fall indicator with different aperture shapes.

FIG. 8A, 8B, and 8C depict perspective views of different exemplary fall arresters implementing an exemplary fall indicator.

[0007] Like reference symbols in the various drawings indicate like elements.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0008] FIG. 1 depicts a perspective view of an exemplary safety harness deployment scenario, along with a zoomed-in side-elevation view of an exemplary fall arrester implementing an exemplary fall indicator. A safety harness deployment scenario 100 includes a user 105 suspended from a support rope 110. The support rope 110 is hanging from a roof restraint safety line 115 on top of a building 120, which allows the user to move horizontally while hanging vertically from the support rope 110 on a side of the building 120.

[0009] In the depicted embodiment, the user 105 is coupled to the rope by a fall arrester 125, which in this case, is a rope grab device 125. The user 105 is coupled to the fall arrester 125 by a lanyard 130. In the state shown in FIG. 1, a user 105 has just experienced a fall event (e.g., they have accidentally fallen off of the work platform 135) and is dangling from the rope 110. In this exemplary scenario, because the fall arrester 125 is strong enough to support the user 105, the fall arrester 125 has successfully saved the user 105 from potentially severe injury by falling off the building 120. However, because the fall arrester 125 has experienced a fall event, the fall arrester 125 is now used and may experience fatigue, wear-and-tear, and/or deterioration.

[0010] Accordingly, to apprise the user 105 and perhaps other persons that the fall arrester 125 has experienced a fall event and may be less than 100% functional/safe-to-use, a fall indicator system 140 is provided which visually indicates that a fall event has taken place. In this exemplary embodiment, the fall indicator system 140 includes a fall indicator 145. The fall indicator 145 may be mechanically coupled (fastened) to a brake lever 150 of the fall arrester 125 via a fastener (not shown). Before a fall event has taken place, the fall indicator 145 is fastened to the brake lever 150 and supports the weight of the user 105. After a fall event has taken place, a cutting force caused by the falling force of the user 105 on the fall indicator 145 results in the fall indicator 145 being at least partially detached from the brake lever 150. This separation of the fall indicator 145 from the rest of the fall arrester 125 provides a visual indication that the fall arrester 125 has experienced a fall event, thus advantageously providing a warning to the user 105 and other persons that the fall arrester 125 may need to be safety checked for wear-and-tear, repaired, or otherwise replaced with a new, unused, and safe fall arrester.

[0011] FIG. 2 depicts a perspective view of an exemplary fall arrester implementing an exemplary fall indicator. A fall arrester 200 includes a base 205. The base 205 possesses a channel 210 through which a support rope, for example, may pass through. The base 205 is mechanically coupled to a brake lever 215, which may be referred to as a fall support coupler, in some examples. In some examples, the brake lever 215 is pivotably coupled to the base 205 at a pivot point 220 (e.g., a pivot pin mechanically coupled to the base 205). This may allow for a braking surface (not shown) of the brake lever 215 to physically and frictionally engage a support rope lying in the channel 210 when a downward (fall) force on a distal end 218 of the brake lever 215 causes the brake lever 215 to pivot about pivot point 220, thus braking the fall arrester 200 in the event of a fall.

[0012] At the distal end 218 of the brake lever 215, a fall indicator 225 is attached to the brake lever 215 via a fastener 230. In some examples, the fastener 230 may be a rivet, which may beneficially provide for strong and resilient mechanical fastening between the brake lever 215 and the fall indicator 225. The fall arrester 200 includes a plurality of apertures 235. The plurality of apertures 235 includes at least one aperture of the brake lever 215 and at least one aperture of the fall indicator 225, which at least partially overlap in a pre-fall state. In various examples, a user of the fall arrester 200 may couple themselves to the fall arrester 200 by inserting a carabiner (not shown) through the plurality of apertures 235, where the carabiner is coupled to a lanyard (not shown) that is in turn coupled to a fall safety harness (not shown) worn by the user. In some examples, the fall indicator 225 may be configured pivot about the brake lever 215 (e.g., due to a slip/clearance-fit coupling of the fastener 230). In various examples, the fall indicator 225 may be held in a mostly fixed but somewhat movable position relative the brake lever 215 (e.g., due to a location/transition-fit coupling of the fastener 230). In various examples, the fall indicator 225 may be held in a fixed position relative the brake lever 215 (e.g., due to a press/interference-fit coupling of the fastener 230). The various fits may have various advantages, which may include elegant simplicity (e.g., a low number of parts) and easy assembly, which may, in some examples, have a positive impact on manufacturing cost.

[0013] In the depicted embodiment, the fall indicator 225 includes at least one symbol 240. The at least one symbol 240 may convey a visual message to an onlooker that the purpose of the fall indicator 225 is to be an indicium of whether the fall arrester 200 has been subject to a fall. In this exemplary depiction, the at least one symbol 240 is writing that reads "FALL INDICATOR." Furthermore, the construction of the fall indicator 225 includes a first flange 241 and a second flange 242 that are integrally formed with a center portion 243. In some examples, the flanges 241, 242 extend away from the center portion 243, such that in a pre-fall state, the fastener 230 mechanically couples the brake lever 215 to both the first flange 241 and the second flange 242. In this depicted example, the first and second flanges 241, 242 extend parallel to one another and in the same direction, and the first and second flanges 241, 242 define a fall indicator channel where, in a pre-fall state, the brake lever 215 lies at least partially within the fall indicator channel.

[0014] In the depicted example, both the brake lever 215 and the fall indicator 225 lie and extend in a common plane P1. In some examples, the brake lever 215 and the fall indicator 225 may lie in different planes that are substantially parallel to one another (e.g., a first plane and a second plane that have respective normal vectors angled with respect to one another by about 0.01°, 0.1°, 0.5°, 1°, 2°, or about 5° or more. In some examples, the brake lever 215 may be configured to rotate within the plane P1. In some examples, the fall indicator 225 may be configured to rotate within the plane P1 (or another plane substantially parallel to P1). In the depicted example, the plane P1 lies in the z-x plane of the system in FIG. 2.

[0015] In various examples, the coordinate system associated with a given fall arrester may include x-y-z components. In some embodiments, when a fall occurs, a fall force vector (described further below) may be applied to the fall indicator and/or the brake lever (also referred to as a fall support coupler). A fall force vector may have a vector component that is directed in a downward (e.g., -z) direction, due to a coupled user falling from a height, for example. In various examples, the fall force vector may be directed (radially) away from the base. In the depicted example, a vector component applied at the fall indicator aperture may be directed away from the base in an angle lying in the z-x plane, with a vector projection directed at least partially in the positive x axis.

[0016] FIG. 3 depicts an exploded view of an exemplary fall arrester system implementing an exemplary fall indicator. A fall arrester system 300 includes a rope 305, a fall arrester 200, and a carabiner 310. The rope 305 may be inserted through the channel 210 of the base 205 of the fall arrester 200. The carabiner 310 may be inserted through the plurality of holes 235 of the fall arrester 200. In this exploded view, additional details of the brake lever 215 are shown.

[0017] Specifically, the brake lever 215 includes a pivot aperture 245 which allows the braking lever 215 to pivotably couple to the base 205 at the pivot point 220. The brake lever 215 includes a braking surface 250 configured to engage the surface of the rope 305, for example, to cause the fall arrester 200 to brake relative to the rope 305. In this exemplary depiction, the braking surface 250 is at a proximal end of the brake lever 215. The braking lever 215 includes at least one symbol 255. The at least one symbol 255 may convey a visual message to an onlooker that the fall arrester 200 has been subject to a fall event, which may provide an indicium of whether the fall arrester 200 has been subject to a fall. In this exemplary depiction, the at least one symbol 255 is writing that reads "DON'T USE THIS DEVICE IF YOU SEE THIS TEXT." The braking lever 215 includes a first aperture 260. In a fall-event state, the material (e.g., steel) surrounding the first aperture 260 may support the weight of a fallen user.

[0018] The fall indicator 225 includes a second aperture 265. In a pre-fall state, the second aperture 265 is at least partially aligned with the first aperture 260. Furthermore, the fall indicator 225 includes a fastener feature (e.g., hole) 270, while the brake lever 215 includes a complementary fastener feature (e.g., hole) 275. The fastener 230 may cooperate with the fastener features 270, 275, to fasten the fall indicator to the brake lever 215. In a pre-fall state, the material (e.g., aluminum) surrounding the second aperture 265, in conjunction with the fastener 230 and the rest of the fall arrester 200, may support at least some of the weight of a user.

[0019] FIGs. 4A, 4B, 4C, 4D, 4E, 4F, and 4G depict various views illustrating exemplary stages of a fall arrest system subject to a fall event. In a pre-fall state 400A (perspective view), the base 205 of the fall arrester 200 surrounds the rope 305, while the carabiner 310 is inserted through the apertures of the brake lever 215 and the fall indicator 220. In a pre-fall state 400B (side elevation view), the base 205 is shown as being transparent for the purpose of illustrating the internal parts of the fall arrester 200. Because little to no downward force is being applied to the distal end of the brake lever by the carabiner 310, the fall arrester 200 is free to move up and down relative to the rope 305. It is worth noting that in the states 400A and 400B, the at least one symbol (warning) 255 on the brake lever 215 is completely obscured by the fall indicator 225. FIGs. 4A-4C may be considered as depicting the apertures 235 in a first alignment orientation.

[0020] In an intermediate state 400C, the carabiner 310 is supporting at least some weight of a user, represented by force vector 222. The carabiner 310 may support the weight of a user, for example, via a lanyard (not shown) that is coupled between the carabiner 310 and the user. In various examples, the carabiner 310 may be an optional feature. This causes the distal end of the brake lever 215 to pivot about pivot point 220, which in turn causes the braking surface 250 at a proximal end of the brake lever 215 to brakingly engage the rope 305. This also causes the angle θ at which the fall arrester 200 is oriented relative to a vertical axis aligned with the rope 305 to adjust (e.g., due to the adjusted center of mass/gravity of the fall arrester/carabiner/lanyard/user system). In the depiction of 400C, enough weight is applied to the fall arrester 200 to transition it into a braking state, but not enough weight is applied to the fall arrester 200 to cause the fall indicator 225 to become detached/sheared/decoupled from the braking lever 215. Accordingly, in the intermediate state 400C, the fall indicator 225 is still fastened to the braking lever 215 by the fastener 230.

[0021] In a (post) fall-event state 400D (e.g., where a user coupled to the fall arrester 200 has fallen), sufficient force (e.g., at least 3 kN) as signified by the force vector 222 has been applied to the fall indicator 225 by the carabiner 310 to cause the fall indicator 225 to at least partially detach from the brake lever 215. It is worth noting that in the state 400D, the at least one symbol 255 on the brake lever 215 is at least partially visible (e.g., at least partially unobscured by the fall indicator 225). In some examples, the amount of force required to separate the fall indicator 225 from the brake lever 215 may be predetermined according to the specific material properties (e.g., strength, shear, hardness, resilience) of the fall indicator 225, the brake lever 215, and/or the fastener 230. In some examples, an important material property may be ductility. The ductility attribute may be especially important for the fall indicator 225 itself, because a low ductility of material secures a good condition of fall indicator 225 (e.g., almost no deformation) in force range of about 0 kN to about 3kN, for example. For optimal function of the fall indicator 225, it may be important to suddenly crack the fall indicator when the force exceeds about 3kN or more, for example. This sudden crack is based on low ductility of material. Some examples of values/numbers for ductility properties may be detailed by the ductility of material EN AW 5083, which may be used for fall indicator 225, is about 11% (e.g., about 5%-15%). This 11% number may mean that fall indicator 225 can increase length only for 11%, and any increase in length after 11% will result in a sudden crack. In some examples, the maximum ductility of material for fall indicator 225 may be 11%.

