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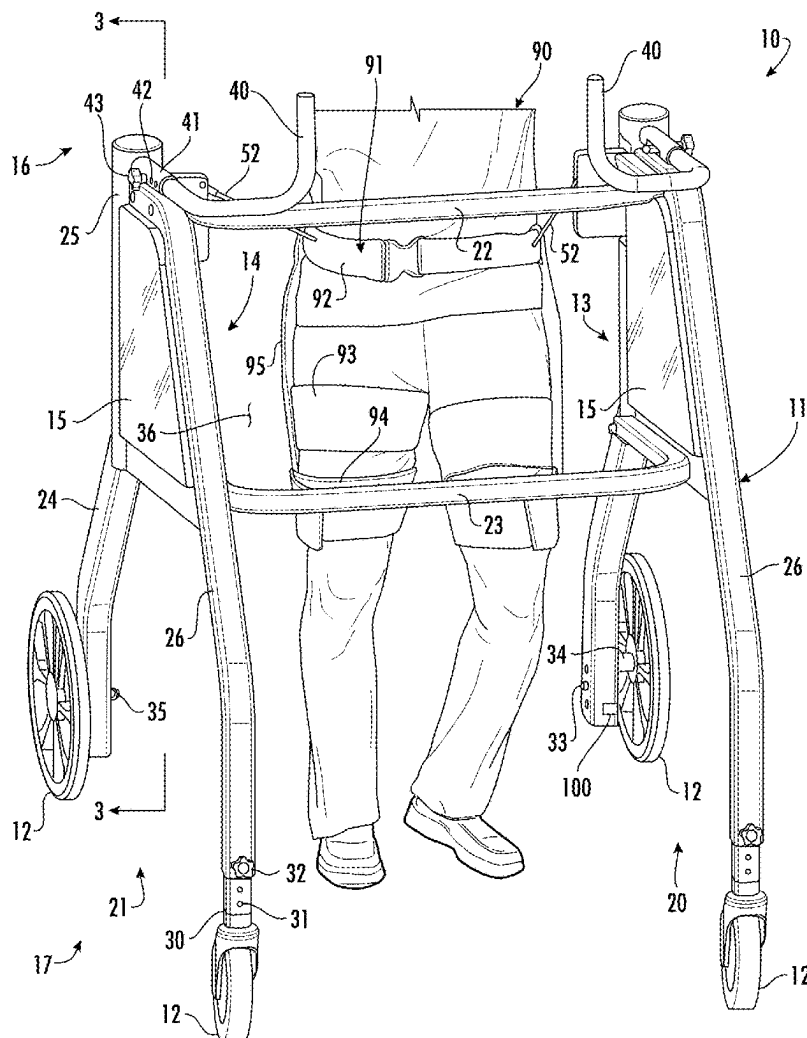
(19) **United States**(12) **Patent Application Publication**
Burns et al.(10) **Pub. No.: US 2025/0255770 A1**(43) **Pub. Date: Aug. 14, 2025**(54) **BODYWEIGHT UNLOADING LOCOMOTIVE
DEVICE****Publication Classification**(51) **Int. Cl.****A61H 3/04** (2006.01)**A61H 3/00** (2006.01)(52) **U.S. Cl.****CPC** **A61H 3/04** (2013.01); **A61H 2003/007**
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Andrew J.D. Burns, Bend, OR (US)(21) Appl. No.: **19/192,853**(22) Filed: **Apr. 29, 2025****Related U.S. Application Data**

- (63) Continuation-in-part of application No. 18/130,292, filed on Apr. 3, 2023, now Pat. No. 12,285,380, which is a continuation-in-part of application No. 17/362,799, filed on Jun. 29, 2021, now Pat. No. 11,617,704, which is a continuation of application No. 17/160,221, filed on Jan. 27, 2021, now Pat. No. 11,071,677.
- (60) Provisional application No. 62/967,011, filed on Jan. 28, 2020.

(57)

ABSTRACT

A bodyweight unloading locomotive device includes a frame configured to support locomotive movement, and a sprung arm having a fixed end fixed to the frame, an opposed free end, and a length extending between the fixed and free ends. A cam assembly is mounted for rotational movement, and a fulcrum is mounted proximate to the sprung arm and configured for movement along the length of the sprung arm between the fixed and free ends. A first tether extends from the free end of the sprung arm to the cam assembly, and a second tether extends from the cam assembly to a load, wherein the sprung arm exerts an unloading force on the load.



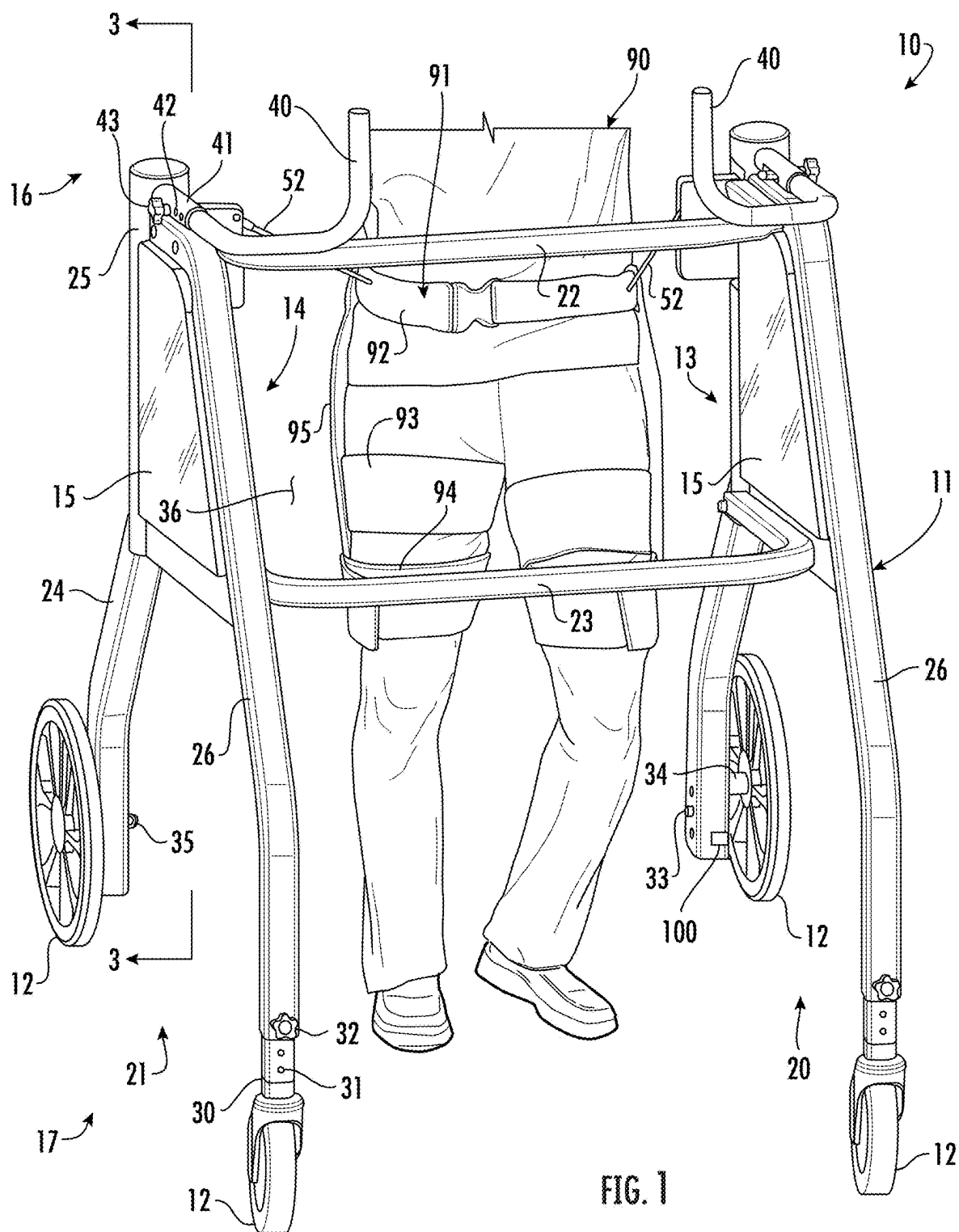
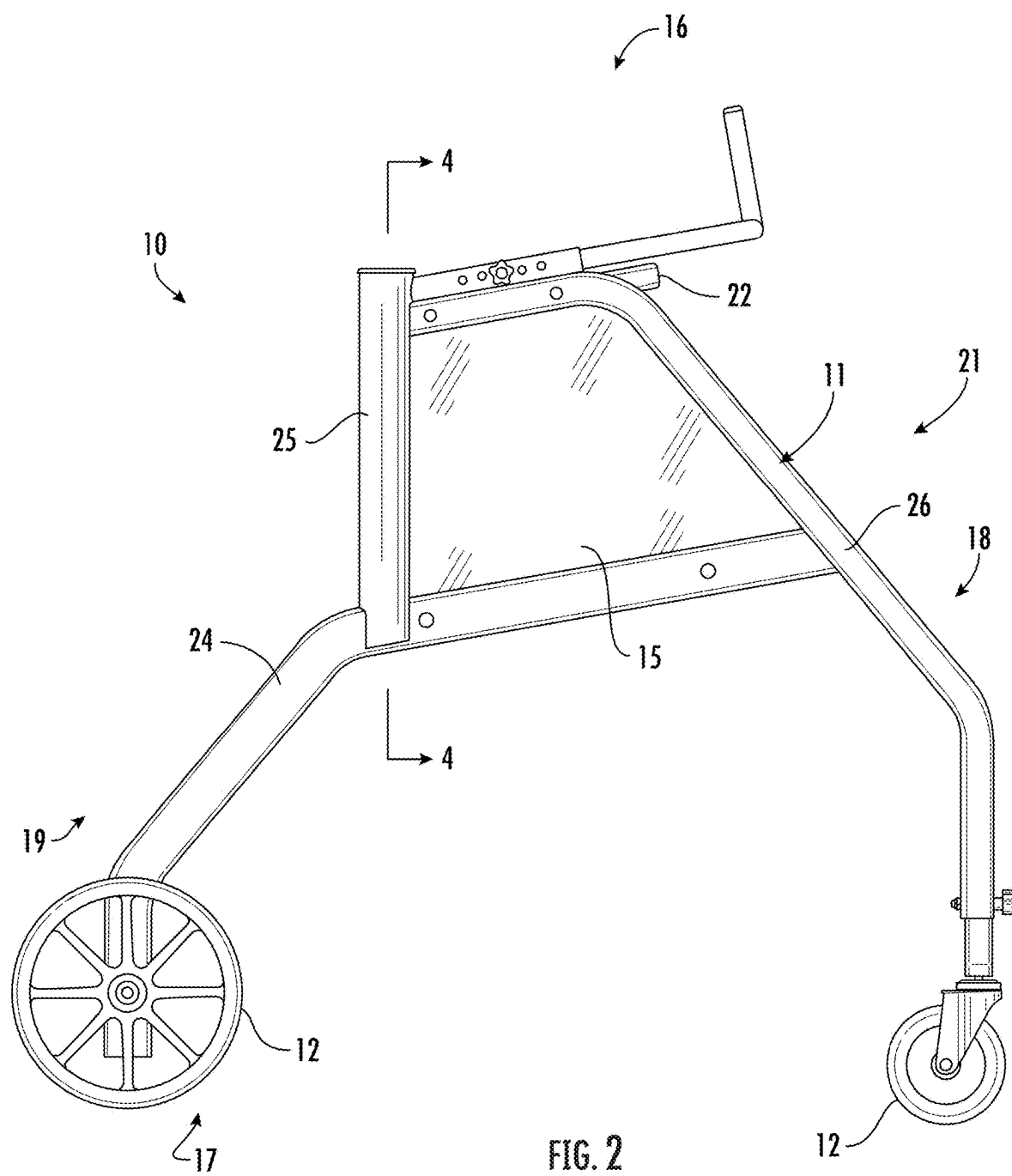


