US 20250255770A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2025/0255770 A1**

Burns et al.

(43) **Pub. Date: Aug. 14, 2025**

(54) **BODYWEIGHT UNLOADING LOCOMOTIVE DEVICE**

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(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.

Publication Classification

(51) **Int. Cl.**

A61H 3/04 (2006.01)

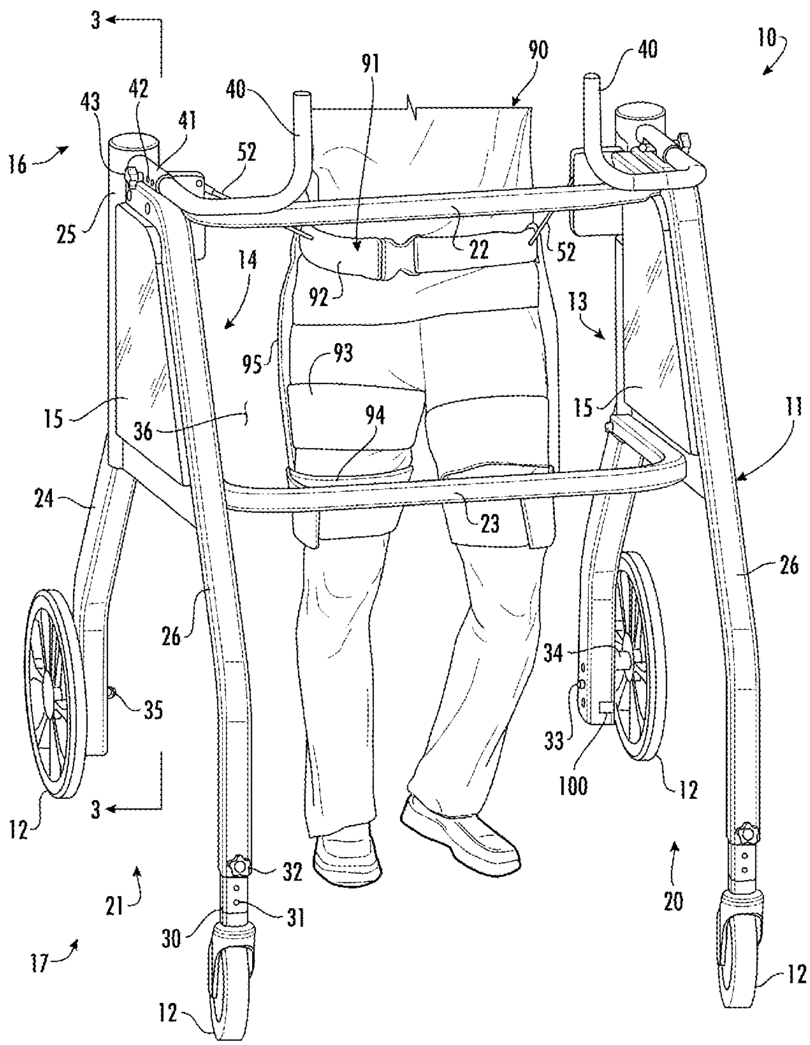
A61H 3/00 (2006.01)

(52) **U.S. Cl.**

CPC *A61H 3/04* (2013.01); *A61H 2003/007* (2013.01); *A61H 2201/1418* (2013.01); *A61H 2201/1652* (2013.01)

(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.