[0022] For example, the brake lever 215 and the fastener 230 may be made of (stainless) steel, while the fall indicator 225 may be made of aluminum. In such an example, the stronger steel may resist cutting/shearing, while the weaker aluminum may be cut/sheared by the fastener 230, which results in the fall indicator 225 being cut away from the rest of the fall arrester 200. In various embodiments, the brake lever 215 and the fall indicator may be made from steel, while the fastener 230 may be made from aluminum. In such an example, the stronger steel may resist cutting/shearing, while the fastener 230 made of weaker aluminum may be cut/sheared by the fall indicator 225 and/or the braking lever 215, which results in the fall indicator 225 being unfastened from the rest of the fall arrester 200. In various examples, the materials and/or mechanical material properties of the brake lever 215, the fastener 230, and the fall indicator 225 may be optimized to achieve the desired effect.

[0023] In the post-fall state 400E, the carabiner 310 has been removed from both the braking lever 215 and the fall indicator 225, which are no longer fastened to one another. In the post-fall state 400F, the fall indicator 225 has been completely removed from the braking lever 215. In the post-fall state 400G, the at least one symbol 255 of the brake lever 215 is now fully visible (e.g., completely unobscured by the fall indicator 225). In the states 400D-400G, the (at least partial) visibility of the warning symbol 255 may advantageously apprise a person, such as the user 105, that the fall arrester 200 has experienced a fall event and may require inspection, repair, or replacement. FIGs. 4D-4E may be considered as depicting the apertures 235 in a second (mis-)alignment orientation.

[0024] In various examples, the force vector 222 may not always be a downwardly directed force vector. For example, the force vector 222 may be a vector having a force component that is: (1) substantially parallel to P1, (2) greater than or equal to a minimum amount of predetermined force (e.g., 3 kN), and (3) directed radially away from the base 205. In some examples, the largest magnitude component of a fall force vector may be in a downward direction (e.g., due to the force of gravity accelerating a falling user towards the center of the Earth).

[0025] FIGs. 5A, 5B, 5C, and 5D depict various views of an exemplary fall arrester implementing an exemplary fall indicator. The fall safety system 500A shown in FIG. 5A (right side elevation view) may substantially resemble the state 400C depicted in FIG. 4C. The fall safety system 500A illustrates detail view A-A, which is shown in FIGs. 5C and 5D. The fall safety system 500B also illustrates a view of the detail view A-A (partially cutting away a distal end of braking lever 215 and fall indicator 225), which is shown in FIGs. 5C and 5D. In the detail views A-A shown in systems 500C and 500D, a vertical cross-section of the braking lever 215 and fall indicator 225 is shown. The fall indicator 225 includes the central portion 243 bridging the first and second flanges 241, 241. The fastener 230 mechanically couples the flanges of the fall indicator 225 to the braking lever 215. In this depicted embodiment, the fastener 230 is a rivet that passes through and occupies the area of the fastener coupling features (holes) 270, 275 of the fall indicator 225 and braking lever 215, respectively.

[0026] In this exemplary depiction, the vertical cross-sectional (2-D) areas 505, 510 on the top portions of the flanges 241, 242 (above the fastener 230) are configured to be cut by the fastener 230 when sufficient force is applied to the fall indicator 225. Theses cross-sectional areas 505, 510 are governed by the following shear stress formula:

$$\mathrm{F_c} = \tau_\mathrm{K} * \mathrm{S_c}$$

[0027] Where F_c is the cutting force, τ_K is the strength of the material (shear stress), and S_c is the cross-sectional area to be cut. In an illustrative embodiment, the vertical 2D area of each cross-sectional area 505, 510 may be 9.4 mm^2, for example. Therefore, because there are two identical cross-sectional areas to be cut, S_c is twice the individual areas 505, 510 (e.g., $S_c = 2 * 9.4\ mm^2 = 18.8\ mm^2$). Assuming the fall indicator 225 is made out of aluminum (e.g., Alu EN AW 5083), the ultimate tensile strength of the fall indicator 225 material is $R_m = 275$ MPa. The strength of this material (τ_K) is related to the ultimate tensile strength (R_m) by the equation:

$$\tau_\mathrm{K} = \frac{\mathrm{R_m}}{\sqrt{3}}$$

[0028] As such, the strength of the fall indicator 225 material in this case would be $\tau_K = 275\ \text{MPa} / \sqrt{3} = 158.8$ MPa. Accordingly, the force required to cut both specified areas of this exemplary aluminum fall indicator 225 would be $F_c = \tau_K * S_c = 158.8\ \text{MPa} * 18.8\ mm^2 = 2985\ \text{N} \approx 3$ kN. So, in this exemplary case, if the target/optimal force for cutting F_T in a given situation is in the vicinity of F_c (e.g., +/- about 0.01%, 0.1%, 1%, 2%, 5%, or about 10% or more), then fall indicator 225 will be cut in accordance with the above calculations.

[0029] In some embodiments, a similar calculation may be applied to the cross-sectional areas of the fastener 230, for example, in the case where the fastener 230 is configured to be cut instead of the fall indicator 225. To illustrate, a vertical cross-sectional area of the rivet 230 may be used as S_c above, while the strength of the rivet 230 material may be used as τ_K/R_m as detailed above. The above calculations are merely exemplary. Parameters of the system (e.g., areas, materials, strengths) may be customized to suit various needs. For example, reinforced, higher strength materials may be used for a relatively heavy user, while less strong materials may be used for a relatively light person. Upon reading the present disclosure, a person of ordinary skill in the art would be able to use the above calculations to custom tailor a given fall arrester to suit the needs of a specific application.

[0030] FIGs. 6A, 6B, and 6C depict various views (perspective, exploded, and cross-sectional, respectively) of an exemplary fall arrester implementing an exemplary fall indicator. The operation of, and various components of, the fall arrester 600 may be substantially similar to the operation of, and various components of, the fall arrester 200. The fall arrester 600 includes a base 605 having a channel 620 for receiving a rope, for example. The base 605 is pivotably coupled (via pivot point 620 and pivot aperture 645) to brake lever 615 having a distal end 618. Fastened to the brake lever 615 (via fastener 630) is fall indicator 625, such that the fall indicator 625 is located at the distal end 618. The fall arrester 600 includes a plurality of apertures 635. Visually presented on the fall indicator 625 are symbols 640. Brake lever 615 includes, at a proximal end, a braking surface 650 and a visual warning symbol (not shown).

[0031] The plurality of apertures 635 includes a first aperture 660 of the brake lever and at least one second aperture(s) 665 of the fall indicator 625. The fastener 620 in this exemplary embodiment couples with (e.g., passes through) a fastener feature (e.g., hole) 670 of the fall indicator 625 and a complementary fastener feature (e.g., hole) 675 of the braking lever 615. The fastener feature 670 of the fall indicator 625 is located at first and second flanges 641, 642, which are joined by a central portion 643.

[0032] The fall arrester 600 includes a spring mechanism 680 (e.g., a hinge spring) that is configured to pivotably bias the braking lever 615 relative to the base 605. The spring mechanism 680 is mechanically coupled to the base 605 by a spring pin 685. The braking lever 615 includes a spring aperture 690 that receives an end of the spring mechanism 680 to bias the braking lever 615. The bias direction of the braking lever 615 may oppose a force vector applied to the distal end 618 by the weight of a user coupled to the fall arrester 600.

[0033] In the cross section view of FIG. 6C, the first aperture 660 is oval-shaped, while the second aperture 665 is circular-shaped. In various embodiments, the overlap and association between the first aperture and the second aperture of a fall arrester in a pre-fall state may be optimized (as detailed below). Furthermore, the exact placement of a fastener that mechanically couples a fall support coupler with a fall indicator may be optimized (as detailed below). Various features or components of the fall arrester 200 may be swapped out with, combined with, added to, or omitted from the fall arrester 600 (and vice-versa).

[0034] FIGs. 7A, 7B, 7C, 7D, and 7E depict perspective views of an exemplary fall arrester implementing an exemplary fall indicator with different aperture shapes. A first aperture shape 700A is a circular shape. A second aperture shape 700B is a polygonal shape. A third aperture shape 700C is a curved-star shape. A fourth aperture shape 700D is a star shape. A fifth aperture shape 700 is an oval shape. In some examples, an aperture of a fall support coupler may come in different shapes. Different aperture shapes may optimize for various applications or project goals. In some examples, different aperture shapes may provide for better performance in different situations. For example, the shape/size of the hole in fall indicator 225 relative to the size/shape of hole in the brake lever 215 may be optimized to maximize the amount of for

[0035] FIG. 8A, 8B, and 8C depict perspective views of different exemplary fall arresters implementing an exemplary fall indicator. While the above described embodiments relate to rope grab devices having braking levers, a fall indicator may not be limited to just these realms. A fall indicator may be included in other types of safety devices, for example. A common thread between each device including a fall indicator may be the following: (1) a fall support coupler configured support the weight of a user in the event of a fall, where the fall support coupler includes a first aperture; (2) a fall indicator mechanically coupled to the fall support coupler via a fastener, in a first mode, wherein the fall indicator includes a second aperture that is at least partially aligned with the first aperture in a first alignment orientation associated with the first mode; and (3) when a minimum amount of predetermined force is applied to the fall indicator, a cutting force at least partially detaches the fall indicator from the fall support coupler in a second mode to indicate that a fall event has taken place, such that the second aperture falls out of the first alignment orientation with the first aperture in the second mode.

[0036] A fall arrester 800A is a fall arrester configured for moving a user along a horizontal lifeline. Some examples of these types of fall arresters may include the Söll Xenon® Standard Shuttle (product number 27466 / 1030225) produced by Honeywell International Inc. The fall arrester 800A includes a base 805A. The base 805A includes a channel 810A configured to receive and anchor a user to a horizontal lifeline. The base 805A is operably coupled to a fall support coupler 815A. The fall support coupler 815A is fastened (via a fastener 830A) to a fall indicator 825A. The fall indicator 825A includes visual symbols 840A. The fall arrester 800A includes a plurality of apertures 835A (at least one aperture of the fall support coupler 815A and at least one aperture for the fall indicator 825A).

[0037] Similar to the fall arresters 200 and 600 described above, when a minimum amount of predetermined force is applied to the fall indicator, a cutting force at least partially detaches the fall indicator from the fall support coupler in a second mode to indicate that a fall event has taken place, such that the second aperture (of fall indicator 825A) falls out of the first alignment orientation with the first aperture (of the fall support coupler 815A) in the second mode. Put another way, when a fall force vector having a force component that is: (1) substantially parallel to P2, (2) greater than or equal to a minimum amount of predetermined force, and (3) directed radially away from the base 805A, is applied to the second aperture of the fall indicator 825A as a result of a fall event, a shearing force may mechanically decouple the fall indicator 825A from the fall support coupler 815A to mechanically displace the fall indicator 825A away from the fall support coupler 815A and indicate that a fall event has taken place, such that the second aperture falls out of alignment with the first aperture.

[0038] A fall arrester 800B is a fall arrester configured for use with a vertical cable system. Some examples of these types of fall arresters may include the Söll Vi-Go™ Guided-type fall arrester (product number 27826 / 1034574) produced by Honeywell International Inc. The fall arrester 800B includes a base 805B. The base 805B includes a channel 810A configured to receive and anchor a user to a vertical cable. The base 805B is operably coupled to a fall support coupler 815B. The fall support coupler 815B is fastened (via a fastener 830B) to a fall indicator 825B. The fall indicator 825B may optionally include visual symbols (not shown). The fall arrester 800B includes a plurality of apertures 835B (at least one aperture of the fall support coupler 815B and at least one aperture for the fall indicator 825B).

[0039] Similar to the fall arresters 200 and 600 described above, when a minimum amount of predetermined force is applied to the fall indicator, a cutting force at least partially detaches the fall indicator from the fall support coupler in a second mode to indicate that a fall event has taken place, such that the second aperture (of fall indicator 825B) falls out of the first alignment orientation with the first aperture (of the fall support coupler 815B) in the second mode. Put another way, when a fall force vector having a force component that is: (1) substantially parallel to P3, (2) greater than or equal to a minimum amount of predetermined force, and (3) directed radially away from the base 805B, is applied to the second aperture of the fall indicator 825B as a result of a fall event, a shearing force may mechanically decouple the fall indicator 825B from the fall support coupler 815B to mechanically displace the fall indicator 825B away from the fall support coupler 815B and indicate that a fall event has taken place, such that the second aperture falls out of alignment with the first aperture.