FIG. 1



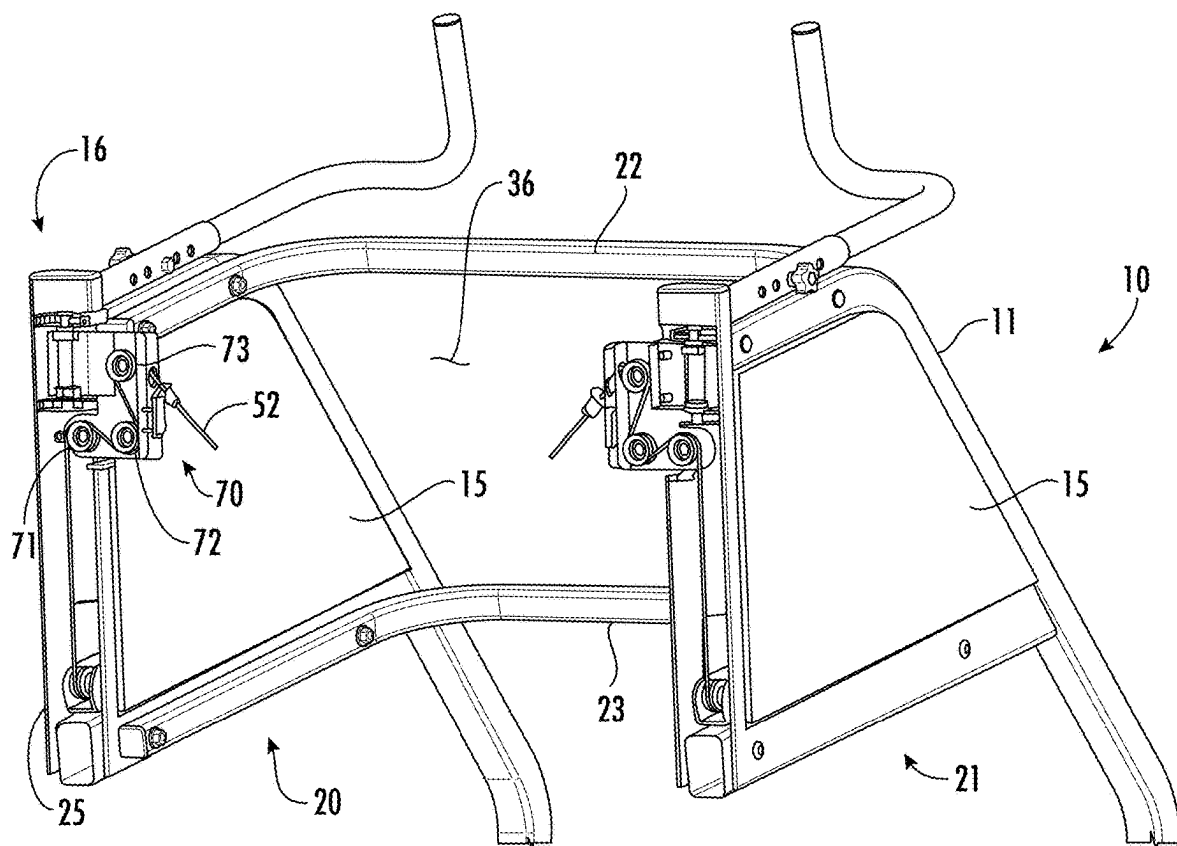


FIG. 4A

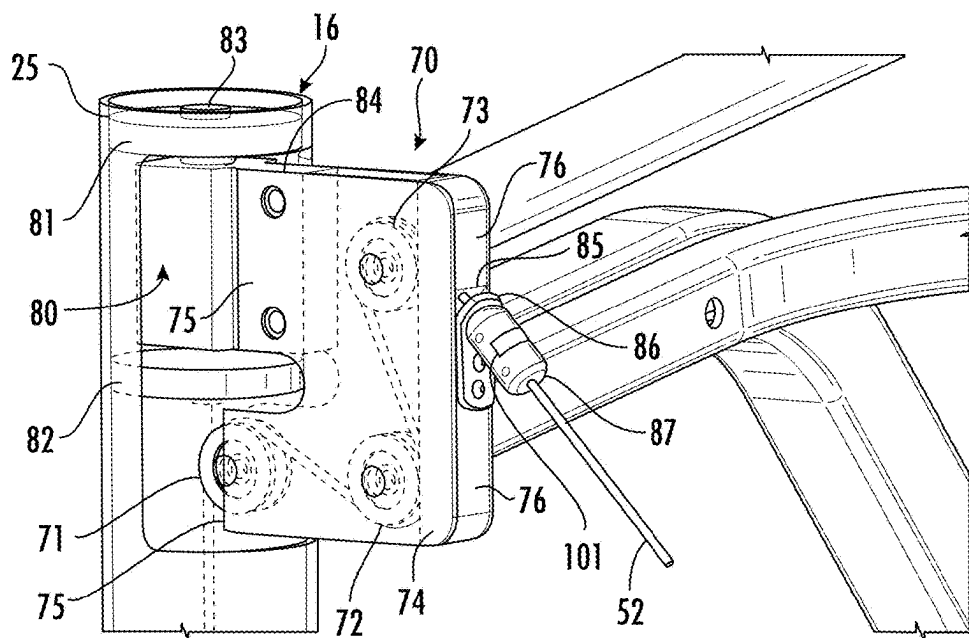


FIG. 4B

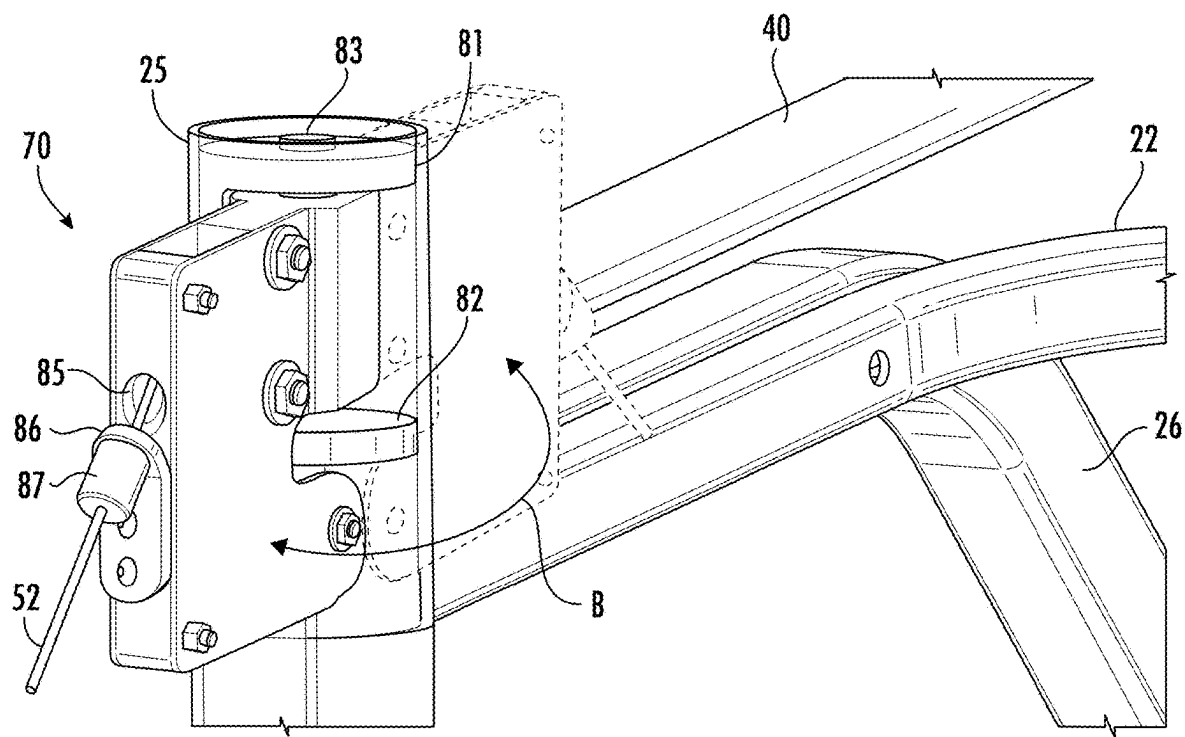


FIG. 4C

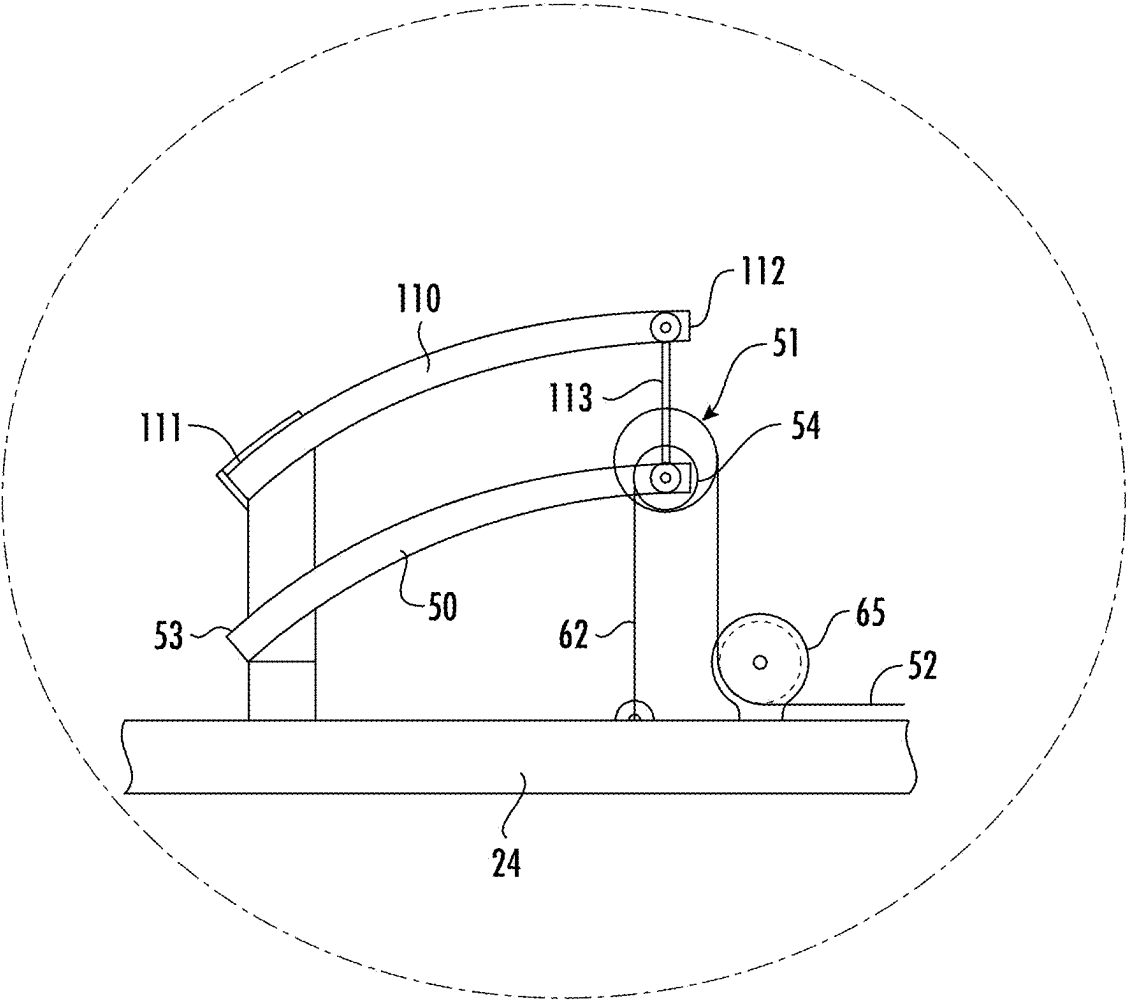


FIG. 5

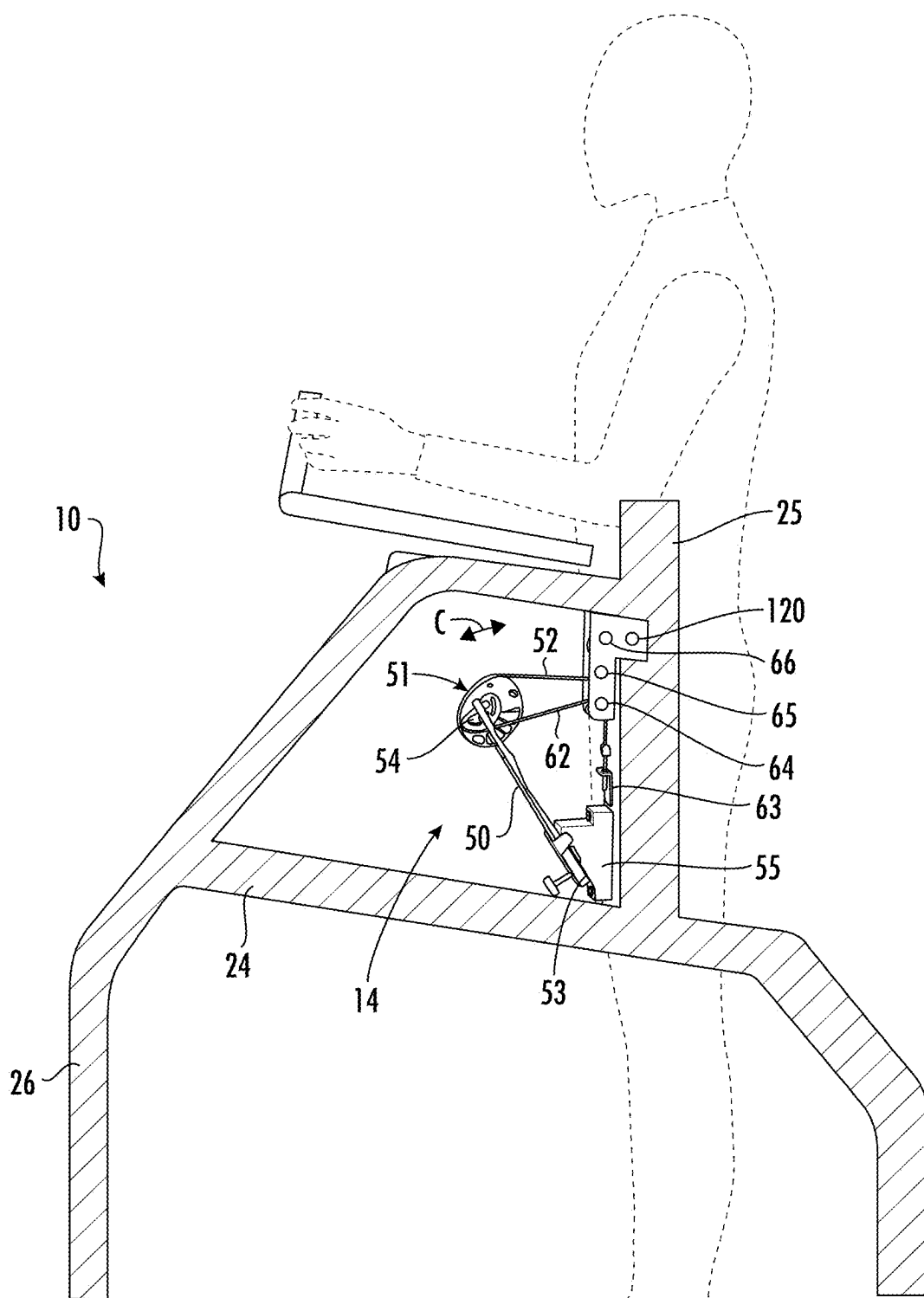


FIG. 6

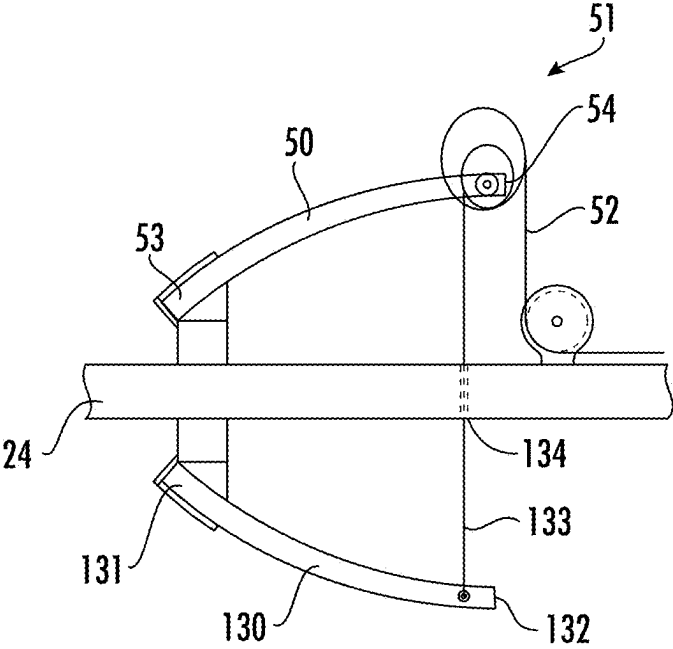


FIG. 7

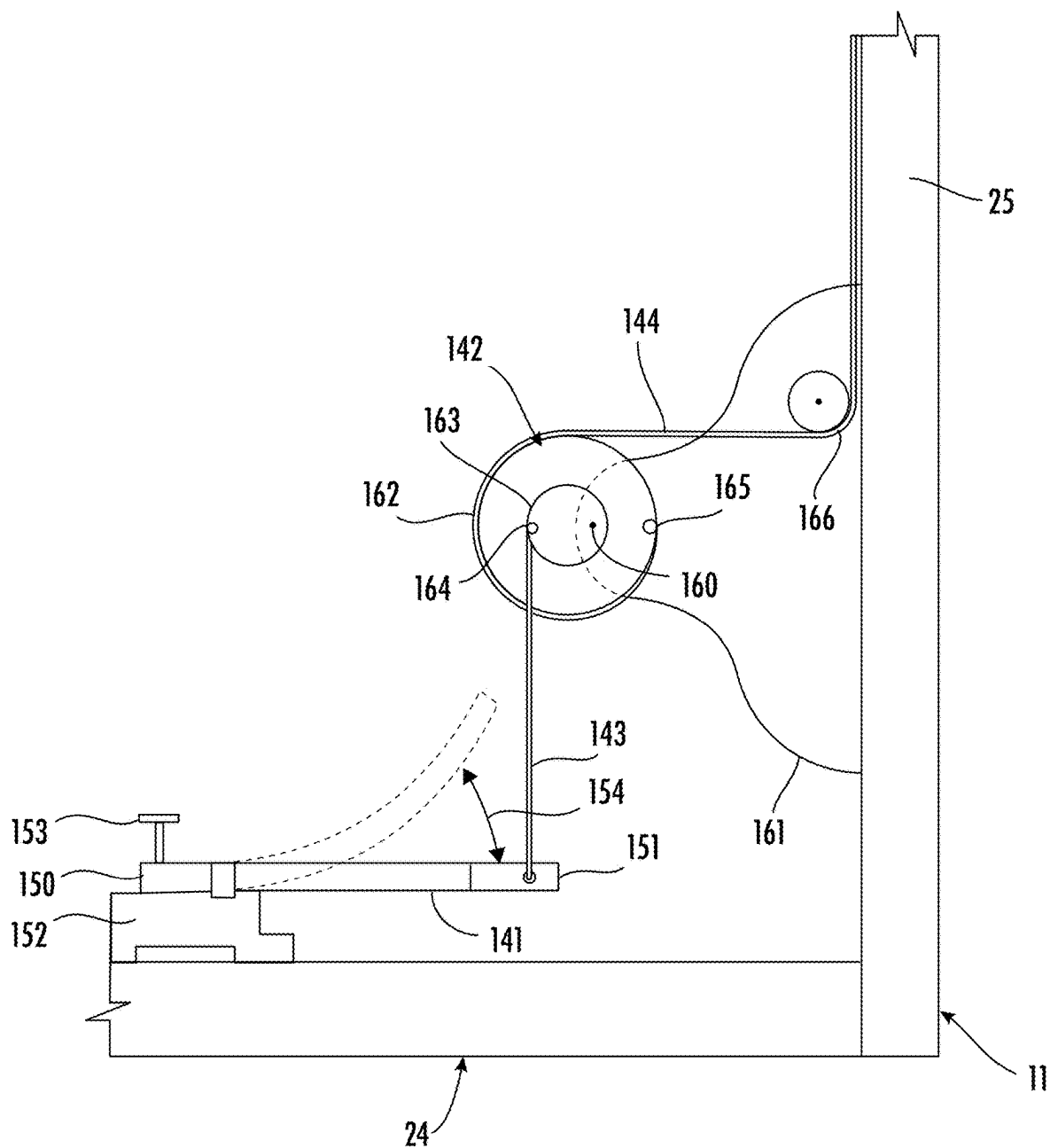


FIG. 8

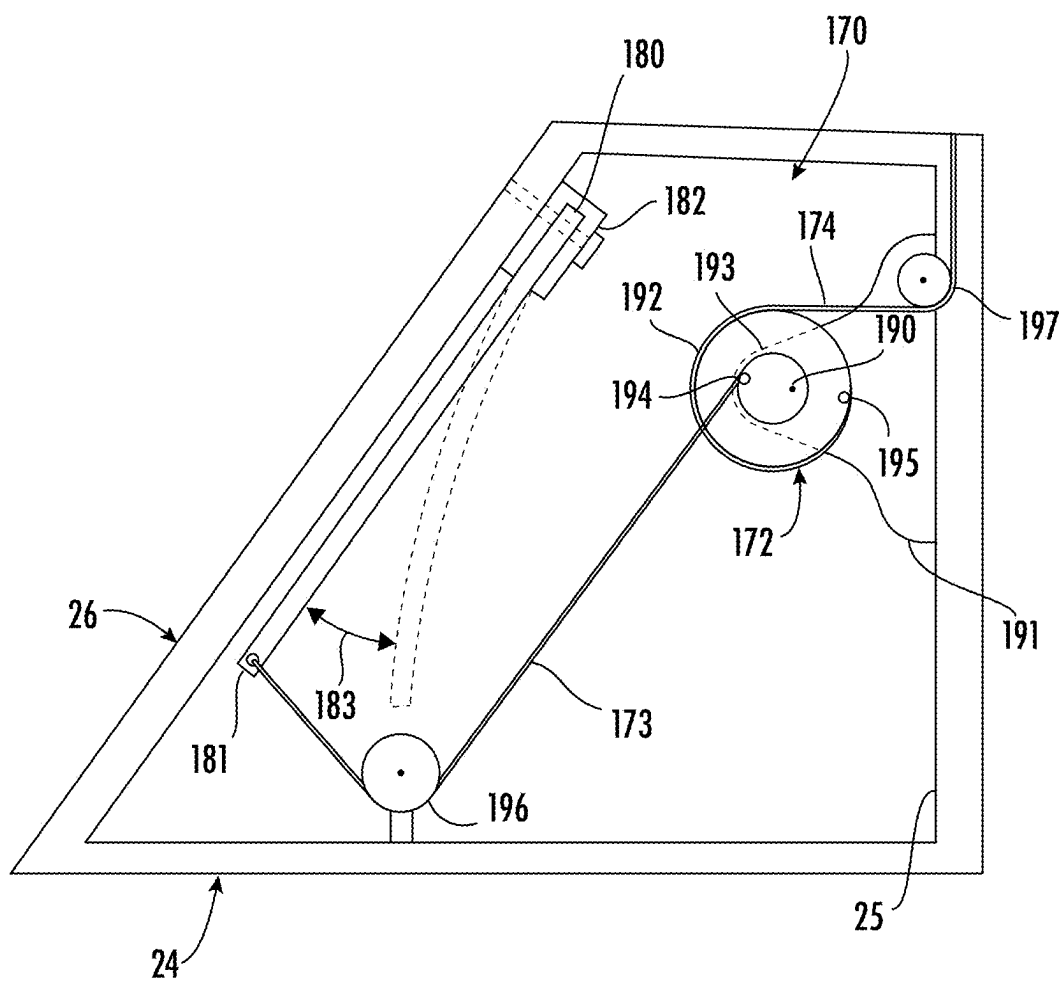
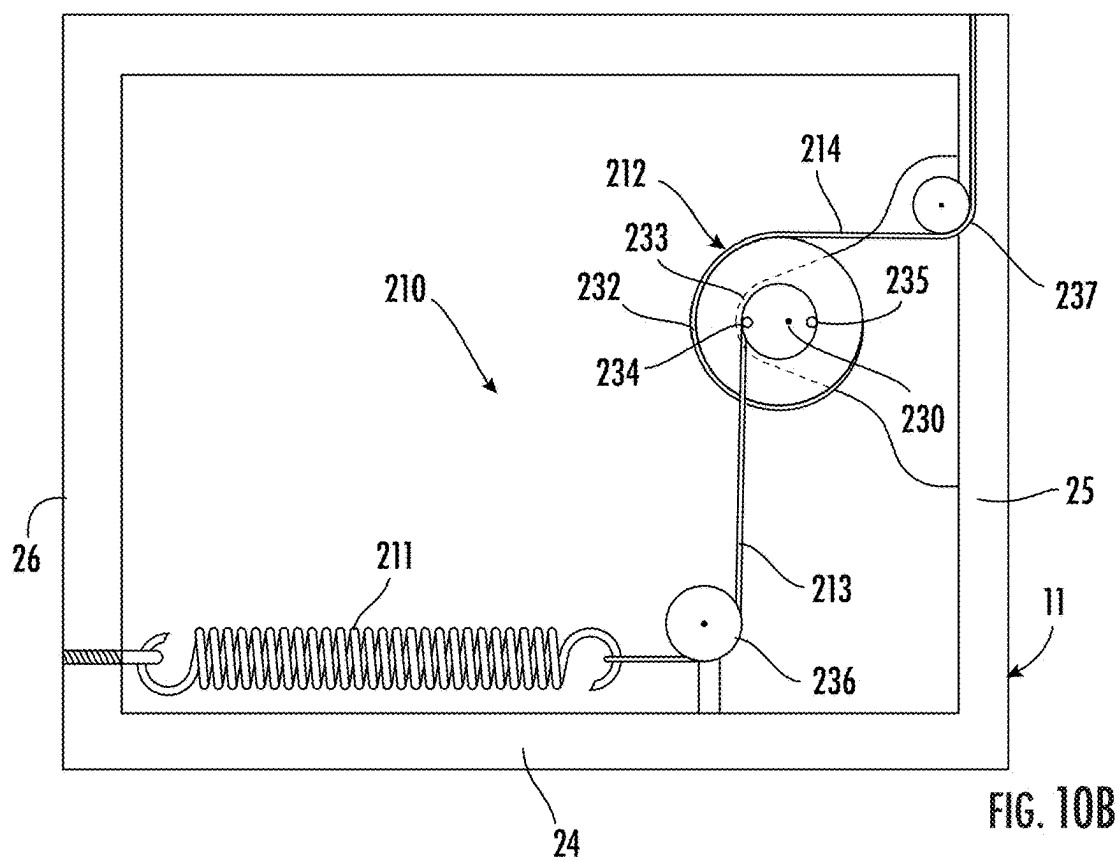
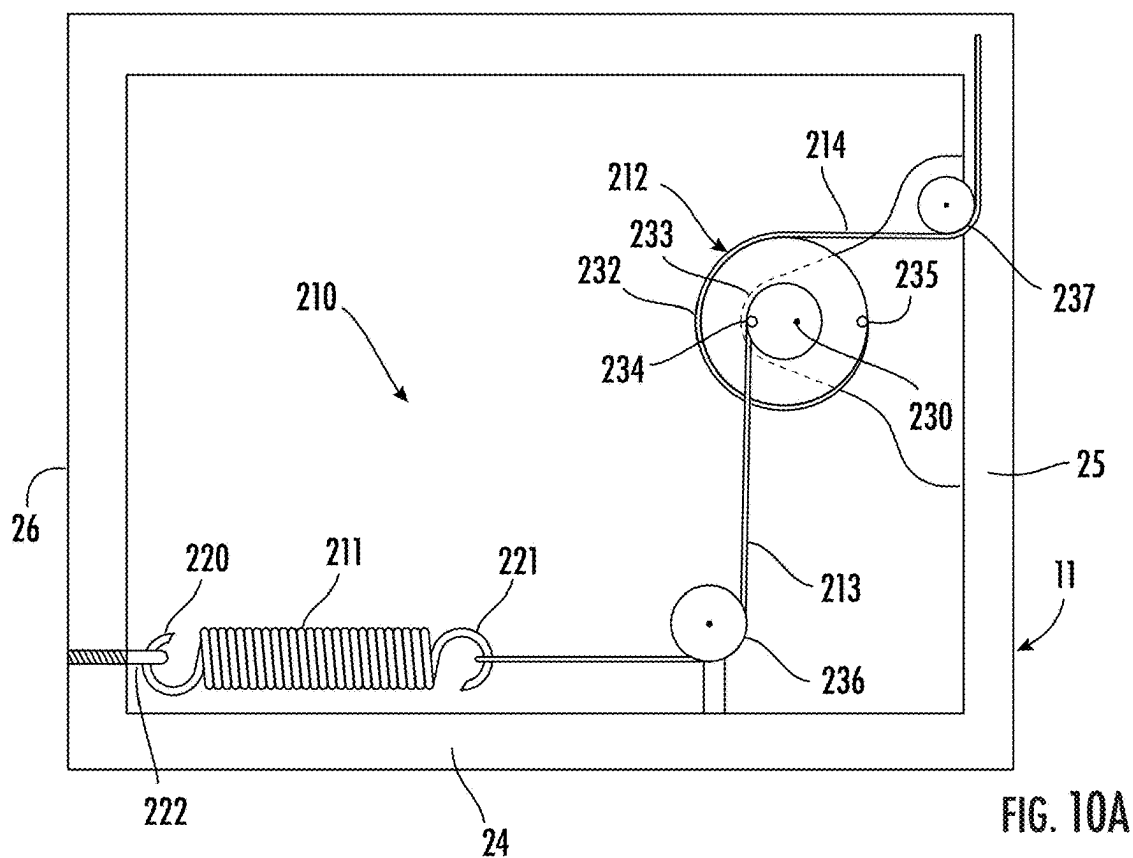
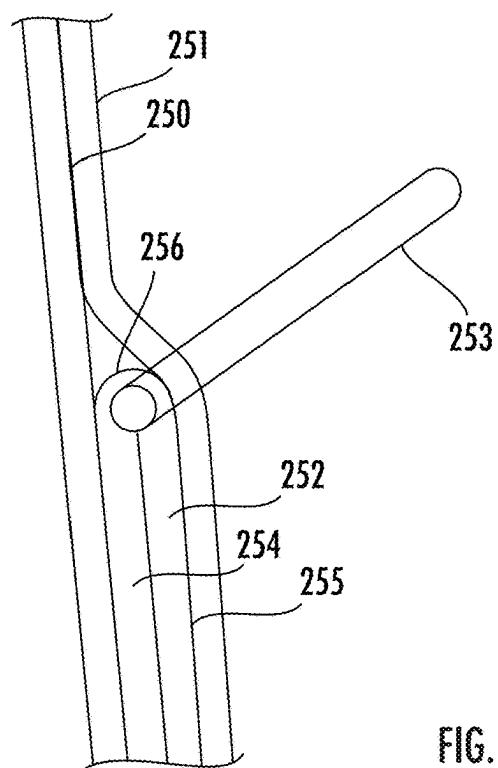
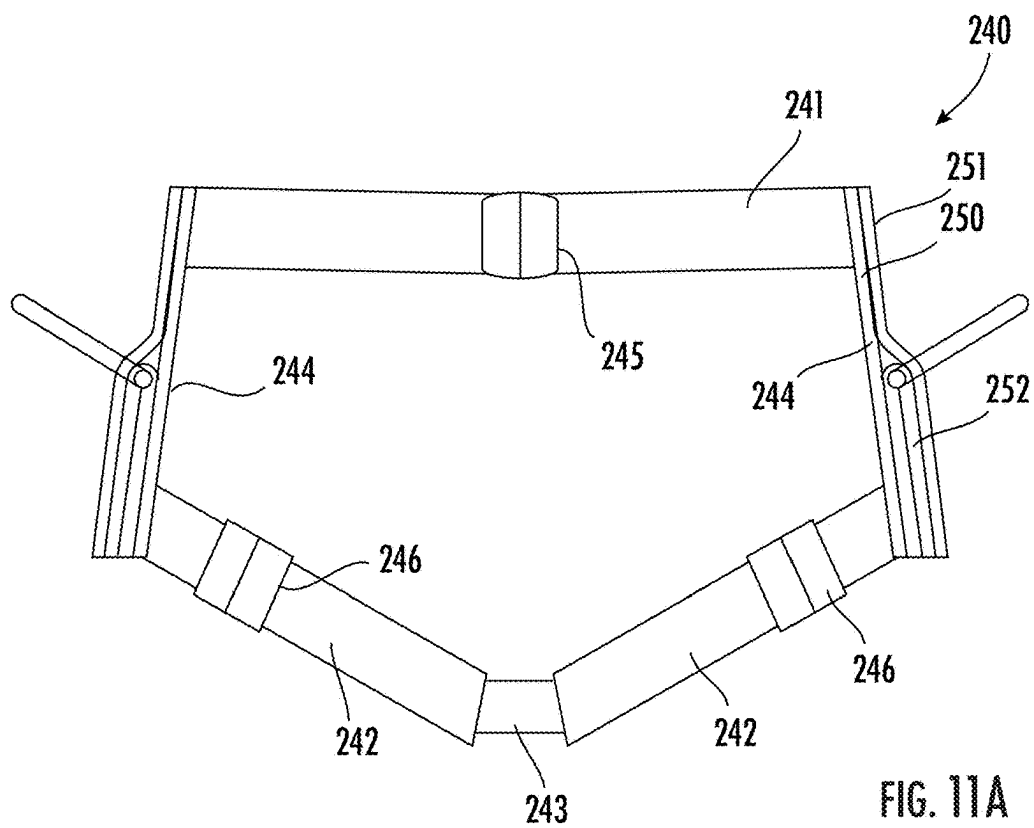
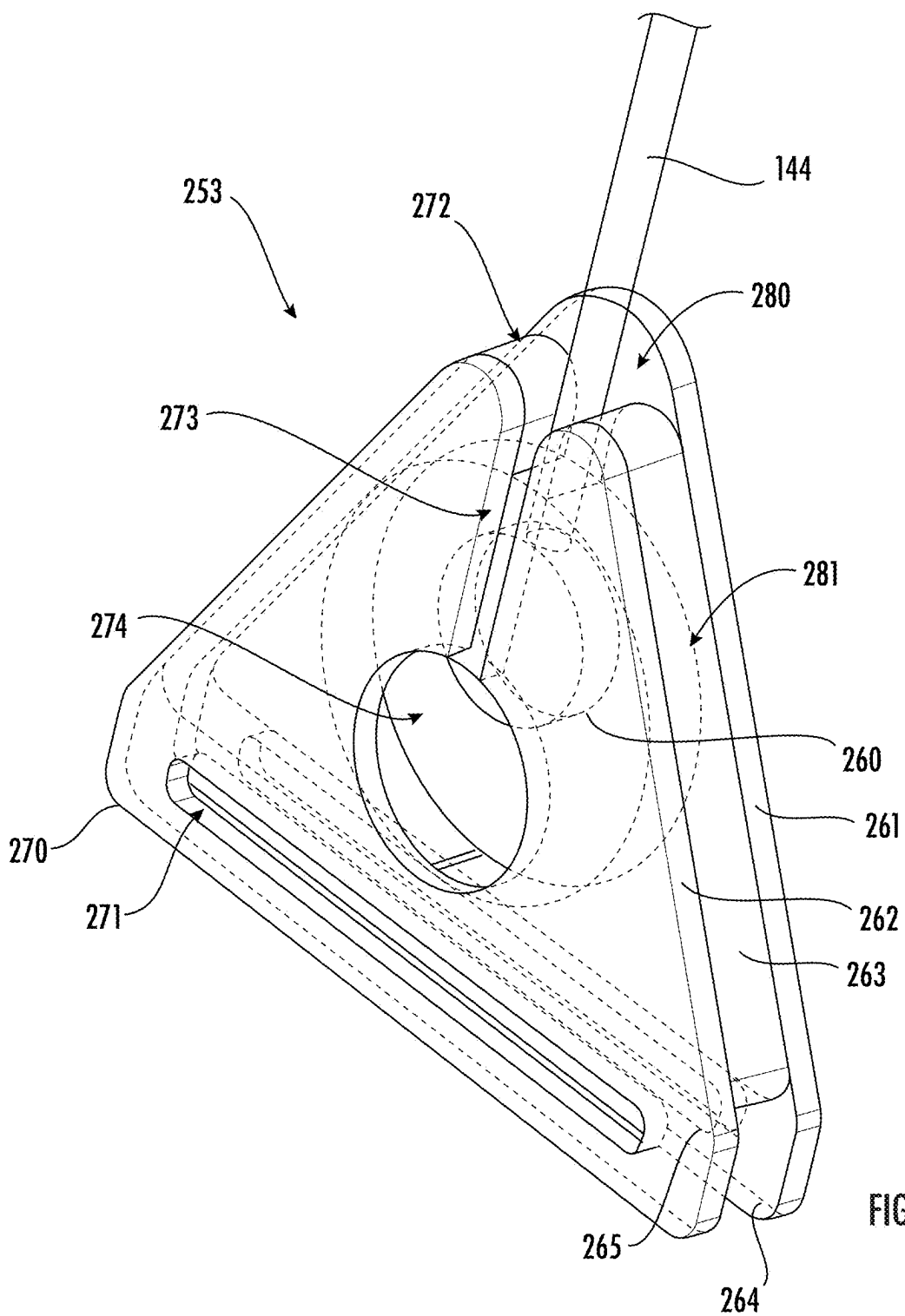
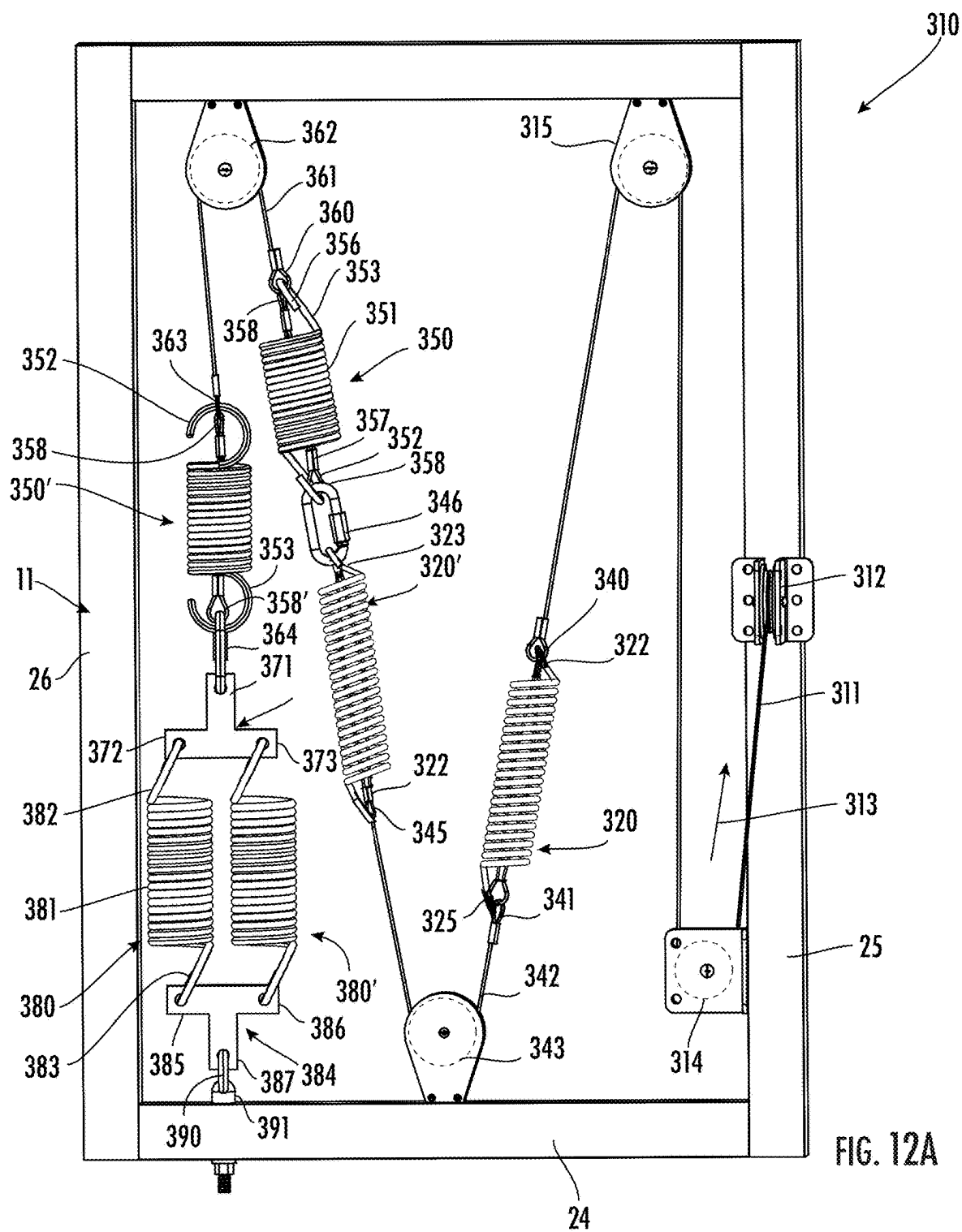