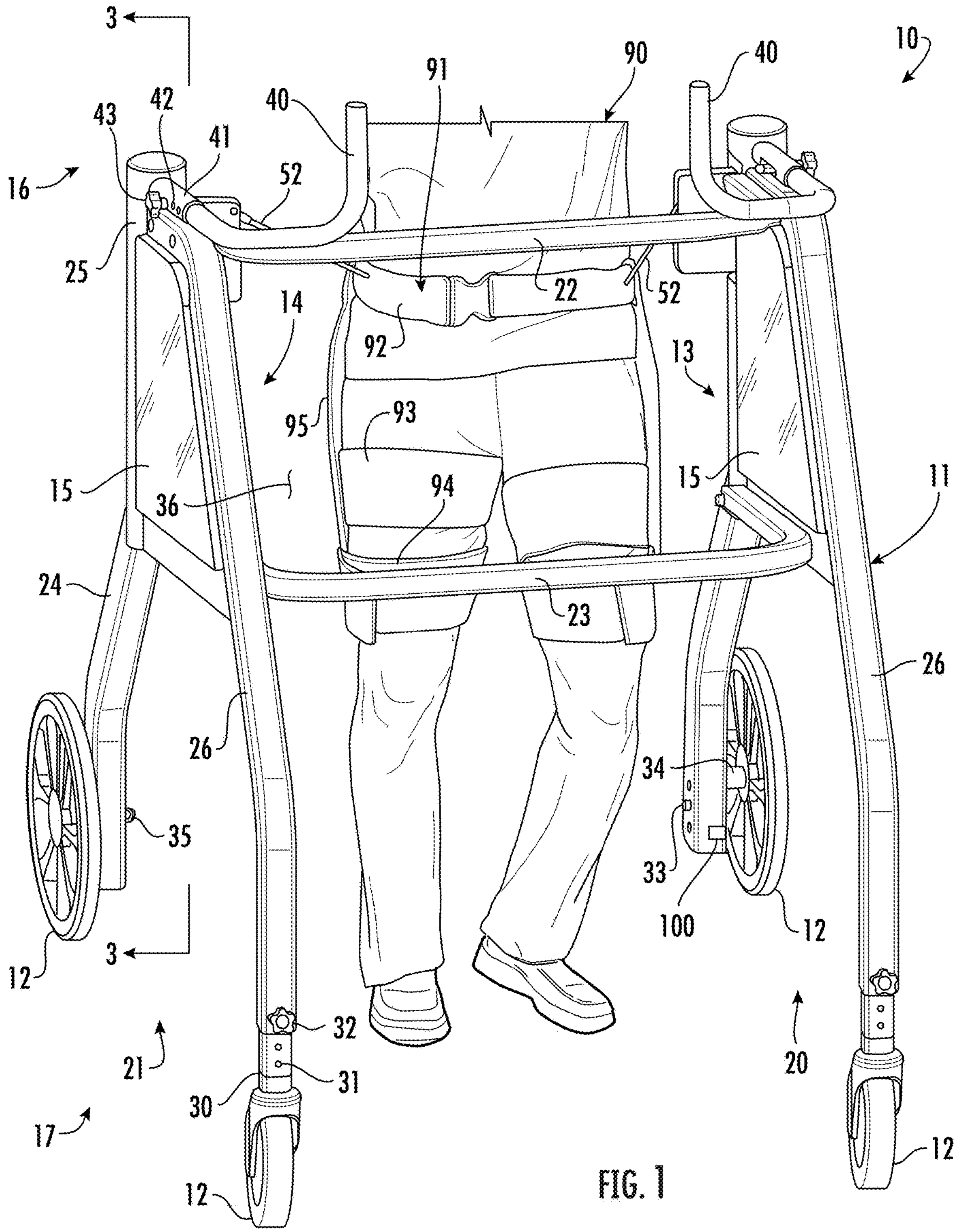

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FIG. 1

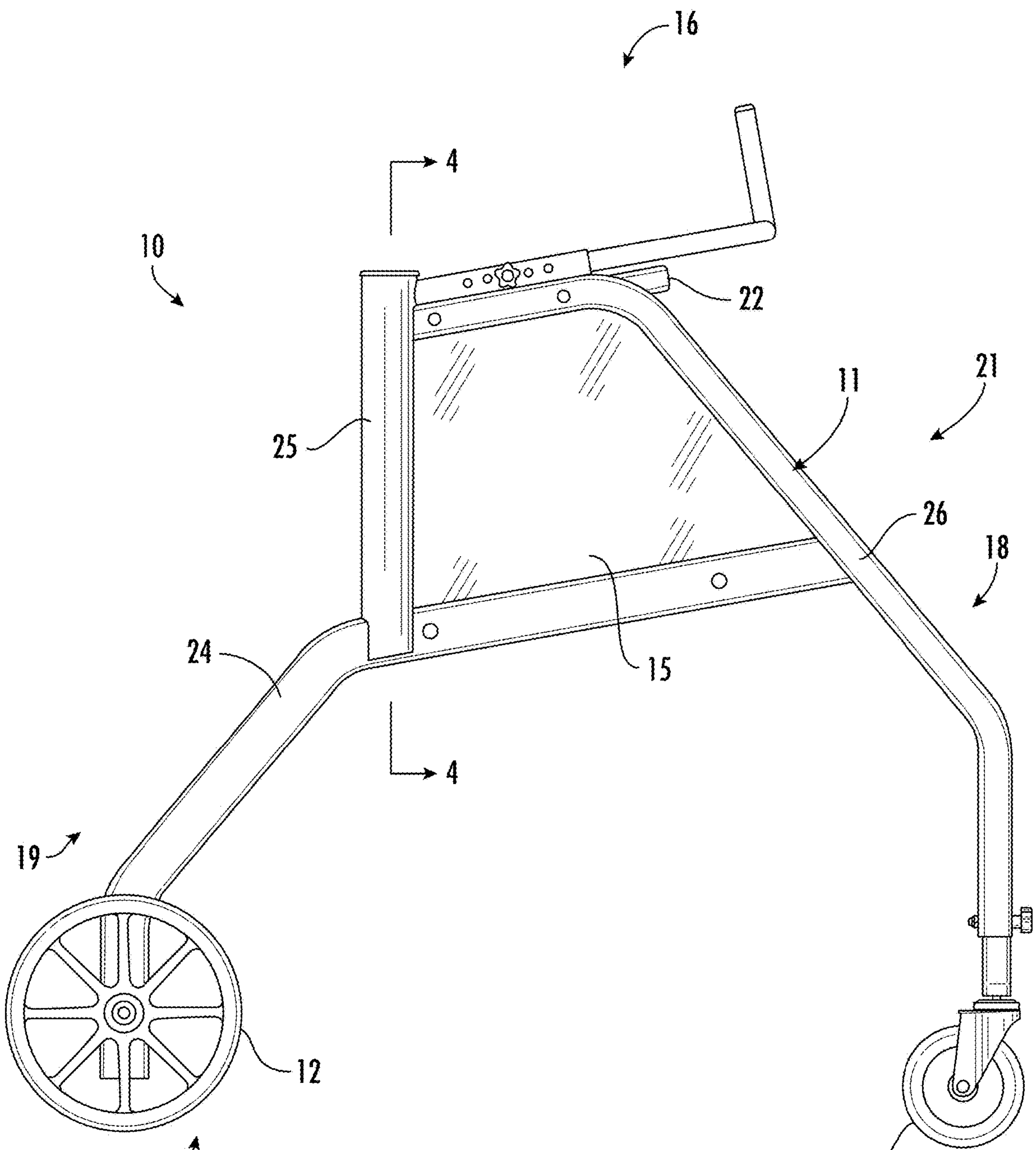

FIG. 2

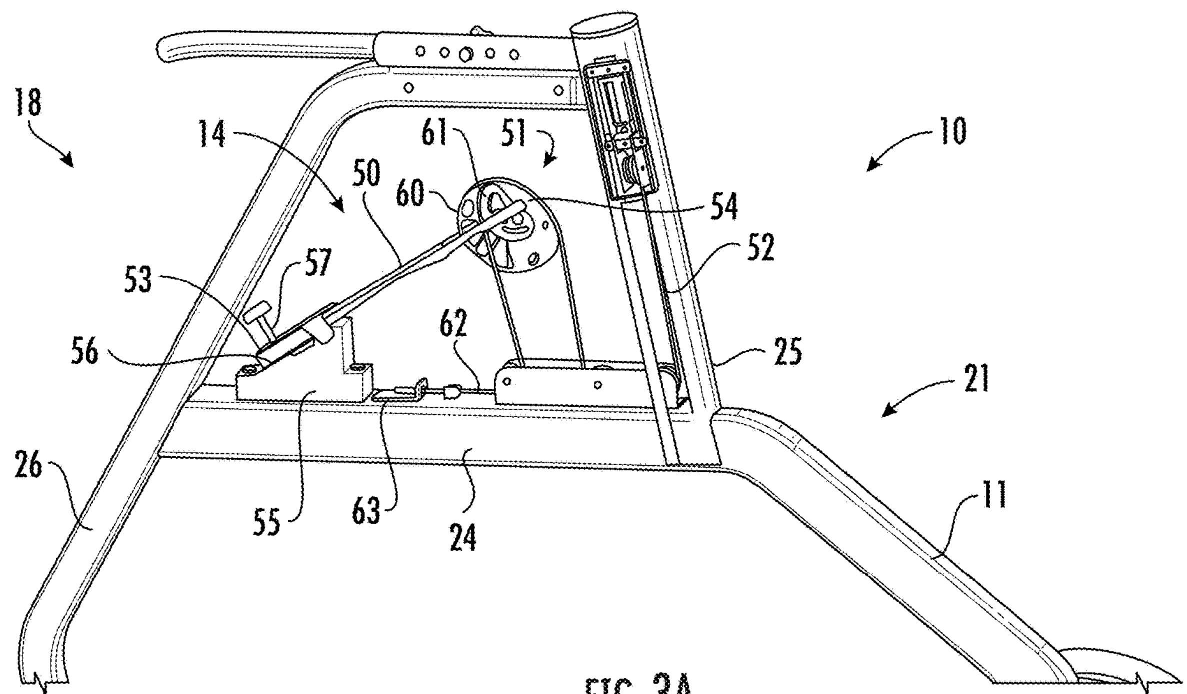
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FIG. 3A