[0040] A fall arrester 800C is a fall arrester configured for safety anchoring a user to a rail. Some examples of these types of fall arresters may include the Miller Glide-Loc™ II Universal Fall Arrester (part number 25805-Z7) produced by Honeywell International Inc. The fall arrester 800C includes a base 805C. The base 805C includes a rail engagement surface 810C configured to couple a user to a rail. The base 805C is operably coupled to a fall support coupler 815C. The fall support coupler 815C is fastened (via a fastener 830C) to a fall indicator 825C. The fall indicator 825C may optionally include a visual symbol (not shown). The fall arrester 800C includes a plurality of apertures 835C (at least one aperture of the fall support coupler 815C and at least one aperture for the fall indicator 825C).

[0041] Similar to the fall arresters 200 and 600 described above, when a minimum amount of predetermined force is applied to the fall indicator, a cutting force at least partially detaches the fall indicator from the fall support coupler in a second mode to indicate that a fall event has taken place, such that the second aperture (of fall indicator 825C) falls out of the first alignment orientation with the first aperture (of the fall support coupler 815C) in the second mode. Put another way, when a fall force vector having a force component that is: (1) substantially parallel to P4, (2) greater than or equal to a minimum amount of predetermined force, and (3) directed radially away from the base 805C, is applied to the second aperture of the fall indicator 825C as a result of a fall event, a shearing force may mechanically decouple the fall indicator 825C from the fall support coupler 815C to mechanically displace the fall indicator 825C away from the fall support coupler 815C and indicate that a fall event has taken place, such that the second aperture falls out of alignment with the first aperture.

[0042] As shown in FIGs. 8A-8C, each fall arrester may have both the fall support coupler and the fall indicator may lie and extend in a common plane P2-P4, respectively. In some examples, the fall support coupler and the fall indicator may lie in different planes that are substantially parallel to one another (e.g., a first plane and a second plane that have respective normal vectors angled with respect to one another by about 0.01°, 0.1°, 0.5°, 1°, 2°, or about 5° or more. In some examples, the fall support coupler may be configured to rotate within or through the planes P2-P4. In some examples, the fall indicator may be configured to rotate within or through the planes P2-P4 (or another plane substantially parallel to P2-P4).

[0043] Although various embodiments have been described with reference to the Figures, other embodiments are possible. For example, the fall indicator may couple to the brake lever, or other mechanically related element. In some implementations, the fall indicator may be coupled to a cam to which a lanyard is directly or indirectly secured. The cam may, upon experiencing forces associated with a fall event, directly or indirectly engage a brake mechanism or similar mechanism to secure the attachment of the lanyard to an anchor point. In some implementations, a gear mechanism may directly or indirectly couple between the cam (to which the fall indicator is attached) and the stabilizing mechanism (e.g., brake lever). In some embodiments, a folded or welded tab may be formed to couple or engage the fall indicator to the stabilizing mechanism. In various examples, the fall arresters 200, 600, and 800A-C may be referred to as mobile fall arrest devices that are meant for use as personal protective equipment (PPE).

[0044] In some examples, a pre-fall state may be synonymous with a first mode, while a post-fall state or fall-event state may be synonymous with a second mode. In various embodiments, a target/optimal/cutting force may be about 100, 200, 500, 1000, 2000, 5000, 6000, 7000, 8000, 9000, or about 10,000 Newtons or more. In various embodiments, there may be at least two factors that have impacts on braking force acting on user. The 1st factor may be the mass of the user, and the 2nd factor may be the "fall factor," which depends on the length of the connector (e.g., a lanyard) between the user and fall arrest device. According to EN 353-2, maximum user weight may be about 100kg and the maximum length of the connector may be about 1 meter. Based on this information, we can calculate that in the worst-case scenario, the maximum braking force will be about 6 kN. This means that a user, who has a mass of 60 kg, will produce lower braking force (perhaps less than 3kN), which may not activate the shearing/cutting function of the fall indicator. This may be reasonable, however, because a fall arrest system may not need a "sensitive" fall indicator for a safe braking force range (e.g., about 0 kN to about 3kN). In some examples, an optimal breaking force of about 3 kN may be based on the fact that the maximum allowed force for personal protective equipment (PPE) devices in Europe is about 6 kN. This may mean that a standard force for activation of the fall indicator function may be approximately half of this value (e.g., about 3kN). This reasoning may explain why 3 kN may be an optimal force for the fall indicator breaking function is many situations and examples. The fall arrester may, in some examples, be symmetric (mirrored structurally) about a central plane that passes through the center of the fall arrester (e.g., a right-side is a substantial mirror image of the left-side).

[0045] In various embodiments, the position of the fastener relative to the fall support coupler and the fall indicator may be optimized. For example, the fastener may be placed such that in a pre-fall state, the top of the aperture of the fall indicator is near the top of the aperture of the fall support coupler, while the bottom of the aperture of the fall indicator is spaced apart from the aperture of the fall support coupler (see, e.g., FIGs. 2 and 4C). Such a configuration may allow for the bulk of the weight being supported by the material at the bottom of the aperture of the fall indicator, thus advantageously putting maximum stress on the fall indicator instead of the fall support coupler in the pre-fall state. In various examples, the fastener may be strategically placed so that when an angle θ is formed between a vertical gravity vector and the fall arrester (see, e.g., FIG. 4C), the distance between the bottom of the first and second apertures is maximized. This may allow for maximum force on/displacement of the fall indicator (see, e.g., FIG. 4D), thus ensuring that the indicator breaks when sufficient force is applied to the fall arrester.

[0046] Various embodiments may include a fall arrester (e.g., 200, 600, 800A-C) for indicating when a fall event has taken place. The fall arrester may include a base (e.g., 205) configured to mechanically couple to an object. In some examples the object may be a threaded or metallic rope (e.g., 305). In various examples, the object may be a rail. The fall arrester may include a fall support coupler (e.g., 215) that: (1) is mechanically coupled to the base, (2) extends longitudinally in a first plane (e.g., P1-P4), and (3) is configured to support the weight of a user (e.g., 105) in the event of a fall. In various embodiments, the fall support coupler includes a first aperture (260). The fall arrester may include a fall indicator (e.g., 225) that: (1) extends longitudinally in a second plane substantially parallel to the first plane, (2) is at least partially overlaying the fall support coupler, (3) is mechanically coupled to the fall support coupler via a fastener (e.g., 230), and (4) is configured to at least partially support the weight of the user before a fall has taken place. The fall indicator may, for example, include a second aperture (e.g., 265) in alignment with the first aperture while the fall indicator is mechanically coupled to the fall support coupler via the fastener. In various examples, when a fall force vector (e.g., 222) having a force component that is: (1) substantially parallel to the first and second planes, (2) greater than or equal to a minimum amount of predetermined force, and (3) directed radially away from the base, is applied to the second aperture of the fall indicator as a result of a fall event, a shearing force may mechanically decouple the fall indicator from the fall support coupler to mechanically displace the fall indicator away from the fall support coupler and indicate that a fall event has taken place, such that the second aperture may fall out of alignment with the first aperture.

[0047] In some examples, the fall indicator includes a center portion (e.g., 243), a first flange (e.g., 241), and a second flange (e.g., 242), with the first and second flanges being integrally formed with, and extending away from, the center portion, such that the fastener is mechanically coupled to both the first flange and the second flange. The second aperture may, in some embodiments, include a first flange aperture and a second flange aperture (see, e.g., FIGs. 3 and 6B). In some examples, the fastener may include a rivet or a bolt. The first and second flanges may, in some embodiments, extend parallel to the second plane. The fall arrester may include the first and second flanges that define a fall indicator channel, where the fall support coupler lies at least partially within the fall indicator channel, for example.

[0048] When the fall force vector is applied to the second aperture of the fall indicator as a result of a fall event, for example, the fall indicator may at least partially shear in an area (e.g., 505, 510) where the fall indicator is mechanically coupled to the fastener. In various examples, the fastener may be a cutting fastener. The fall indicator may be formed of aluminum, for example, while the fastener may be formed of steel, for example.

[0049] In various embodiments, the fall indicator may include at least one first visual symbol (e.g., 240), while the fall support coupler comprises at least one second visual symbol (e.g., 255), such that before the fall force vector is applied to the second aperture of the fall indicator as a result of a fall event, the second visual symbol may be completely obscured by the fall indicator, and after the shearing force mechanically decouples the fall indicator from the fall support coupler as a result of the fall event, the second visual symbol may be at least partially (or perhaps completely) unobscured by the fall indicator. In various examples, the minimum amount of predetermined force may be at least 3 kilonewtons, while in other examples, the minimum amount of predetermine force may be the weight of an average human being.

[0050] In some embodiments, the fall arrester may be a rope grab device (e.g., 200). In some embodiments, the fall support coupler includes a braking lever (e.g., 215) that is pivotably coupled to the base. In some embodiments, the braking lever includes a braking engagement surface (e.g., 250). In some embodiments, the base includes a base channel (e.g., 210) configured to receive a rope (e.g., 305). In some embodiments, the fall support coupler lies at least partially within the base channel. In some implementations, a size of the second aperture may be smaller than a size of the first aperture.

[0051] A number of implementations have been described. Nevertheless, it will be understood that various modification may be made. For example, advantageous results may be achieved if the steps of the disclosed techniques were performed in a different sequence, or if components of the disclosed systems were combined in a different manner, or if the components were supplemented with other components. Accordingly, other implementations are within the scope of the following claims.

Embodiments

[0052] Embodiment 1. A fall arrester (200, 600, 800A-C) for indicating when a fall event has taken place, the fall arrester comprising:

a base (205) configured to mechanically couple to an object (305);
a fall support coupler (215) that: (1) is mechanically coupled to the base, (2) extends longitudinally in a first plane (P1), and (3) is configured to support the weight of a user (105) in the event of a fall, wherein the fall support coupler comprises a first aperture (260); and,
a fall indicator (225) that: (1) extends longitudinally in a second plane substantially parallel to the first plane, (2) is at least partially overlaying the fall support coupler, (3) is mechanically coupled to the fall support coupler via a fastener (230), and (4) is configured to at least partially support the weight of the user before a fall has taken place, wherein the fall indicator comprises a second aperture (265) in alignment with the first aperture while the fall indicator is mechanically coupled to the fall support coupler via the fastener,
wherein when a fall force vector (222) having a force component that is: (1) substantially parallel to the first and second planes, (2) greater than or equal to a minimum amount of predetermined force, and (3) directed radially away from the base, is applied to the second aperture of the fall indicator as a result of a fall event, a shearing force mechanically decouples the fall indicator from the fall support coupler to mechanically displace the fall indicator away from the fall support coupler and indicate that a fall event has taken place, such that the second aperture falls out of alignment with the first aperture.

[0053] Embodiment 2. The fall arrester of embodiment 1, wherein:

the fall indicator comprises a center portion (243), a first flange (241), and a second flange (242), with the first and second flanges being integrally formed with, and extending away from, the center portion, such that the fastener is mechanically coupled to both the first flange and the second flange, and,
the second aperture comprises a first flange aperture and a second flange aperture.

[0054] Embodiment 3. The fall arrester of embodiment 2, wherein the fastener comprises a rivet.

[0055] Embodiment 4. The fall arrester of embodiment 2, wherein the first and second flanges extend parallel to the second plane.

[0056] Embodiment 5. The fall arrester of embodiment 4, wherein the first and second flanges define a fall indicator channel, and the fall support coupler lies at least partially within the fall indicator channel.

[0057] Embodiment 6. The fall arrester of embodiment 1, wherein when the fall force vector is applied to the second aperture of the fall indicator as a result of a fall event, the fall indicator at least partially shears in an area (505, 510) where the fall indicator is mechanically coupled to the fastener, which comprises a cutting fastener.

[0058] Embodiment 7. The fall arrester of embodiment 6, wherein the fall indicator comprises aluminum and the fastener comprises steel.