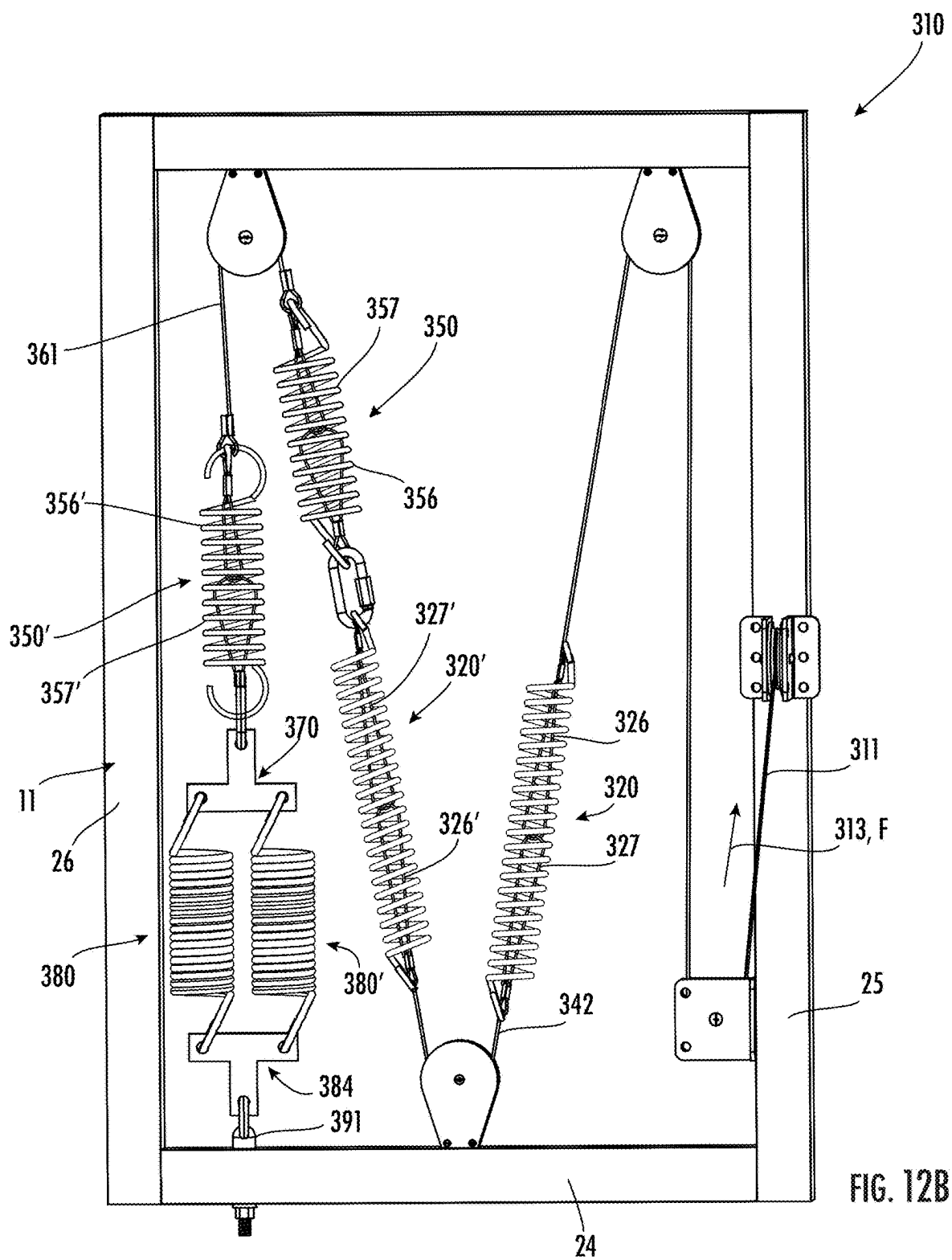
FIG. 9

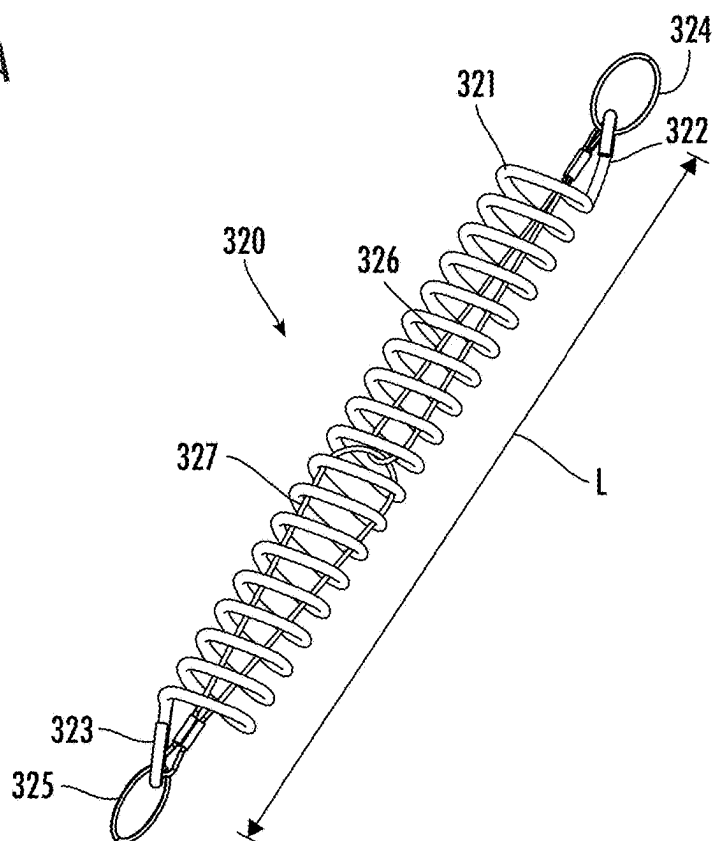
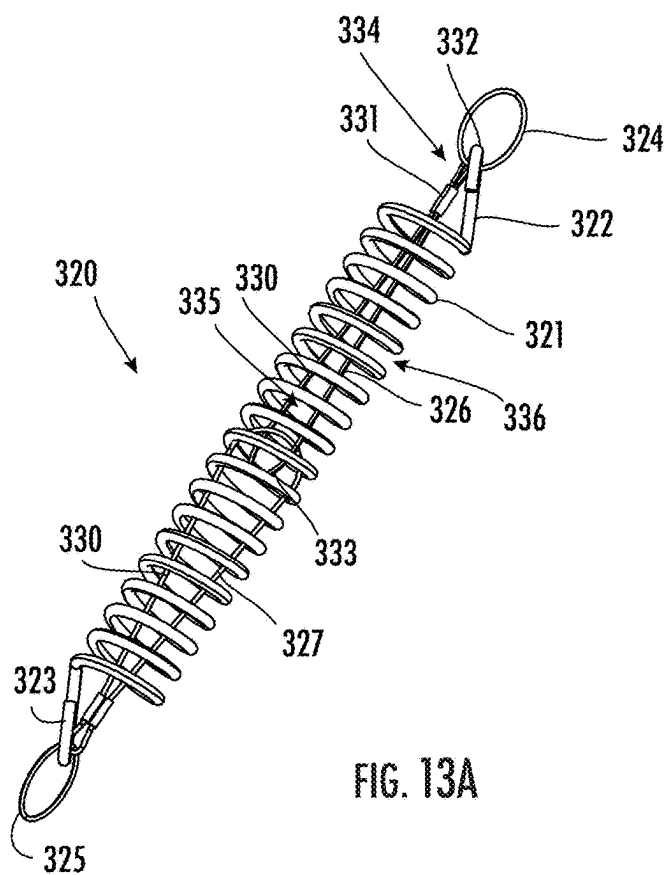












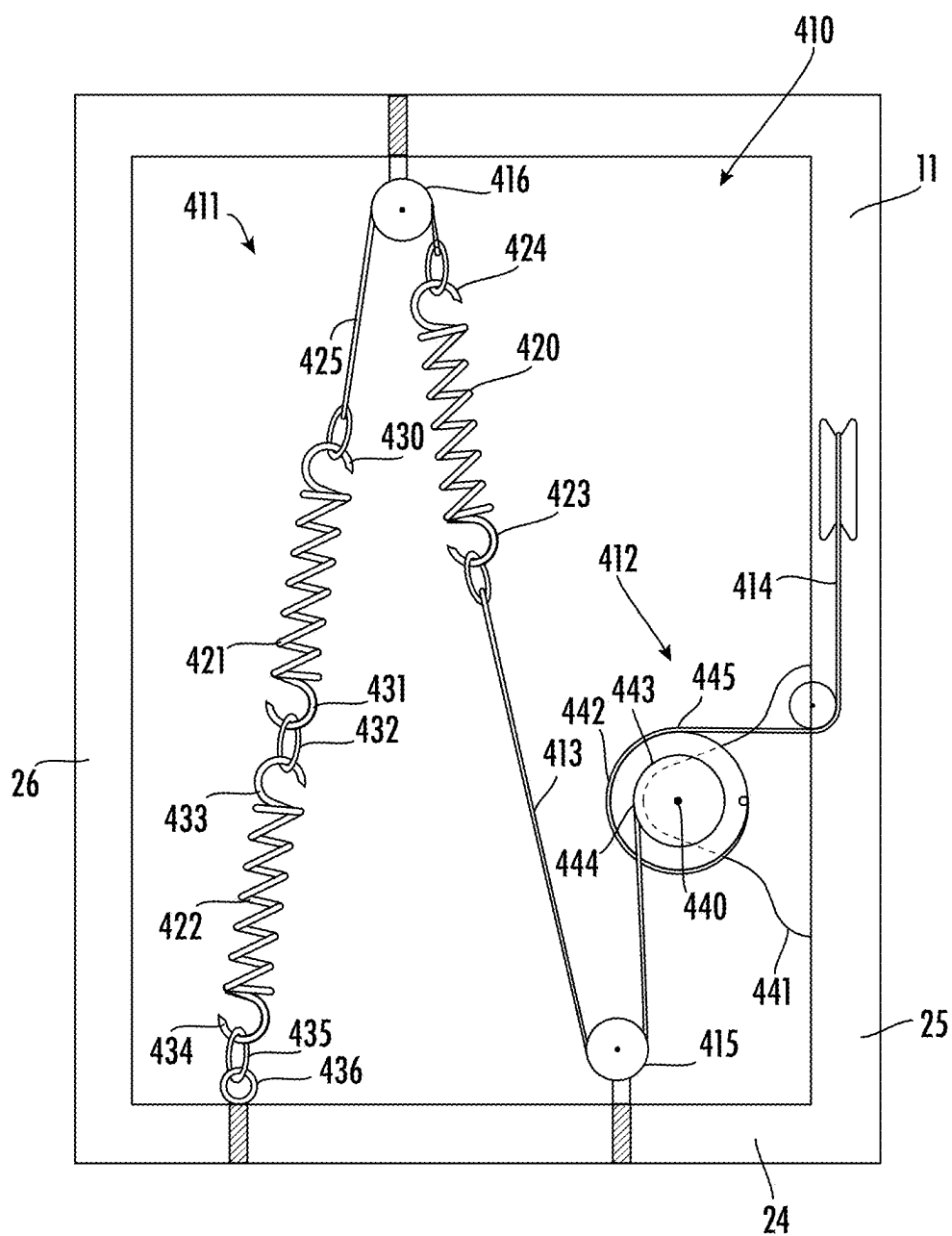
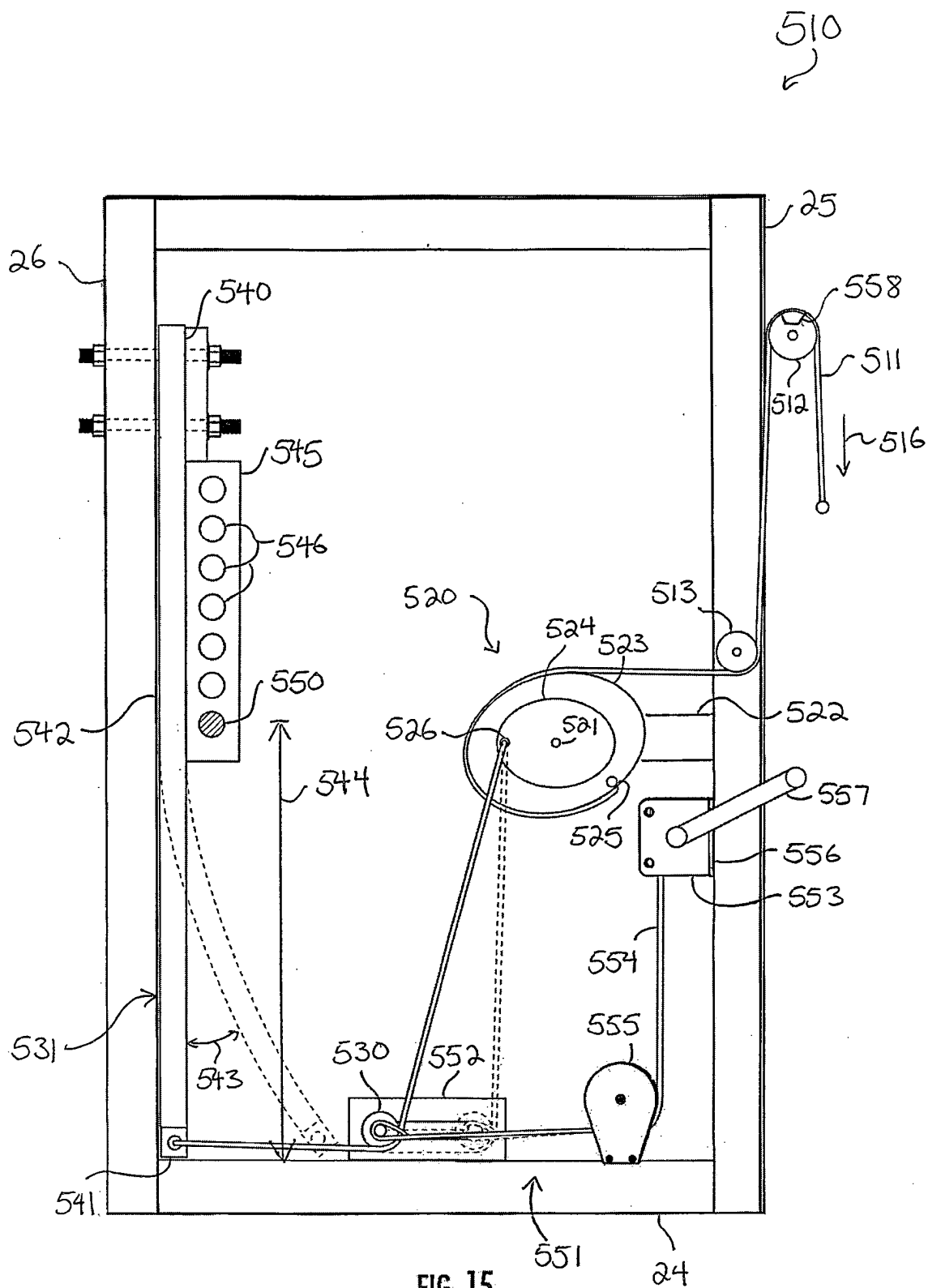


FIG. 14



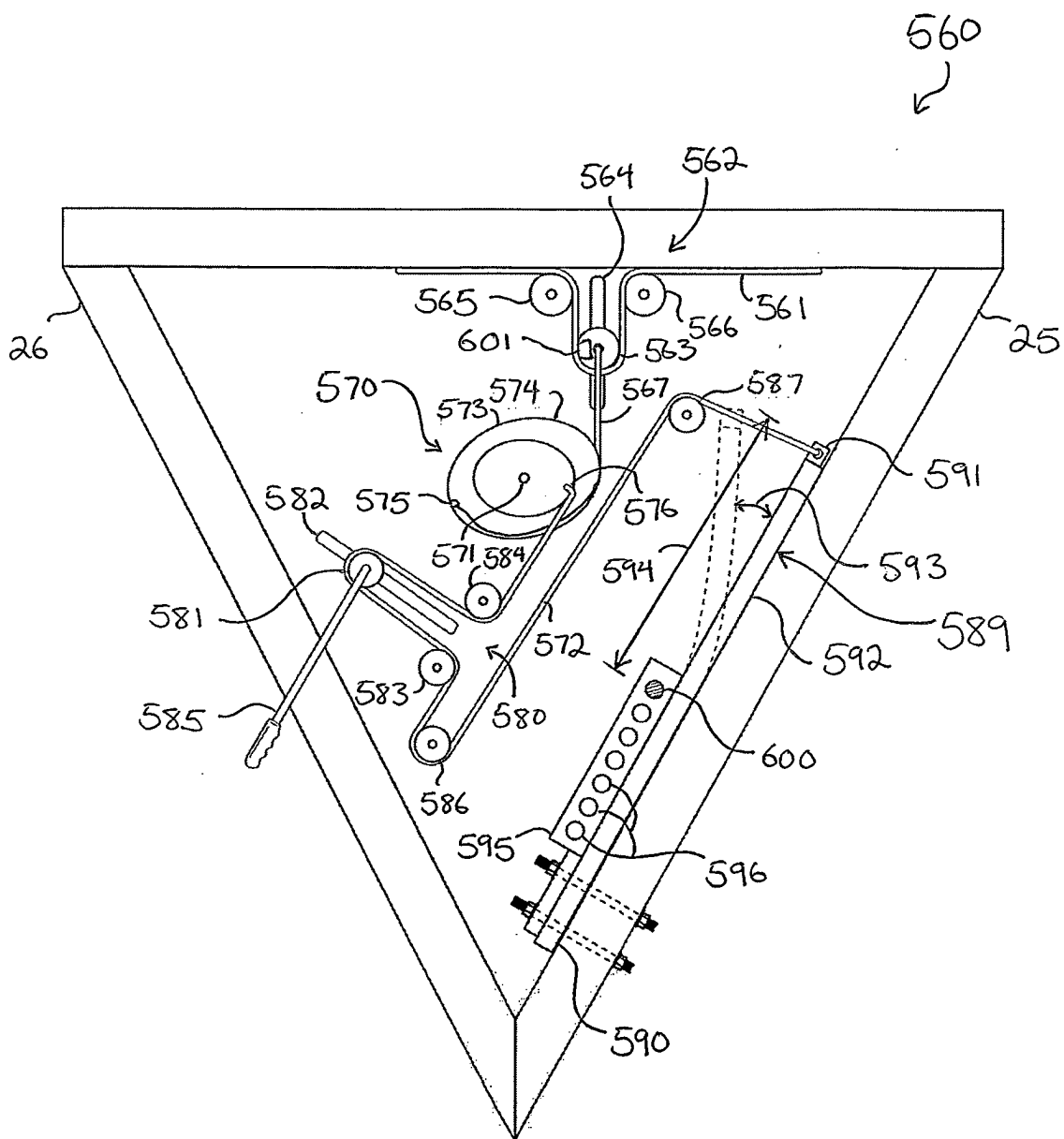


FIG. 16

BODYWEIGHT UNLOADING LOCOMOTIVE DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation-in-part of and claims the benefit of prior U.S. patent application Ser. No. 18/130,292, filed Apr. 3, 2023, which is a continuation-in-part of and claims the benefit of prior U.S. patent application Ser. No. 17/362,799, filed Jun. 29, 2021, which is a continuation-in-part of and claims the benefit of prior U.S. patent application Ser. No. 17/160,221, filed Jan. 27, 2021, which claims the benefit of U.S. Provisional Application No. 62/967,011, filed Jan. 28, 2020, all of which are hereby incorporated by reference in their entireties.