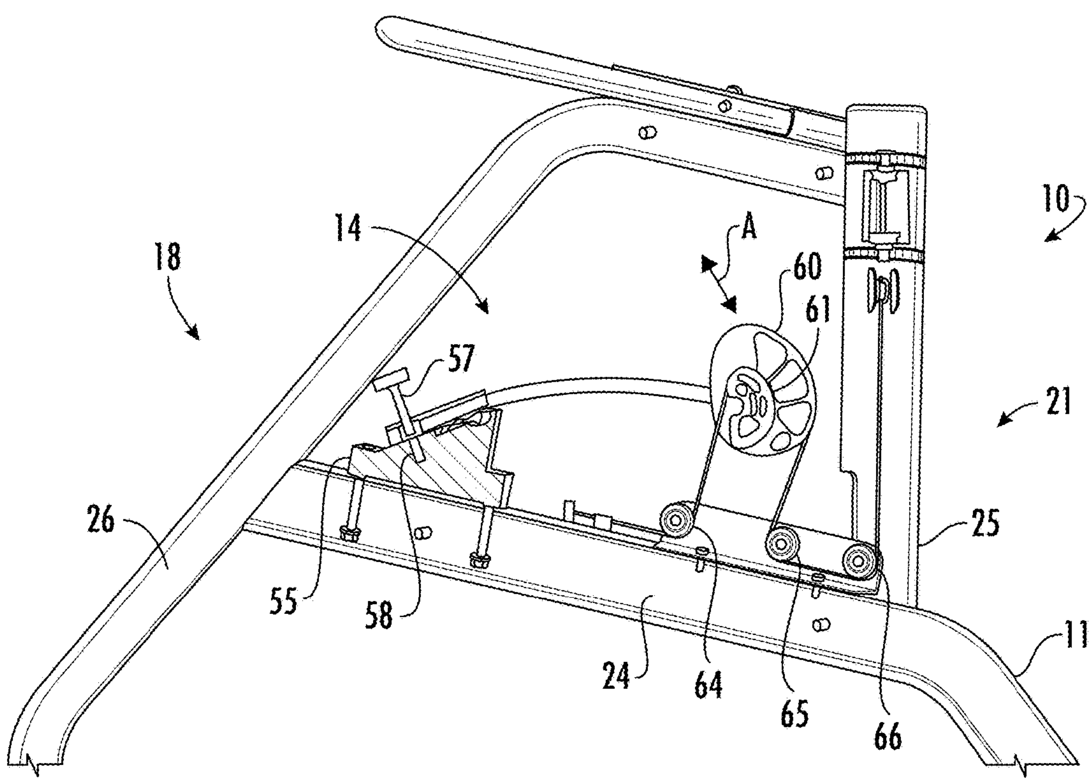
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FIG. 3B

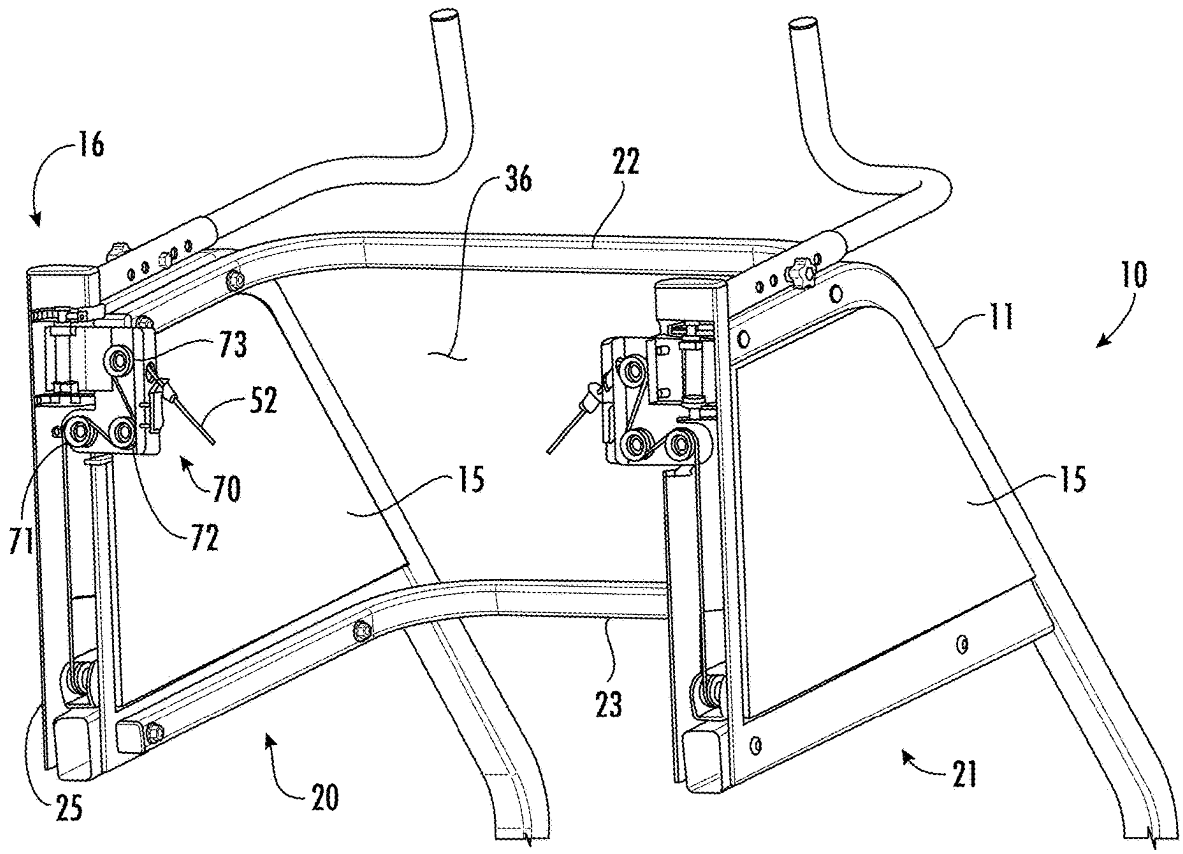
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FIG. 4A

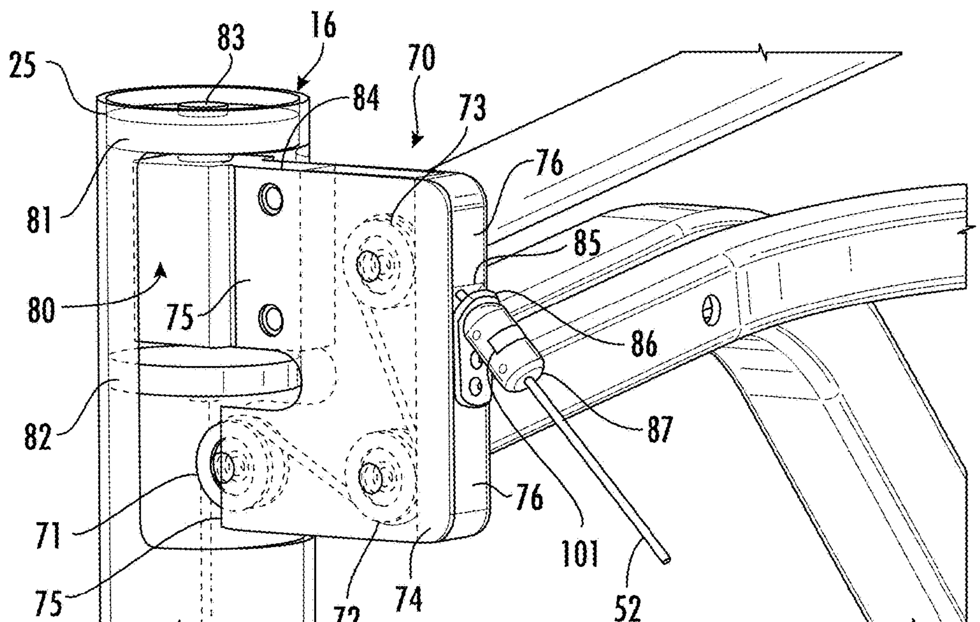
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FIG. 4B