[0059] Embodiment 8. The fall arrester of embodiment 1, wherein the fall indicator comprises at least one first visual symbol (240), and the fall support coupler comprises at least one second visual symbol (255), such that before the fall force vector is applied to the second aperture of the fall indicator as a result of a fall event, the second visual symbol is completely obscured by the fall indicator, and after the shearing force mechanically decouples the fall indicator from the fall support coupler as a result of the fall event, the second visual symbol is at least partially unobscured by the fall indicator.

[0060] Embodiment 9. The fall arrester of embodiment 1, wherein the minimum amount of predetermined force comprises at least 3 kilonewtons.

[0061] Embodiment 10. The fall arrester of embodiment 1, wherein:

the fall arrester comprises a rope grab device (200),
the fall support coupler comprises a braking lever (215) that is pivotably coupled to the base,
the braking lever comprises a braking engagement surface (250),
the base comprises a base channel (210) configured to receive a rope (305), and
the fall support coupler lies at least partially within the base channel.

[0062] Embodiment 11. The fall arrester of embodiment 1, wherein a size of the second aperture is smaller than a size of the first aperture.

[0063] Embodiment 12. The fall arrester of embodiment 10, wherein the fall indicator comprises at least one first visual symbol (240), and the fall support coupler comprises at least one second visual symbol (255), such that before the fall force vector is applied to the second aperture of the fall indicator as a result of a fall event, the second visual symbol is completely obscured by the fall indicator, and after the shearing force mechanically decouples the fall indicator from the fall support coupler as a result of the fall event, the second visual symbol is at least partially unobscured by the fall indicator.

[0064] Embodiment 13. The fall arrester of embodiment 10, wherein a size of the second aperture is smaller than a size of the first aperture.

[0065] Embodiment 14. The fall arrester of embodiment 7, wherein:

the fall arrester comprises a rope grab device (200),
the fall support coupler comprises a braking lever (215) that is pivotably coupled to the base,
the braking lever comprises a braking engagement surface (250),
the base comprises a base channel (210) configured to receive a rope (305), and
the fall support coupler lies at least partially within the base channel.

[0066] Embodiment 15. The fall arrester of embodiment 5, wherein:

the fall arrester comprises a rope grab device (200),
the fall support coupler comprises a braking lever (215) that is pivotably coupled to the base,
the braking lever comprises a braking engagement surface (250),
the base comprises a base channel (210) configured to receive a rope (305), and
the fall support coupler lies at least partially within the base channel.

Claims

1. A fall arrester (200, 600, 800A-C) for indicating when a fall event has taken place, the fall arrester comprising:

a base (205) configured to mechanically couple to an object (305);
a fall support coupler (215) that: (1) is mechanically coupled to the base, (2) extends longitudinally in a first plane (P1), and (3) is configured to support the weight of a user (105) in the event of a fall, wherein the fall support coupler comprises a first aperture (260);
a rope grab device (200), comprises a braking lever (215) that is pivotably coupled to the base (205),

the braking lever comprises a braking engagement surface (250),
the base (205) comprises a base channel (210) configured to receive a rope (305), and the fall support coupler lies at least partially within the base channel (210); and,

a fall indicator (225) that: (1) extends longitudinally in a second plane substantially parallel to the first plane, (2) is at least partially overlaying the fall support coupler, (3) is mechanically coupled to the fall support coupler via a fastener (230), and (4) is configured to at least partially support the weight of the user before a fall has taken place, wherein the fall indicator comprises a second aperture (265) in alignment with the first aperture while the fall indicator is mechanically coupled to the fall support coupler via the fastener,
wherein when a fall force vector (222) having a force component that is greater than or equal to a minimum amount of predetermined force is applied to the second aperture of the fall indicator, the fall indicator is decoupled from the fall support coupler to mechanically displace the fall indicator away from the fall support coupler and indicate that a fall event has taken place.

2. The fall arrester of claim 1, wherein:

the fall indicator comprises a center portion (243), a first flange (241), and a second flange (242), with the first and second flanges being integrally formed with, and extending away from,

the center portion, such that the fastener is mechanically coupled to both the first flange and the second flange, and,
the second aperture comprises a first flange aperture and a second flange aperture.

3. The fall arrester of claim 2, wherein the fastener comprises a rivet.

4. The fall arrester of claim 2, wherein the first and second flanges extend parallel to the second plane.

5. The fall arrester of claim 4, wherein the first and second flanges define a fall indicator channel, and the fall support coupler lies at least partially within the fall indicator channel.

6. The fall arrester of claim I, wherein when the fall force vector is applied to the second aperture of the fall indicator as a result of a fall event, the fall indicator at least partially shears in an area (505, 510) where the fall indicator is mechanically coupled to the fastener, which comprises a cutting fastener.

7. The fall arrester of claim 6, wherein the fall indicator comprises aluminum and the fastener comprises steel.

8. The fall arrester of claim 1, wherein the fall indicator comprises at least one first visual symbol (240), and the fall support coupler comprises at least one second visual symbol (255), such that before the fall force vector is applied to the second aperture of the fall indicator as a result of a fall event, the second visual symbol is completely obscured by the fall indicator, and after a shearing force mechanically decouples the fall indicator from the fall support coupler as a result of the fall event, the second visual symbol is at least partially unobscured by the fall indicator.

9. The fall arrester of claim 1, wherein the minimum amount of predetermined force comprises at least 3 kilonewtons.

10. The fall arrester of claim 1, wherein a size of the second aperture is smaller than a size of the first aperture.

11. A fall arrester system (300) comprising:
a rope (305):

a fall arrester (200, 600, 800A-C) for indicating when a fall event has taken place, the fall arrester comprising:

a base (205) configured to mechanically couple to an object (305), wherein the base comprises a base channel (210) to receive the rope (305);
a fall support coupler (215) that: (1) is mechanically coupled to the base, (2) extends longitudinally in a first plane (P1), and (3) is configured to support the weight of a user (105) in the event of a fall, wherein the fall support coupler comprises a first aperture (260), and wherein the fall support coupler (215) lies at least partially within the base channel (210);
a rope grab device (200), comprises a braking lever (215) that is pivotably coupled to the base (205), wherein the braking lever comprises a braking engagement surface (250); and
a fall indicator (225) that: (1) extends longitudinally in a second plane substantially parallel to the first plane, (2) is at least partially overlaying the fall support coupler, (3) is mechanically coupled to the fall support coupler via a fastener (230), and (4) is configured to at least partially support the weight of the user before a fall has taken place, wherein the fall indicator comprises a second aperture (265) in alignment with the first aperture while the fall indicator is mechanically coupled to the fall support coupler via the fastener,
wherein when a fall force vector (222) having a force component that is greater than or equal to a minimum amount of predetermined force is applied to the second aperture of the fall indicator, the fall indicator is decoupled from the fall support coupler to mechanically displace the fall indicator away from the fall support coupler and indicate that a fall event has taken place; and

a carabiner (310) configured to be coupled with the fall arrester (200, 600, 800A-C) through a plurality of apertures (235) of the fall arrester (200, 600, 800A-C).

12. The fall arrester system (300) of claim 11, wherein the carabiner (310) is configured to at least partially support the weight of the user via a lanyard that is coupled between the carabiner (310) and the user.

13. The fall arrester system (300) of claim 11, wherein the carabiner (310) is configured to at least partially support the weight of the user represented by the force vector (222).

14. The fall arrester system (300) of claim 11, wherein

the fall indicator comprises a center portion (243), a first flange (241), and a second flange (242), with the first and second flanges being

integrally formed with, and extending away from, the center portion, such that the fastener is mechanically coupled to both the first flange and the second flange, and,
the second aperture comprises a first flange aperture and a second flange aperture.

