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Inventor(s)

Hill; Edward George

ACTUATOR LOCKING SYSTEM AND METHOD

Abstract

Examples of the disclosed technology provide actuator locking systems and methods with enhanced reliability. The disclosed systems and methods facilitate a compact design that can improve safety and machine life for machines that implement them. Moreover, the systems and methods can be utilized in various types of machines, including spacecraft, aircraft, and other machines that adapt to different structural configurations for different operational scenarios (including different operational environments). To achieve a compact, reliable design, examples utilize a series of specially designed cuffs arranged along a shaft. Namely, an actuator locking system of the presently disclosed technology may comprise: (1) a primary link cuff; (2) a secondary link cuff; and (3) a drive link cuff. The cuffs can be arranged along a shaft with the secondary link cuff positioned between the primary link cuff and the drive link cuff.

Inventors: Hill; Edward George (Riverside, CA)

Applicant: VIRGIN GALACTIC HOLDINGS, INC. (Tustin, CA)

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Background/Summary

BACKGROUND

[0001] Certain machines can adapt to different structural configurations for different operational scenarios. For example, a spacecraft may comprise a feathering system that folds flight control surfaces (e.g., wings, rudders, or other spacecraft surfaces that control flight) of a spacecraft upwards during reentry into Earth's atmosphere. Feathering gives the spacecraft a unique capability to change its shape in space to ensure a safe, flight proven, aerodynamically controlled re-entry into the Earth's atmosphere on a repeated basis.

[0002] For example, once a rocket motor burn is completed, pilots may extend the feathering system upwards, which results in the aft wing and tail booms rotating upward to approximately a 60-degree vertical orientation. This “feathered” configuration provides stability during re-entry to the Earth's atmosphere. Namely, the spacecraft acts like a shuttlecock or birdie, orienting the spacecraft to a proper re-entry attitude. The orientation creates high drag, which slows the spaceflight down quickly while high in the atmosphere. This orientation also allows thermal loads generated from re-entering the atmosphere to spread evenly over the surface area of the spaceflight rather than concentrating on a few small points. Once the spaceflight has re-entered the atmosphere, the feather system is rotated back down, returning the flight control surfaces to their original (downwards) position. This allows the pilots to glide the spacecraft smoothly to Earth for a runway landing.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The present disclosure, in accordance with one or more various examples, is described in detail with reference to the following figures. The figures are provided for purposes of illustration only and merely depict examples.

[0004] FIG. 1 illustrates a perspective view of an actuator locking system, in accordance with various examples of the presently disclosed technology.

[0005] FIG. 2 illustrates another perspective view of an actuator locking system, in accordance with various examples of the presently disclosed technology.

[0006] FIGS. 3A-3D illustrate zoomed in views of structural features for an actuator locking system, in accordance with various examples of the presently disclosed technology.

[0007] FIG. 4 illustrates another zoomed in view of structural features for an actuator locking system, in accordance with various examples of the presently disclosed technology.

[0008] FIG. 5 illustrates a cross-section view of an actuator locking system, in accordance with various examples of the presently disclosed technology.

[0009] The figures are not exhaustive and do not limit the present disclosure to the precise form disclosed.

DETAILED DESCRIPTION

[0010] As alluded to above, certain machines can adapt to different structural configurations for different operational scenarios. For example (and as described above), a spacecraft or other aircraft may comprise a feathering system that actuates flight control surfaces into different desired configurations for different phases of operation. Machines other than spacecraft and aircraft may similarly actuate various structures to adapt those machines to different structural configurations as desired for various operational scenarios (including different operating environments).

[0011] Many of the above-described machines include actuator locking systems that “lock” (or otherwise provide structural reinforcement to fix) structural components of their respective machines into the different structural configurations. For example, a machine may comprise an actuator locking system that locks structural components of the machine into a first structural

configuration for a first operational scenario. During (or in advance of entering) a second operational scenario, the actuator locking system can unlock the structural components of the machine so they can be moved/adapted to a second structural configuration.

[0012] For the above-described machines, reliable operation of actuator locking systems can be important for maintaining safety and improving machine life.

[0013] For example, the above-referenced feathering system of a spacecraft may include an actuator locking system that locks the flight control surfaces of the spacecraft in an upwards/folded position in a “feathered” configuration during high-speed reentry into Earth's atmosphere. In this example, the actuator locking system can provide additional structural reinforcement to brace the flight control surfaces of the spacecraft in the upwards/folded position against significant aerodynamic forces. When it is appropriate to lower the flight control surfaces of the spacecraft into an “un-feathered” configuration for winged-flight (e.g., when the spacecraft has slowed to a safe speed and the atmosphere has thickened sufficiently to facilitate steering during winged-flight), the actuator locking system can unlock the flight control surfaces of the spacecraft to allow for such a transition.

[0014] As alluded to above, reliable operation for such an actuator locking system can help improve safety and machine life. For example, if the actuator locking system cannot lock the flight control surfaces of the spacecraft in an upwards/folded position as designed, the spacecraft may struggle to maintain a feathered configuration during reentry to the Earth's atmosphere.

Accordingly, the spacecraft may not have proper orientation during this high-speed reentry, which can result in reduced spacecraft stability and overheating for certain components of the spacecraft. A more concerning failure could involve the actuator locking system's inability to unlock the flight control surfaces of the spacecraft to transition the spacecraft from the feathered configuration to the un-feathered configuration. If this were to occur, it could be more difficult to steer the spacecraft to a smooth runway landing.

[0015] Depending on the specific machine/actuator locking system, various types of failures could result in compromised operation of an actuator locking system. For example, the above-referenced actuator locking system for a spacecraft may rely on pneumatic or hydraulic actuators (e.g., pneumatic or hydraulic cylinders). A mechanical failure for a pneumatic/hydraulic actuator (e.g., piston seizure) could prevent the actuator locking system from locking or unlocking as designed. As another example, a rupture to a pneumatic/hydraulic line could result in loss of pressure that prevents proper operation of the actuator locking system.

[0016] Against this backdrop, examples of the presently disclosed technology provide actuator locking systems and methods with enhanced reliability. The disclosed systems and methods facilitate a compact design that can improve safety and machine life for machines that implement them. Moreover, the systems and methods can be utilized in various types of machines, including spacecraft, aircraft, and other machines that adapt to different structural configurations for different operational scenarios (including different operational environments).

[0017] To realize more reliable actuator locking systems and methods, examples utilize a series of specially designed cuffs arranged along a shaft. Namely, an actuator locking system of the presently disclosed technology may comprise: (1) a primary link cuff; (2) a secondary link cuff; and (3) a drive link cuff. The cuffs can be arranged along a shaft with the secondary link cuff positioned between the primary link cuff and the drive link cuff.

[0018] The primary link cuff may be a structural element of a larger primary link comprising a primary link arm and the primary link cuff at a distal end of the primary link arm. A primary actuator (e.g., a primary pneumatic or hydraulic cylinder) can apply linear force to the primary link arm causing the primary link cuff to rotate about the shaft. Relatedly, the secondary link cuff may be a structural element of a larger secondary link comprising a secondary link arm and the secondary link cuff at a distal end of the secondary link arm. A secondary actuator (e.g., a secondary pneumatic or hydraulic cylinder) can apply linear force to the secondary link arm

causing the secondary link cuff to rotate about the shaft. The drive link cuff may comprise a structural element of a larger drive link comprising a drive link arm and the drive link cuff at a distal end of the drive link arm. Rotation of the drive link cuff about the shaft causes the drive link arm to move/rotate.