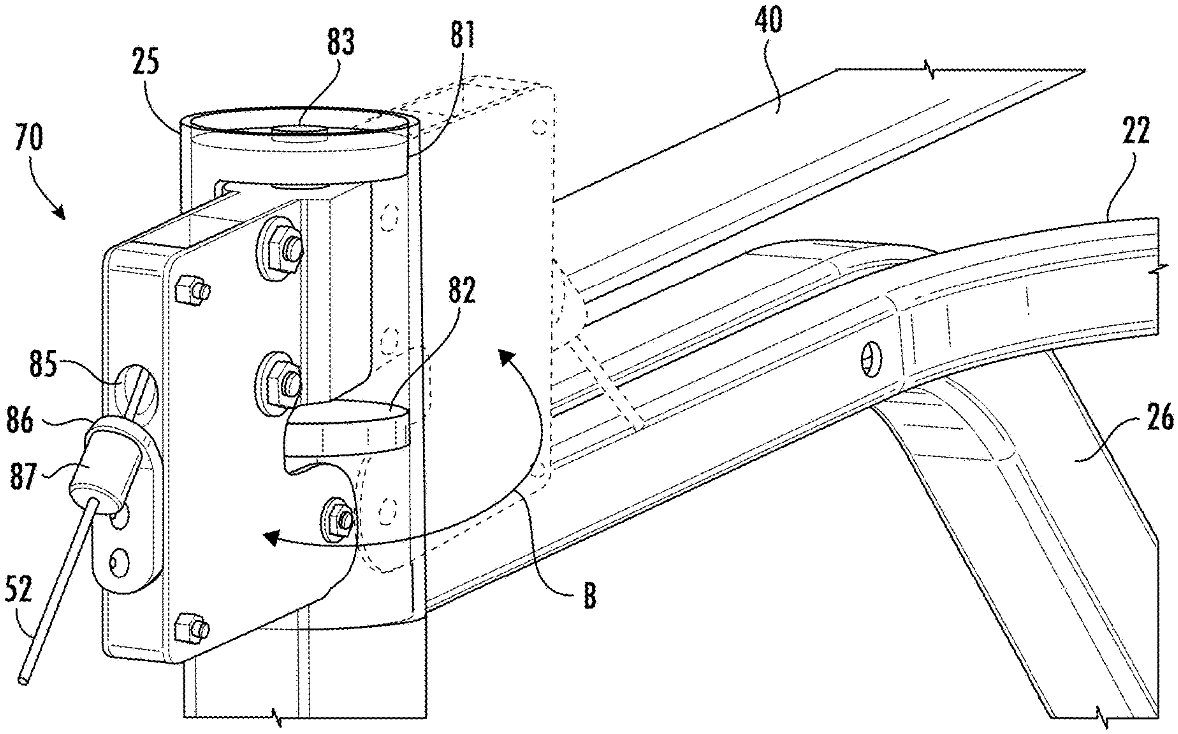

FIG. 4C

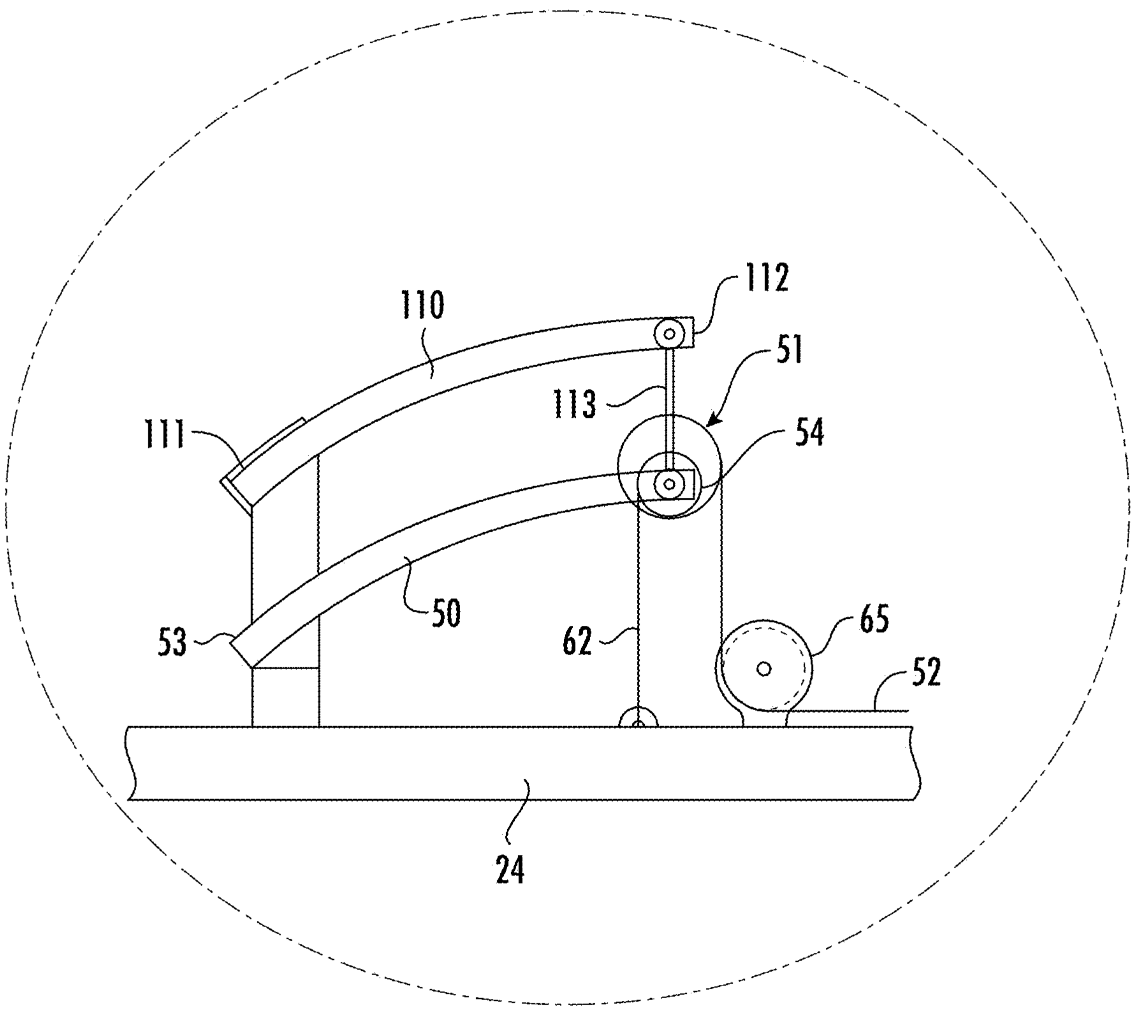

FIG. 5

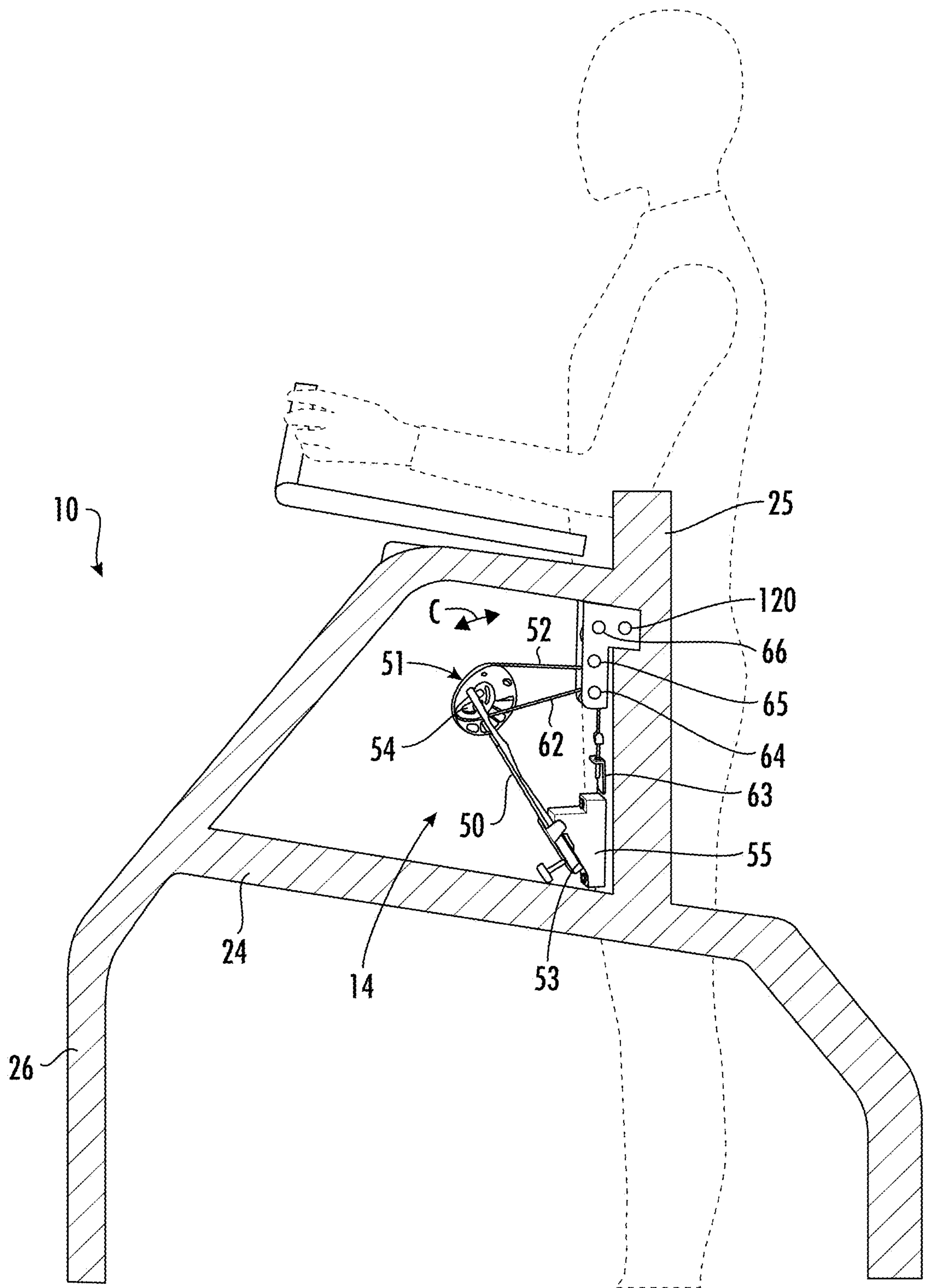

FIG. 6