15. The fall arrester system of claim 14, wherein the fastener comprises a rivet.

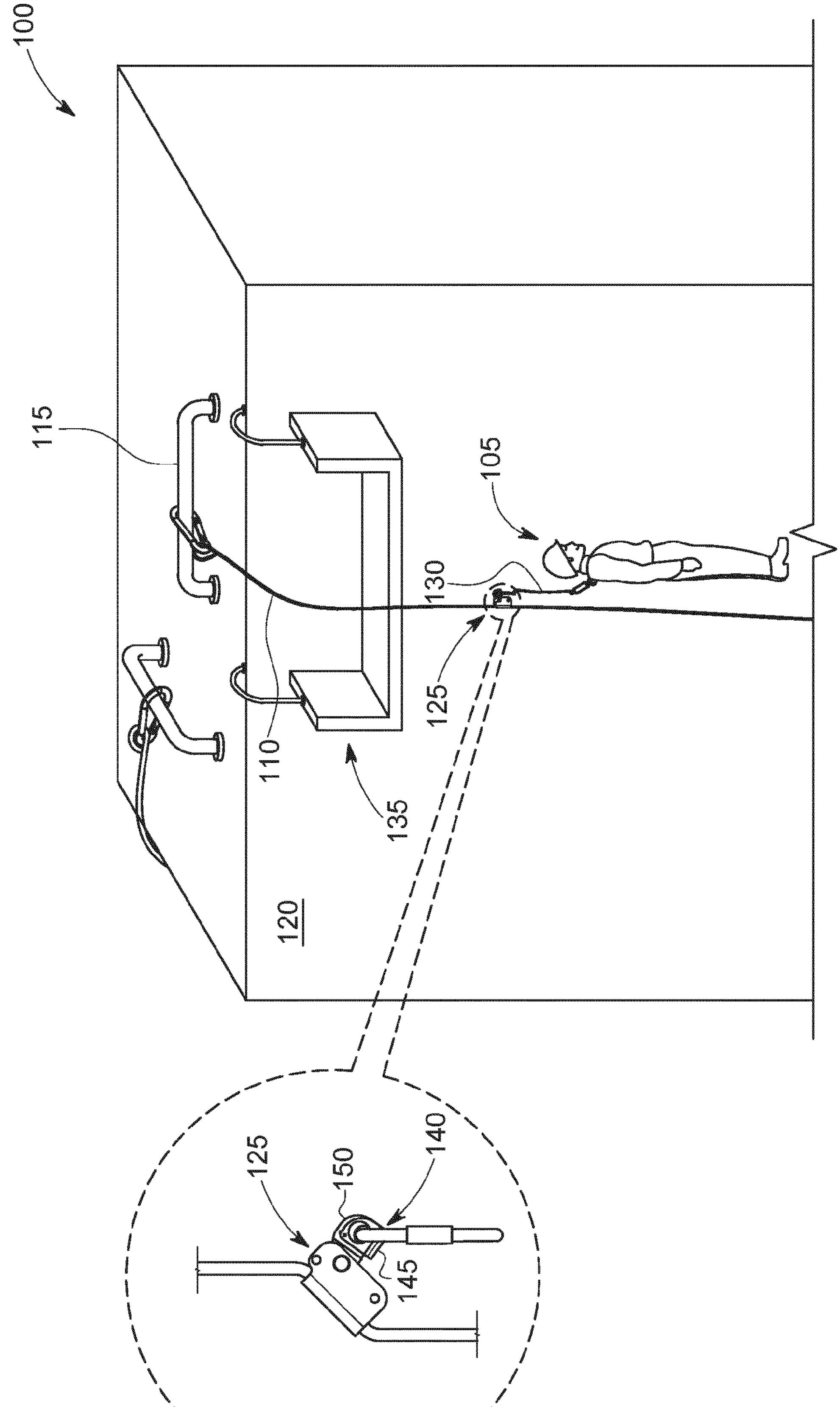


FIG. 1

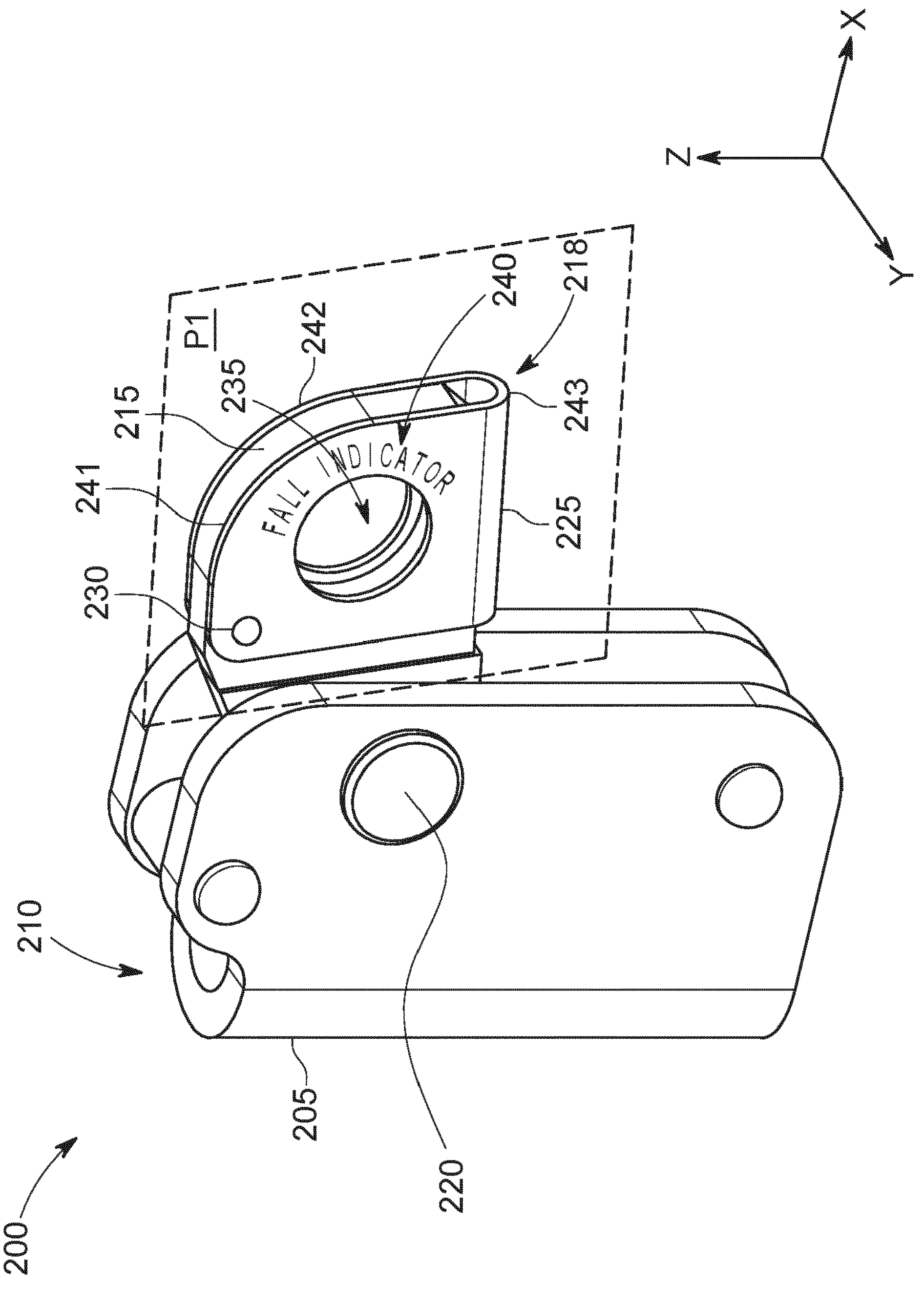

X
Z
Y
P1
242
240
218
215
235
243
241
FALL INDICATOR
225
230
210
205
220
200

FIG. 2

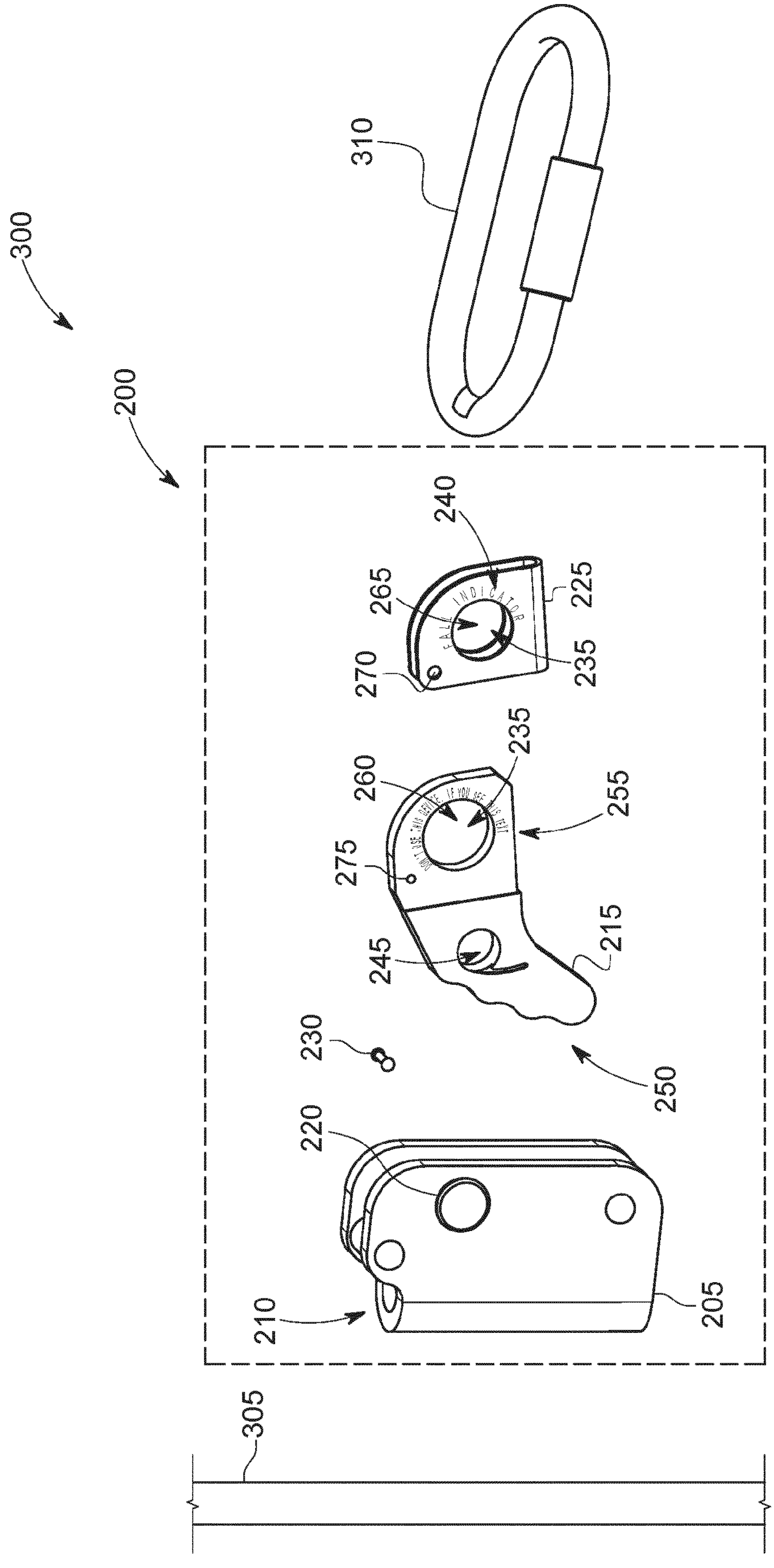

300
200
310
240
265
225
235
270
FALL INDICATOR
260
235
275
255
215
245
230
250
220
210
205
305

FIG. 3

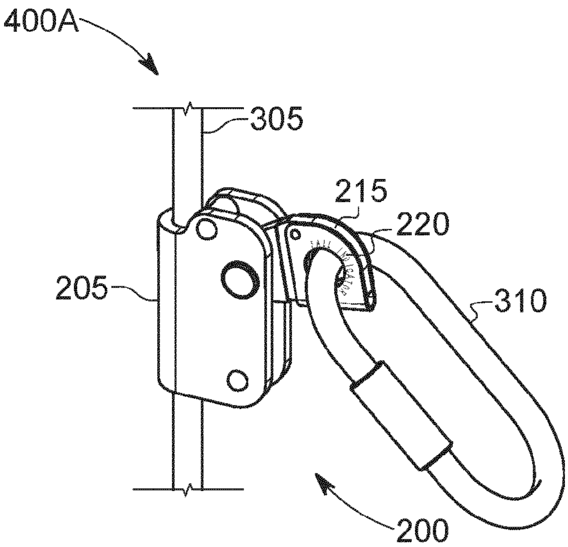


FIG. 4A