[0019] Movement/rotation of the drive link arm can actuate (either directly or via one or more mechanical linkages) a lock of the actuator locking system. In other words, movement/rotation of the drive link arm can: (1) lock one or more structural components of a machine into a first structural configuration; and (2) unlock the one or more structural components to facilitate transition to a second structural configuration. For example, where the actuator locking system is implemented in a feathering system of a spacecraft, movement/rotation of the drive link arm from a first position to a second position may cause flight control surfaces of the spacecraft to lock into an upwards/folded (i.e., feathered) configuration for reentry into Earth's atmosphere. Relatedly, movement/rotation of the drive link arm from the second position to the first position may cause the flight control surfaces of the spacecraft to unlock, thus allowing the flight control surfaces to be lowered into an un-feathered configuration for winged-flight.

[0020] During normal operation, the primary link cuff may interlock with the drive link cuff such that rotational force applied by the primary link cuff to the drive link cuff causes the drive link cuff to rotate about the shaft. Accordingly, the primary actuator which controls rotation of the primary link cuff controls movement/rotation of the drive link arm—and thus controls locking/unlocking for the actuator locking system. By contrast, the secondary link cuff may be non-interlocked with the primary link cuff and the drive link cuff during normal operation. Accordingly, the (interlocked) primary link cuff and drive link cuff can rotate independently from the secondary link cuff.

[0021] However, if there is a failure involving the primary actuator (e.g., a piston seizure, loss of pressure on a pneumatic/hydraulic line that supplies the primary actuator, etc.), secondary actuator-initiated rotation of the secondary link cuff about the shaft in a first rotational direction causes the secondary link cuff to push the primary link cuff along the shaft away from the drive link cuff to un-interlock the primary link cuff from the drive link cuff. Accordingly, the secondary actuator can decouple the (disabled/failed) primary actuator from control of locking/unlocking for the actuator locking system. Moreover, secondary actuator-initiated further rotation of the secondary link cuff about the shaft in the first rotational direction causes the secondary link cuff to interlock with the drive link cuff. With the secondary link cuff and drive link cuff now interlocked (and non-interlocked with the primary link cuff), the secondary actuator can now control movement/rotation of the drive link arm—and thus control locking/unlocking of the actuator locking system.

[0022] To realize the above-described redundancy functionality, the primary link cuff, the secondary link cuff, and the drive link cuff may comprise strategic structural design features.

[0023] For example, the drive link cuff may comprise a raised shoulder (e.g., a structure analogous to a flange) at least partially encircling the shaft. A secondary link cuff-facing surface of the raised shoulder may comprise: (a) a flat portion that maintains an approximately constant distance from the primary link cuff; (b) a ramp rising from, and following the flat portion in the first rotational direction; and (c) a slot following a top of the ramp in the first rotational direction. The ramp may rise a distance (X) towards the primary link cuff along the shaft, where the distance (X) is defined parallel to the shaft. The slot may recess inwards away from the primary link cuff along the shaft. In certain implementations the slot may immediately follow the top of the ramp in the first rotational direction. However, in other implementations the secondary link cuff-facing surface of the raised shoulder may further comprise a top-of-ramp flat portion that immediately follows the top of the ramp in the first rotational direction. Here, the top-of-ramp flat portion may be the distance (X) closer to the primary link cuff than the (lower) flat portion. The slot may immediately follow the top-of-ramp flat portion in the first rotational direction. In other words, the slot may recess inwards from the top-of-ramp flat portion.

[0024] Corresponding to the raised shoulder of the drive link cuff, the secondary link cuff may

comprise a tooth extending parallel to the shaft and away from the primary link cuff (i.e., towards the drive link cuff). The tooth (or more particularly, a distal end of the tooth) may slide along the secondary link cuff-facing surface of the raised shoulder of the drive link cuff as the secondary link cuff and drive link cuff rotate relative to each other about the shaft. During normal operation, the tooth may slide along the flat portion of the secondary link cuff-facing surface of the raised shoulder as the secondary link cuff and drive link cuff rotate relative to each other. With the tooth only sliding along the flat portion, the secondary link cuff should not linearly articulate along the shaft away from the drive link cuff (and towards the primary link cuff).

[0025] However, and as disclosed above, if there is a failure involving the primary actuator, secondary actuator-initiated rotation of the secondary link cuff about the shaft in the first rotational direction can cause the tooth of the secondary link cuff to slide up the ramp of the drive link cuff as the secondary link cuff and drive link cuff rotate relative to each other about the shaft. Sliding of the tooth up the ramp causes the secondary link cuff to linearly articulate along the shaft away from the drive link cuff and towards the primary link cuff. As the secondary link cuff linearly articulates, the secondary link cuff pushes the primary link cuff along the shaft away from the drive link cuff. As described in greater detail below, this pushing of the primary link cuff away from the drive link cuff causes the primary link cuff to un-interlock from the drive link cuff. Accordingly, the (disabled/failed) primary actuator may be effectively decoupled from control of locking/unlocking for the actuator locking system.

[0026] As disclosed above, after the tooth of the secondary link cuff has risen up the ramp of the drive link cuff, further rotation of the secondary link cuff in the first rotational direction causes the tooth to slide into the slot, thus interlocking the secondary link cuff with the drive link cuff. With the secondary link cuff and drive link cuff interlocked (and un-interlocked from with primary link cuff), the secondary actuator can now control movement/rotation of the drive link arm—and thus control locking/unlocking for the actuator locking system.

[0027] In some implementations, the ramp and slot features may be duplicated approximately 180 degrees away on the secondary link cuff-facing surface of the raised shoulder of the drive link cuff. Correspondingly, the tooth feature may be duplicated approximately 180 degrees away on the secondary link cuff. Accordingly, the secondary actuator-initiated rotation of the secondary link cuff about the shaft in the first rotational direction can cause the second tooth of the secondary link cuff to slide up the second ramp of the drive link cuff in concert with the (first) tooth of the secondary link cuff sliding up the (first) ramp of the drive link cuff. Relatedly, the secondary actuator-initiated further rotation of the secondary link cuff in the first rotational direction can cause the second tooth to slide into the second slot of the drive link cuff in concert with the (first) tooth sliding into the (first) slot of the drive link cuff, thus interlocking the secondary link cuff with the drive link cuff. Here, duplicating such features of the drive link cuff and the secondary link cuff can improve stability/balance for the secondary link cuff-drive link cuff interface.

[0028] In certain implementations, the actuator locking system may further comprise a mechanical device that resists compression (e.g., a pre-load spring, a spring and coil coupling, etc.), arranged along the shaft such that the primary link cuff is positioned between the mechanical device and the secondary link cuff.

[0029] Accordingly, the mechanical device may apply linear force to the primary link cuff (either directly or via one or more intermediate structural elements along the shaft) and the secondary link cuff (via the primary link cuff) along the shaft towards the drive link cuff. In other words, the mechanical device may resist linear articulation of the primary link cuff and secondary link cuff along the shaft away from the drive link cuff. Here, addition of the mechanical device can ensure (or at least significantly increase the likelihood) that the tooth of the secondary link cuff enters the slot of the drive link cuff. Relatedly, addition of the mechanical device can decrease the likelihood that the tooth of the secondary link cuff skips over (and does not enter) the slot of the drive link cuff. Namely, the mechanical device applies linear force to the secondary link cuff (via the primary

link cuff) that pushes the tooth of the secondary link cuff into the slot after the tooth has risen up the ramp of the drive link cuff. Relatedly, the mechanical device resists the type of linear articulation by the secondary link cuff away from the drive link cuff that could cause the tooth of the secondary link cuff to skip over (or otherwise not enter) the slot of the drive link cuff.