FIELD

[0002] The present specification relates generally to locomotive equipment, and more particularly to locomotive rehabilitation, therapy, and training equipment.

BACKGROUND

[0003] Locomotion is a basic facet of human life. Mobility can, however, be difficult, injurious, or impossible for some. There are a variety of reasons for why a person may experience partial or complete mobility limitations: orthopedic conditions, neurological disorders, motor deconditioning, accident, injury, disease, and disability, for example. Continuing to move—or even attempting to move—can cause discomfort or injury.

[0004] Others may be injured or overweight but require exercise to become healthier. Some rehabilitation facilities have elaborate systems to partially support the weight of such patients, so that they may exercise toward health. The patients wear harnesses that are tethered to trolleys which ride in tracks in the ceiling. Such systems are complex, require assistance from a physical therapist, and are very expensive and thus limited in availability to the patient. Some of these systems provide a lifting force by spring, which changes as the user moves and displaces the spring. Others have sophisticated sensing technology which monitors movement of the patient and then adjusts the lifting force so as to provide a constant unweighting of the patient.

[0005] In some cases, movement may be possible and, indeed, easy, but the individual nonetheless wishes to lower his risk of injury from such movement. Athletes, for instance, often have a need to train long hours with great intensity. They balance the benefits of high-volume training against the elevated risk of injury. A competitive athlete can, after all, suffer serious physical and mental setbacks from even a mild injury. There are a variety of assistive devices to reduce the likelihood of injury during exercise. For example, runners may use buoyancy devices and run in the water. Or they may run on treadmills while zipped into a pressurized bag that lifts them slightly off the treadmill deck, thereby reducing foot-strike impact.

[0006] Still other people do not require assistance reducing their effective bodyweight but do need help with posture and/or stabilization. For them, leaning or tilting beyond the line of gravity can create a dangerous loss of balance.

[0007] Physical therapists often have other devices which suspend from above to support the user while he or she moves. For example, devices exist which can be placed over

or above a treadmill, usually with harnesses, hooks, or special clothing that partially lifts the patient while walking or running on a treadmill. These devices apply an upward force on a patient to reduce his impact while moving.

[0008] Of course, all of these solutions lack freedom of movement. The user is confined to a pool, a treadmill, or a pre-defined path set in ceiling tracks. The person cannot use any of these to walk to the bathroom or around the neighborhood, for example.

[0009] Further, and more seriously, each alters the normal pattern of motion during walking and running. Harnesses that hang from the ceiling tracks generally support the user at a single location, usually above the head or near the center of the back. Occasionally they lift the user at opposed sides of the hips. In both arrangements, the harness restricts the normal movement of the upper body during locomotion. The user may experience upward lift on one side of his body that is the same as that on the other side of this body. In other words, the user's left and right sides are lifted equally and simultaneously. In normal walking and running, however, the forces along the left side of the body are different than and independent from those along the right side of the body. Such systems do not account for these differences, and may exercise different muscles than those used in normal running and walking, thereby leading to improper or prolonged rehabilitation, therapy, or training.

[0010] Moreover, these systems may exercise different muscles than those used in normal walking and running, thereby leading to improper or prolonged rehabilitation, therapy, or training. The use of these devices in rehabilitation, therapy, or training fails to mimic real-life movement and may lead to improper recovery. An improved solution is needed.

SUMMARY

[0011] In an embodiment, a bodyweight unloading locomotive device includes a frame mounted on wheels for locomotive movement. The frame has opposed left and right sides, and a harness supports a user between those left and right sides. An unloading assembly is carried on each of the left and right sides, wherein the unloading assemblies each includes a sprung arm having a fixed end fixed to the respective left and right side, and an opposed free end. The assemblies further each include a cam assembly mounted on the free end of the sprung arm and a tether routed through the cam assembly and extending to the harness. Each of the unloading assemblies thereby exerts an independent unloading force on the harness with respect to the frame, encouraging natural movement and allowing independent unloading of the left and right sides of the body during such natural movement.

[0012] In another embodiment, a bodyweight unloading locomotive device includes a frame for supporting locomotive movement. The frame has opposed left and right sides, and a harness supports a user between those left and right sides. An unloading assembly is carried on each of the left and right sides. The unloading assemblies each include a spring having a first end fixed to the respective left and right side, and an opposed second end, a cam assembly, and a tether routed through the cam assembly and extending to the harness. A cable is routed through the cam assembly and extends to one of an anchor on the frame and the second end

of the spring. Each of the unloading assemblies exerts an independent unloading force on the harness with respect to the frame.

[0013] In yet another embodiment, a bodyweight unloading locomotive device includes a frame configured to support locomotive movement, and an unloading assembly carried by the frame. The unloading assembly includes a spring having a fixed end coupled to the frame and an opposed free end, a cam assembly mounted to the frame for rotational movement, a first tether extending from the free end of the spring to the cam assembly, and a second tether extending from the cam assembly to a load. The unloading assembly exerts an unloading force on the load with respect to the frame.

[0014] In still another embodiment, a bodyweight stabilizing unloading locomotive device includes a frame configured to support locomotive movement and a stabilizing unloading assembly carried by the frame. The stabilizing unloading assembly includes a first spring assembly with a first spring constant, a second spring assembly with a second spring constant different from the first spring constant, and a third spring assembly with a third spring constant different from the first and second spring constants. At least one of the first, second, and third spring assemblies includes a lockout means which prevents extension of the one of the first, second, and third spring assemblies beyond a maximum extension.

[0015] In yet still another embodiment, a bodyweight stabilizing unloading locomotive device includes a frame configured to support locomotive movement and a stabilizing unloading assembly carried by the frame. The stabilizing unloading assembly includes a first spring assembly with a first spring constant, a second spring assembly with a second spring constant different from the first spring constant, and a third spring assembly with a third spring constant different from the first and second spring constants. At least two of the first, second, and third spring assemblies are arranged in series. At least one of the first, second, and third spring assemblies includes an extension spring, a first cable extending from a first end of the extension spring and having a first cable loop, and a second cable extending from a second end of the extension spring and having a second cable loop, wherein the first and second cable loops are interconnected.

[0016] In another embodiment, a bodyweight stabilizing unloading locomotive device includes a frame configured to support locomotive movement and a stabilizing unloading assembly carried by the frame. The stabilizing unloading assembly includes a first spring assembly with a first spring constant and a first lockout means which prevents extension of the first spring assembly beyond a first maximum extension, a second spring assembly with a second spring constant different from the first spring constant and a second lockout means which prevents extension of the second spring assembly beyond a second maximum extension, and a third spring assembly with a third spring constant different from the first and second spring constants.

[0017] In another embodiment, a bodyweight unloading locomotive device includes a frame configured to support locomotive movement, and a sprung arm having a fixed end fixed to the frame, an opposed free end, and a length extending between the fixed and free ends. A cam assembly is mounted proximate to the sprung arm and configured for movement along the length of the sprung arm between the

fixed and free ends. A first tether extends from the free end of the sprung arm to the cam assembly, and a second tether extends from the cam assembly to a load, wherein the sprung arm exerts an unloading force on the load.

[0018] In another embodiment, a bodyweight unloading locomotive device includes a frame configured to support locomotive movement and a sprung arm having a fixed end fixed to the frame, an opposed free end, and a length extending between the fixed and free ends. A cam assembly is mounted for rotational movement, and a fulcrum is mounted proximate to the sprung arm and configured for movement along the length of the arm between the fixed and free ends. The device includes a pulley assembly and a first tether extending from the free end of the sprung arm to the cam assembly, a second tether extending from the cam assembly to the pulley assembly, and a third tether extending across the pulley assembly between first and second loads. The sprung arm exerts an unloading force on the pulley assembly.

[0019] The above provides the reader with a very brief summary of some embodiments described below. Simplifications and omissions are made, and the summary is not intended to limit or define in any way the disclosure. Rather, this brief summary merely introduces the reader to some aspects of some embodiments in preparation for the detailed description that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Referring to the drawings:

[0021] FIGS. 1 and 2 are front perspective and side elevation views of a bodyweight unloading locomotive device, respectively;

[0022] FIG. 3A is an enlarged side elevation view of the bodyweight unloading locomotive device with a panel removed to expose an unloading assembly carried thereon;

[0023] FIG. 3B is a section view taken along the line 3-3 in FIG. 1, slightly sectioning the bodyweight unloading locomotive device and the unloading assembly carried thereon;

[0024] FIG. 4A is a section view taken along the line 4-4 in FIG. 2, showing pulley cassettes on the bodyweight unloading locomotive device;

[0025] FIGS. 4B and 4C are enlarged rear perspective views of one of the pulley cassettes;

[0026] FIGS. 5-7 are enlarged, generalized diagrams illustrating alternative embodiments of the unloading assembly;

[0027] FIGS. 8-10B are enlarged, generalized diagrams illustrating alternative embodiments of the unloading assembly;

[0028] FIGS. 11A-11C are front, side, and perspective views of a harness, and components thereof, for use in the bodyweight unloading locomotive devices;

[0029] FIGS. 12A and 12B are enlarged, generalized diagrams illustrating alternate embodiments of a stabilizing unloading assembly; and

[0030] FIGS. 13A and 13B are enlarged views of a spring assembly used in the stabilizing unloading assembly of FIGS. 12A and 12B;

[0031] FIG. 14 is a generalized diagram illustrating another alternate embodiment of a stabilizing unloading assembly;

[0032] FIG. 15 is a generalized diagram illustrating another alternate embodiment of an unloading assembly; and

[0033] FIG. 16 is a generalized diagram illustrating another alternate embodiment of an unloading assembly.

DETAILED DESCRIPTION

[0034] Reference now is made to the drawings, in which the same reference characters are used throughout the different figures to designate the same elements. Briefly, the embodiments presented herein are preferred exemplary embodiments and are not intended to limit the scope, applicability, or configuration of all possible embodiments, but rather to provide an enabling description for all possible embodiments within the scope and spirit of the specification. Description of these preferred embodiments is generally made with the use of verbs such as “is” and “are” rather than “may,” “could,” “includes,” “comprises,” and the like, because the description is made with reference to the drawings presented. One having ordinary skill in the art will understand that changes may be made in the structure, arrangement, number, and function of elements and features without departing from the scope and spirit of the specification. Further, the description may omit certain information which is readily known to one having ordinary skill in the art to prevent crowding the description with detail which is not necessary for enablement. Indeed, the diction used herein is meant to be readable and informational rather than to delineate and limit the specification; therefore, the scope and spirit of the specification should not be limited by the following description and its language choices.

[0035] FIGS. 1 and 2 are front perspective and right side elevation views of a bodyweight unloading locomotive device 10 (hereinafter, the “device 10”) for support during movement, regardless of different and independent movements on both sides of the body. The device 10 provides independent, bilateral support proximate the hips of a user, to assist the user in self-propelled, locomotive motion. The device 10 includes an assembled frame 11, four wheels 12, and unloading assemblies 13 and 14 carried on the frame 11. The unloading assemblies 13 and 14 are hidden in FIGS. 1 and 2 by panels 15 carried on the frame 11, but are much more visible in FIGS. 3A and 3B. The unloading assemblies 13 and 14 are coupled to a harness worn by a user, as depicted in FIG. 1, and operate to lift or unload some portion of the user’s bodyweight on the left and right sides of the user’s body.

[0036] The device 10 generally has a top 16, an opposed bottom 17, a front 18, and an opposed back 19. The word “generally” is used here to indicate a general area of the device 10, rather than a specific point, element, feature, or the like. Further, description herein may be made to relative directions or orientations with respect to these terms top, bottom, front, back, and the description may indicate the arrangement of multiple elements or features with respect to each other in the context of above, below, in front of, behind, or the like, relying on the reader’s understanding of the top 16, bottom 17, front 18, and back 19 for contextual reference.

[0037] The frame 11 includes identical left and right sides 20 and 21 rigidly coupled to each other with a top tube 22 and a bottom tube 23. Because the left and right sides 20 and 21 of the frame 11 are identical, only one is described here, with the understanding that the description applies equally to the other. The same reference characters are used for the structural elements and features of both the left and right sides 20 and 21, and the reader will understand that the

context or diction of the relevant description will convey whether the description is of the left or right side 20 or 21.

[0038] The right side 21 includes a main tube 24 extending generally diagonally from the bottom 17 and back 19 of the device 10 to the bottom tube 23 of the frame 11 proximate the front 18, approximately midway between the top 16 and bottom 17 of the device 10. The main tube 24 has a rectangular cross-section, is hollow, and has a thin, strong, durable, but lightweight sidewall constructed out of a material or combination of materials having those properties, such as steel, aluminum, titanium, or carbon fiber. Other suitable constructive materials and cross-sections are included within the scope of this description.

[0039] The main tube 24 is coupled to a vertical tube or housing 25 which rises from the main tube 24 near the back 19 of the device 10. Though the housing 25 is cylindrical, it is also hollow like the main tube 24. The housing 25 holds part of the unloading assembly, as described later.

[0040] A front tube 26 extends diagonally downward, opposite the main tube 24. The front tube 26 has an upper section which is nearly, but not quite, level, a long middle section which is diagonal, and a lower section which is nearly vertical. The top back of the front tube 26 is coupled to the top of the housing 25, and the middle of the front tube 26 is coupled to the front of the main tube 24. The front tube 26, like the main tube 24, preferably but not necessarily has a rectangular cross-section, is hollow, and has a thin, strong, durable, but lightweight sidewall constructed out of a material or combination of materials having those properties, such as steel, aluminum, titanium, or carbon fiber.

[0041] The bottoms of the main tube 24 and the front tube 26 are generally vertical. The bottom of the front tube 26 is open so as to receive a post 30. The wheels 12 are mounted on the post 30 for rolling movement and for swiveling movement so that the device 10 can be pointed and moved in a desired direction. A series of vertically spaced-apart holes 31 are formed in the post 30, and an adjustment knob 32 is threaded through the bottom of the front tube 26 and into one of the many holes 31. The knob 32 allows vertical adjustment of the post 30 to change the height of the device 10 at the front 18; the knob 32 may be loosened or released from front tube 26, the post 30 slid up or down, and the knob 32 then tightened or re-engaged with the front tube 26.

[0042] The bottom of the main tube 24 has a series of vertically spaced-apart holes 33 formed therethrough; these holes 33 receive an axle 34 of each of the wheels 12 at the back 19 of the device 10. The axle 34 can be moved into any of the holes 33 to adjust the height of the device 10 at the back 19. The axle 34 is secured with a pin 35, such as a cotter pin or other suitable engagement, placed through the axle 34 on the opposite side of the main tube 24 from the wheel 12. The wheels 12 in the back 19 preferably, but not necessarily, are mounted for rolling movement but not for swiveling movement.

[0043] The left and right sides 20 and 21 of the frame 11 are coupled by the top tube 22 and the bottom tube 23. The top tube 22 is a rigid tube bent into a U shape, with a straight front section and two side sections or legs oriented at roughly ninety degrees to the front section. These legs are screwed, bolted, welded, or otherwise securely engaged to the top sections of the front tubes 26 on both the left and right sides 20 and 21. Similarly, the bottom tube 23 is a rigid tube bent into a U shape, with a straight front section and two side sections or legs oriented at roughly ninety degrees

to the front section. These legs are screwed, bolted, welded, or otherwise securely engaged to top sections of the main tubes **24** on both the left and right sides **20** and **21**.

[0044] When the user uses the device **10**, the user stands, walks, or runs behind the top and bottom tubes **22** and **23** and between the left and right sides **20** and **21**, as shown in FIG. 1. As such, the top tube **22**, together with the left and right sides **20** and **21** and the bottom tube **23**, defines a user-receiving area **36** accessible from the back **19** of the device **10**.

[0045] A handlebar **40** extends forwardly at the top **16** of the device **10**. A cylindrical sleeve **41** is mounted along the top section of the front tube **26**; the sleeve **41** is hollow, its back is secured against the top of the housing **25**, and its front is open. A series of horizontally spaced-apart holes **42** are formed through the outside of the sleeve **41**; an adjustment knob **43** is threaded through the holes **42** and allows horizontal adjustment of the handlebar **40** to change the reach of the user when using the device **10**. The knob **43** may be loosened or released from sleeve **41**, the handlebar **40** slid into or out of it, and the knob **43** then tightened or re-engaged with the sleeve **41**.

[0046] The handlebar **40** is curved in several different directions. The back of the handlebar **40** is straight so that it may fit in the sleeve **41**. The handlebar **40** has a length, as shown in FIG. 1, so that it extends forwardly beyond the top section of the front tube **26**. The handlebar **40** then bends inwardly for a short section, and then bends upwardly for a short section. Other handlebar **40** configurations are suitable as well.

[0047] The handlebar **40** is hollow and has a thin, strong, durable, but lightweight sidewall constructed out of a material or combination of materials having those properties, such as steel, aluminum, titanium, or carbon fiber. When a user is disposed in the user-receiving area **36** and operating the device **10**, the user can easily reach out and hold the handlebar **40**, gripping any portion thereof as is comfortable to steady the device **10** and assist in movement and steering.

[0048] FIGS. 3A and 3B show the right side **21** of the frame **11**. In FIG. 3A, the panel **15** is removed so that the unloading assembly **14** is visible; FIG. 3B is a section view taken along the line 3-3 of FIG. 1, just barely inside the frame **11**, such that the panel **15** is not visible and the frame **11** is partially sectioned. The unloading assemblies **13** and **14** are carried on, and partially within, the frame **11**; the unloading assembly **13** is on the left side **20**, and the unloading assembly **14** is on the right side **21**. Again, as above with respect to the left and right sides **20** and **21**, because the unloading assemblies **13** and **14** shown here are identical, only the unloading assembly **14** on the right side **21** will be described here with the understanding that the description applies equally to the other. The same reference characters are applicable to the unloading assembly **14** on the left side **20**. However, it should be understood that the unloading assemblies **13** and **14** need not be identical, and this description should not be limited so. Indeed, in some embodiments, it may be desirable to actually have different unloading assemblies. For example, where a user suffers from an asymmetrical weakness, the device **10** may be outfitted with intentionally different unloading assemblies **13** and **14** having different bend, load, and other performance characteristics. For example, for a patient recovering from a stroke, it may be advantageous to provide more unloading force to a side of the patient's body which has

been more severely affected by the stroke, while providing less unloading force to the other side. Nevertheless, for the purposes of the description as it relates to the drawings, these particular unloading assemblies **13** and **14** are identical.

[0049] The unloading assembly **14** includes a flat spring **50**, a stacked cam assembly **51** on the flat spring **50**, a cable or tether **52** routed through the stacked cam assembly **51** and a series of pulleys mounted on the frame **11**.

[0050] The flat spring **50** is a sprung arm: a lightweight, compact, resilient and elongate flat spring member having a first, fixed end **53** and a second, a free end **54**. The fixed end **53** is secured in a sleeve mounted on a block **55** having an angled surface **56**. An adjustment knob **57** passes through a hole in the fixed end and into a threaded bore **58** in the block **55**. The adjustment knob **57** is thus threadably engaged to the block **55** and can be tightened and loosened to change the spring force of the flat spring **50**. For less spring force, the adjustment knob **57** is loosened and backed out of the bore **58**, which allows the fixed end **53** to rise slightly away from the angled surface **56** of the block **55**. For more spring force, the adjustment knob **57** is tightened into the bore **58**, which holds the fixed end **53** closer to the angled surface **56** of the block **55**. The adjustment knob **57** is a means for adjusting the spring force of the flat spring **50**; in other embodiments, the adjustment knob **57** may be an electric, electromechanical or electromagnetic adjustment, or an adjustable bolt, or some other means for changing the spring force.

[0051] Indeed, the flat spring **50** operates as a spring. It is mounted in a horizontal configuration. In this horizontal configuration, the free end **54** is above and behind the fixed end **53**, and it moves between a first, "unloaded" position as shown in FIG. 3A, in which the free end **54** is in a high position above the fixed end **53**, and second, loaded position as shown in FIG. 3B, in which the free end **54** is in a low position closer to the main tube **24**. This movement is indicated by the arcuate double-headed line A in FIG. 3B. It moves toward the loaded position in response to a weight being placed on the harness on the right side **21**, such as by the user walking, and pulling the flat spring **50** down via the tether **52**. In response, the flat spring **50** exerts a biasing force in a direction opposite the pull of gravity and vertical translation of the body downward during locomotion; the flat spring **50** acts to pull the tether **52** back. Other horizontal configurations are possible and may be suitable, including configurations which are vertically or horizontally flipped with respect to the above-described configuration. Generally, however, the horizontal configuration is defined as one in which the spring (the spring arm **50**, in this case) extends horizontally.

[0052] In this way, the flat spring **50** is just a spring which exerts a biasing force in opposition to displacement: extension or compression of a spring. And, in this sense, other springs may be suitable, such as coil springs, pneumatic springs, torsion springs, etc. The flat spring **50** has a non-linear force-displacement curve, such that the force required to displace the flat spring **50** increases as the displacement increases; at larger displacements, a larger force is necessary to displace the free end **54** by the same amount. The flat spring **50** produces a biasing force against its curve, toward the front **18** of the device **10**. As such, when the user is moving forward, this forward bias assists in moving the device **10** forward as well.