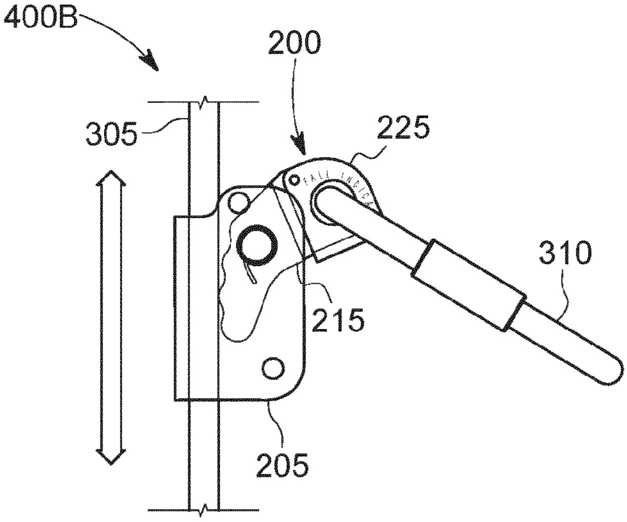


FIG. 4B

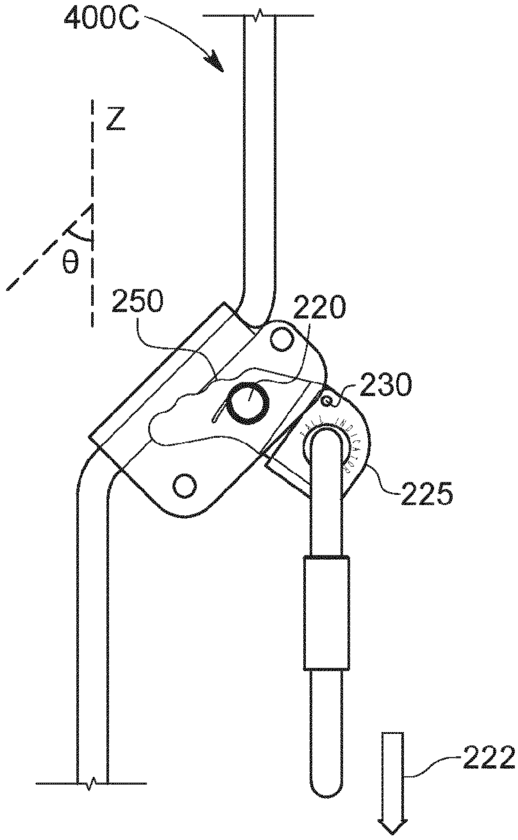


FIG. 4C

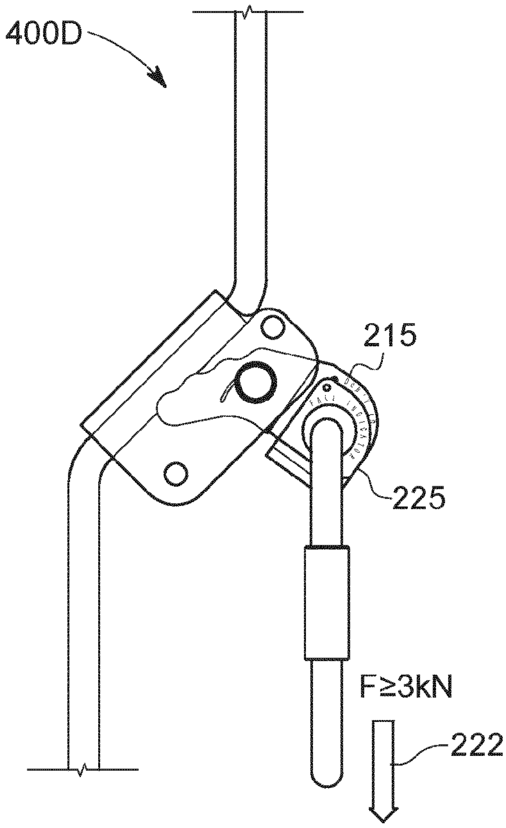


FIG. 4D

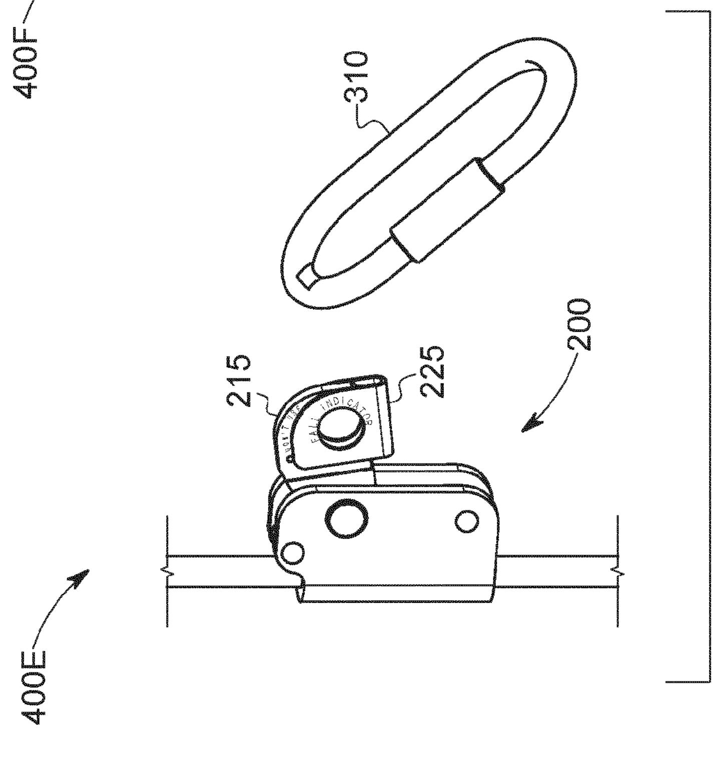


FIG. 4E

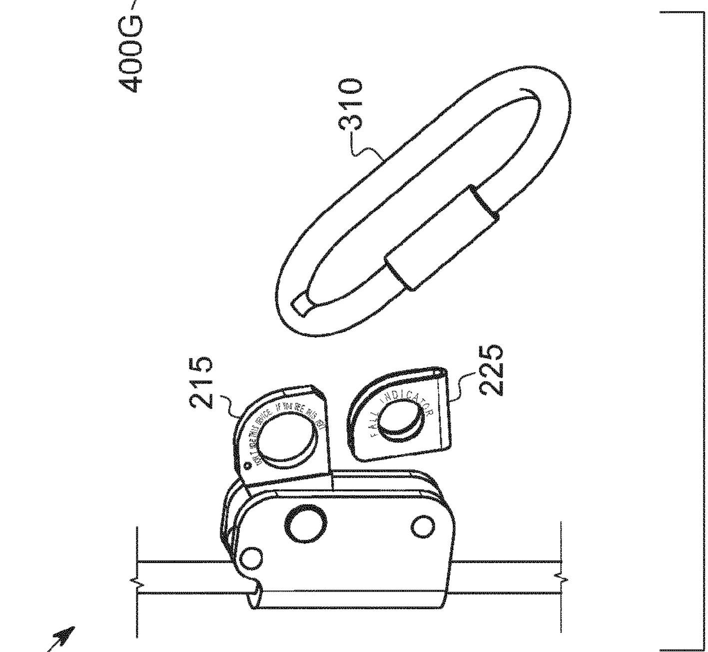


FIG. 4F

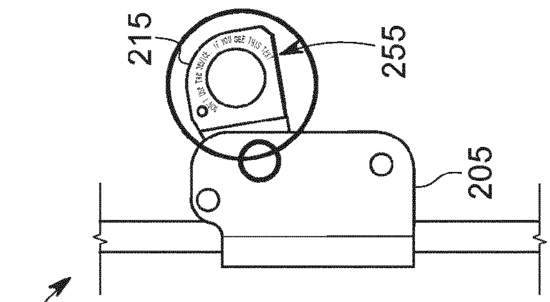


FIG. 4G

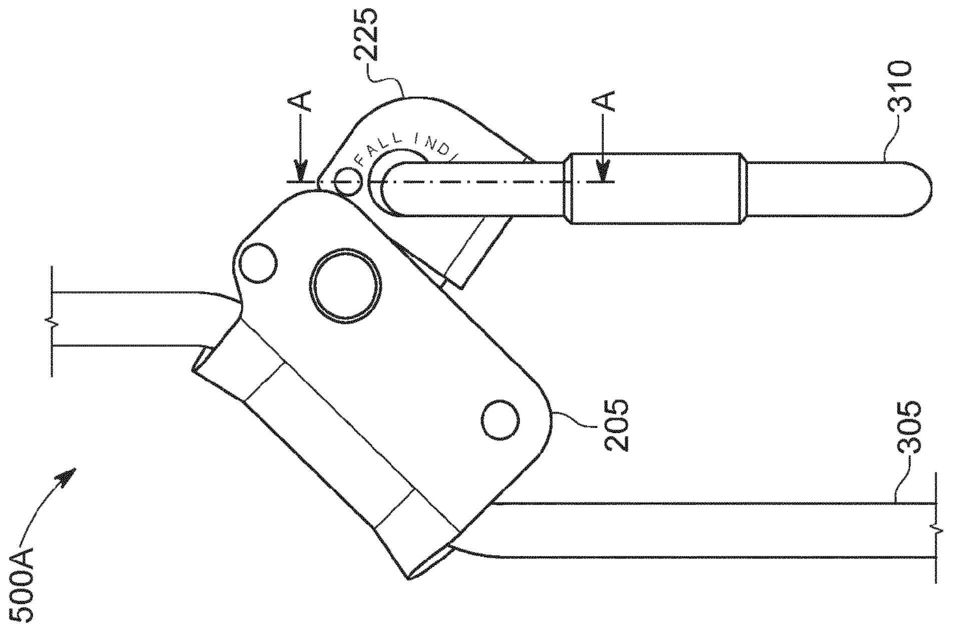


FIG. 5A

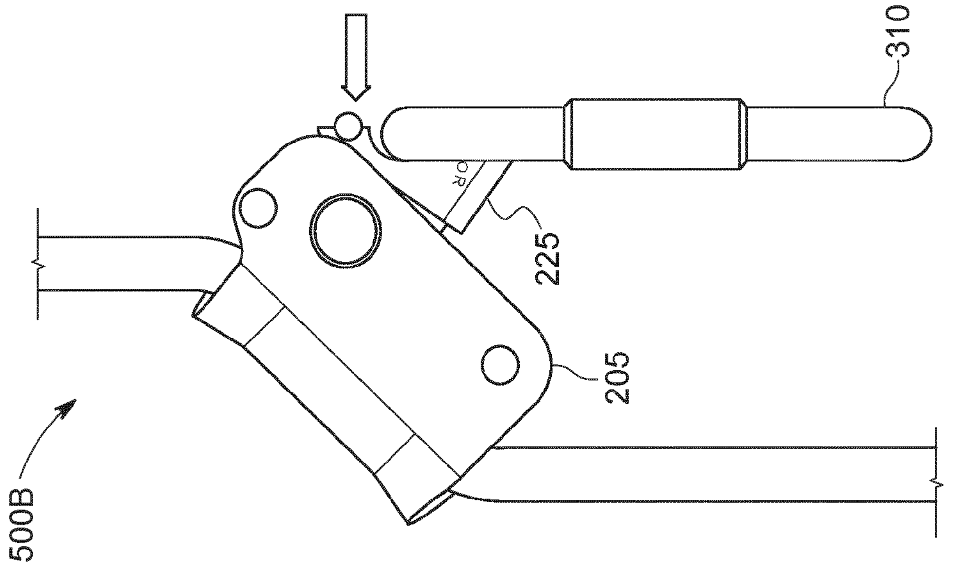


FIG. 5B

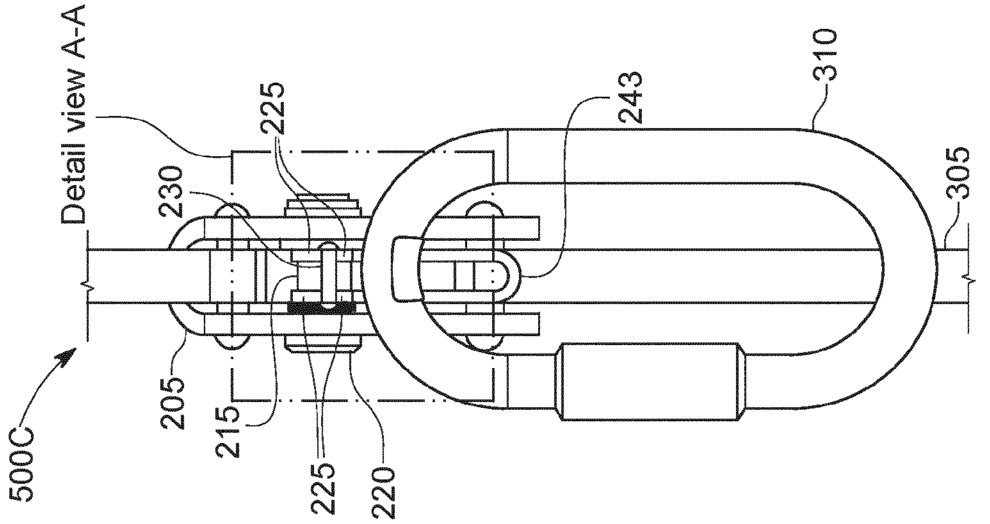
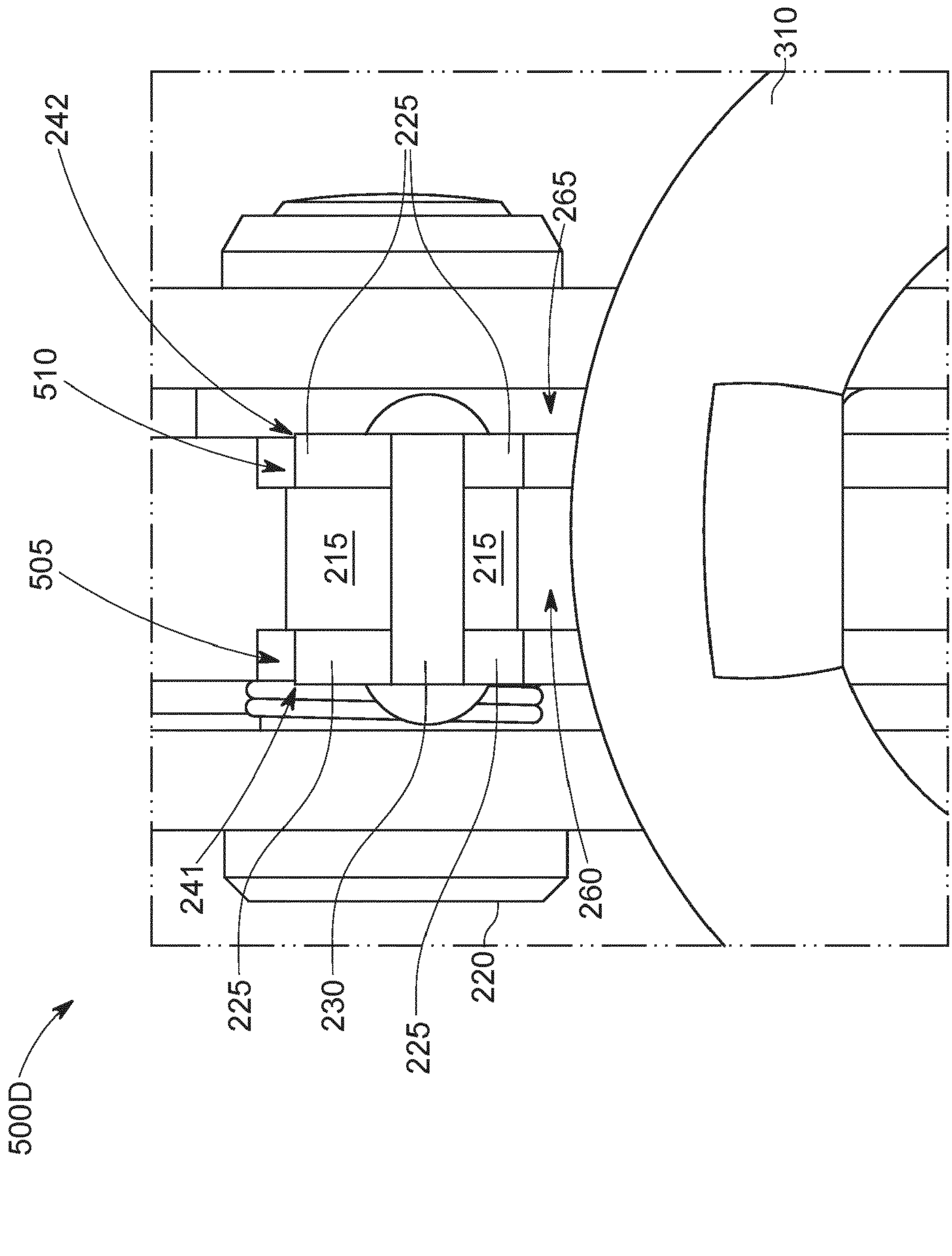