[0030] Here, ensuring (or at least significantly increasing the likelihood) that the tooth of the secondary link cuff enters the slot of the drive link cuff improves safety/operation of the actuator locking system. Namely, if the tooth of the secondary link cuff does not enter the slot of the drive link cuff (e.g., if the tooth were to skip over the slot), the secondary link cuff and the drive link cuff may not interlock as designed. During a fail-safe operation where the primary link cuff is non-interlocked with the drive link cuff, interlocking between the secondary link cuff and the drive link cuff enables the secondary actuator to control locking/unlocking for the actuator locking system. Accordingly, if the secondary link cuff and drive link cuff are also non-interlocked, neither actuator may be able to control locking/unlocking of the actuator locking system. Depending on application, this can be a major concern. For example, if the actuator locking system is implemented in a feathering system of a spacecraft, and neither actuator can unlock the flight control surfaces of the spacecraft to transition the spacecraft from a feathered configuration to an un-feathered configuration, it could be difficult/impossible to steer the spacecraft to a safe landing.

[0031] In some implementations, the actuator locking system may further comprise a stopping flange arranged along the shaft such that the primary link cuff is positioned between the stopping flange and the secondary link cuff. In implementations that include both the mechanical device and the stopping flange, the mechanical device and stopping flange may concentrically overlap about the shaft facilitated by an inner radius/diameter for the mechanical device that is wider than an outer radius/diameter of the stopping flange.

[0032] Similar to the mechanical device that resists compression, the stopping flange may improve safety/operation for the actuator locking system by preventing the tooth of the secondary link cuff from skipping over (and not entering) the slot of the drive link cuff. Here, placement of the stopping flange along the shaft may correspond with intelligently designed features of the raised shoulder of the drive link cuff to achieve such functionality. For example, and as alluded to above, the ramp of the drive link cuff may rise a distance (X) towards the stopping flange (and the primary link cuff), where the distance (X) is defined parallel to the shaft. The slot may comprise a first slot edge following the ramp in the first rotational direction, and defining an entrance into the slot for the tooth of the secondary link cuff after rising up the ramp. The slot may comprise a second slot edge at an opposite end of the slot in the first rotational direction. Here, the second slot edge may extend a distance (Y) closer to the stopping flange than the first slot edge, where the distance (Y) is also defined parallel to the shaft. The stopping flange may be positioned to prevent the primary link cuff and the secondary link cuff from linearly articulating greater than a distance (X+Y) away from the drive link cuff along the shaft. Accordingly, the stopping flange prevents the secondary link cuff from linearly articulating away from the drive link cuff by a sufficient distance for the tooth of the secondary link cuff to clear the (higher) height of the second slot edge (i.e., (X+Y))—thus preventing the tooth from skipping over the slot.

[0033] Referring now to structure of the primary link cuff, in certain implementations the primary link cuff may comprise a raised shoulder (e.g., analogous to a flange) at least partially encircling the shaft. When the secondary link cuff linearly articulates away from the drive link cuff and towards the primary link cuff (i.e., when the tooth of the secondary link cuff slides up the ramp of the drive link cuff), a primary link-facing surface of the secondary link cuff can push against a secondary link-facing surface of the raised shoulder of the primary link cuff causing the primary link cuff to linearly articulate along the shaft away from the drive link cuff, thus un-interlocking the primary link cuff from the drive link cuff.

[0034] In certain implementations, the primary link cuff may comprise a ring of castellations at a drive link cuff-facing surface of the primary link cuff. Correspondingly, the drive link cuff may

comprise a ring of castellations at a primary link cuff-facing surface of the drive link cuff. Accordingly, the ring of castellations of the primary link cuff may interlock with the ring of castellations of the drive link cuff when the primary link cuff and the drive link cuff are interlocked. By contrast, when the primary link cuff is pushed away from the drive link cuff, the rings of castellations may mechanically disengage from each other, effectuating un-interlocking of the primary link cuff from the drive link cuff. In certain implementations, the ring of castellations of the primary link cuff and the ring of castellations of the drive link cuff may be asymmetrical. In other words, the rings of castellations may only interlock in a single configuration. This can improve safety for the actuator locking system by decreasing the likelihood of accidental re-interlocking/re-engagement of the rings of castellations when there is a failure involving the primary actuator.

[0035] Examples of the presently disclosed technology are described in greater detail in conjunction with the following FIGs.

[0036] FIG. 1 illustrates a perspective view of an actuator locking system **100**, in accordance with various examples of the presently disclosed technology.

[0037] As depicted in this example, actuator locking system **100** comprises a primary link **102**, a secondary link **104**, and a drive link **106** arranged along a shaft **150**. Secondary link **104** is positioned between primary link **102** and drive link **106**.

[0038] As depicted in this example, primary link **102** comprises a primary link arm **102 (b)** and a primary link cuff **102 (a)** at a distal end of primary link arm **102 (b)**. Linear force applied to a proximal end of primary link arm **102 (b)** (e.g., by a primary actuator not pictured) may cause primary link cuff **102 (a)** to rotate about shaft **150**.

[0039] As depicted in this example, secondary link **104** comprises a secondary link arm **104 (b)** and a secondary link cuff **104 (a)** at a distal end of secondary link arm **104 (b)**. Linear force applied to a proximal end of secondary link arm **104 (b)** (e.g., by a secondary actuator not pictured) may cause secondary link cuff **104 (a)** to rotate about shaft **150**.

[0040] As depicted in this example, drive link **106** comprises a drive link arm **106 (b)** and a drive link cuff **106 (a)** at a distal end of drive link arm **106 (b)**. Rotation of drive link cuff **106 (a)** about shaft **150** causes drive link arm **106 (b)** to move/rotate. As alluded to above, movement/rotation of drive link arm **106 (b)** can actuate a lock (either directly or via one or more mechanical linkages) of actuator locking system **100**. In other words, movement/rotation of drive link arm **106 (b)** can: (1) lock, into a first structural configuration, one or more structural components of a machine that actuator locking system **100** is implemented in; and (2) unlock the one or more structural components to facilitate transition to a second structural configuration.

[0041] Structural details of primary link cuff **102 (a)**, secondary link cuff **104 (a)**, and drive link cuff **106 (a)** will be described in greater detail in conjunction with FIGS. 3A-3D.

[0042] As depicted, actuator locking system **100** may further comprise a pre-load spring **130** arranged along shaft **150** such that primary link cuff **102 (a)** is positioned between pre-load spring **130** and secondary link cuff **104 (a)**. While in the specific example of FIG. 1 actuator locking system **100** comprises pre-load spring **130**, in other implementations actuator locking system **100** may instead comprise another type of mechanical device that resists compression. For example, actuator locking system **100** may comprise a spring-and-coil coupling in place of pre-load spring **130**.