[0053] The stacked cam assembly 51 is mounted for rotation on the free end 54. The stacked cam assembly 51 includes outer and inner cams 60 and 61, placed side-by-side on the free end 54. Both cams 60 and 61 are mounted for rotation with respect to each other about the same axis of rotation, however, the cams 60 and 61 are fixed to each other to prevent relative rotation.

[0054] The outer cam 60 is larger, and the inner cam 61 is smaller. Both cams 60 and 61 are eccentrics with different profiles or shapes; their axes of rotation are offset from their respective geometric centers, such that as they rotate, their lever arms change and the ratio of their respective lever arms change. In this way, with the tether 52 wrapped around the outer cam 61 and the tether 62 wrapped around the inner cam 60, in grooves formed therein, the flat spring 50 and cam assembly 51 together form a constant-force displacement system. In other words, beyond a pre-determined pre-loaded displacement, additional displacement does not significantly change the force required for continued displacement. This is described in greater detail below. Further, in other embodiments of the device 10, different cam combinations are used, including assemblies with three or more cams, cams of different sizes than presented here, similarly-sized cams, etc. It is noted here that the word “cam” includes a rotating wheel and an eccentrically-mounted wheel or eccentric wheel. A cam is a mechanical element that converts rotational and translational movement. In the scope of this description, a cam is a wheel, pulley, or other rotating element which is preferably but not necessarily mounted eccentrically. Eccentric rotation is rotation of an element about an axis which is offset from the geometric center of the element. Thus, the shape or profile of the outer perimeter of the element may define it as a cam, or the location of the axis of rotation may define the element as a cam. All of these definitions are considered within the scope of this disclosure, without exclusion, for all embodiments described herein.

[0055] Another tether, an inelastic anchor cable 62, is tied between the inner cam 61 and a tie-down 63. This anchor cable 62 is part of the unloading assembly 14. The tie-down 63 is an anchor preventing the end of the anchor cable 62 attached thereto from moving; the other end of the anchor cable 62 is fixed to the inner cam 61. Mounted on top of the main tube 24 is a pulley assembly including three pulleys 64, 65, and 66. One end of the anchor cable 62 is fixed to the top of the front of the inner cam 61 and lays in a groove therein before extending down to the pulley 64. With rotation of the inner cam 61, the anchor cable 62 wraps around the circumference of the inner cam 61 and effectively shortens the anchor cable 62, bending the flat spring 50 toward the loaded position. The length of the anchor cable 62 can be adjusted at the tie-down 63 to increase or decrease the pre-load on the flat spring 50.

[0056] The tether 52 has an opposite orientation to the larger outer cam 60. It has two ends. One end of the tether 52 is fixed to front side of the cam 60; this end is wrapped over the top of the cam 60 but in a different direction from the anchor cable 62, such that it is fixed to the front side of the cam 60 and then extends over and around the circumference of the cam 60. From there, the tether 52 extends downward to the pulleys 65 and 66. The pulley 66 is partially mounted inside the housing 25. As the tether 52 routes under the pulley 65, it is redirected from a roughly vertical direction to a roughly horizontal one, and as the

tether 52 routes under the pulley 66, it is redirected from that roughly horizontal direction to a roughly vertical one inside the hollow housing 25.

[0057] The three pulleys 64, 65, and 66 have parallel axes; each spins in the same direction. All three pulleys 64, 65, and 66 are mounted proximate each other, along the main tube 24, and in the same plane, such that they only act to redirect the anchor cable 62 or tether 52 in a new direction along that plane. However, the tether 52 rises up from the pulley 66 inside the housing 25 to a different set of pulleys which orient the tether 52 for attachment to the harness.

[0058] FIGS. 4A-4C illustrate a pulley cassette 70 containing these other pulleys 71, 72, and 73 which redirect the tether 52. The pulley cassette 70 is part of the unloading assembly 13 (or 14) and is mounted for swinging movement in the housing 25 of the frame 11 and includes an outer housing 74 with an inner side 75 and an opposed outer side 76. The outer side 76 is directed away from the frame 11, inward into the user receiving area 36. The inner side 75 is partially carried within the housing 25. Proximate the top 16, the housing 25 has a large open window 80. The pulley cassette 70 swings forward and backward in this window 80. Two discs 81 and 82 are secured within the housing 25; the disc 81 is proximate the top 16, and the disc 82 is just slightly lower. Extending coaxially between the discs 81 and 82 is a pin 83. Fixed to the inner side 75 of the pulley cassette 70 is a leaf with a knuckle 84. The knuckle 84 has a vertical bore which is loosely mounted over the pin 83. Thus, the knuckle 84 pivots on the pin 83, and the pulley cassette 70 swings with the knuckle between a forward position (shown in broken line in FIG. 4C) and a rearward position (shown in solid line) along the double-arrowed arcuate line B in FIG. 4C. FIG. 4C shows a wide range of angular movement, but preferably the pulley cassette is limited in swinging more than thirty degrees in front of or behind a neutral position, which is shown in FIGS. 4A and 4B.

[0059] Within the housing 74 are three axles on which the pulleys 71, 72, and 73 are mounted for rolling movement. When the pulley cassette 70 is in the neutral position of FIGS. 4A and 4B, these pulleys 71, 72, and 73 are mounted in a perpendicular offset fashion to the pulleys 64, 65, and 66. The tether 52 extends up from the pulley 66, inside the housing 25, and routes over the first pulley 71, then under the second pulley 72, and then again over the third pulley 73. A hole 85 is formed through the outer side 76 of the housing 74, and a strong bracket mounted outside the hole 85 has a hole corresponding thereto. A stop 87 is secured on the tether 52 to prevent the tether 52 from being pulled into the pulley cassette 70 farther than desired.

[0060] In operation, a user uses the device 10 to assist in locomotive movement. The device 10 is useful for physical therapy, rehabilitation, and athletic training. Returning to FIG. 1, a user 90 is illustrated in the user-receiving area 36 using the device 10. The user is wearing a harness 91. Any suitable harness 91 may be used; this harness 91 includes an adjustable waist belt 92, adjustable thigh straps 93, adjustable above-the-knee straps 94, and outer or lateral straps 95 on each side of the harness 91 inelastically connecting the waist belt 92, thigh strap 93, and above-the-knee strap 94. In FIG. 1, the tethers 52 from both unloading assemblies 13 and 14 are shown directly attached to the waist belt 92. Attachment of the tethers 52 to a point at the level of the region between the hip joint and the waist is preferred. In other

embodiments, the tethers **52** may terminate with clips such as carabiners for coupling to loops on the waist belt **92**. The tethers **52** are attached to opposing sides of the waist belt **92**, just above the hip joints. In this way, each tether **52** independently acts on one respective side of the body.

[0061] The harness **91** couples the user **90** to the device **10**. When the user **90** walks, his hips move up and down. In normal locomotion, when the left leg is moved forward, his left hip rises slightly and his right hip drops slightly, and his pelvis rotates to a small degree. When it does, on the left side **20**, the cassette pulley **70** swings forward slightly, the tether **52** retracts (until limited by the stop **87** encountering the bracket **86**), and the flat spring **50** bends to a lesser degree toward its unloaded position. The force exerted by the flat spring **50** is in the forward direction, which assists in moving the device **10** forward slightly. At the same time, on the right side **21**, the cassette pulley **70** swings backward slightly, and the tether **52** extends to accommodate the dropping of the right hip and rotation of the pelvis. This pulls the tether **52** through the pulley cassette **70** and through the pulleys **64**, **65**, and **66**, thereby causing the cam assembly **51** to rotate and the flat spring **50** to bend to a greater degree. The left and right side **20** and **21** flat springs **50** independently exert a bias on the tethers **52** on their respective sides; in response, the user **90** feels his weight on both the right and left sides of this body at least partially unloaded. Further, because the unloading assemblies **13** and **14** each independently are a constant-force displacement system, rather than a simple spring force or exponential force displacement system, the user **90** experiences a constant or consistent unloading despite the extent of the displacement on either side. In other words, whether the user **90** raises his right hip or drops his right hip a little or a lot, the unloading force he experiences is constant. In yet other words, if the user drops his right hip a significant distance, he does not experience a proportionally greater unloading. For example, the device **10** can be set up to provide a constant fifty pounds of unloading force. If the user drops his hip a little, he will feel that fifty pounds of unloading; if the user drops his hip a lot, he will still feel that same fifty pounds of unloading.

[0062] Moreover, the sides of his body move independently—and are allowed to move independently—because the unloading assemblies **13** and **14** are independent of each other. In more detailed operation, when the hip of the user **90** moves a distance, the tether **52** moves this distance as well, and unwinds from the cam **60**. The anchor cable **62** spools onto the cam **61**, shortening its effective length and causing the flat spring **50** to flex. The cam assembly **51** unreels and the flat spring **50** bends to a greater degree. Because the flat spring **50** and cam assembly **51** combine to form a constant-force displacement, however, the patient feels a constant upward unloading force on that side of the harness **91**. The displacement of the tether **52**—whether it is one inch or six inches—does not cause a proportional change in the upward force. Rather, the displacement causes essentially no change in unloading force. In this way, the device **10** provides a constant unloading of each side of the user's body, independently of each other.

[0063] In other embodiments, a sensor **100** proximate one of the wheels **12** measures rolled distance. A sensor **101** in the stop **87**, or in the pulley cassette **70**, or somewhere along the tether **52**, measures acceleration and thus force, and possibly also angle of incline. The sensors **100** and **101** each may include a microprocessor, gyroscope, accelerometer,

memory chip, PCB, and like electronic components. The readings from these two sensors **100** and **101** are correlated for later analytics; doctors and physical therapists can use this information to determine stride length, stance and swing phase duration, speed, work energy, and other kinematic and kinetic parameters of locomotion, and this information can be compared for each side of the body as well as over time to evaluate rehabilitation. Moreover, in some embodiments, these sensors **100** and **101** are coupled in wired or wireless data communication to a display head unit, such as a smartphone or other electronic device, preferably mounted on the top tube **22**, which displays such information to the user **90**. The user **90** can toggle through this and other information by depressing a physical button or touching the display of the head unit.

[0064] In some instances, the wheels of the device **10** may be removed. This removes the mobility of the device **10**, but it can instead now be placed on or around a treadmill. The bottom **17** of the frame may be bolted onto or otherwise secured to the treadmill using the holes **31** and **33**. Alternatively, pads or cushions applied to the bottom **17** of the frame **11** can support the device **10** around the treadmill. The user can then walk or run on the treadmill with his weight supported as described above.

[0065] FIG. 5 shows an alternate embodiment of the unloading assembly **13** of the device **10**. The below description applies equally to an alternate embodiment of the unloading assembly **14**. In this embodiment, two flat springs are used in combination. FIG. 5 is stylized in the form of a free body diagram, but a reader understanding the description hereto will nonetheless readily appreciate and understand FIG. 5.

[0066] The flat spring **50** is mounted as in FIG. 3A: the fixed end **53** is fixed to the main tube **24** and the free end **54** is free. The cam assembly **51** is mounted for rotation to the free end **54**, and the anchor cable **62** is fixed while the tether **52** routes around the pulley **65** to extend to the harness. However, in this embodiment, a second flat spring **110** is used. The flat spring **110** is also a sprung arm preferably, but not necessarily, identical in structure, features, and construction to the flat spring **50**; it also includes a fixed end **111** and a free end **112**. The flat spring **110** is mounted in a parallel fashion to the flat spring **50**. As the term is used here, “parallel” is analogous to two elements in an electrical circuit and does not necessarily refer to a geometric relationship or alignment between the two flat springs **50** and **110**. Specifically, the flat spring **50** and cam assembly **51** are in a first position, and the second flat spring **110** is carried in a second position; the first and second positions are different but are registered with each other in a vertically offset fashion. The flat springs **50** and **110** in this embodiment are coextensive, but they need not be.

[0067] The second flat spring **110** is stacked above the flat spring **50**. A rigid, inelastic cable **113** ties or couples the free end **112** of the flat spring **110** to the free end **54** of the flat spring **50**, such that movement of the free end **54** immediately and directly imparts movement to the free end **112**. This coupled arrangement increases the spring force of the flat spring **50**. The tether **52** remains wrapped around the cam assembly **51** on the flat spring **50**. Stacking flat springs on the frame **11** in this way allows the device **10** to unload more weight from the user during operation. In other

embodiments, three or more flat springs could be stacked, though this would not likely be necessary for all but the most demanding of weight needs.

[0068] FIG. 6 shows another alternate embodiment of the device 10. While the unloading assembly 14 in FIGS. 3A and 3B is mounted in a horizontal configuration in which the flat spring 50 extends rearwardly in a general direction and its free end 54 is behind its fixed end 53, here in FIG. 6, the unloading assembly 14 is mounted in a vertical configuration. This unloading assembly 14 is mounted on the vertical housing 25 rather than the horizontal top of the main tube 24. The flat spring 50 is still mounted to the block 55, but the block 55 is fixed vertically on the housing 25, such that the flat spring 50 extends upward, rather than rearward. The free end 54 of the flat spring 50 is above the fixed end 53, and when the flat spring 50 flexes, the free end 54 is displaced rearwardly toward the housing 25. The flat spring 50 produces a biasing force against its curve, toward the front 18 of the device 10. As such, when the user is moving forward, this forward bias assists in moving the device 10 forward as well. FIG. 6 shows in solid line the unloading assembly 14 in an unloaded position, and the unloading assembly 14 moves along the double-arrowed arcuate line C toward the housing to a loaded position, similar in displacement to the loaded position shown for the horizontal configuration of FIG. 3B. Other vertical configurations are possible and may be suitable, including configurations which are vertically or horizontally flipped with respect to the above-described configuration. Generally, however, the vertical configuration is defined as one in which the spring (the spring arm 50, in this case) extends vertically. The pulleys 64, 65, and 66 are also moved to a vertical arrangement, but the anchor cable 62 still routes through the pulley 64 and is secured to the tie-down 63, which is on the housing 25. The tether 52 also still routes through the pulleys 65 and 66 but now also extends through an additional pulley 120 which redirects the tether 52 upwardly through the housing to the pulley cassette 70.

[0069] FIG. 7 shows yet another alternate embodiment of the unloading assembly 13 of the device 10, somewhat similar to that shown in FIG. 5. The below description applies equally to an alternate embodiment of the unloading assembly 14. In this embodiment, two flat springs are used in combination. FIG. 7 is stylized in the form of a free body diagram, but a reader understanding the description hereto will readily appreciate and understand FIG. 7.

[0070] The flat spring 50 is mounted as in FIG. 3A: the fixed end 53 is fixed to the main tube 24 and the free end 54 is free. The cam assembly 51 is mounted for rotation to the free end 54, and the anchor cable 62 is fixed while the tether 52 routes around the pulley 65 to extend to the harness. However, in this embodiment, a second flat spring 130 is used. The flat spring 130 is also a sprung arm and is preferably, but not necessarily, identical in structure, features, and construction to the flat spring 50; it also includes a fixed end 131 and a free end 132. The flat spring 130 is mounted in a parallel fashion to the flat spring 50, however, it is mounted below the main tube 24, or opposite the flat spring 50. As the term is used here, “parallel” is analogous to two elements in an electrical circuit and does not refer to a geometric relationship or alignment between the two flat springs 50 and 130. Specifically, the flat spring 50 and cam assembly 51 are in a first position, and the second flat spring 130 is carried in a second position; the first and second

positions are different but are registered with each other in a vertically offset fashion. The flat springs 50 and 130 in this embodiment are coextensive, but they need not be.

[0071] The second flat spring 130 is stacked below the flat spring 50 and has an inverted position: while the flat spring 50 flexes downwardly under a load, the second flat spring 130 flexes upwardly. An inelastic cable 133 couples the free end 132 of the flat spring 130 to the inner cam 61 at the free end 54 of the flat spring 50, such that rotation of the inner cam 61 directly imparts upward movement of the free end 132 of the flat spring 130 as well as downward movement of the free end 54 of the flat spring 50. The cable 133 passes through a bore 134 in the main tube 24. This coupled arrangement increases the spring force of the unloading assembly beyond that of the unloading assembly 13 or 14. The tether 52 remains wrapped around the outer cam 60 of the cam assembly 51 on the flat spring 50. Coupling flat springs on the frame 11 in this way allows the device 10 to unload more weight from the user during operation. In other embodiments, three or more flat springs could be stacked on either side of the main tube 24 and coupled together, though this would not likely be necessary in all but the most demanding of weight needs.

[0072] In some embodiments, the cam assembly 51 need not be mounted directly onto the flat spring 50, or, in other words, the cam assembly 51 can be separate from the spring. For example, the flat spring 50 of FIG. 7 could be modified to be a rigid, inflexible, unyielding arm 50. In this embodiment, the cam assembly 51 is simply mounted to an arm 50, similar to a rigid post, above the main tube 24. The arm 50 is thus simply considered part of the frame 11, or a rigid extension thereof. The cam assembly 51 is thus coupled to the second or free end 132 of the bendable flat spring 130 with the inelastic cable 133, and to the harness with the tether 52. The flat spring 130 is the only arm that moves in this arrangement; when the harness drops, the tether 52 pulls on and rotates the cam assembly 51, and the cable between the cam assembly 51 and the flat spring 130 pulls on and bends the flat spring 130. This embodiment is exemplary of unloading assemblies in which the cam assembly and the flat spring are separate, illustrating that the cam assembly need not be carried on or mounted to the flat spring. Indeed, the unloading assembly still operates effectively as a constant-force displacement system when the cable 133 (or anchor cable 62) couples the cam assembly in one direction to a spring (such as the flat spring 130) and the tether 52 couples the cam assembly in an opposing direction to the harness, regardless of the mounting of the cam assembly on or off the spring. This alternate version of FIG. 7 describes such an arrangement in an exemplary fashion. In other embodiments, the spring arm and cam assembly may be separated and not mounted to each other, and the arrangement of the cam assembly and spring arm are actually reversed: the cam assembly 51 is mounted on the main tube 24, the spring arm 50 is mounted on the main tube 24 apart from the cam assembly 51 extends away, an anchor cable 62 coupled to a tie-down 63 extends to the cam assembly 51, and then a tether 52 extends from the cam assembly 51 to over the free end 54 of the flat spring 50 and then toward the harness (likely through a pulley assembly).

[0073] FIGS. 8-10B illustrate other alternate embodiments of unloading assemblies suitable for use with the device 10. The below descriptions apply equally to an unloading assembly used on the left or right sides 20 of the frame 21

or in an alternate location to support the user within the device 10. FIG. 8 illustrates a stylized, free-body diagram of an unloading assembly 140 but nevertheless shows the structural elements and features of the assembly 140. The unloading assembly 140 is positioned within the frame 11 proximate the main tube 24 and the vertical tube or housing 25.

[0074] The unloading assembly 140 includes a flat spring 141, a cam assembly 142, a first tether 143 extending from the flat spring 141 to the cam assembly 142, and a second tether 144 extending from the cam assembly 142 and running up (or in some cases, inside) the housing 25 to the pulley cassette 70 described above. As described, the unloading assembly 140 exerts an unloading force on the harness 91 and a load carried therein with respect to the frame 11, in response to the load being applied at the harness 91.

[0075] The flat spring 141 is a sprung arm: a lightweight, compact, resilient and elongate flat spring member having a first, fixed end 150 and a second, free end 151. The fixed end 150 is secured in a sleeve mounted on a block 152. An adjustment knob 153 passes through a hole in the fixed end 150 and into a threaded bore in the block 152. The adjustment knob 153 is thus threadably engaged to the block 152 and can be tightened and loosened to change the spring force of the flat spring 141. For less spring force, the adjustment knob 153 is loosened and backed out of the bore, which allows the fixed end 150 to rise slightly away from the block 152. For more spring force, the adjustment knob 153 is tightened into the bore, which holds the fixed end 150 closer to the block 152. The adjustment knob 153 is a means for adjusting the spring force of the flat spring 141; in other embodiments, the adjustment knob 153 may be an electric, electromechanical or electromagnetic adjustment, or an adjustable bolt, or some other means for changing the spring force.

[0076] The flat spring 141 operates as a spring. It is mounted in a horizontal configuration. In this horizontal configuration, the free end 151 is level with the fixed end 150 and moves between a first, “unloaded” position as shown in solid line in FIG. 8, and a second, “loaded” position as shown in broken line in FIG. 8, in which the free end 151 is in a high position away from the main tube 24 and above the fixed end 150. This movement is indicated by the arcuate double-arrowed line 154.

[0077] The flat spring 141 moves toward the loaded position in response to a load being placed in the harness 91, such as by the user 90 walking, and pulling the flat spring 141 up via the second tether 144. Throughout this description, “load” is used to describe any weight or other downward force exerted on the harness 91, and it should be understood as such. A load is preferably a live load, such as a user 90 in the harness, or it may be some other weight or downward force acting on the unloading assembly 140. In response to application of the load, the flat spring 141 exerts a biasing force in a direction opposite the pull of gravity and vertical translation of the user 90 downward during locomotion or elongation of the second tether 144 with lateral translation of the pelvis; the flat spring 141 acts to pull the second tether 144 back. Other horizontal configurations are possible and may be suitable, including configurations which are vertically or horizontally flipped with respect to the above-described configuration. Generally, however, the

horizontal configuration is defined as one in which the spring (the spring arm 141, in this case) extends horizontally.

[0078] In this way, the flat spring 141 is just a spring which exerts a biasing force in opposition to displacement, whether that is through deflection, extension, or compression of a spring. And, in this sense, other springs may be suitable, such as coil springs, pneumatic springs, torsion springs, etc. The flat spring 141 has a non-constant force-displacement curve, such that the force produced by the flat spring 141 increases as the displacement of the free end 151 increases; at larger displacements, the spring force is larger. The flat spring 141 is directed horizontally toward the housing 25, and the free end 151 terminates below the cam assembly, such that deflection of the flat spring 141 causes the spring 141 to yield and deflect upward toward the cam assembly 142.

[0079] The cam assembly 142 is mounted for rotation on an axle 160 carried on a bracket 161. The bracket 161 is secured to the housing 25 and extends forwardly. The cam assembly 142 includes outer and inner cams 162 and 163. The stacked cam assembly 142 includes outer and inner cams 162 and 163, mounted coaxially side-by-side on the bracket 161. Both cams 162 and 163 are mounted for rotation with respect to each other about the same axis of rotation, but the cams 162 and 163 are fixed to each other to prevent relative rotation to each other.

[0080] The outer cam 162 is larger, and the inner cam 163 is smaller. Both cams 162 and 163 are circular wheels in this drawing. They are concentric to each other but the axle 160 about which they are mounted is not concentric, and therefore the cams 162 and 163 are mounted for eccentric rotation. In other words, their axes of rotation are offset from their respective geometric centers, such that as they rotate, their lever arms change and the ratio of their respective lever arms change. In other embodiments, the axle 160 is mounted concentrically to the cams 162 and 163, and in other embodiments, the cams 162 and 163 have shapes other than circles.

[0081] The first tether 143 is an inelastic cable, band, cord, or other tether. One end of the first tether 143 is coupled to the free end 151 of the flat spring 141, and the other end of the first tether 143 is coupled to the inner cam 163. The inner cam 163 has at least a single groove formed into its perimeter, and as the inner cam 163 rotates, the first tether 143 rolls and unrolls from this groove.

[0082] Similarly, the second tether 144 is an inelastic cable, band, cord, or other tether. One end of the second tether 144 is coupled to the outer cam 162. From there, the second tether 144 extends over to and then up the housing 25 and to the pulley cassette 70 and then eventually to the harness 91. Though the pulley cassette 90 and harness 91 are not shown in FIG. 8, the reader will understand their location and arrangement from the description above. The outer cam 162 has at least a single groove formed into its perimeter, and as the outer cam 162 rotates, the second tether 144 rolls and unrolls from this groove.