FIG. 5C



Detail view A-A

FIG. 5D

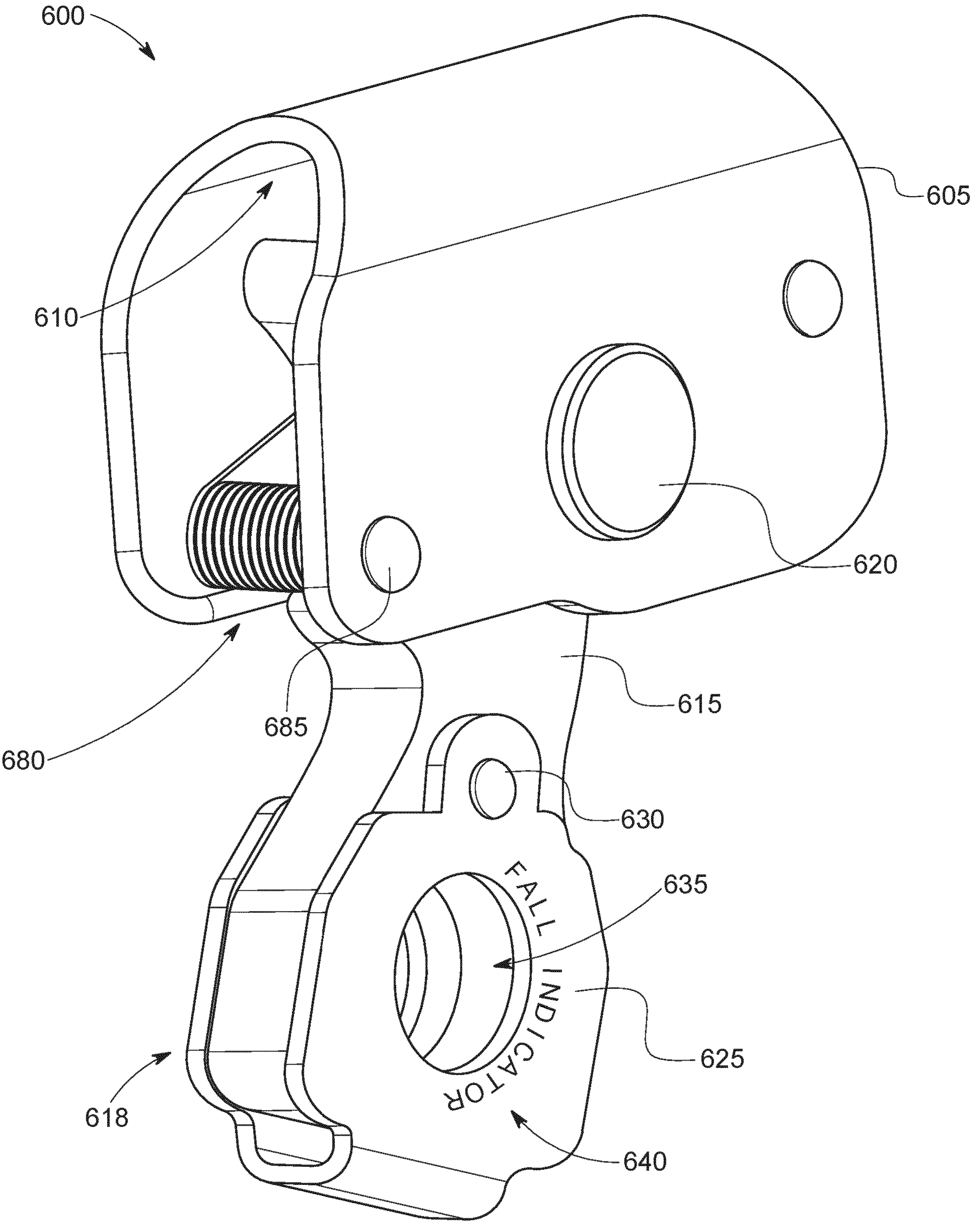


FIG. 6A

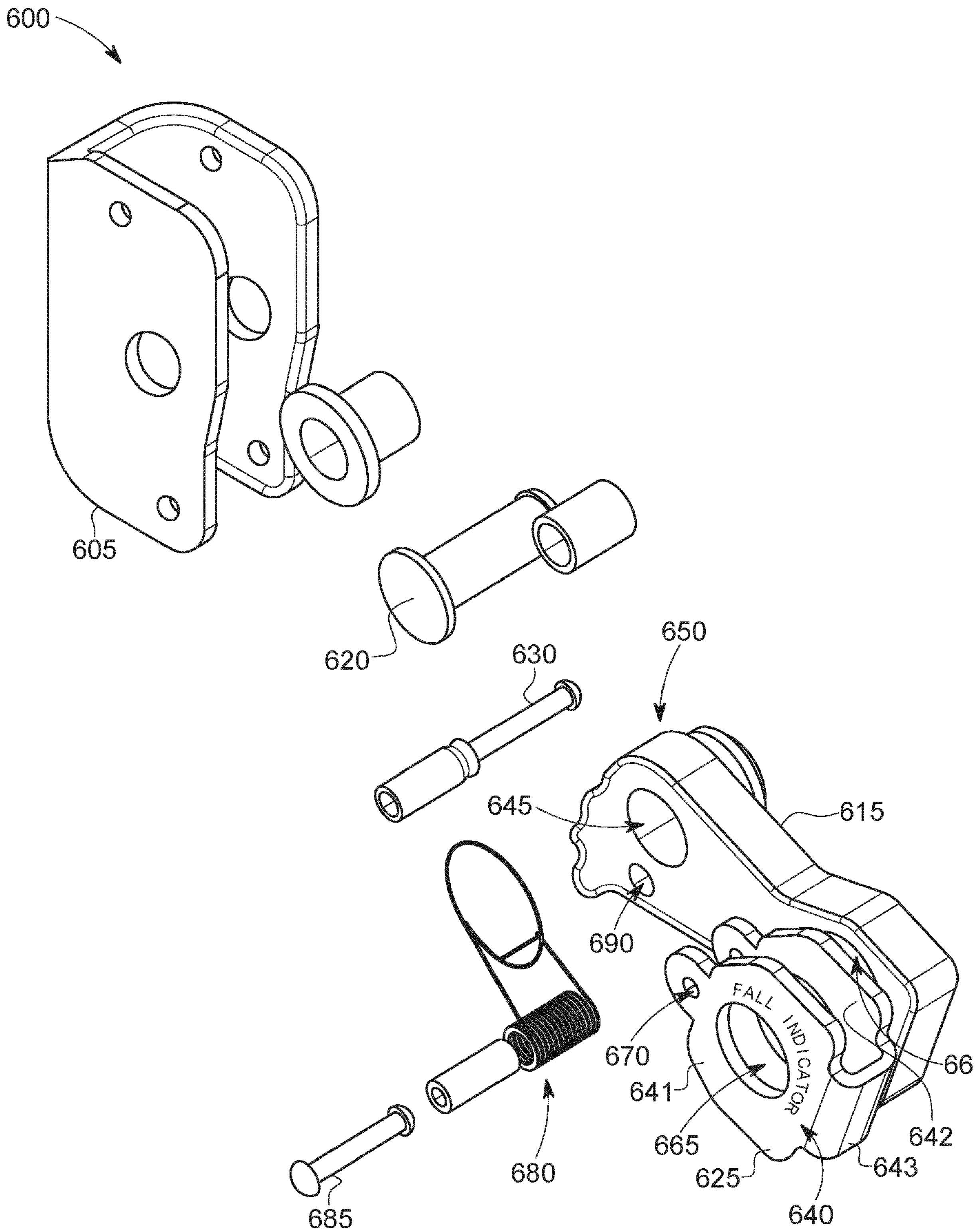

600
605
620
630
650
645
615
690
670
660
641
665
642
643
625
640
680
685
FALL INDICATOR

FIG. 6B

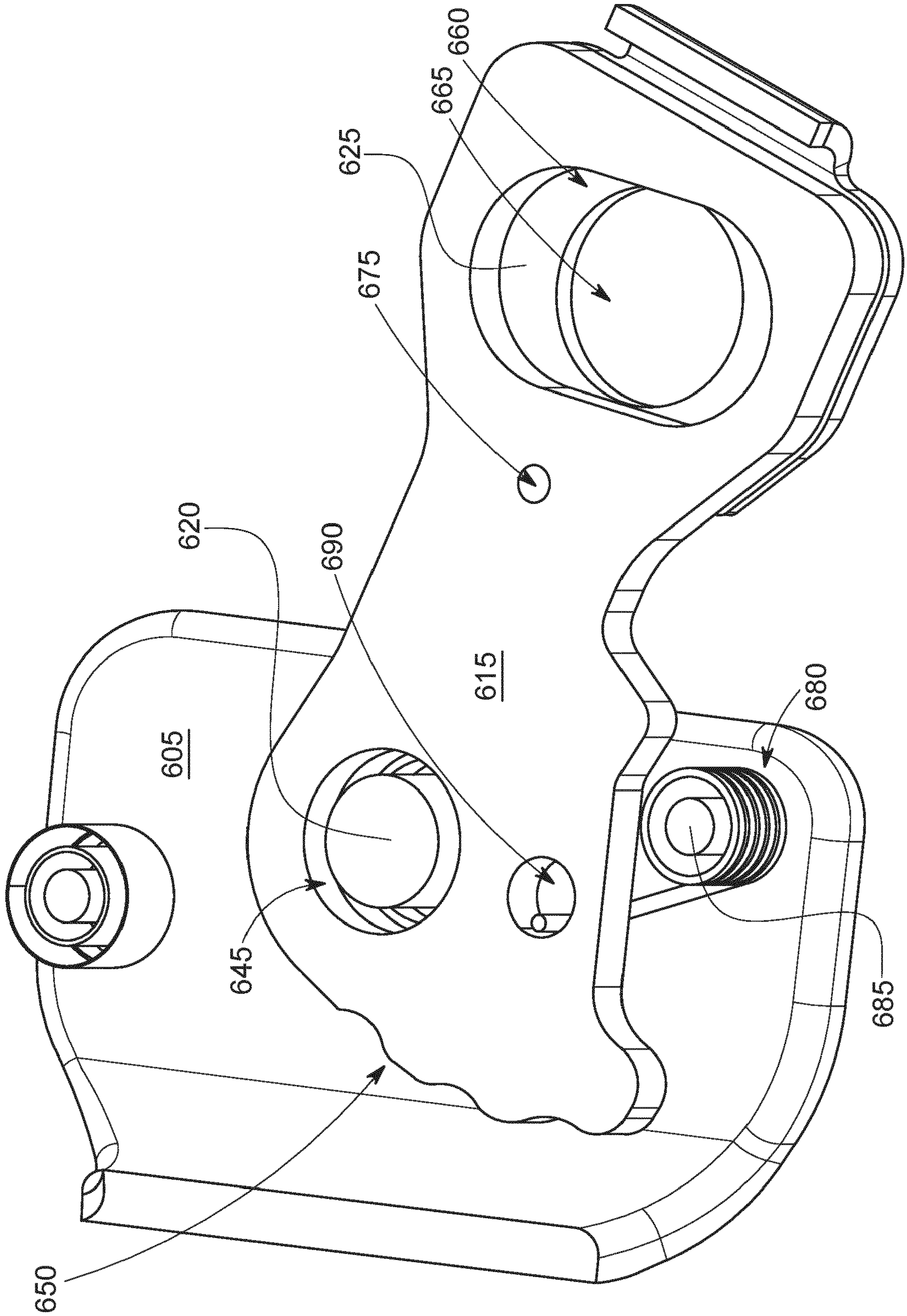


FIG. 6C

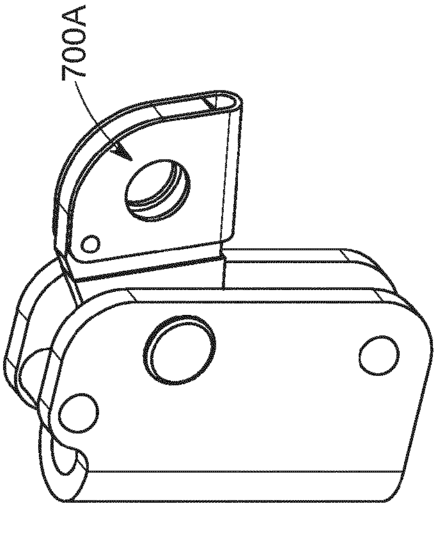


FIG. 7A

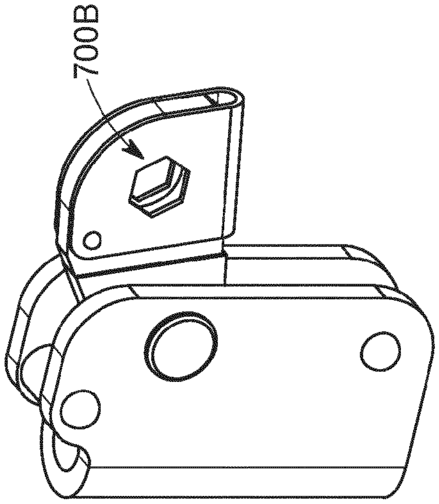


FIG. 7B