[0043] As alluded to above, pre-load spring **130** may apply linear force to primary link cuff **102 (a)** (either directly or via one or more intermediate structural elements along shaft **150** such as flange **114**) and secondary link cuff **104 (a)** (via primary link cuff **102 (a)**) along shaft **150** towards drive link cuff **106 (a)**. In other words, pre-load spring **130** may resist linear articulation of primary link cuff **102 (a)** and secondary link cuff **104 (a)** along shaft **150** away from drive link cuff **106 (a)**. Here, addition of pre-load spring **130** can ensure (or at least significantly increase the likelihood) that a tooth of secondary link cuff **104 (a)** (depicted in greater detail in conjunction with FIGS. 3A-

3D) enters a slot of drive link cuff **106 (a)** (also depicted in greater detail in conjunction with FIGS. 3A-3D). Relatedly, the addition of pre-load spring **130** can decrease the likelihood that the tooth of secondary link cuff **104 (a)** skips over (and does not enter) the slot of drive link cuff **106 (a)**. Namely, pre-load spring **130** applies linear force to secondary link cuff **104 (a)** (via primary link cuff **102 (a)**) that pushes the tooth of secondary link cuff **104 (a)** into the slot of drive link cuff **106 (a)** after the tooth has risen up a ramp of drive link cuff **106 (a)** (depicted in greater detail in conjunction with FIGS. 3A-3D). Relatedly, pre-load spring **130** resists the type of linear articulation by secondary link cuff **104 (a)** away from drive link cuff **106 (a)** that could cause the tooth of secondary link cuff **104 (a)** to skip over (or otherwise not enter) the slot of drive link cuff **106 (a)**.

[0044] In certain implementations pre-load spring **130** may span between a flange **112** and a flange **114**, which are also arranged along shaft **150**. Here, flange **114** may be positioned between pre-load spring **130** and primary link cuff **102 (a)**. Flange **114** may linearly articulate in concert with primary link cuff **102 (a)** along shaft **150**. By contrast, flange **112** may maintain a fixed position along shaft **150**. Accordingly, pre-load spring **130** may compress and expand between flange **112** and flange **114** as primary link cuff **102 (a)** and secondary link cuff **104 (a)** linearly articulate along shaft **150** away from and towards drive link cuff **106 (a)**.

[0045] In some implementations actuator locking system **100** may comprise a flange **118** arranged in a fixed position along shaft **150**. Flange **118** can prevent/stop drive link cuff **106 (a)** from linearly articulating away from secondary link cuff **104 (a)** along shaft **150**.

[0046] As depicted in more detail via the example concentric view of FIG. 5, a first portion of secondary link cuff **104 (a)** can overlap a portion of primary link cuff **102 (a)** along shaft **150**. Relatedly, a second portion of secondary link cuff **104 (a)** may overlap a portion of drive link cuff **106 (a)** along the shaft **150**. Such overlapping may be facilitated by a wider inner diameter for secondary link cuff **104 (a)** as compared to the outer diameters of the portion of primary link cuff **102 (a)** and the portion of drive link cuff **106 (a)**. As depicted, a bearing **504** can radially separate secondary link cuff **104 (a)** from the portion of primary link cuff **102 (a)** and the portion of drive link cuff **106 (a)**.

[0047] FIG. 2 illustrates another perspective view of actuator locking system **100**, in accordance with various examples of the presently disclosed technology.

[0048] As depicted, FIG. 2 illustrates a few additional components of actuator locking system **100** that were not illustrated in FIG. 1. Relatedly, certain features/components of actuator locking system **100** which were described in conjunction with FIG. 1 will not be described again here for brevity.

[0049] As depicted in FIG. 2, in certain implementations actuator locking system **100** may further comprise a primary actuator **202** and a secondary actuator **204**. Primary actuator **202** and secondary actuator **204** may comprise various types of actuators such as pneumatic actuators (e.g., pneumatic cylinders), hydraulic actuators (e.g., hydraulic cylinders), etc. Where primary actuator **202** and secondary actuator **204** comprise pneumatic actuators or hydraulic actuators, each actuator may be supplied from a separate fluid line and a separate fluid reservoir so that a failure associated with one fluid line/fluid reservoir does not impact the other fluid line/fluid reservoir.

[0050] As depicted, linear force applied by primary actuator **202** to a proximal end of primary link arm **102 (b)** can cause primary link cuff **102 (a)** to rotate about shaft **150** (not directly visible in FIG. 2). Similarly, linear force applied by secondary actuator **204** to a proximal end of secondary link arm **104 (b)** can cause secondary link cuff **104 (a)** to rotate about shaft **150**.

[0051] As depicted, in some implementations actuator locking system **100** may further comprise mechanical linkages **206**. Mechanical linkages **206** may comprise one or more mechanical linkages connected to drive link arm **106 (b)**. As depicted, movement/rotation of drive link arm **106 (b)** can effectuate movement/rotation of mechanical linkages **206**. Here, mechanical linkages **206** may actuate a lock/unlock mechanism for actuator locking system **100**.

[0052] For example, where actuator locking system **100** is implemented in a feathering system of a spacecraft, movement/rotation of drive link arm **106 (b)** from a first position to a second position may cause mechanical linkages **206** to move/rotate from a corresponding first position to a corresponding second position. Moving mechanical linkages **206** from the first position to the second position may cause flight control surfaces of the spacecraft to lock into an upwards/folded (i.e., feathered) configuration for reentry into Earth's atmosphere. Relatedly, movement/rotation of drive link arm **106 (b)** from the second position to the first position may cause mechanical linkages **206** to move/rotate from the corresponding second position to the corresponding first position. Moving mechanical linkages **206** from the second position to the first position may cause the flight control surfaces of the spacecraft to unlock, thus allowing the flight control surfaces to be lowered into a un-feathered configuration for winged-flight.

[0053] As depicted, and as alluded to above, when primary link cuff **102 (a)** is interlocked with drive link cuff **106 (a)**, primary actuator **202** can control movement/rotation of drive link arm **106 (b)** and mechanical linkages **206**.

[0054] However, if there is a failure involving primary actuator **202** (e.g., a piston seizure, loss of pressure on a pneumatic/hydraulic line that supplies primary actuator **202**, etc.), secondary actuator **204**-initiated rotation of secondary link cuff **104 (a)** about shaft **150** in a first rotational direction causes secondary link cuff **104 (a)** to push primary link cuff **102 (a)** along shaft **150** away from drive link cuff **106 (a)** to un-interlock primary link cuff **102 (a)** from drive link cuff **106 (a)**. Accordingly, secondary actuator **204** can decouple the (disabled/failed) primary actuator **202** from control of locking/unlocking for actuator locking system **100**. Moreover, secondary actuator **204**-initiated further rotation of secondary link cuff **104 (a)** about shaft **150** in the first rotational direction causes secondary link cuff **104 (a)** to interlock with drive link cuff **106 (a)**. With secondary link cuff **104 (a)** and drive link cuff **106 (a)** now interlocked (and un-interlocked from primary link cuff **102 (a)**), secondary actuator **204** can now control movement/rotation of drive link arm **106 (b)** and mechanical linkages **206**—and thus control locking/unlocking of actuator locking system **100**.

[0055] Structural features for the cuffs that facilitate the above-described fail-safe functionality are described in greater detail in conjunction with FIGS. 3A-3D.

[0056] FIGS. 3A-3D illustrative zoomed in views of structural features for actuator locking system **100**, in accordance with various examples of the presently disclosed technology.

[0057] As depicted, secondary link cuff **104 (a)** comprises a tooth **104 (a) (i)** extending away from primary link cuff **102 (a)** along shaft **150**. As alluded to above, tooth **104 (a) (i)** (or more particularly a distal end of tooth **104 (a) (i)**) may slide along a secondary link cuff **104 (a)**-facing surface of a raised shoulder **106 (a) (i)** of drive link cuff **106 (a)** as secondary link cuff **104 (a)** and drive link cuff **106 (a)** rotate relative to each other.