[0083] The first and second tethers 143 and 144 are arranged oppositely to each other on the cam assembly 142. The first tether 143 is secured at an attachment point 164 on the inner cam 163 and extends downward to the flat spring 141. The second tether 144 is secured at an attachment point 165 on the outer cam 162 and extends upward to the pulley cassette. The attachment points 164 and 165 are diametrically opposed to each other. In other embodiments, the

attachment points **164** and **165** may be in different locations, but the tethers extend outward in opposite directions. Because of this opposite arrangement, when the load is applied to the harness, the second tether unrolls from the outer cam **162**, rotating the second **162** in a clockwise direction (as shown on the page), and the first tether rolls onto the inner cam **163**.

[0084] The second tether **144** extends generally upward in FIG. **8** because it is redirected by a pulley **166**. A small pulley **166**, mounted to the bracket **161** for rotation near the top of the bracket **161**, redirects the second tether **144** from its horizontal tangent coming off the outer cam **162** into an upward orientation just along the outside of the housing **25** up to the pulley cassette **70**. In some embodiments, the pulley **166** directs the second tether **144** inside the housing **25**.

[0085] With the first tether **143** wrapped around the inner cam **163** and the second tether **144** wrapped around the outer cam **162**, in the grooves formed therein, the flat spring **141** and cam assembly **142** together form a constant-force displacement system. In other words, beyond a pre-determined displacement, additional displacement does not significantly change the tension in or force on the second tether **144** required for continued displacement. Further, in other embodiments of the device **10**, different cam combinations are used, including assemblies with three or more cams, cams of different sizes and shapes than presented here, similarly-sized cams, etc.

[0086] FIG. **9** illustrates a stylized, free-body diagram of an unloading assembly **170** but nevertheless shows the structural elements and features of the assembly **170**. The unloading assembly **170** is positioned within the frame **11** between the front tube **26**, the main tube **24**, and the vertical tube or housing **25**.

[0087] The unloading assembly **170** includes a flat spring **171**, a cam assembly **172**, a first tether **173** extending from the flat spring **171** to the cam assembly **172**, and a second tether **174** extending from the cam assembly **172** and running inside the housing **25** to the pulley cassette **70** described above. As described, the unloading assembly **170** exerts an unloading force on the harness **91** and a load carried in the harness with respect to the frame **11**.

[0088] The flat spring **171** is a sprung arm: a lightweight, compact, resilient and elongate flat spring member having a first, fixed end **180** and a second, free end **181**. The fixed end **180** is secured in a sleeve mounted on a block **182**. Unlike the unloading assembly **140**, no adjustment knob is used on the flat spring **171**, but the reader will readily appreciate that it could be incorporated, and it should nonetheless be considered part of the scope of the disclosure. Further, in other embodiments, the spring force of the flat spring **171** may be adjusted by an electric, electromechanical or electromagnetic adjustment, or an adjustable bolt, or some other means for changing the spring force.

[0089] The flat spring **171** operates as a spring. It is mounted in a diagonal configuration. The block **182** in which the fixed end **180** is secured is fixed to the front tube **26** near its top. The flat spring **171** then extends along the diagonal length of the front tube **26** toward the main tube **24**. The free end **181** is below and in front of the fixed end **180** and moves between a first, “unloaded” position as shown in solid line in FIG. **9**, and a second, “loaded” position as shown in broken line in FIG. **9**, in which the free end **181** is

drawn back away from the front tube **26** and toward the housing **25**. This movement is indicated by the arcuate double-arrowed line **183**.

[0090] As with the other unloading assemblies, the flat spring **171** moves toward the loaded position in response to a load being placed in the harness **91**, such as by the user **90** walking, and pulling the flat spring **171** down via the second tether **174**. In response, the flat spring **171** exerts a biasing force in a direction opposite the pull of gravity and vertical translation of the user **90** downward during locomotion or elongation of the second tether **174** with lateral translation of the pelvis; the flat spring **171** acts to pull the second tether **174** back. Other configurations are possible and may be suitable, including configurations which are vertically or horizontally flipped with respect to the above-described configuration. Generally, however, the diagonal configuration is defined as one in which the spring (the spring arm **171**, in this case) extends diagonally, especially but not necessarily along the front tube **26**.

[0091] The flat spring **171** is a spring which exerts a biasing force in opposition to displacement, whether that is through deflection, extension, or compression. In this sense, other springs may be suitable, such as coil springs, pneumatic springs, torsion springs, etc. The flat spring **171** has a non-constant force-displacement curve, such that the force produced by the flat spring **171** increases as the displacement of the free end **181** increases; at larger displacements, the spring force is larger.

[0092] The cam assembly **172** is mounted for rotation on an axle **190** carried on a bracket **191**. The bracket **191** is secured to the housing **25** and extends forwardly. The cam assembly **172** includes outer and inner cams **192** and **193**. The stacked cam assembly **172** includes outer and inner cams **192** and **193**, mounted coaxially side-by-side on the bracket **191**. Both cams **192** and **193** are mounted for rotation with respect to each other about the same axis of rotation, however, the cams **192** and **193** are fixed to each other to prevent relative rotation.

[0093] The outer cam **192** is larger, and the inner cam **193** is smaller. Both cams **192** and **193** are circular wheels in this embodiment. They are concentric to each other but the axle **190** about which they are mounted is not concentric, and therefore the cams **192** and **193** are eccentrically mounted for rotation. In other words, their axes of rotation are offset from their respective geometric centers, such that as they rotate, their lever arms change and the ratio of their respective lever arms change. In other embodiments, the axle **190** is mounted concentrically to the cams **192** and **193**, and in other embodiments, the cams **192** and **193** have shapes other than circles.

[0094] The first tether **173** is an inelastic cable, band, cord, or other tether. One end of the first tether **173** is coupled to the free end **181** of the flat spring **171**, and the other end of the first tether **173** is coupled to the inner cam **193**. The inner cam **193** has at least a single groove formed into its perimeter, and as the inner cam **193** rotates, the first tether **173** rolls and unrolls from this groove.

[0095] Similarly, the second tether **174** is an inelastic cable, band, cord, or other tether. One end of the second tether **174** is coupled to the outer cam **192**. From there, the second tether **174** extends up through the housing **25** and to the pulley cassette **70** and then eventually to the harness **91**. Though the pulley cassette **90** and harness **91** are not shown in FIG. **9**, the reader will understand their location and

arrangement from the description above. The outer cam 192 has at least a single groove formed into its perimeter, and as the outer cam 192 rotates, the second tether 174 rolls and unrolls from this groove.

[0096] The first and second tethers 173 and 174 are arranged oppositely to each other on the cam assembly 172. The first tether 173 is secured at an attachment point 194 on the inner cam 193 and extends downward to the flat spring 171. The second tether 174 is secured at an attachment point 195 on the outer cam 194 and then extends generally upward to the pulley cassette. The attachment points 194 and 195 are diametrically opposed to each other on the cam assembly 172. In other embodiments, the attachment points 194 and 195 may be in different locations, but the tethers extend outward in opposite directions.

[0097] Two pulleys 196 and 197 redirect the orientations of the first and second tethers 173 and 174. A first pulley 196 is mounted to the main tube 24 for rotation and redirects the first tether 173. The first tether 173 extends diagonally downward from the free end 181, wraps under and around the first pulley 196, and then extends diagonally upward to the attachment point 194 on the inner cam 193. A second pulley 197 is mounted to the bracket 191 for rotation near the top of the bracket 191. A small cutout is made in the housing 25 to allow the pulley 197 to be partially disposed within housing 25. The pulley 197 redirects the second tether 174 from its horizontal tangent coming off the outer cam 192 into an upward orientation just inside the housing 25 up to the pulley cassette 70. In some embodiments, the pulley 197 directs the second tether 174 along the outside of the housing 25.

[0098] With the first tether 173 wrapped around the inner cam 193 and the second tether 174 wrapped around the outer cam 192, in the grooves formed therein, the flat spring 171 and cam assembly 172 together form a constant-force displacement system. In other words, beyond a pre-determined displacement, additional displacement does not significantly change the tension in or force on the second tether 174 required for continued displacement. Further, in other embodiments of the device 10, different cam combinations are used, including assemblies with three or more cams, cams of different sizes and shapes than presented here, similarly-sized cams, etc.

[0099] FIGS. 10A and 10B illustrate unloaded and loaded positions of another embodiment of an unloading assembly 210. The drawings are stylized, free-body diagrams but nevertheless show the structural elements and features of the assembly 210. The unloading assembly 210 is positioned within the frame 11 between the front tube 26 (here shown as vertical), the main tube 24, and the vertical tube or housing 25.

[0100] The unloading assembly 210 includes a spring 211, a cam assembly 212, a first tether 213 extending from the spring 211 to the cam assembly 212, and a second tether 214 extending from the cam assembly 212 and running inside the housing 25 to the pulley cassette 70 described above. The unloading assembly 210 exerts an unloading force on the harness 91, and a load carried therein, with respect to the frame 11.

[0101] The spring 211 is a coiled extension spring. The spring 211 has a first, fixed end 220 and a second, free end 221. The fixed end 220 is coupled to a bolt 222, such as an eye bolt, which is threaded into or otherwise secured in the front tube 26. The spring 211 is mounted in a horizontal

configuration, oriented along the horizontal length of the main tube 24. The free end 221 of the spring 211 is disposed toward the housing 24. FIG. 10A shows a first, “unloaded” position, and FIG. 10B shows a second, “loaded” position. In the unloaded position, the spring 211 is compressed and has a shorter length. In the loaded position, the spring 211 is extended and has a longer length. The spring 211 stretches along the length of the main tube 24 when placed under load.

[0102] As with the other unloading assemblies, the spring 211 moves toward the loaded position in response to a load being placed in the harness 91, such as by the user 90 walking, and pulling the spring 211 into extension via the second tether 214. In response, the spring 211 exerts a biasing force in a direction opposite the pull of gravity and vertical translation of the user 90 downward during locomotion or elongation of the second tether 214 with lateral translation of the pelvis; the spring 211 acts to pull the second tether 214 back. Other configurations are possible and may be suitable with the spring 211, including configurations which are vertically or horizontally flipped with respect to the above-described configuration. Generally, however, the horizontal configuration is defined as one in which the spring 211 extends horizontally, especially but not necessarily along the main tube 24.

[0103] The cam assembly 212 is mounted for rotation on an axle 230 carried on a bracket 231. The bracket 231 is secured to the housing 25 and extends forwardly. The cam assembly 212 includes outer and inner cams 232 and 233. The stacked cam assembly 212 includes outer and inner cams 232 and 233, mounted coaxially side-by-side on the bracket 231. Both cams 232 and 233 are mounted for rotation with respect to each other about the same axis of rotation, however, the cams 232 and 233 are fixed to each other to prevent relative rotation.

[0104] The outer cam 232 is larger, and the inner cam 233 is smaller. Both cams 232 and 233 are circular wheels in this embodiment. They are concentric to each other but the axle 230 about which they are mounted is not concentric, and therefore the cams 232 and 233 are eccentrically mounted. In other words, their axes of rotation are offset from their respective geometric centers, such that as they rotate, their lever arms change and the ratio of their respective lever arms change. In other embodiments, the axle 230 is mounted concentrically to the cams 232 and 233, and in other embodiments, the cams 232 and 233 have shapes other than circles.

[0105] The first tether 213 is an inelastic cable, band, cord, or other tether. One end of the first tether 213 is coupled to the free end 221 of the spring 211, and the other end of the first tether 213 is coupled to the inner cam 233. The inner cam 233 has at least a single groove formed into its perimeter, and as the inner cam 233 rotates, the first tether 213 rolls and unrolls from this groove.

[0106] Similarly, the second tether 214 is an inelastic cable, band, cord, or other tether. One end of the second tether 214 is coupled to the outer cam 232. From there, the second tether 214 extends up through the housing 25 and to the pulley cassette 70 and then eventually to the harness 91. Though the pulley cassette 90 and harness 91 are not shown in FIGS. 10A and 10B, the reader will understand their location and arrangement from the description above. The outer cam 232 has at least a single groove formed into its perimeter, and as the outer cam 232 rotates, the second tether 214 rolls and unrolls from this groove.

[0107] The first and second tethers **213** and **214** are arranged oppositely to each other on the cam assembly **212**. The first tether **213** is secured at an attachment point **234** on the inner cam **233** and extends generally downward to the spring **211**. The second tether **214** is secured at an attachment point **235** on the outer cam **234** and then extends generally upward to the pulley cassette. The attachment points **234** and **235** are diametrically opposed to each other on the cam assembly **212**. In other embodiments, the attachment points **234** and **235** may be in different locations, but the tethers extend outward in opposite directions.

[0108] Two pulleys **236** and **237** redirect the orientations of the first and second tethers **213** and **214**. A first pulley **236** is mounted to the main tube **24** for rotation and redirects the first tether **213**. The first tether **213** extends horizontally from the free end **221** of the spring **211**, wraps around the first pulley **236**, and then extends vertically upward to the attachment point **234** on the inner cam **233**. A second pulley **237** is mounted to the bracket **231** for rotation near the top of the bracket **231** and slightly within the housing **25**. It redirects the second tether **214** from its horizontal tangent coming off the outer cam **232** into an upward orientation just inside the housing **25** up to the pulley cassette **70**. In some embodiments, the pulley **237** directs the second tether **214** along the outside of the housing **25**.

[0109] With the first tether **213** wrapped around the inner cam **233** and the second tether **214** wrapped around the outer cam **232**, in the grooves formed therein, the spring **211** and cam assembly **212** together form a constant-force displacement system. In other words, beyond a pre-determined displacement, additional displacement does not significantly change the tension in or force on the second tether **214** required for continued displacement. Further, in other embodiments of the device **10**, different cam combinations are used, including assemblies with three or more cams, cams of different sizes and shapes than presented here, similarly-sized cams, etc.

[0110] FIGS. 11A-11C illustrate a harness **240** and components thereof. The harness **240** is preferably used instead of the harness **91** described above. This harness **240** includes an adjustable waist belt **241**, adjustable thigh straps **242**, a cross-piece **243** connecting the thigh straps **242**, and outer or lateral straps **244** on each side of the harness **240** inelastically connecting the waist belt **241** to each of the thigh straps **242**.

[0111] The waist belt **241** is a length of webbing or other suitable strong and durable material, fastened into a loop with a buckle **245** at the front of the harness **240**. Similarly, the thigh straps **242** are each lengths of webbing or other suitable strong and durable material, fastened into loops with buckles **246**. The length of webbing may be pulled through the buckles **245** and **246** to adjust each of the waist belt **241** and thigh straps **242** so that they fit the user snugly.

[0112] The lateral straps **244** couple the thigh straps **242** to the waist belt **241**. The lateral straps **244** are identical and only one is described herein, with the understanding that the description applies equally to both. The lateral strap **244**, shown in both FIGS. 11A and 11B, includes an inner strap **250** and an outer strap **251**. The inner strap **250** is a length of webbing or other suitably strong and durable material and is sewn directly to the waist belt **241** and the thigh strap **242**. The outer strap **251** is also a length of webbing or other suitably strong and durable material. The outer strap **251** is sewn to the inner strap **250** along approximately the top half

of the inner strap **250**. The outer strap **251** then separates from the inner strap **250**. A ring strap **252** is disposed between the inner and outer straps **250** and **251** along the bottom half thereof.

[0113] The ring strap **252** holds the ring **253** shown in FIG. 11C. The ring strap **252** is a length of webbing or other suitably strong and durable material, folded over itself to define an inner portion **254**, an outer portion **255**, and a bend **256** at the top between the inner and outer portions **254** and **255**. During manufacture of the harness **240**, the ring **253** is fit between the inner and outer portions **254** and **255** and disposed in and against the bend **256**. Then, the inner and outer portions **254** and **255** are sewn to each other to close the ring strap **252** and secure the ring **253** therein. The outer strap **251** is further sewn onto the outer portion **255** of the ring strap **252**, and in some cases also sewn to the inner portion **254** and/or the inner strap **250** to secure the lateral strap **244**.

[0114] The ring **253** is secured in the lateral strap **244** to hold one of the tethers. In FIG. 11C, the tether identified with reference character **144** is used, corresponding to the unloading assembly **140** of FIG. 8, but the reader should understand that the second tether **144** could be one of the other various tethers (or first or second tethers) described in this specification which leads from an unloading assembly. The second tether **144** terminates in a disc-shaped puck **260** shown in broken line in FIG. 11C. The puck **260** is hard, durable, and permanently fixed to the end of the second tether **144**. It slips into and is secured in the ring **253** to couple and engage the harness **240** to the unloading assembly **140**.

[0115] The ring **253** includes a backer plate **261**, a front plate **262**, and a sidewall **263** formed therebetween. The backer plate **261** is flat and triangular, having a bottom **264** through which a longitudinal slot **265** is formed entirely. The slot **265** is shown in broken line in FIG. 11C. The front plate **262** is flat and generally triangular. The front plate **262** has a bottom **270** through which a longitudinal slot **271** is formed entirely. The slots **265** and **271** are coextensive and registered with each other. The bend **256** of the ring strap **252** is passed through both of the slots **265** and **271** to secure the ring **253** to the lateral strap **244**.

[0116] The front plate **262** also has an open top **272**. A slit **273** is formed medially through the front plate **262**, between the open top **272** and a circular hole **274**. The top **272**, slit **273**, and hole **274** cooperate to define a passage for the end of the second tether **144**. The second tether **144** and puck **260** are applied through that passage and then moved upward, thereby becoming captured within the ring **253**. The sidewall **263** prevents the puck **260** from coming loose from the ring **253**. The sidewall **263** extends between the back and front plates **261** and **262** and includes an opening **280** registered with and below the open top **272** of the front plate **262**. From the opening **280**, the sidewall **263** is registered along the outside of the ring **253** to just above the slots **265** and **271**. The sidewall has a large internal cavity **281**, shown in broken line in FIG. 11C. The internal cavity **281** is preferably but not necessarily circular. The internal cavity **281** is offset from the circular hole **274**, proximate the top of the ring **253**. In this way, when the puck **260** is applied through the circular hole **274**, it moves into the internal cavity **281**. When a user wears the harness **240** and applies a load to the unloading assembly **140**, the puck **260** will slide upward within the internal cavity **281** toward the top of the ring **253**, into a captured position where it cannot inadver-

tently come loose. The puck 260 cannot be withdrawn from the ring 253 without unloading the tether 144 and pulling the puck 260 down and out of the circular hole 274.

[0117] The embodiments of the unloading assemblies 140, 170, and 210 are used in the device 10 similarly to the unloading assemblies 13 and 14. The harness 240 is used similarly in the device 10 to the harness 91. Based on the foregoing descriptions, the reader will understand the operation of the device with substitution of any of the unloading assemblies 140, 170, or 210 or with the harness 240.

[0118] FIGS. 12A and 12B illustrate unloaded and loaded positions of another embodiment of a stabilizing assembly 310. The stabilizing assembly 310 is positioned within a version of the frame 11 between the front tube 26 (here shown as vertical), the main tube 24, and the vertical tube or housing 25. The stabilizing assembly 310 is useful for stabilizing a user in the device to prevent the user from excessive tilt, lean, or sway beyond the line of gravity. The stabilizing assembly 310 is useful for maintaining the posture of a user within a defined space within the device.

[0119] The stabilizing assembly 310 includes a set of springs, tethers, and pulleys which produce a force opposing the force of gravity on the body created by a user leaning to one side of the device or another, which force is applied to the harness 240 of previous embodiments. The assembly 310 includes a lead tether 311 which enters the housing 25 and can be either directly or indirectly connected to the harness 240, preferably in a generally horizontal direction from the housing 25 to the harness 240. In the embodiment shown in these drawings, the lead tether 311 routes around a pulley 312 before it enters the housing 25 and extends to the harness 240.

[0120] When the user puts on the harness 240 and uses the device, he generates a force along the lead tether 311 in the direction indicated by the arrowed line 313. This force propagates through the entire stabilizing assembly 310. The stabilizing assembly 310 acts to counter that force.

[0121] From the pulley 312, the lead tether 311 extends down to another pulley 314 mounted on the side of the housing 25. The pulley 314 is mounted for rotation between two plates, and so is shown in hidden, broken line in FIG. 12A. The lead tether 311 routes around the pulley 314 and then extends up to yet another pulley 315. This pulley 315 is mounted for rotation between two plates and is also shown in hidden line. The pulley 315 is mounted to the top of the frame 11. The pulleys 314 and 315 are not critical for the design but help align the assembly 310 within the frame 11. The lead tether 311 then routes around the pulley 315 and extends back down to a light spring assembly 320. The light spring assembly 320 is shown in detail in FIGS. 13A and 13B, in first and second conditions.

[0122] Turning to those FIGS. 13A and 13B, the light spring assembly 320 includes a coiled extension spring 321 terminating in two opposed hooks 322 and 323 coupled to rings 324 and 325, respectively. The coiled extension spring 321 is constructed from a material or combination of materials having resilient spring properties, such as metal. Preferably, the coiled extension spring 321 has a linear or constant rate, such that the spring 321 deforms evenly across its length in response to application of force. In other embodiments, however, it is preferable for the spring to have a dual, progressive, variable, or other type of rate.

[0123] The light spring assembly 320 also includes two lockout means 326 and 327. The lockout means or, more

simply, “lockouts” 326 and 327 can have a variety of structures, features, and constructions. In the exemplary embodiment shown here, the lockouts 326 and 327 are two inextensible loops connected to each other. In other embodiments, the lockout means is a hydraulic or pneumatic piston, or a solenoid. In other embodiments, the lockout means may be interconnected sliders. In yet other embodiments, the lockout means has other structures and configurations.

[0124] The lockouts 326 and 327 shown in these drawings are identical, and so only the lockout 326 is described in detail here, with the understanding that the description applies equally to the lockout 327. The lockout 327 has the same structural elements and features as the lockout 326, and so the description here adopts the same reference characters to denote those structural elements and features of the lockout 327, except that they are marked with a prime (“’”) symbol to distinguish them from those of the lockout 326.

[0125] The lockout 326 is constructed from a cable 330, preferably a metal cable with inextensible and inelastic material characteristics. The cable 330 has the form of a continuous loop with no gaps, free ends, or discontinuities. A double ferrule 331 is placed over the cable 330 proximate a first end 332. The double ferrule 331 is a fitting with two ferrules or rings registered side-by-side. It is clamped or crimped onto the cable 330. The double ferrule 331 binds two opposed sides of the cable 330 closely to each other, thereby forming a first loop 334 proximate to the first end 332 of the cable 330. The double ferrule 331 also defines a second loop 335. The second loop 335 extends from the double ferrule 331 to the second end 333 and is comparatively much larger than the first loop 334.

[0126] Most of the length of the lockout 326 is within the light spring assembly 320, in an interior space 336 bound by the coiled extension spring 321. The coils of the coiled extension spring 321 hold the lockout 326 in that interior space 336. The cable 330 has some rigidity and so cannot inadvertently escape the confines of the coiled extension spring 321. The double ferrule 331 and the first loop 334 are both just beyond the coils of the coiled extension spring 321, proximate the hook 322.

[0127] The first loop 334 is coupled to the ring 324, so that the lockout 326 is secured to the ring 324. The second loop 335 of the cable 330 is disposed within the interior space 336 of the coiled extension spring 321 and is interconnected with the cable 330' of the lockout 327. The two second loops 335 and 335' intersect and overlap each other, such that the cable 330 of the loop 335 passes through the loop 335' of the other cable 330'. Because of this, pulling either one of the loops 335 and 335' draws that loop taught against the other loop.