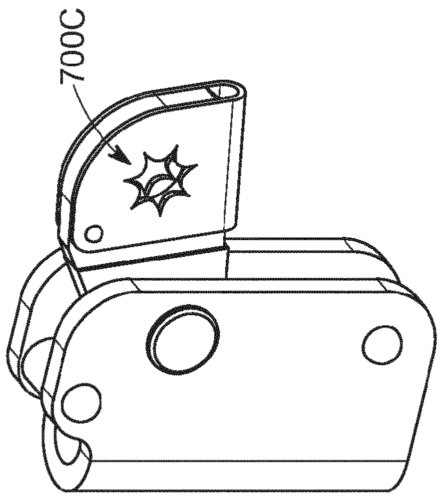


FIG. 7C

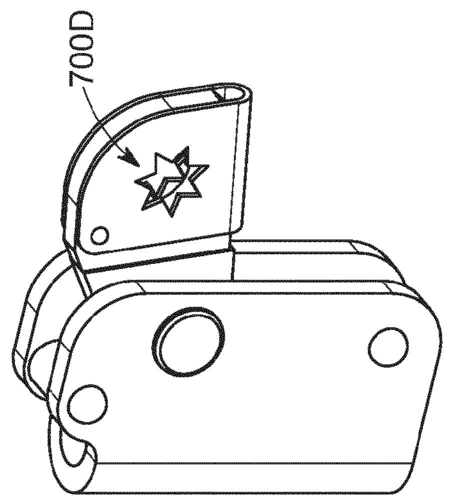


FIG. 7D

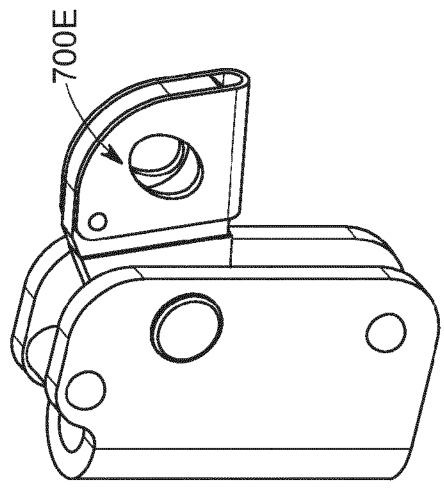


FIG. 7E

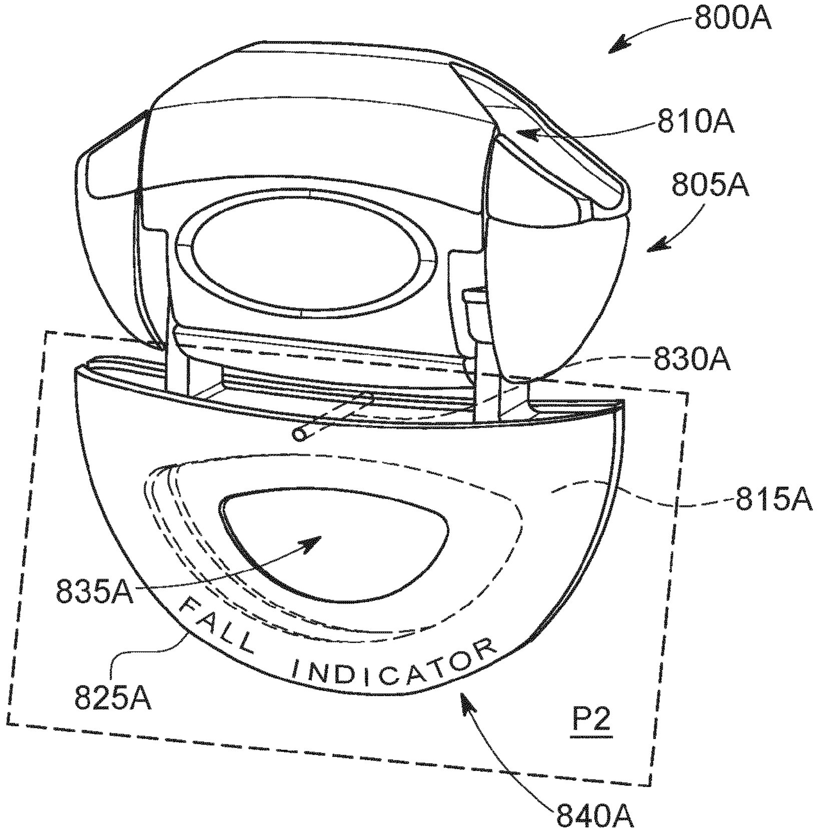

800A
810A
805A
830A
815A
835A
FALL INDICATOR
825A
P2
840A

FIG. 8A

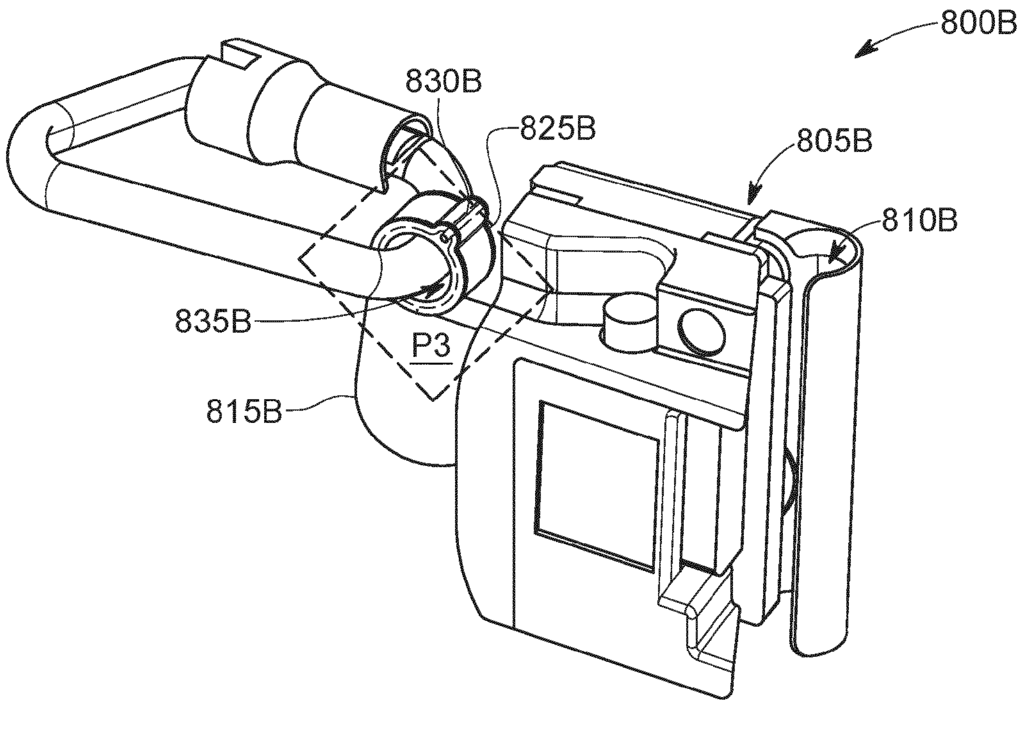

800B
830B
825B
805B
810B
835B
P3
815B

FIG. 8B

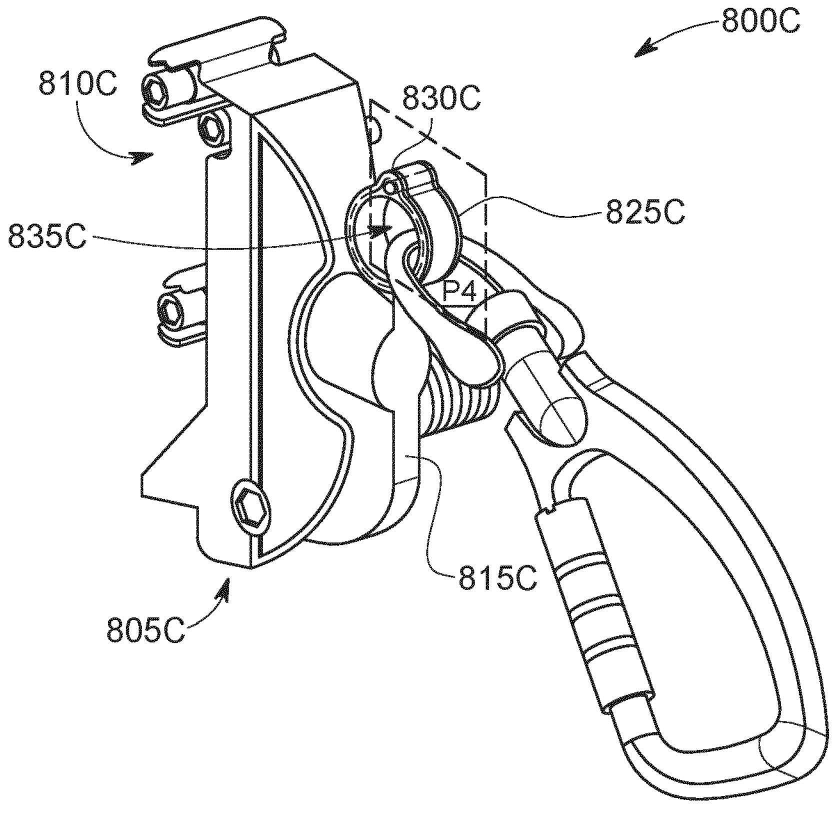


FIG. 8C