[0058] Referring now to drive link cuff **106 (a)**, drive link cuff **106 (a)** may comprise raised shoulder **106 (a) (i)** at least partially encircling shaft **150**. The secondary link cuff **104 (a)**-facing surface of raised shoulder **106 (a) (i)** may comprise: (a) a flat portion **106 (a) (i) (F)** that maintains an approximately constant distance from the primary link cuff **102 (a)**; (b) a ramp **106 (a) (i) (R)** rising from, and following flat portion **106 (a) (i) (F)** in a first rotational direction; and (c) a slot **106 (a) (i) (S)** following a top of ramp **106 (a) (i) (R)** in the first rotational direction. Ramp **106 (a) (i) (R)** may rise a distance (X) towards primary link cuff **102 (a)**, where the distance (X) is defined parallel to shaft **150**. Slot **106 (a) (i) (S)** may recess inwards away from primary link cuff **102 (a)** along shaft **150**. As described in greater detail below, slot **106 (a) (i) (S)** may recess inwards less than the distance (X) to prevent primary link cuff **104 (a)** and drive link cuff **106 (a)** from re-interlocking when tooth **104 (a) (i)** slides into slot **106 (a) (i) (S)**. In other implementations, tooth **104 (a) (i)** and/or slot **106 (a) (i) (S)** may include structural features that prevent tooth **104 (a) (i)** from recessing inwards as far as the distance (X).

[0059] In certain implementations, slot **106 (a) (i) (S)** may immediately follow the top of ramp **106**

(a) (i) (R) in the first rotational direction. However, in other implementations the secondary link cuff **104** (a)-facing surface of raised shoulder **106** (a) (i) may further comprise a top-of-ramp flat portion that immediately follows the top of ramp **106** (a) (i) (R) in the first rotational direction. Here, the top-of-ramp flat portion may be the distance (X) closer to primary link cuff **102** (a) than flat portion **106** (a) (i) (F). Slot **106** (a) (i) (S) may immediately follow the top-of-ramp flat portion in the first rotational direction. In other words, slot **106** (a) (i) (S) may recess inwards from the top-of-ramp flat portion.

[0060] In certain implementations, raised shoulder **106** (a) (i) may further comprise a brow **106** (a) (i) (B) immediately following slot **106** (a) (i) (S) in the first rotational direction. Such a feature is described in greater detail below in conjunction with a second brow **106** (a) (i) (B2) depicted in FIG. 3B, which is analogous in form and function to brow **106** (a) (i) (B).

[0061] As depicted in FIG. 3B, in certain implementations raised shoulder **106** (a) (i) may have duplicative features spaced approximately 180 degrees apart. For example, raised shoulder **106** (a) (i) may further comprise: (a) a second flat portion (not depicted), analogous to (first) flat portion **106** (a) (i) (F), that maintains an approximately constant distance from the primary link cuff **102** (a); (b) a second ramp **106** (a) (i) (R2) rising from, and following the second flat portion in the first rotational direction; and (c) a second slot **106** (a) (i) (S2) following a top of second ramp **106** (a) (i) (R2) in the first rotational direction. Like ramp **106** (a) (i) (R), second ramp **106** (a) (i) (R2) may rise the distance (X) towards primary link cuff **102** (a) along shaft **150**. Like slot **106** (a) (i) (S), second slot **106** (a) (i) (S) may recess inwards away from primary link cuff **102** (a) along shaft **150**.

[0062] Correspondingly, secondary link cuff **104** (a) may comprise a second tooth (not depicted) analogous to tooth **104** (a) (i). Like the duplicative features of raised shoulder **106** (a) (i), the second tooth may be spaced approximately 180 degrees apart from tooth **104** (a) (i).

[0063] As depicted, during normal operation (i.e., when primary link cuff **102** (a) is interlocked with drive link cuff **106** (a) and secondary link cuff **104** (a) is non-interlocked with the other cuffs), tooth **104** (a) (i) may slide along flat portion **106** (a) (i) (F) between ramp **106** (a) (i) (R) in the first rotational direction and second brow **106** (a) (i) (B2) in the second rotational direction. As depicted best in FIG. 3B, second brow **106** (a) (i) (B2) may comprise a steep/sharp incline (e.g., an incline approaching 90 degrees) that defines a boundary for flat portion **106** (a) (i) (F) in the second rotational direction. This steep/sharp incline may prevent tooth **104** (a) (i) from climbing upwards and entering second slot **106** (a) (i) (S2) from the second rotational direction. Accordingly, the steep/sharp incline of second brow **106** (a) (i) (B2) can prevent mistaken un-interlocking of primary link cuff **102** (a) from drive link cuff **106** (a) that would be caused by tooth **104** (a) (i) climbing up second brow **106** (a) (i) (B2). Relatedly, the steep/sharp incline of second brow **106** (a) (i) (B2) can prevent mistaken interlocking between secondary link cuff **104** (a) and drive link cuff **106** (a) that would be caused by tooth **104** (a) (i) entering second slot **106** (a) (i) (S2) from the second rotational direction.

[0064] While not depicted, during normal operation the second tooth of secondary link cuff **104** (a) may slide along the second flat portion of raised shoulder **106** (a) (i) in the same/similar manner. Namely, the second tooth may slide along the second flat portion between second ramp **106** (a) (i) (R2) in the first rotational direction and brow **106** (a) (i) (B) in the second rotational direction. Analogous to second brow **106** (a) (i) (B2), brow **106** (a) (i) (B1) may comprise a steep/sharp incline (e.g., an include approaching 90 degrees) that defines a boundary for the second flat portion in the second rotational direction. This steep/sharp incline may prevent the second tooth from climbing up and entering slot **106** (a) (i) (S) from the second rotational direction. Accordingly, the steep/sharp incline of brow **106** (a) (i) (B) can prevent mistaken un-interlocking of primary link cuff **102** (a) from drive link cuff **106** (a) that would be caused by the second tooth climbing up brow **106** (a) (i) (B1). Relatedly, the steep/sharp incline of brow **106** (a) (i) (B) can prevent mistaken interlocking between secondary link cuff **104** (a) and drive link cuff **106** (a) that would be caused by the second tooth entering slot **106** (a) (i) (S) from the second rotational direction.

[0065] Referring now to primary link cuff **102 (a)**, as depicted primary link cuff **102 (a)** comprises a raised shoulder **102 (a) (i)** at least partially encircling shaft **150**. Primary link cuff **102 (a)** also comprises a ring of castellations **102 (a) (ii)** at a drive link cuff **106 (a)**-facing surface of primary link cuff **102 (a)**. Drive link cuff **106 (a)** comprises a corresponding/reciprocal ring of castellations **106 (a) (ii)** at a primary link **102 (a)**-facing surface of drive link cuff **106 (a)**. As alluded to above, in certain implementations, ring of castellations **102 (a) (ii)** and ring of castellations **106 (a) (ii)** may be asymmetrical. In other words, the rings of castellations may only interlock in a single configuration. This can improve safety for actuator locking system **100** by decreasing the likelihood of accidental re-interlocking/re-engagement of the rings of castellations when there is a failure involving primary actuator **202** (not visible in FIGS. 3A-3D).

[0066] As depicted in FIGS. 3A-3B, during normal operation ring of castellations **102 (a) (ii)** and ring of castellations **106 (a) (ii)** may interlock, thus interlocking primary link cuff **102 (a)** with drive link cuff **106 (a)**.