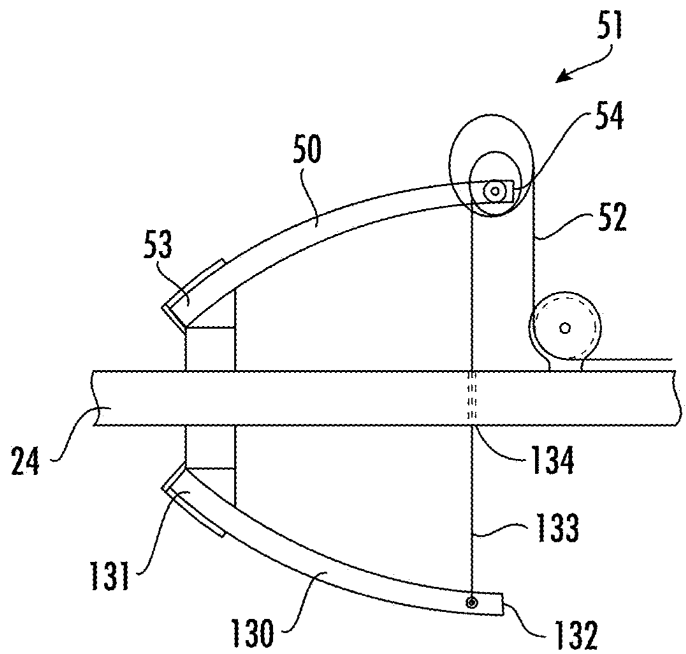

FIG. 7

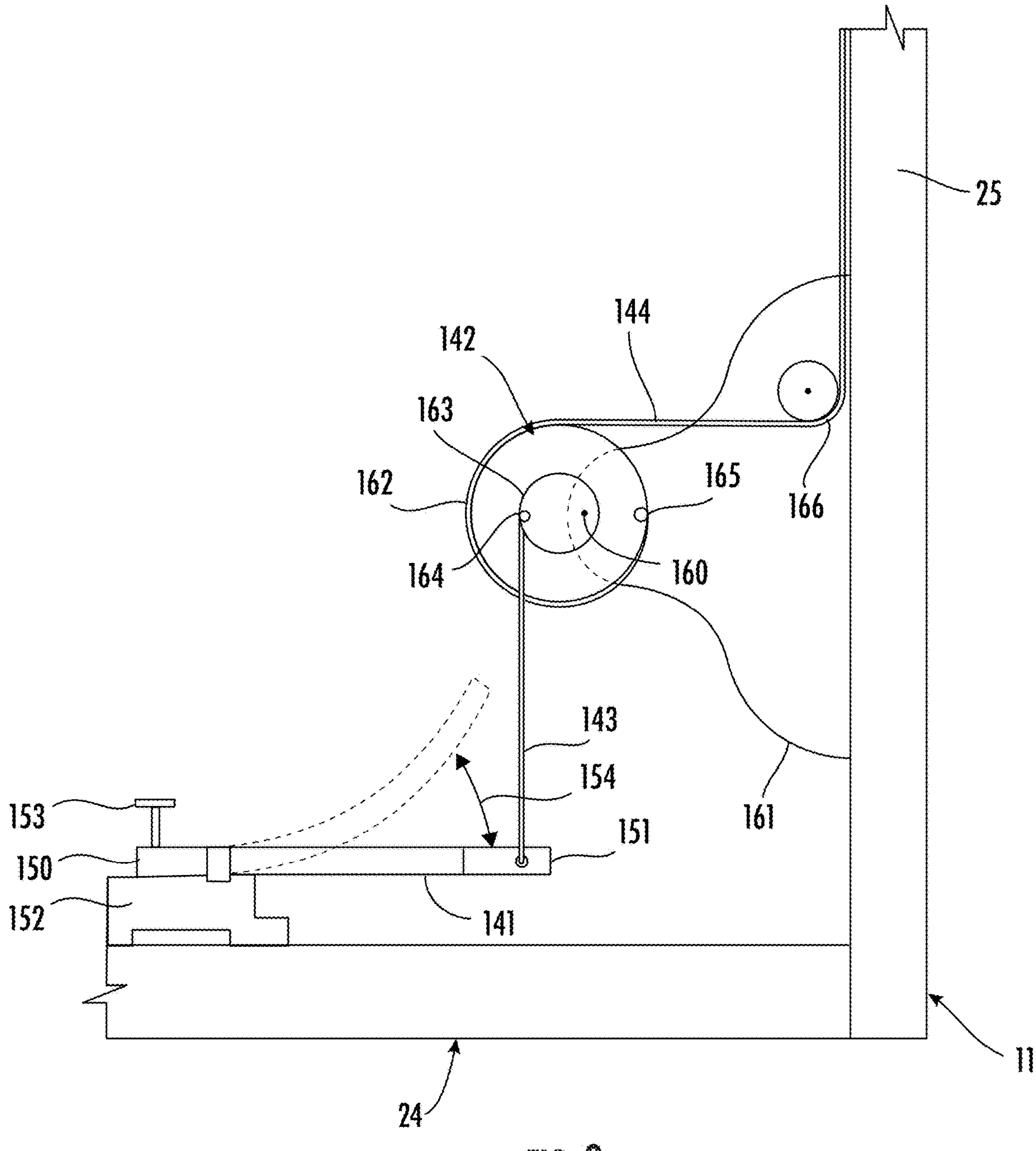
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FIG. 8