[0128] The cables 330 and 330' of the lockouts 326 and 327 are inextensible. While they are flexible in most directions when loose, once they are pulled tight in opposite directions along the length of the coiled extension spring 321 and all slack in the cables 330 and 330' disappears, the cables 330 and 330' are taught against each other and reach a maximum combined extension length, shown with the reference character L in FIG. 13B. Once so pulled, the cables 330 and 330' are inextensible, inflexible along that direction of the coiled extension spring 321, though still capable of flexing in other directions. The maximum combined extension length L defines a maximum extension of the light spring assembly 320, beyond which the light spring assembly 320 cannot be stretched.

[0129] The hooks 322 and 323 of the light spring assembly 320 are connected, respectively, to the rings 324 and 325 like the first loops 334 and 334'. Thus, when the rings 324 and 325 are pulled apart, the hooks 322 and 323 are pulled apart, and the coiled extension spring 321 produces a force in opposition to the direction of the pull. If the rings 324 and 325 are pulled apart to the maximum length L, then the lockouts 326 and 327 become taught and prevent the light spring assembly 320 from extending any further. This defines a second or extended position of the light spring assembly 320. When the light spring assembly 320 is stretched to the maximum length L, it continues to produce a force in opposition to the direction of the pull, but it also acts as a rigid and inextensible element along the direction of the pull, preventing further stretch and thus transferring force further down the stabilizing assembly 310.

[0130] In the embodiment shown in FIGS. 12A, the hook 322 is connected to an eyelet 340 at the end of the lead tether 311. The other hook 323 is connected to an eyelet 341 of an intermediate tether 342. The first loops 334 and 334' of the lockouts 326 and 327 of the light spring assembly 320 are also connected to the eyelets 340 and 341, respectively. FIG. 12A shows the light spring assembly 310 in a first or compressed position. In other embodiments of the stabilizing assembly, the lead tether 311 terminates in a looped end, and a ring, coupler, link with a jaw, or like fastener connects the looped end of the lead tether 311 to the light spring assembly 320. All tethers described herein may also have this alternate construction.

[0131] The intermediate tether 342 extends down to a pulley 343 mounted to the main tube 24. The pulley 343 is mounted for rotation between two plates, and so is shown in hidden, broken line in FIG. 12A. The intermediate tether 342 routes around the pulley 343 and then extends up to another light spring assembly 320', identified with a prime symbol (") to distinguish it from the other light spring assembly 320. The light spring assembly 320' is identical to the light spring assembly 320. Its hook 322 and its first loop 334 are attached to an eyelet 345 at the end of the intermediate tether 342. Its other hook 323 and the first loop 334' are connected to a coupler 346, such as a carabiner or other coupler with a moveable jaw or the like. In other embodiments, the coupler 346 is another tether similar to the lead and intermediate tethers 311 and 342.

[0132] The coupler 346 is a linkage with a gate or other mechanism allowing the light spring assembly 320' to be removably attached. The coupler 346 is also attached to a medium spring assembly 350.

[0133] The medium spring assembly 350 is similar to the light spring assembly 320 in many respects. The medium spring assembly 350 includes the same structural elements as the light spring assembly 320, such as a coiled extension spring 351 and hooks 352 and 353. The coiled extension spring 351 is constructed from a material or combination of materials having resilient spring properties, such as metal. The coiled extension spring 351 has a linear or constant rate, such that the spring 351 deforms evenly across its length in response to application of force. In other embodiments, however, it is preferable for the coiled extension spring 351 to have a dual, progressive, variable, or other type of rate.

[0134] The coiled extension spring 351 has a higher spring constant than the spring constant of the coiled extension spring 321 of the light spring assembly 320. This means that a greater force must be applied to the medium spring

assembly 350 to produce the same stretch or displacement that is achieved when a lower force is applied to the light spring assembly 320. Said in another way, a force applied to the medium spring assembly 350 will result in a smaller displacement than will the same force applied to the light spring assembly 320.

[0135] The medium spring assembly 350 also includes two lockouts 356 and 357. The lockouts 356 and 357 can have a variety of structures, features, and constructions. In the embodiment shown here, the lockouts 356 and 357 are two inextensible loops connected to each other. The lockouts 356 and 357 are identical to each other and to the lockouts 326 and 327, so description of their structural elements and features is not necessary here. The lockouts 356 and 357 terminate in first loops 358 and 358' which are identical to the first loops 334 and 334'. In some embodiments, it is preferable that the cables of the lockouts 356 and 357 have a thicker gauge or greater strength than do the lockouts 326 and 327.

[0136] Both the hook 352 and the first loop 358 of the medium spring assembly 350 are attached to the coupler 346. At the other end of the medium spring assembly 350, both the hook 353 and the first loop 358' are attached to an eyelet 360 at an end of a tail tether 361. The tail tether 361 extends up to a pulley 362 mounted to the top of the frame 11. The pulley 362 is mounted for rotation between two plates, and is shown in hidden, broken line in FIG. 12A. The tail tether 361 routes around the pulley 362 and then extends down to terminate an eyelet 363 connected to another medium spring assembly 350'. The medium spring assembly 350' is identified with a prime symbol (") to distinguish it from the other medium spring assembly 350.

[0137] The medium spring assembly 350' is identical to the medium spring assembly 350 already described. Its hook 352 and its first loop 358 are attached to the eyelet 363 on the tail tether 361. Its other hook 353 and the first loop 358' are connected to a coupler 364, such as a carabiner. In other embodiments, the coupler 364 is another tether similar to the lead, intermediate, or tail tethers 311, 342, or 361.

[0138] The coupler 364 is a linkage with a gate or other mechanism allowing the medium spring assembly 350' to be removably attached. The coupler 364 is also attached to a yoke 370. The yoke 370 includes an upstanding (as it is oriented in the view of FIG. 12A) tab 371 and two lateral tabs 372 and 373 projecting laterally and oppositely to each other below the upstanding tab 371. The yoke 370 is rigid, constructed from a material having rigid qualities, like metal or high-density plastic. Each of the tabs 371, 372, and 373 is formed with through-holes. The medium spring assembly 350' is coupled to the through-hole in the upstanding tab 371.

[0139] Two heavy spring assemblies 380 and 380' are connected to the through-holes in the tabs 372 and 373, respectively. The heavy spring assemblies 380 and 380' are identical to each other in every way except location, and as such, this specification describes only the heavy spring assembly 380 with the understanding that the description applies equally to the heavy spring assembly 380'. The drawings use the same reference characters for the various structural elements and features of both of the heavy spring assemblies 380 and 380', but those of the heavy spring assembly 380' carry a prime (") symbol to distinguish them from those of the heavy spring assembly 380.

[0140] The heavy spring assembly 380 includes a coiled extension spring 381. The coiled extension spring 381

terminates in two opposed hooks **382** and **383**. The coiled extension spring **381** is constructed from a material or combination of materials having resilient spring properties, such as metal. Preferably, the coiled extension spring **381** has a linear or constant rate, such that the spring **381** deforms evenly across its length in response to application of force. In other embodiments, however, it is preferable for the spring to have a dual, progressive, variable, or other type of rate.

[0141] The coiled extension spring **381** has a higher spring constant than the spring constant of either of the coiled extension springs **321** and **351** of the light and medium spring assemblies **320** and **350**. A force applied to the heavy spring assembly **380** will result in a smaller displacement than will the same force applied to the medium spring assembly **350**.

[0142] In the embodiment shown in FIGS. **12A** and **12B**, the heavy spring assembly **380** includes the coiled extension spring **381** and no internal lockouts. This is possible because the spring constant of the coiled extension **381** is preferably very high, and the heavy spring assembly **380** is unlikely to displace or stretch very far under even the highest loads. However, in some embodiments, it may still be preferable that the heavy spring assembly **380** includes lockouts and structures similar to those of the medium and light spring assemblies **350** and **320**.

[0143] In such alternate embodiments, the heavy spring assembly **380** includes two lockouts. Preferably, those lockouts are inextensible loops constructed from cable interconnected with each other. The cable is preferably constructed from metal in the form of a continuous loop with no gaps, free ends, breaks, or other discontinuities. More preferably, the cable is a braided metal wire rope. A double ferrule is fit over the cable proximate a first end of the cable and is clamped or crimped onto the cable. This binds two opposed sides of the cable closely to each other, thereby forming a small first loop and a larger second loop.

[0144] Most of the length of the lockout is within this alternate embodiment of the heavy spring assembly **380**, in an interior space bound by the coiled extension spring **381**. The coils of the coiled extension spring **381** hold the lockout in that interior space. The cable of the lockout has rigidity and so cannot inadvertently escape the confines of the coiled extension spring **381**. The double ferrule and the first loop are both just beyond the coils of the coiled extension spring **381**, proximate the hook **382**. Both the first hook **382** and the first loop are then preferably coupled to a ring. The second loop is disposed in the interior space within the coiled extension spring and is interconnected with the second loop of the heavy spring assembly's other lockout. Those two second loops intersect and overlap each other, such that pulling either of the lockouts of the heavy spring assembly draws that lockout taught against the other lockout.

[0145] Still describing the alternate embodiment of the heavy spring assembly, the cables of the lockouts are inextensible, so that once they are pulled in opposite directions and all slack in the cables disappears, the cables are taught against each other and reach a maximum extension length, which defines a maximum extension of the alternate heavy spring assembly embodiment, beyond which it cannot be stretched.

[0146] Returning to the embodiment shown in FIG. **12A**, the hooks **383** and **383'** of the heavy spring assemblies **380** and **380'** are attached to a yoke **384**. The yoke **384** is a rigid

piece of material constructed from metal or high-density plastic and resists deformation. The yoke **384** includes two lateral tabs **385** and **386** projecting laterally and oppositely to each other, and a downwardly-projecting or depending tab **387** extending downward from between the two lateral tabs **385** and **386**. Each of the tabs **385**, **386**, and **387** is formed with a through-hole. The heavy spring assemblies **380** and **380'** are coupled to the through-holes in the lateral tabs **385** and **386**, respectively. A coupler **390** is coupled to the through-hole in the depending tab **387**. The coupler **390** is a linkage such as a carabiner, and preferably includes a gate or other mechanism so that it can be easily slipped onto the yoke **384**. The coupler **390** is also attached to an anchor **391** fixed in the main tube **24** of the frame **11**, thereby securing the yoke **384** in place proximate to the main tube **24**.

[0147] In operation, the embodiment of the stabilizing assembly **310** is used similarly to the unloading assemblies **13**, **14**, **140**, **170**, and **210** and can be used with the harnesses **91** and **240**. For these purposes, this specification describes use of the stabilizing assembly **310** with the harness **240**. The user dons the harness **240** so that the rings **253** are disposed near the user's hips. On one side of the device, the user attaches the lead tether **311** of the stabilizing assembly **310** on that side to the one of the rings **253** also on that side. On the other side of the device, the user attaches the lead tether of that side's stabilizing assembly **310** to the other ring **253**.

[0148] The lead tether **311** extends from the harness **240** into the frame housing **25**, as shown in FIG. **12A** and then through the pulleys **314** and **315** to the light spring assembly **320**. FIG. **12A** shows the stabilizing assembly **310** from one side of the device, and the reader will understand that an identical stabilizing assembly **310** is on the other side of the device. In the view of FIG. **12A**, the stabilizing assembly **310** is in a first or unloaded position, and it moves into a second or loaded position, as shown in FIG. **12B**, when a force is applied at the ring **253** on the respective side of the harness **240**.

[0149] As the user moves horizontally with the device and dips, the ring **253** pulls on the lead tether **311**, exerting a loading force **F** along the lead tether **311** in the direction indicated by the arrowed line **313** in FIG. **12A**. This force **F** propagates through the entire stabilizing assembly **310**, causing the stabilizing assembly **310** to move into the loaded position shown in FIG. **12B**. The stabilizing assembly **310** responds in opposition to that force **F**, producing a stabilizing force felt by the user and returning the user toward a neutral position with respect to the device.

[0150] The loading force **F** has a magnitude which propagates through the lead tether **311**. The lead tether **311**, and the intermediate tether **342** and the tail tether **361** are constructed from an inelastic and inextensible material such as metal or synthetic fiber. As such, the tethers **311**, **342**, and **361** do not stretch under the force **F** and transfer all of the force **F** along their lengths. Thus, the force **F** propagates through the entire stabilizing assembly **310**, including the tethers **311**, **342**, and **361** as well as the light, medium, and heavy spring assemblies **320**, **320'**, **350**, **350'**, **380**, and **380'**. Each of the spring assemblies responds differently to the force **F** because of their different spring constants and their different positions relative each other.

[0151] The light and medium spring assemblies **320**, **320'**, **350**, and **350'** are arranged in series along the lead **311** and intermediate tethers **342** and **361**. The pull force **F** applies equally to all of them.

[0152] Application of force **F** causes the light spring assembly **320** to yield and stretch according to its spring constant, up until the point at which the lockouts **326** and **327** are pulled taught. Application of force **F** causes the other light spring assembly **320'** to also yield and stretch according to its spring constant, up until the point at which the lockouts **326** and **327** are pulled taught. Because the light spring assemblies **320** and **320'** are identical in every respect to each other but for location, they stretch at the same rate and lock out at the same displacement as each other. FIG. 12B shows the lockouts **326** and **327** of the light spring assembly **320** pulled against each other but not taught. When the light spring assembly **320** locks out, the lockouts **326** and **327** are pulled taught. However, showing the lockouts **326** and **327** pulled taught would make them difficult discern in these drawings.

[0153] In some cases, where the pull force **F** is low, only the light spring assemblies **320** and **320'** may stretch; the pull force **F** may be too small to produce a noticeable displacement in the other spring assemblies. In other cases, where the pull force **F** is higher, the light spring assemblies **320** and **320'** stretch and lock out, and the medium spring assemblies **350** and **350'** yield and stretch as well.

[0154] In such cases in which the pull force **F** is higher, the medium spring assemblies **350** and **350'** noticeably yield. Because the medium spring assemblies **350** and **350'** are arranged in series with the light spring assemblies **320** and **320'**, they are subjected to the same force **F** at the same time as the light spring assemblies **320** and **320'**. Application of that force **F** causes the medium spring assembly **350** to yield and stretch according to its spring constant, up until the point at which its lockouts **356** and **357** are pulled taught. Then the medium spring assembly **350** becomes inextensible and stretches no more. Application of the force **F** causes the other medium spring assembly **350'** to also yield and stretch according to its spring constant, up until the point at which its lockouts are pulled taught. Because the medium spring assemblies **350** and **350'** are identical in every respect to each other but for location, they stretch at the same rate and lock out at the same displacement as each other. FIG. 12B shows the lockouts **356** and **357** of the medium spring assembly **320** pulled against each other but not taught. When the medium spring assembly **320** locks out, the lockouts **356** and **357** are pulled taught. However, showing the lockouts **356** and **357** pulled taught would make them difficult discern in these drawings.

[0155] In cases in which the pull force **F** is much higher, the heavy spring assemblies **380** and **380'** noticeably yield. Because the heavy spring assemblies **380** and **380'** are arranged in series with the light and medium spring assemblies **320**, **320'**, **350** and **350'**, they are subjected to the same force **F** at the same time as the light and medium spring assemblies **320**, **320'**, **350** and **350'**. However, because the heavy spring assemblies **380** and **380'** are arranged in parallel with each other, each of the heavy spring assemblies **380** and **380'** is subject to half of the force **F**, or a force **F/2**.

[0156] Application of that force **F/2** causes the heavy spring assemblies **380** and **380'** to yield and stretch according to their spring constants. Preferably, the spring constants are very high, and the heavy spring assemblies yield **380** and

380' very little and only in response to very high forces. In embodiments in which incredibly high forces may be experienced, the alternate heavy spring assembly embodiment may be preferred. That alternate embodiment uses lockouts to limit further movement of the harness **240**. In that alternate embodiment, the heavy spring assemblies **380** and **380'** yield up until the point at which their lockouts are pulled taught. Generally, however, the alternate embodiment of the heavy spring assembly is not necessary, and the embodiment shown in these drawings is sufficient.

[0157] As the user walks, the stabilizing assembly **310** cycles between the loaded and unloaded position, or between positions between the loaded and unloaded positions. The stabilizing assembly **310** produces a stabilizing force in opposition to the pull force **F** created by the user's motion, so that the user feels more stable or in balance.

[0158] FIG. 14 illustrates another embodiment of a stabilizing assembly **410**. The drawings are stylized, free-body diagrams but nevertheless show the structural elements and features of the assembly **410**. The stabilizing assembly **410** is positioned within the frame **11** between the front tube **26** (here shown as vertical), the main tube **24**, and the vertical tube or housing **25**.

[0159] The stabilizing assembly **410** includes a spring assembly **411**, a cam assembly **412**, a first tether **413** extending from the spring assembly **411** to the cam assembly **412**, and a second tether **414** extending from the cam assembly **412** and running inside the housing **25**, and then preferably extending to the harness **240**. The stabilizing assembly **410** exerts a stabilizing force on the harness **240** with respect to the frame **11** to prevent the user from excessive tilt or lean and maintain his posture along or near the line of gravity.

[0160] The first tether **413** extends back away from the cam assembly **412**, down and around a pulley **415**, and to the spring assembly **411**. In the embodiment shown here, the spring assembly **411** includes three coiled extension springs **420**, **421**, and **422** arranged in series with each other. The first spring **420** is a leading spring in that it is connected to the first tether **413**. It is disposed between the pulley **415** secured to the main tube **24** and another pulley **416** secured to the top of the frame **11**. The first spring **420** has opposed free ends **423** and **424**. The free end **423** is coupled to an eyelet, ring, coupler, loop, link, or other end of the first tether **413**. The free end **424** is coupled to an eyelet, ring, coupler, loop, link, or other end of an intermediate tether **425**.

[0161] The intermediate tether **425** extends up from the first spring **420** to the pulley **416** mounted to the top of the frame **11**. The intermediate tether **425** routes around the pulley **416** and then extends down to the second spring **421**.

[0162] The second spring **421** has opposed free ends **430** and **431**. The free end **430** is coupled to an eyelet, ring, coupler, loop, link, or other end of the intermediate tether **425**. The other free end **431** is coupled to a coupler **432**, such as a carabiner or other coupler with a moveable jaw or the like. That coupler **432** connects the second spring **421** and the third spring **422** directly.

[0163] The third spring **422** has opposed free ends **433** and **434**. The free end **433** is coupled to the coupler **432** and thus to the second spring **421**, and the other free end **434** is coupled to another coupler **435** (such as a carabiner, coupler with a moveable jaw, or the like) that is secured to an anchor **436** fixed to the main tube **24**.

[0164] In some embodiments, the first, second, and third springs 420, 421, and 422 are identical and have a linear or constant spring rate, such that they each deform evenly across their lengths in response to application of force. In other embodiments, the identical springs have dual, progressive, variable, or other types of spring rates.

[0165] In still other embodiments, the first, second, and third springs 420, 421, and 422 are not identical. For example, in some embodiments, the spring constant of the second spring 421 is higher than the spring constant of the first spring 420, and the spring constant of the third spring 422 is higher than the spring constant of the second spring 421. In other embodiments, the first, second, and third springs 420, 421, and 422 have other different spring constants with respect to each other.

[0166] FIG. 14 shows the spring assembly 410 in an unloaded position, in which the first, second, and third springs 420, 421, and 422 are either unloaded or only very lightly loaded. The unloaded spring assembly 410 has a shorter overall length. The spring assembly 410 moves into or toward a loaded position when the stabilizing assembly 410 is placed under a load that a user produces when walking, leaning, or moving. The spring assembly 410 moves toward the cam assembly 412 during movement.

[0167] The cam assembly 412 is mounted for rotation on an axle 440 carried on a bracket 441. The bracket 441 is secured to the housing 25 and extends forwardly. The cam assembly 412 includes outer and inner cams 442 and 443. The stacked cam assembly 412 includes outer and inner cams 442 and 443, mounted coaxially side-by-side on the bracket 441. Both cams 442 and 443 are mounted for rotation about the same axis of rotation, however, the cams 442 and 443 are fixed to each other to prevent relative rotation.

[0168] The outer cam 442 is larger, and the inner cam 443 is smaller. Both cams 442 and 443 are circular wheels or discs in this embodiment. They are concentric to each other but the axle 440 about which they are mounted is not concentric, and therefore the cams 442 and 443 are eccentrically mounted. In other words, their axes of rotation are offset from their respective geometric centers, such that as they rotate, their lever arms change and the ratio of their respective lever arms change. In other embodiments, the axle 440 is mounted concentrically to the cams 442 and 443, and in other embodiments, the cams 442 and 443 have shapes other than circles.

[0169] The first tether 413 is an inelastic cable, band, cord, or other tether. One end of the first tether 413 is coupled to the free end 423 of the first spring 420, and the other end of the first tether 413 is coupled to the inner cam 443. The inner cam 443 has at least a single groove formed into its perimeter, and as the inner cam 443 rotates, the first tether 413 rolls and unrolls from this groove.

[0170] Similarly, the second tether 414 is an inelastic cable, band, cord, or other tether. One end of the second tether 414 is coupled to the outer cam 442. From there, the second tether 414 extends up through the housing 25 and then out to the harness 240. Though the harness 240 is not shown in FIG. 14, the reader will understand its location and arrangement from the description above. The outer cam 442 has at least a single groove formed into its perimeter, and as the outer cam 442 rotates, the second tether 414 rolls and unrolls from this groove.

[0171] The first and second tethers 413 and 414 are arranged oppositely to each other on the cam assembly 412. The first tether 413 is secured at an attachment point 444 on the inner cam 443 and extends generally downward to the pulley 415 before turning upward to the spring assembly 411. The second tether 414 is wound around the outer cam 442 and secured at an attachment point 445 and extends generally upward. The attachment points 444 and 445 are not proximate to each other on the cam assembly 412. In other embodiments, the attachment points 444 and 445 may be in different locations, but the tethers 413 and 414 extend outward in opposite directions.

[0172] As the user walks, the stabilizing assembly 410 cycles between the loaded and unloaded positions. The stabilizing assembly 410 produces a stabilizing force in opposition to the pull force created by the user's motion, acting to maintain the user in stability and in balance.

[0173] FIG. 15 illustrates another embodiment of an unloading assembly 510. The unloading assembly 510 is positioned within a version of the frame 11 between the front tube 26 (here shown as vertical), the main tube 24, and the vertical tube or housing 25. The unloading assembly 510 is useful for unloading bodyweight of a user during standing and walking. The unloading assembly 510 is useful for maintaining the posture of a user within a defined space within the device.

[0174] The unloading assembly 510 includes a spring, tethers, and pulleys which produce a force opposing the force of gravity on the body created by a user while walking or standing, which force is applied to the harness 240 described above with respect to previous embodiments or similar harnesses. The assembly 510 includes a first, or lead, tether 511 which extends from the harness and then routes around a pulley 512 coupled to the housing 25. The drawing here shows the lead tether 511 as it extends from the pulley 512 down to another pulley 513. In embodiments, the other pulley 513 is inside the housing 25 and the lead tether crosses into the housing 25 as it extends between those pulleys 512 and 513. In other embodiments, the lead tether 511 and the pulleys 512 and 513 are outside of the housing 25.

[0175] When the user puts on the harness 240 and uses the device, he generates a force along the lead tether 511 in the direction indicated by the arrowed line 516. This force propagates through the entire unloading assembly 510. The unloading assembly 510 acts to counter that force.