[0067] However, as depicted in FIG. 3C, secondary actuator **204**-initiated rotation of secondary link cuff **104 (a)** in the first rotational direction can cause tooth **104 (a) (i)** to slide up ramp **106 (a) (i) (R)**. Sliding of tooth **104 (a) (i)** up ramp **106 (a) (i) (R)** causes secondary link cuff **104 (a)** to linearly articulate away from drive link cuff **106 (a)** and towards primary link cuff **102 (a)** along shaft **150**. Such linear articulation of secondary link cuff **104 (a)** causes a primary link cuff **102 (a)**-facing surface of secondary link cuff **104 (a)** to push a secondary link cuff **104 (a)**-facing surface of raised shoulder **102 (a) (i)** away from drive link cuff **106 (a)** along shaft **150**. Such pushing causes primary link cuff **102 (a)** to linearly articulate away from drive link cuff **106 (a)** along shaft **150**. As primary link cuff **102 (a)** linearly articulates away from drive link cuff **106 (a)** along shaft **150**, ring of castellations **102 (a) (ii)** and ring of castellations **106 (a) (ii)** may un-interlock (i.e., disengage) from each other. With ring of castellations **102 (a) (ii)** and ring of castellations **106 (a) (ii)** un-interlocked, primary link cuff **102 (a)** and drive link cuff **106 (a)** may also un-interlock.

[0068] As depicted in FIG. 3D, secondary actuator **204**-initiated further rotation of secondary link cuff **104 (a)** in the first rotational direction can cause tooth **104 (a) (i)** to enter slot **106 (a) (i) (S)** after rising up ramp **106 (a) (i) (R)**. Linear force applied by pre-load spring **130** can further facilitate tooth **104 (a) (i)** entering slot **106 (a) (i) (S)** by pushing primary link cuff **102 (a)** and secondary link cuff **104 (a)** towards drive link cuff **106 (a)**.

[0069] As depicted in FIG. 3D, with tooth **104 (a) (i)** interlocked in slot **106 (a) (i) (S)**, secondary link cuff **104 (a)** and drive link cuff **106 (a)** may be interlocked, while primary link cuff **102 (a)** remains non-interlocked from drive link cuff **106 (a)**. Accordingly, secondary actuator **204** (not fully visible in FIGS. 3A-3D) can control rotation of drive link cuff **106 (a)** in lieu of primary actuator **202** (also not fully visible in FIGS. 3A-3D).

[0070] As alluded to above, to prevent ring of castellations **102 (a) (ii)** and ring of castellations **106 (a) (ii)** from re-interlocking when tooth **104 (a) (i)** is interlocked in slot **106 (a) (i) (S)**, slot **106 (a) (i) (S)** and/or tooth **104 (a) (i)** may be dimensioned to ensure that tooth **104 (a) (i)** slides inwards a distance less than the distance (X) that tooth **104 (a) (i)** rose up ramp **106 (a) (i) (R)**.

[0071] As depicted in FIG. 3D, slot **106 (a) (i) (S)** may comprises a first slot edge slot **106 (a) (i) (S) (1)** following ramp **106 (a) (i) (R)** in the first rotational direction, and defining an entrance into slot **106 (a) (i) (S)** for tooth **104 (a) (i)** after rising up ramp **106 (a) (i) (R)**. Slot **106 (a) (i) (S)** may also comprise a second slot edge **106 (a) (i) (S) (2)** at an opposite end of slot **106 (a) (i) (S)** in the first rotational direction. Here, second slot edge **106 (a) (i) (S) (2)** may extend a distance (Y) closer to primary link cuff **102 (a)** than first slot edge **106 (a) (i) (S) (1)**, where the distance (Y) is also defined parallel to shaft **150**. As alluded to above, a stopping flange of actuator locking system **100** (depicted in FIG. 4) may be positioned to prevent primary link cuff **102 (a)** and secondary link cuff **104 (a)** from linearly articulating greater than a distance (X+Y) away from drive link cuff **106 (a)** along shaft **150**. Accordingly, the stopping flange can prevent secondary link cuff **104 (a)** from linearly articulating away from drive link cuff **106 (a)** by a sufficient distance for tooth **104 (a) (i)**

to clear the (higher) height of second slot edge **106 (a) (i) (S) (2)** (i.e., the (X+Y))—thus preventing tooth **104 (a) (i)** from skipping over slot **106 (a) (i) (S)**.

[0072] FIG. 4 illustrates another zoomed in view of structural features of actuator locking system **100**, in accordance with various examples of the presently disclosed technology

[0073] As depicted, FIG. 4 illustrates a few components of actuator locking system **100** not directly illustrated in the previous FIGs. Relatedly, certain features/components of actuator locking system **100** which were described in conjunction with the previous FIGs. will not be described again here for brevity.

[0074] As depicted, in certain implementations actuator locking system **100** may further comprise a stopping flange **113** positioned between flange **114** and flange **112** along shaft **150**. In some implementations, actuator locking system **100** may also further comprise a retainer **111** that holds flange **112** in a fixed position along shaft **150**.

[0075] Like flange **112**, stopping flange **113** may maintain a fixed position along shaft **150**. As depicted, in certain implementations stopping flange **113** and flange **112** may be mechanically connected as part of a common structure that maintains a fixed position along shaft **150**.

[0076] As depicted, and as described in conjunction with FIG. 1, pre-load spring **130** may span flange **112** and **114**. In certain implementations, a first end of pre-load spring **130** may be mechanically connected to flange **112** and a second end of pre-load spring **130** may be mechanically connected flange **114**.

[0077] As described in conjunction with FIG. 1, flange **114** may linearly articulate along shaft **150** in concert with primary link cuff **102 (a)** and secondary link cuff **104 (a)**. Accordingly, as primary link cuff **102 (a)** and secondary link cuff **104 (a)** linearly articulate towards and away from drive link cuff **106 (a)**, pre-load spring **130** may expand and compress as flange **114** moves relative to flange **112**.

[0078] As depicted, stopping flange **113** may have a smaller outer diameter than pre-load spring **130**'s inner diameter. Accordingly, pre-load spring **130** can concentrically overlap stopping flange **113** in a radial direction from shaft **150**. Thus, stopping flange **113** may not obstruct pre-load spring **130** as pre-load spring **130** expands and compresses.

[0079] Because stopping flange **113** maintains a fixed position along shaft **150**, a flange **114**-facing surface of stopping flange **113** can stop/prevent flange **114** from continuing to linearly articulate towards flange **112**. In this way, the flange **114**-facing surface of stopping flange **113** can stop/prevent primary link cuff **102 (a)** and secondary link cuff **104 (a)** from continuing to linearly articulate away from drive link cuff **106 (a)**. In other words, the flange **114**-facing surface of stopping flange **113** can set a maximum boundary for linear articulation for primary link cuff **102 (a)** and secondary link cuff **104 (a)** away from drive link cuff **106 (a)**.

[0080] As alluded to above, similar to pre-load spring **130**, stopping flange **113** can improve safety/operation for actuator locking system **100** by preventing tooth **104 (a) (i)** from skipping over (and not entering) slot **106 (a) (i) (S)**. Here, placement of stopping flange **113** along shaft **150** may correspond with the staggered heights for first slot edge **106 (a) (i) (S) (1)** and second slot edge **106 (a) (i) (S) (2)**.