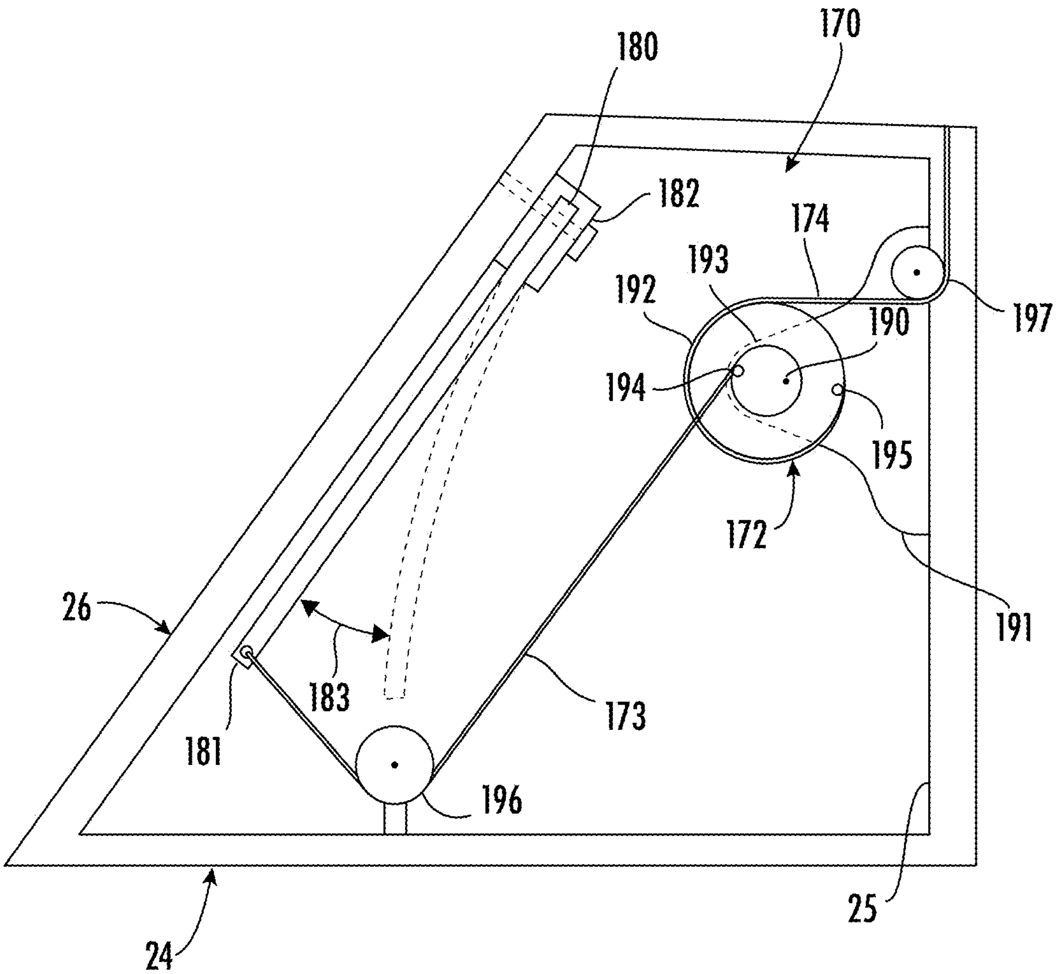
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FIG. 9