[0176] From the pulley 513, the lead tether extends to a cam assembly 520. The cam assembly 520 is mounted for rotation on an axle 521 carried on a bracket 522 secured to the housing 25 or other part of the frame. The cam assembly 520 includes outer and inner cams 523 and 524. The stacked cam assembly 520 includes the outer and inner cams 523 and 524 mounted coaxially side-by-side on the bracket 522. Both cams 523 and 524 are mounted for rotation; however, the cams 523 and 524 are fixed to each other to prevent relative rotation.

[0177] The outer cam 523 is larger, and the inner cam 524 is smaller. Both cams 523 and 524 are elliptical or oval in this embodiment, but are circular in other embodiments. They are concentric to each other about the axle 521. In other embodiments, the axle 521 is off-center with respect to the cams 523 and 524 such that they are eccentrically mounted.

[0178] The lead tether **511** is an inelastic cable, band, cord, or similar tether. One end of the lead tether **511** is coupled to the harness, and the other end of the lead tether **511** is coupled to the outer cam **523** at a mount point **525**. The outer cam **523** has at least a single groove formed into its perimeter, and as the outer cam **523** rotates, the lead tether **511** rolls and unrolls from this groove.

[0179] A second, or tail, tether **514** is coupled to the inner cam **524** at a mount point **526** and then extends from the inner cam **524** to a pulley **530**. The tail tether **514** is an inelastic cable, band, cord, or other tether. Preferably, but not necessarily, the two mount points **525** and **526** are opposite each other. Like the outer cam **523**, the inner cam **524** has at least a single groove formed into its perimeter, and as the inner cam **524** rotates, the tail tether **514** rolls and unrolls from this groove.

[0180] The tail tether **514** extends from the inner cam **524**, down to and around the pulley **530**, and then over to a flat spring **531**. The flat spring **531** is a sprung arm: a lightweight, compact, resilient, and elongate flat spring member having a first, fixed end **540** and a second, free end **541**. The fixed end **540** is secured directly to the front tube **26**, here with bolts. In other embodiments, it is secured within a block similar to the block **182** shown and described in earlier embodiments. The flat spring **531** operates as a spring. The flat spring **531** has its fixed end **540** secured to the front tube **26** and then has a length **542** extending down along the front tube **26** to the free end **541**. The flat spring **531** is preferably uniform in its cross section throughout its length. The free end **541** moves between a first, “unloaded” position as shown in solid line in FIG. **15** and a second, “loaded” position as shown in broken line in FIG. **15**. This movement is indicated by the double-headed line **543**.

[0181] The flat spring **531** moves toward the loaded position in response to a load being placed in the harness during standing or walking. Such a force causes the tail tether **514** to pull the flat spring **531** over. In response, the flat spring **531** exerts a biasing force in a direction opposite the pull; the flat spring **531** acts to pull the tail tether **514** back.

[0182] The flat spring **531** is a spring which exerts a biasing force in opposition to displacement. That force is inversely proportional to an effective length **544** of the flat spring **531**. In the embodiment shown in FIG. **15**, while the flat spring **531** has a length **542**—its total length—between the first and second ends **540** and **541**, it also has an effective length **544**, which is the portion of the length **542** which can bend and yield. The user can adjust this effective length **544**.

[0183] As shown in FIG. **15**, a bracket **545** is proximate the first end **540** of the flat spring **531**. The bracket **545** is a rigid and strong member, preferably made from metal such as steel or aluminum. In embodiments, the bracket **545** has a box, U-shaped, or other cross-section, so long as it effectively resists deflection. The bracket **545** is formed with several discrete holes **546** along its length. Each of the holes is sized and shaped to closely receive a pin or peg **550**. In FIG. **15**, the peg **550** is fit into the bottom-most hole **546**. When installed in this hole **546** or any hole **546** in the bracket **545**, the peg **550** is closely fit therein but also has a portion of its shank which extends out over the flat spring **531**, such that the flat spring **531** abuts the peg **550** and is prevented from deflection beyond it. The peg **550** acts as a fulcrum at this location, a point about which the flat spring **531** can bend. Thus, the effective length **544** of the flat spring **531** measures from that fulcrum location to the free end **541**

of the flat spring **531**. This is shown in FIG. **15** as a double-headed line between the peg **550** and the free end **541**.

[0184] The user can change the effective length **544** by removing the peg **550** from the bottom-most hole **546** and positioning it in one of the other holes **546**. As the user moves the peg **550** among fulcrum locations, the effective length **544** changes. Moving the position of the peg **550** changes the effective length **544** of the flat spring **531** and allows fractional adjustment of the spring rate of the flat spring **531**. The user can, in effect, make the flat spring **531** more or less resistant to deflection under load by adjusting the location of the peg **550**.

[0185] In the embodiment shown herein, the unloading assembly **510** has a fulcrum which can be moved between the fixed and free ends **540** and **541** of the flat spring **531** among locations which are discrete with respect to each other. Each hole **546** defines one of those discrete locations. In other embodiments, the location of the fulcrum is continuously adjustable. In some embodiments, a fulcrum assembly rolls along the length **542** of the flat spring **531**. The fulcrum assembly includes a pin or abutment edge that projects over the flat spring **531**, similarly to the peg **550**, to abut the flat spring **531** and establish a fulcrum point. For example, in some embodiments, the fulcrum assembly includes a toothed rack extending parallel to the flat spring and a housing which travels over the rack. The housing includes a toothed pinion gear which engages with the rack to allow the housing to be moved in incremental, continuous adjustments. In some embodiments, this housing travels next to the flat spring **531** and the pin projects laterally over it, and in other embodiments, this housing travels atop the flat spring **531** and includes an abutment edge defining the fulcrum point. In these embodiments, the unloading assembly **510** has a fulcrum which can be finely moved between the fixed and free ends **540** and **541** of the flat spring **531** among locations which are continuous with respect to each other.

[0186] Whether the unloading assembly **510** uses a discretely-adjusted fulcrum or a continuously-adjusted fulcrum, increasing the effective length **544** (in the embodiment of FIG. **15**, moving the peg **550** “up”) of the flat spring **531** decreases its spring constant, and decreasing the effective length **544** (in the embodiment of FIG. **15**, moving the peg **550** “down”) of the flat spring **531** increases its spring constant. The user can thus change the biasing force produced by the unloading assembly **510** without having to swap out a new flat spring **531**.

[0187] In operation, the unloading assembly **510** is capable of producing a large amount of unloading force on the harness. This helps the user unload weight on the legs and thereby enhances rehabilitation. As the pelvis and harness move during walking, the unloading assembly **510** produces a constant lifting force countering the force of gravity on the body. The unloading assembly **510** can be pre-loaded. The unloading assembly includes a pre-loading assembly **551** to assist with this. For example, the user may wish to set the initial unloading assembly to provide twenty-five pounds of unloading force. In some situations, the user may wish to change the unloading force produced by the unloading assembly **510** to a higher or lower unloading force by moving the position of the peg **550** in the bracket **545**.

[0188] The pre-loading assembly **551** includes the pulley **530**, a track **552**, a winch **553**, and a tether **554** extending

between the winch 553 and the pulley 530. The pulley 530 routes the tail tether 514 between the flat spring 531 and cam assembly 520. It can be moved. The pulley 530 is mounted in the track 552, within a slot in a housing. The pulley 530 has an axle with a shaft that is bearing mounted in the slot of the track 552 for translational movement, so that the pulley 530 can be moved a certain distance between a first position toward the flat spring 531, as shown in solid line in FIG. 15, and a second position away from the flat spring 531, as shown in broken line in FIG. 15. The change in the distance between the first and second positions of the flat spring 531 corresponds to the distance between the first and second positions of the pulley 530.

[0189] One end of the tether 554 is looped onto a side of the pulley 530, operatively coupling those two elements together. The tether 554 then extends from the pulley 530, around a re-routing pulley 555, and then up to the winch 553. The winch 553 includes a ratchet within a housing 556 and a crank 557 coupled to the ratchet. The tether 554 attaches to the ratchet so that, when the user rotates the crank 557, the tether 554 winds without unwinding. Winding the tether 554 draws the pulley 530 from the first position in the track 552 to the second position. In embodiments of the unloading assembly 510, the pulley 512 has a brake 558, such as a disc brake, which can clamp down on the pulley 512 to prevent its rotation and thus prevent movement of the lead tether 511. In some embodiments, the pulley 512 is replaced by a braked capstan. When the brake 558 is applied, the lead tether 511 is held firm. Then, winding the tether 554 toward the second position draws the tail tether 514 out, thereby causing the free end 541 of the flat spring 531 to move and the flat spring 531 to deflect. The flat spring 531 produces a resistive force that otherwise would act to pull the tail tether 514 and the lead tether 511, but because the brake 558 is applied, the lead tether 511 is prevented from movement. Instead, the flat spring 531 deflects and then is held in position. This pre-loads the unloading assembly with an unloading force. Should the user wish to de-load the device, the user depresses a release on the winch, and the pulley 530 slides back to the first position. When the pulley is in the second position, the tail tether 514 is aligned in a tangential position to the cam assembly, while when the pulley is in the first position, it is not.

[0190] While the brake 558 is applied, the user dons the harness and fits it to get comfortable in the unloading assembly 510. The user adjusts the harness to take up any slack, and the user can then release the brake 558 on the pulley 512. As the brake 558 is released, the user feels the pre-loaded force applied through the tail tether 514, through the lead tether 511, and to the harness.

[0191] As the user walks, the unloading assembly 510 cycles between this pre-loaded condition of the lead tether 511 and an elongated condition of the lead tether 511 resulting from the natural movement of the body during walking. Although the lead tether elongates and retracts, the unloading assembly 510 produces a constant lifting force in opposition to the force of gravity on the body.

[0192] FIG. 16 illustrates another embodiment of a unloading assembly 560. The unloading assembly 560 is positioned within a version of the frame 11 between the front tube 26 (here shown as diagonal), the housing 25 (also shown as diagonal), and a horizontal top tube. The unloading assembly 560 is useful for stabilizing and unloading some or all of the bodyweight of a user in the device to reduce the

weight burden on the legs. The unloading assembly 560 is useful for maintaining the posture of a user within a defined space within the device.

[0193] The unloading assembly 560 includes a spring, tethers, and pulleys which produce a force opposing the loads, or the force of gravity on the user while standing or walking, which unloading force is applied to the harness 240 described above with respect to previous embodiments or similar harnesses. The unloading assembly 560 opposes the forces created by both sides of the harness.

[0194] The assembly 560 includes a pulley assembly 562 routing a first, or lead, tether 561. The lead tether 561 is only partially shown in FIG. 16; the lead tether 561 extends to the left in the drawings to a first end attached to one side of the harness (not shown, but which is a first load on the assembly 560) and extends to the right in the drawings to a second end attached to the other side of the harness (not shown, but which is a second load on the assembly 560). Thus, the lead tether 561 extends between the two sides of the harness, and each side provides a load as the user walks. The pulley assembly 562 fit onto the lead tether 561 is a compound pulley assembly. It includes a first, or major, pulley 563 mounted in a vertical track 564. The major pulley 563 has an axle with a shaft that is bearing mounted in the track 564 for translational movement in the track 564, so that the major pulley 563 can be moved between a first position toward the top tube and a second position away from the top tube. In FIG. 16, the major pulley 563 is shown in an intermediate position between the first and second positions.

[0195] The pulley assembly 562 further includes first and second minor pulleys 565 and 566 flanking the track 564 and the major pulley 563 disposed therein. Although the first and second minor pulleys 565 and 566 are identified as “minor” in seeming contrast with the “major” pulley 563, these terms are used only to distinguish the pulleys 563, 565, and 566 and not for any other reason. The first and second minor pulleys 565 and 566 are mounted in fixed locations for rotation about their respective central axes.

[0196] The lead tether 561 routes through these pulleys 563, 565, and 566. From the first end off the left side of the drawing, the lead tether 561 extends to the first minor pulley 565, wraps around one side of the first minor pulley 565 (the top side as shown in these drawings), and then extends down to route around the major pulley 563 and back up to the second minor pulley 566. The lead tether 561 routes around the major pulley 563 on an opposite side than it does the first and second minor pulleys 565 and 566. These are opposite sides of the pulley assembly 562.

[0197] An intermediate tether 567 extends downward from the major pulley 563. The intermediate tether 567 is coupled to the shaft of the major pulley 563. It extends down to the cam assembly 570, which is mounted for rotation on an axle 571 carried on a bracket secured to the frame (the bracket is not shown in FIG. 16 but will be understood from description of other brackets herein). The cam assembly 570 includes outer and inner cams 573 and 574. The stacked cam assembly 570 includes the outer and inner cams 573 and 574 mounted coaxially side-by-side on the bracket. Both cams 573 and 574 are mounted for rotation; however, the cams 573 and 574 are fixed to each other to prevent relative rotation.

[0198] The outer cam 573 is larger, and the inner cam 574 is smaller. Both cams 573 and 574 are elliptical or oval in this embodiment but are circular in other embodiments.

They are concentric to each other about the axle **571**. In other embodiments, the axle **571** is off-center with respect to the cams **573** and **574** such that they are eccentrically mounted.

[0199] The intermediate tether **567** is an inelastic cable, band, cord, or like tether. One end of the intermediate is coupled to the major pulley **563**, and the other end of the intermediate tether **567** is coupled to the outer cam **573** at a mount point **575**. The outer cam **573** has at least a single groove formed into its perimeter, and as the outer cam **573** rotates, the intermediate tether **567** rolls and unrolls from this groove.

[0200] A tail tether **572** is coupled to the inner cam **574** at a mount point **576** and then extends from the inner cam **574** to a pulley assembly **580**. The pulley assembly **580** is a compound pulley assembly **580**. It includes a first, or major, pulley **581** mounted in a track **582**. The major pulley **581** has an axle with a shaft that is bearing mounted in the track **582** for translational movement in the track **582**, so that the major pulley **581** can be moved between a first position, toward the front tube **26** and away from the first and second minor pulleys **583** and **584**, and a second position, away from the front tube **26** and toward the first and second minor pulleys **583** and **584**. In this way, the major pulley **581** defines a moveable pulley. In FIG. **16**, the major pulley **581** is shown in an intermediate position between the first and second positions.

[0201] The pulley assembly **580** further includes first and second minor pulleys **583** and **584** flanking the track **582** and the major pulley **581** disposed therein. Although the first and second minor pulleys **583** and **584** are identified as “minor” in seeming contrast with the “major” pulley **581**, these terms are used only to distinguish the pulleys **581**, **583**, and **584** and not for any other reason. The first and second minor pulleys **583** and **584** are mounted in fixed locations for rotation about their respective central axes.

[0202] The tail tether **572** routes through these pulleys **581**, **583**, and **584**. From the inner cam **574**, the tail tether **572** extends to the second minor pulley **584**, wraps around one side of the second minor pulley **584** (the bottom side as shown in these drawings), and then extends up to route around the major pulley **581** (the top side thereof) and back down to and around the first minor pulley **583** (the bottom side thereof). The tail tether **572** routes around the major pulley **581** on an opposite side than it does the first and second minor pulleys **583** and **584**. These are opposite sides of the pulley assembly **580**.

[0203] The major pulley **581** can be moved in translational movement along the track **582**. A handle **585** extends from the major pulley **581** and can be used to manually position the major pulley **581** anywhere along the track **582**. This allows the use to pre-load the unloading assembly **560** in a similar fashion to the winch **553** in the unloading assembly **510**. In other embodiments of the unloading assembly **560**, the major pulley **581** is connected to a winch similar to the winch **553**.

[0204] From the first minor pulley **583**, the tail tether **572** next extends around two redirection pulleys **586** and **587** and then to a flat spring **589**. The flat spring **589** is a sprung arm: a lightweight, compact, resilient, and elongate flat spring member having a first, fixed end **590** and a second, free end **591**. The fixed end **590** is secured directly to the housing **25**, here with bolts. The flat spring is preferably uniform in its cross-section throughout its length. In other embodiments, it

is secured within a block similar to the block **182** shown and described in earlier embodiments. The flat spring **589** operates as a spring. The flat spring **589** has its fixed end **590** secured to the housing **25** and then has a length **592** extending down along the housing **25** to the free end **591**. The free end **591** moves between a first, “unloaded” position as shown in solid line in FIG. **16** and a second, “loaded” position as shown in broken line in FIG. **16**. This movement is indicated by the double-arrowed line **593**.

[0205] The flat spring **589** moves toward the loaded position in response to a load being placed in the harness, such as by the force of gravity on the user. Such a force causes the tail tether **572** to bend the flat spring **589**. In response, the flat spring **589** exerts a biasing force in a direction opposite the pull; the flat spring **589** acts to pull the tail tether **572** back.

[0206] The flat spring **589** is a spring which exerts a biasing force in opposition to displacement. That force is inversely proportional to an effective length **594** of the flat spring **589**. In the embodiment shown in FIG. **16**, while the flat spring **589** has a length **592**—its total length—between the first and second ends **590** and **591**, it also has an effective length **594**, which is the portion of the length **592** which can bend and yield. The user can adjust this effective length **594**.

[0207] As shown in FIG. **16**, a bracket **595** is proximate the first end **590** of the flat spring **589**. The bracket **595** is a rigid and strong member, preferably made from metal such as steel or aluminum. In embodiments, the bracket **595** has a box, U-shaped, or other cross-section, so long as it effectively resists deflection. The bracket **595** is formed with several discrete holes **596** along its length. Each of the holes is sized and shaped to closely receive a pin or peg **600**. In FIG. **16**, the peg **600** is fit into the top-most hole **596**. When installed in this hole **596** or any hole **596**, the peg **600** is closely fit therein but also has a portion of its shank which extends out over the flat spring **589**, such that the flat spring **589** abuts the peg **600** and is prevented from deflection beyond it. The peg **600** acts a fulcrum at this location, a point about which the flat spring **589** can bend. Thus, the effective length **594** of the flat spring **589** measures from that fulcrum location to the free end **591** of the flat spring **589**. This is shown in FIG. **16** as a double-arrowed line between the peg **600** and the free end **591**.

[0208] The user can change the effective length **594** by removing the peg **600** from the top-most hole **596** and positioning it in one of the other holes **596**. As the user moves the peg **600** among fulcrum locations, the effective length **594** changes. As the effective length **594** changes, the spring constant or spring rate changes. The user can, in effect, make the flat spring **589** more or less resistant to deflection under load by adjusting the location of the peg **600**.

[0209] In the embodiment shown herein, the unloading assembly **560** has a fulcrum which can be moved between the fixed and free ends **590** and **591** of the flat spring **589** among locations which are discrete with respect to each other. Each hole **596** defines one of those discrete locations. In other embodiments, the location of the fulcrum is continuously adjustable. In some embodiments, a fulcrum assembly rolls along the length **592** of the flat spring **589**. The fulcrum assembly is similar to the one described above with respect to the unloading assembly **510** shown in FIG. **15**. Whether the unloading assembly **560** uses a discretely-adjusted fulcrum or a continuously-adjusted fulcrum, increasing the effective length **594** (in the embodiment of

FIG. 16, moving the peg 600 “down”) of the flat spring 589 decreases its spring constant, and decreasing the effective length 594 (in the embodiment of FIG. 16, moving the peg 600 “up”) of the flat spring 589 increases its spring constant. [0210] In operation, the unloading assembly 560 is capable of producing a large amount of unloading force on the harness. This helps the user unload weight and thereby enhances rehabilitation. As the user walks, the unloading assembly 560 produces a constant force countering the force of gravity on the user. In some situations, however, the user may wish to set the unloading assembly 560 to provide an initial unloading force. In other words, the unloading assembly 560 can be pre-loaded. For example, the user may wish to set the unloading assembly to provide fifty pounds of unloading force from a neutral position. The pulley assembly 580 assists with this in the same way that pre-loading assembly 551 assists in the unloading assembly 510. As such, further description of the operation of the pulley assembly 580 is unnecessary here, except to note that the unloading assembly 560 includes a brake 601 on the major pulley 563 to prevent movement of the lead tether 561 while the user is pre-loading the unloading assembly 560. [0211] A preferred embodiment is fully and clearly described above so as to enable one having skill in the art to understand, make, and use the same. Those skilled in the art will recognize that modifications may be made to the description above without departing from the spirit of the specification, and that some embodiments include only those elements and features described, or a subset thereof. To the extent that modifications do not depart from the spirit of the specification, they are intended to be included within the scope thereof.

What is claimed is:

1. A bodyweight unloading locomotive device comprising:
 - a frame configured to support locomotive movement;
 - a sprung arm having a fixed end fixed to the frame, an opposed free end, and a length extending between the fixed and free ends;
 - a cam assembly mounted for rotational movement;
 - a fulcrum mounted proximate to the sprung arm and configured for movement along the length of the sprung arm between the fixed and free ends; and
 - a first tether extending from the free end of the sprung arm to the cam assembly, and a second tether extending from the cam assembly to a load, wherein the sprung arm exerts an unloading force on the load.
2. The device of claim 1, wherein the fulcrum is configured for movement along discrete locations between the fixed end and the free end of the sprung arm.
3. The device of claim 1, wherein the fulcrum is configured for movement along continuous locations between the fixed end and the free end of the sprung arm.
4. The device of claim 1, further comprising a pulley, wherein, between the sprung arm and the cam assembly, the first tether extends through around the pulley.
5. The device of claim 4, wherein the pulley is mounted for translational movement between first and second positions.
6. The device of claim 5, wherein the pulley is connected to a winch device to impart movement of the pulley between the first and second positions.

7. The device of claim 5, wherein:
 - in the first position of the pulley, the first tether extends from the pulley to the cam assembly in a direction which is not tangential to the cam assembly; and
 - in the second position of the pulley, the first tether ends from the pulley to the cam assembly in a direction which is tangential to the cam assembly.
8. The device of claim 1, further comprising a brake configured to prevent movement of the second tether.
9. The device of claim 1, wherein the sprung arm is a flat spring with a uniform cross section throughout the length of the sprung arm.
10. A bodyweight unloading locomotive device comprising:
 - a frame configured to support locomotive movement;
 - a sprung arm having a fixed end fixed to the frame, an opposed free end, and a length extending between the fixed and free ends;
 - a cam assembly mounted for rotational movement;
 - a fulcrum mounted proximate to the sprung arm and configured for movement along the length of the arm between the fixed and free ends;
 - a pulley assembly; and
 - a first tether extending from the free end of the sprung arm to the cam assembly, a second tether extending from the cam assembly to the pulley assembly, and a third tether extending across the pulley assembly between first and second loads;
 wherein the sprung arm exerts an unloading force on the pulley assembly.
11. The device of claim 10, wherein the fulcrum is configured for movement between the fixed end and the free end of the sprung arm among locations which are discrete with respect to each other.
12. The device of claim 10, wherein the fulcrum is configured for movement between the fixed end and the free end of the sprung arm among locations which are continuous with respect to each other.
13. The device of claim 10, further comprising a first pulley mounted for translational movement between first and second positions, wherein the first tether extends through the first pulley between the sprung arm and the cam assembly.
14. The device of claim 13, wherein the first pulley is configured to be moved between the first and second positions manually.
15. The device of claim 10, wherein the pulley assembly includes a major pulley, first and second minor pulleys flanking the major pulley, and the third tether extends from the first load, around a first side of the first minor pulley, around a second side of the major pulley, around a first side of the second minor pulley, and to the second load, wherein the first sides are opposed from the second side on the pulley assembly.
16. The device of claim 15, wherein the major pulley is mounted for translational movement between first and second positions toward and away from the first and second minor pulleys.
17. The device of claim 16, wherein the major pulley is mounted for free translational movement between the first and second positions such that it defines a moveable pulley.

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