[0081] For example, and as alluded to above, ramp **106 (a) (i) (R)** may rise a distance (X) towards stopping flange **113**, where the distance (X) is defined parallel to shaft **150**. Second slot edge **106 (a) (i) (S) (2)** may extend a distance (Y) closer to stopping flange **113** than first slot edge **106 (a) (i) (S) (1)**, where the distance (Y) is also defined parallel to shaft **150**. Accordingly, stopping flange **113** may be positioned to prevent primary link cuff **102 (a)** and secondary link cuff **104 (a)** from linearly articulating greater than a distance (X+Y) away from drive link cuff **106 (a)** along shaft **150**. Accordingly, stopping flange **113** prevents secondary link cuff **104 (a)** from linearly articulating away from drive link cuff **106 (a)** by a sufficient distance for tooth **104 (a) (i)** to clear the (higher) height of second slot edge **106 (a) (i) (S) (2)** (i.e., (X+Y))—thus preventing tooth **104 (a) (i)** from skipping over slot **106 (a) (i) (S)**.

[0082] FIG. 5 illustrates a cross-section view of actuator locking system **100**, in accordance with various examples of the presently disclosed technology.

[0083] As depicted, drive link cuff **106 (a)**, secondary link cuff **104 (a)**, primary link cuff **102 (a)**, flange **114**, pre-load spring **130**, flange **112**, and retainer **111** are arranged along (cylindrical) shaft **150**.

[0084] A bearing **502** may radially separate shaft **150** from drive link cuff **106 (a)**, primary link cuff **102 (a)**, flange **114**, flange **112**, and retainer **111**.

[0085] As depicted, a first portion of secondary link cuff **104 (a)** overlaps a portion of primary link cuff **102 (a)** along shaft **150**. Relatedly, a second portion of secondary link cuff **104 (a)** overlaps a portion of drive link cuff **106 (a)** along the shaft **150**. Such overlapping may be facilitated by a wider inner diameter for secondary link cuff **104 (a)** as compared to the outer diameters of the portion of primary link cuff **102 (a)** and the portion of drive link cuff **106 (a)**. As depicted, a bearing **504** can radially separate secondary link cuff **104 (a)** from the portion of primary link cuff **102 (a)** and the portion of drive link cuff **106 (a)**.

[0086] It should be understood that the various features, aspects and functionality described in one or more of the individual embodiments are not limited in their applicability to the particular embodiment with which they are described. Instead, they can be applied, alone or in various combinations, to one or more other embodiments, whether or not such embodiments are described and whether or not such features are presented as being a part of a described embodiment. Thus, the breadth and scope of the present application should not be limited by any of the above-described exemplary embodiments.

[0087] Terms and phrases used in this document, and variations thereof, unless otherwise expressly stated, should be construed as open ended as opposed to limiting. As examples of the foregoing, the term “including” should be read as meaning “including, without limitation” or the like. The term “example” is used to provide exemplary instances of the item in discussion, not an exhaustive or limiting list thereof. The terms “a” or “an” should be read as meaning “at least one,” “one or more” or the like; and adjectives such as “conventional,” “traditional,” “normal,” “standard,” “known.” Terms of similar meaning should not be construed as limiting the item described to a given time period or to an item available as of a given time. Instead, they should be read to encompass conventional, traditional, normal, or standard technologies that may be available or known now or at any time in the future. Where this document refers to technologies that would be apparent or known to one of ordinary skill in the art, such technologies encompass those apparent or known to the skilled artisan now or at any time in the future.

[0088] The presence of broadening words and phrases such as “one or more,” “at least,” “but not limited to” or other like phrases in some instances shall not be read to mean that the narrower case is intended or required in instances where such broadening phrases may be absent. The use of the term “component” does not imply that the aspects or functionality described or claimed as part of the component are all configured in a common package. Indeed, any or all of the various aspects of a component, whether control logic or other components, can be combined in a single package or separately maintained and can further be distributed in multiple groupings or packages or across multiple locations.

[0089] Additionally, the various embodiments set forth herein are described in terms of exemplary block diagrams, flow charts and other illustrations. As will become apparent to one of ordinary skill in the art after reading this document, the illustrated embodiments and their various alternatives can be implemented without confinement to the illustrated examples. For example, block diagrams and their accompanying description should not be construed as mandating a particular architecture or configuration.

Claims

1. A system comprising a primary link cuff; a secondary link cuff; and a drive link cuff; wherein the primary link cuff, the secondary link cuff, and the drive link cuff are arranged along a shaft with the secondary link cuff positioned between the primary link cuff and the drive link cuff such that when the drive link cuff is interlocked with the primary link cuff and non-interlocked with the secondary link cuff: rotation of the secondary link cuff about the shaft in a first rotational direction causes the secondary link cuff to push the primary link cuff along the shaft away from the drive link cuff to un-interlock the primary link cuff from the drive link cuff, and further rotation of the secondary link cuff about the shaft in the first rotational direction causes the secondary link cuff to interlock with the drive link cuff.
2. The system of claim 1, wherein: rotational force applied by the primary link cuff to the drive link cuff causes the drive link cuff to rotate about the shaft when the drive link cuff is interlocked with the primary link cuff and non-interlocked with the secondary link cuff; and rotational force applied by the secondary link cuff to the drive link cuff causes the drive link cuff to rotate about the shaft when the drive link cuff is interlocked with the secondary link cuff and non-interlocked with the primary link cuff.
3. The system of claim 1, further comprising a pre-load spring arranged along the shaft, wherein: the primary link cuff is positioned between the pre-load spring and the secondary link cuff along the shaft; the pre-load spring applies linear force to the primary link cuff and the secondary link cuff towards the drive link cuff; the secondary link cuff comprises a tooth extending away from the primary link cuff along the shaft; the drive link cuff comprises a raised shoulder at least partially encircling the shaft; a secondary link cuff-facing surface of the raised shoulder of the drive link cuff comprises: a ramp rising towards the primary link cuff, and a slot, following in the first rotational direction, an end of the ramp closest to the primary link cuff, wherein the slot recesses inwards away from the primary link cuff along the shaft; and when the drive link cuff is interlocked with the primary link cuff and non-interlocked with the secondary link cuff: rotation of the secondary link cuff about the shaft in the first rotational direction causes a distal end of the tooth to slide up the ramp towards the primary link cuff, and further rotation of the secondary link cuff about the shaft in the first rotational direction, in combination with the linear force applied by the pre-load spring, causes the distal end of the tooth to slide into the slot, thereby interlocking the secondary link cuff with the drive link cuff.
4. The system of claim 3, wherein: the primary link cuff comprises a raised shoulder at least partially encircling the shaft; when the distal end of the tooth of the secondary link cuff slides up the ramp of the raised shoulder of the drive link cuff, the secondary link cuff linearly articulates along the shaft towards the primary link cuff; and the linear articulation of the secondary link cuff along the shaft towards the primary link cuff causes a primary link cuff-facing surface of the secondary link cuff to push a secondary link cuff-facing surface of the raised shoulder of the primary link cuff away from the drive link cuff, thereby un-interlocking the primary link cuff from the drive link cuff.
5. The system of claim 1, further comprising: a primary link comprising a primary link arm and the primary link cuff at a distal end of the primary link arm, wherein linear force applied to the primary link arm causes rotation of the primary link cuff about the shaft; a secondary link comprising a secondary link arm and the secondary link cuff at a distal end of the secondary link arm, wherein linear force applied to the secondary link arm causes rotation of the secondary link cuff about the shaft; and a drive link comprising a drive link arm and the drive link cuff at a distal end of the drive link arm, wherein rotational force applied to the drive link cuff about the shaft causes movement of the drive link arm.
6. The system of claim 5, further comprising: a primary actuator configured to apply linear force to the primary link arm; and a secondary actuator configured to apply linear force the secondary link arm.