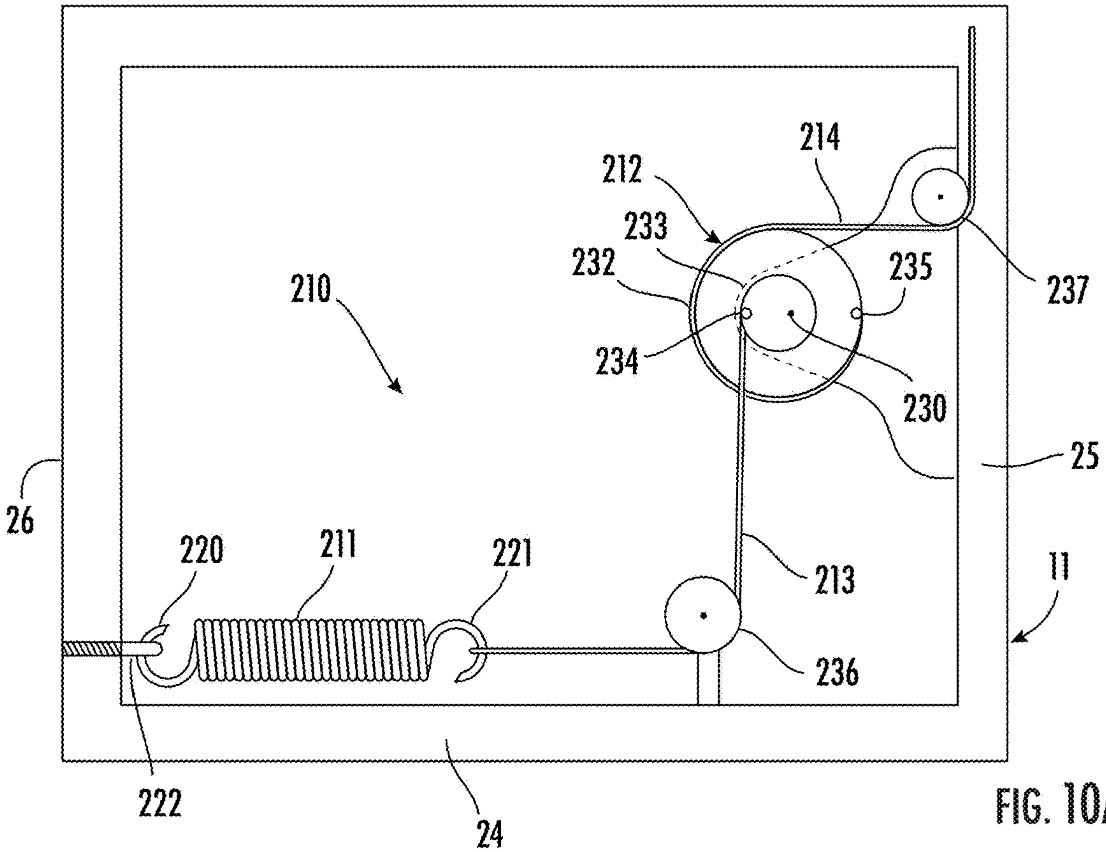

FIG. 10A

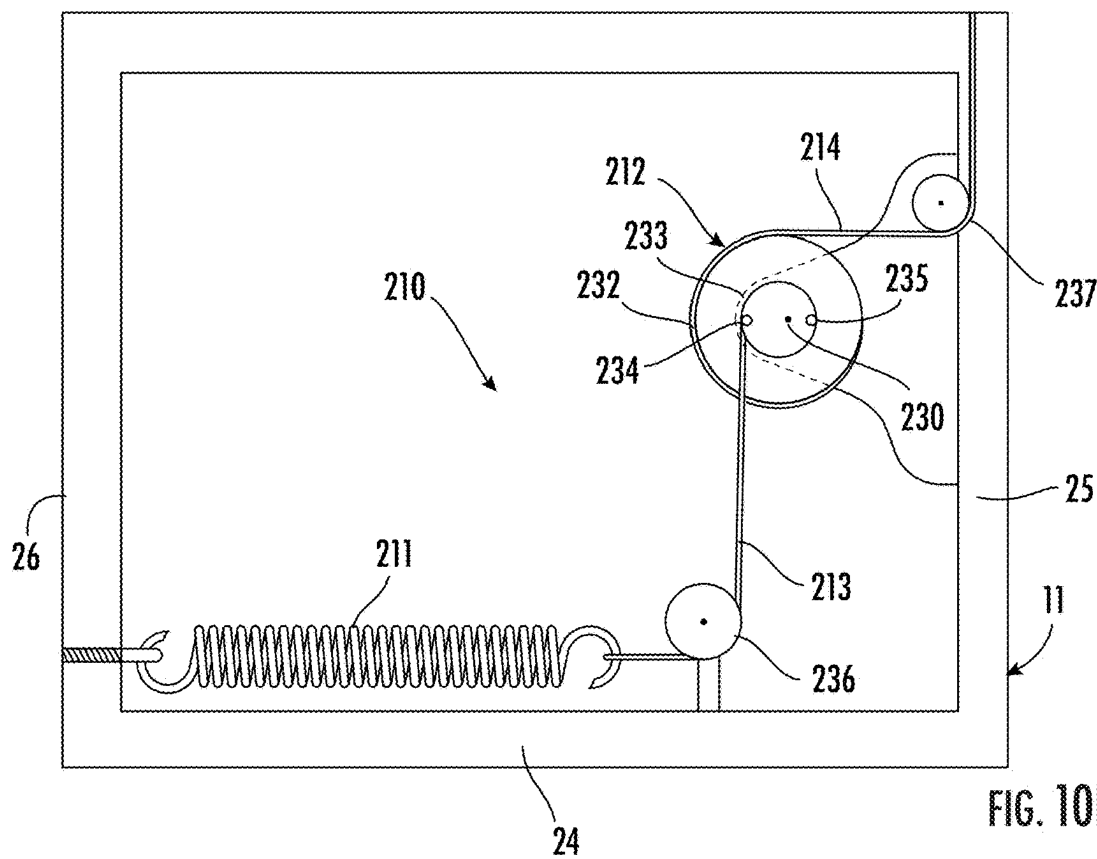

FIG. 10B

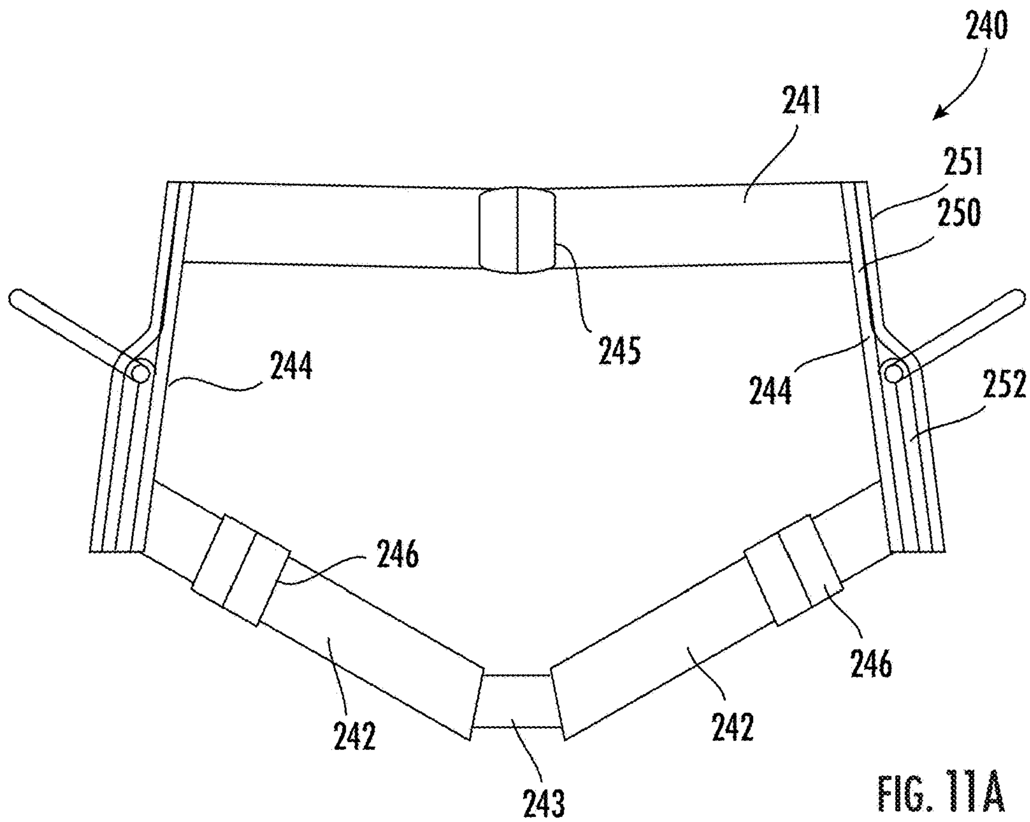

FIG. 11A

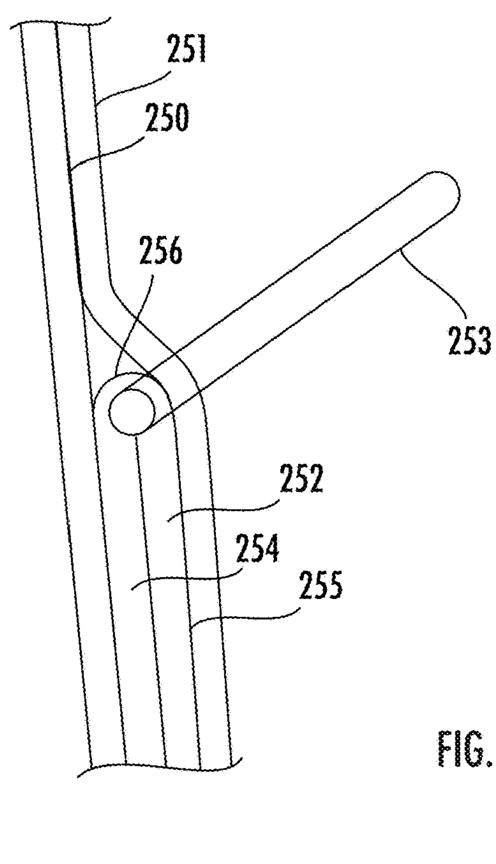