7. The system of claim 6, wherein the primary actuator and the secondary actuator comprise pneumatic cylinders or hydraulic cylinders.
8. The system of claim 5, wherein the drive link arm actuates one or more mechanical linkages configured to lock wings of a spacecraft in a fixed position.
9. The system of claim 3, further comprising a stopping flange arranged along the shaft such that the primary link cuff is positioned between the stopping flange and the secondary link cuff along the shaft, wherein: the slot of the raised shoulder of the drive link cuff comprises: a first slot edge that the distal end of the tooth of the secondary link cuff slides over to enter the slot after sliding up the ramp of the raised shoulder of the drive link cuff, the first slot edge positioned at a first end of the slot; and a second slot edge positioned at a second end of the slot; the ramp of the raised shoulder of the drive link cuff rises a distance (X) towards the stopping flange, the distance (X) defined parallel to the shaft; the second slot edge extends closer to the stopping flange than the first slot edge by a distance (Y), the distance (Y) defined parallel to the shaft; and the stopping flange prevents the primary link cuff and the secondary link cuff from linearly articulating away from the drive link cuff along the shaft by a distance greater than (X+Y).
10. The system of claim 3, wherein: a first portion of the secondary link cuff overlaps a portion of the primary link cuff along the shaft; a second portion of the secondary link cuff overlaps a portion of the drive link cuff along the shaft; and the system further comprises a bearing arranged along the shaft such that the bearing separates, in a radial direction with respect to the shaft: the first portion of the secondary link cuff from the portion of the primary link cuff, and the second portion of the secondary link cuff from the portion of the drive link cuff.
11. The system of claim 1, wherein: the primary link cuff comprises a ring of castellations at a drive link cuff-facing end of the primary link cuff; the drive link cuff comprises a ring of castellations at a primary link cuff-facing end of the drive link cuff; and the ring of castellations of the primary link cuff interlock with the ring of castellations of the drive link cuff when the primary link cuff and the drive link cuff are interlocked.
12. The system of claim 11, wherein the ring of castellations of the primary link cuff and the ring of castellations of the drive link cuff are asymmetrical.
13. A system comprising a primary link cuff; a secondary link cuff comprising a tooth extending away from the primary link cuff along a shaft; and a drive link cuff comprising a raised shoulder at least partially encircling the shaft, wherein a secondary link cuff-facing surface of the raised shoulder of the drive link cuff comprises: a ramp rising towards the primary link cuff along the shaft, and a slot, following in a first rotational direction, an end of the ramp closest to the primary link cuff, wherein the slot recesses inwards away from the primary link cuff along the shaft; wherein the primary link cuff, the secondary link cuff, and the drive link cuff are arranged along the shaft with the secondary link cuff positioned between the primary link cuff and the drive link cuff such that when the drive link cuff is interlocked with the primary link cuff and non-interlocked with the secondary link cuff: rotation of the secondary link cuff about the shaft in the first rotational direction causes a distal end of the tooth of the secondary link cuff to slide up the ramp of the drive link cuff causing the secondary link cuff to push the primary link cuff along the shaft away from the drive link cuff to un-interlock the primary link cuff from the drive link cuff, and further rotation of the secondary link cuff about the shaft in the first rotational direction causes the distal end of the tooth to slide into the slot of the drive link cuff, thereby interlocking the secondary link cuff with the drive link cuff.
14. The system of claim 13, wherein: rotational force applied by the primary link cuff to the drive link cuff causes the drive link cuff to rotate about the shaft when the drive link cuff is interlocked with the primary link cuff and non-interlocked with the secondary link cuff; and rotational force applied by the secondary link cuff to the drive link cuff causes the drive link cuff to rotate about the shaft when the drive link cuff is interlocked with the secondary link cuff and non-interlocked with the primary link cuff.

15. The system of claim 13, further comprising a compressible mechanical device arranged along the shaft, wherein: the primary link cuff is positioned between the compressible mechanical device and the secondary link cuff along the shaft; the compressible mechanical device applies linear force to the primary link cuff and the secondary link cuff towards the drive link cuff; and the linear force applied by the compressible mechanical device on the primary link cuff and the secondary link cuff towards the drive link cuff, in combination with the further rotation of the secondary link cuff about the shaft in the first rotational direction, causes the distal end of the tooth of the secondary link cuff to slide into the slot of the drive link cuff.

16. The system of claim 13, wherein: the primary link cuff comprises a raised shoulder at least partially encircling the shaft; when the distal end of the tooth of the secondary link cuff slides up the ramp of the raised shoulder of the drive link cuff, the secondary link cuff linearly articulates along the shaft towards the primary link cuff; and the linear articulation of the secondary link cuff along the shaft towards the primary link cuff causes a primary link cuff-facing surface of the secondary link cuff to push a secondary link cuff-facing surface of the raised shoulder of the primary link cuff away from the drive link cuff, thereby un-interlocking the primary link cuff from the drive link cuff.

17. The system of claim 13, further comprising: a primary link comprising a primary link arm and the primary link cuff at a distal end of the primary link arm, wherein linear force applied to the primary link arm causes rotation of the primary link cuff about the shaft; a secondary link comprising a secondary link arm and the secondary link cuff at a distal end of the secondary link arm, wherein linear force applied to the secondary link arm causes rotation of the secondary link cuff about the shaft; and a drive link comprising a drive link arm and the drive link cuff at a distal end of the drive link arm, wherein rotational force applied to the drive link cuff about the shaft causes movement of the drive link arm.

18. The system of claim 17, further comprising: a primary actuator configured to apply linear force to the primary link arm; and a secondary actuator configured to apply linear force the secondary link arm.

19. The system of claim 17, wherein the drive link arm actuates one or more mechanical linkages configured to lock wings of a spacecraft in a fixed position.

20. A system comprising: a primary link cuff; a secondary link cuff comprising a tooth extending away from the primary link cuff along a shaft; a drive link cuff comprising a raised shoulder at least partially encircling the shaft, wherein a secondary link cuff-facing surface of the raised shoulder of the drive link cuff comprises: a ramp rising towards the primary link cuff along the shaft, and a slot, following in a first rotational direction, an end of the ramp closest to the primary link cuff, wherein the slot recesses inwards away from the primary link cuff along the shaft; and a mechanical device that applies linear force to the primary link cuff and the secondary link cuff towards the drive link cuff; wherein the mechanical device, the primary link cuff, the secondary link cuff, and the drive link cuff are arranged along the shaft with the primary link cuff positioned between the mechanical device and the secondary link cuff, and the secondary link cuff positioned between the primary link cuff and the drive link cuff such that: rotational force applied by the primary link cuff to the drive link cuff causes the drive link cuff to rotate about the shaft when the drive link cuff is interlocked with the primary link cuff and non-interlocked with the secondary link cuff, rotational force applied by the secondary link cuff to the drive link cuff causes the drive link cuff to rotate about the shaft when the drive link cuff is interlocked with the secondary link cuff and non-interlocked with the primary link cuff, and when the drive link cuff is interlocked with the primary link cuff and non-interlocked with the secondary link cuff: rotation of the secondary link cuff about the shaft in the first rotational direction causes a distal end of the tooth of the secondary link cuff to slide up the ramp of the drive link cuff causing the secondary link cuff to push the primary link cuff along the shaft away from the drive link cuff to un-interlock the primary link cuff from the drive link cuff, and further rotation of the secondary link cuff about the shaft in the first

rotational direction, in combination with the linear force applied by the mechanical device, causes the distal end of the tooth to slide into the slot of the drive link cuff, thereby interlocking the secondary link cuff with the drive link cuff.