FIG. 11B

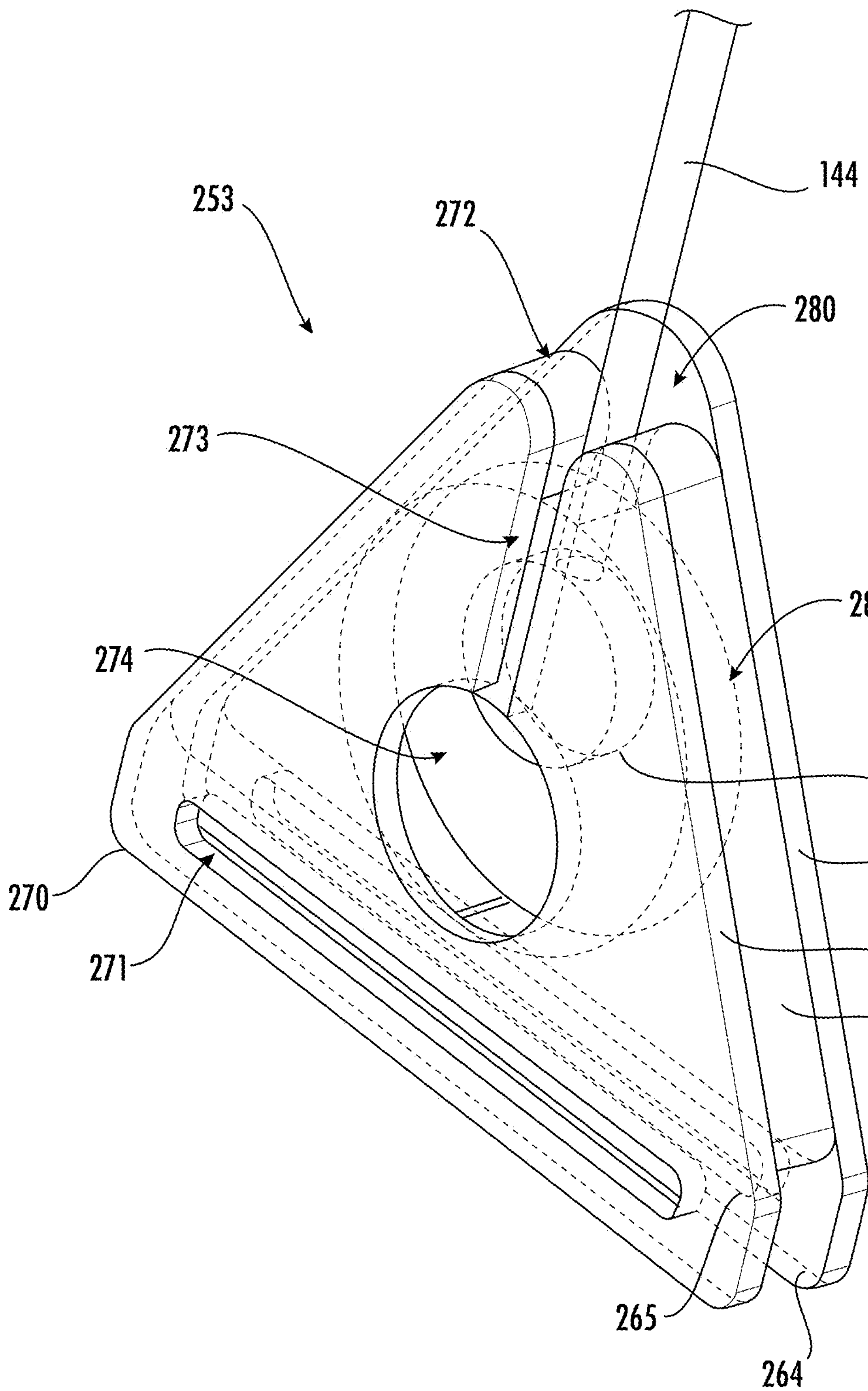

FIG. 11C

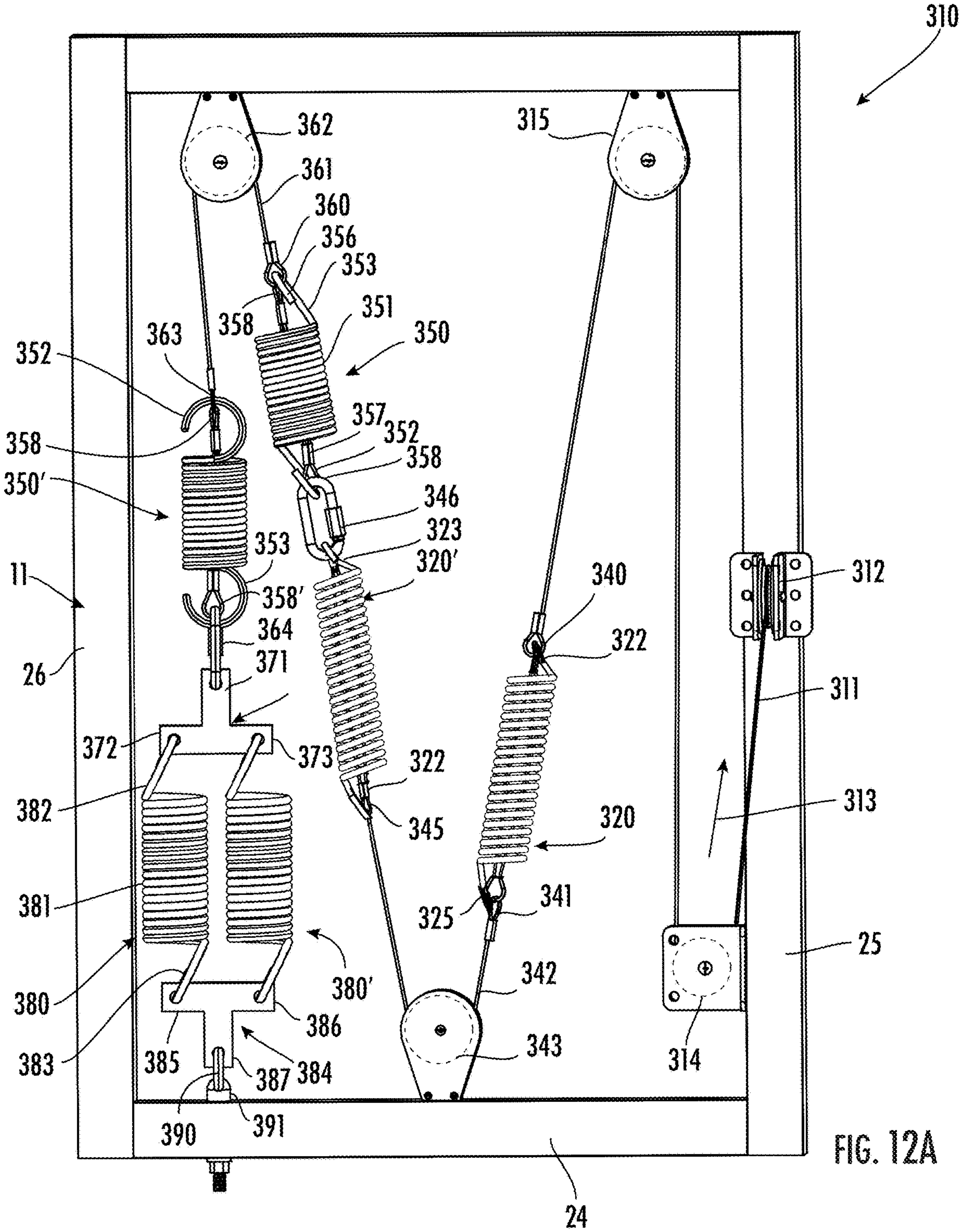
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FIG. 12A

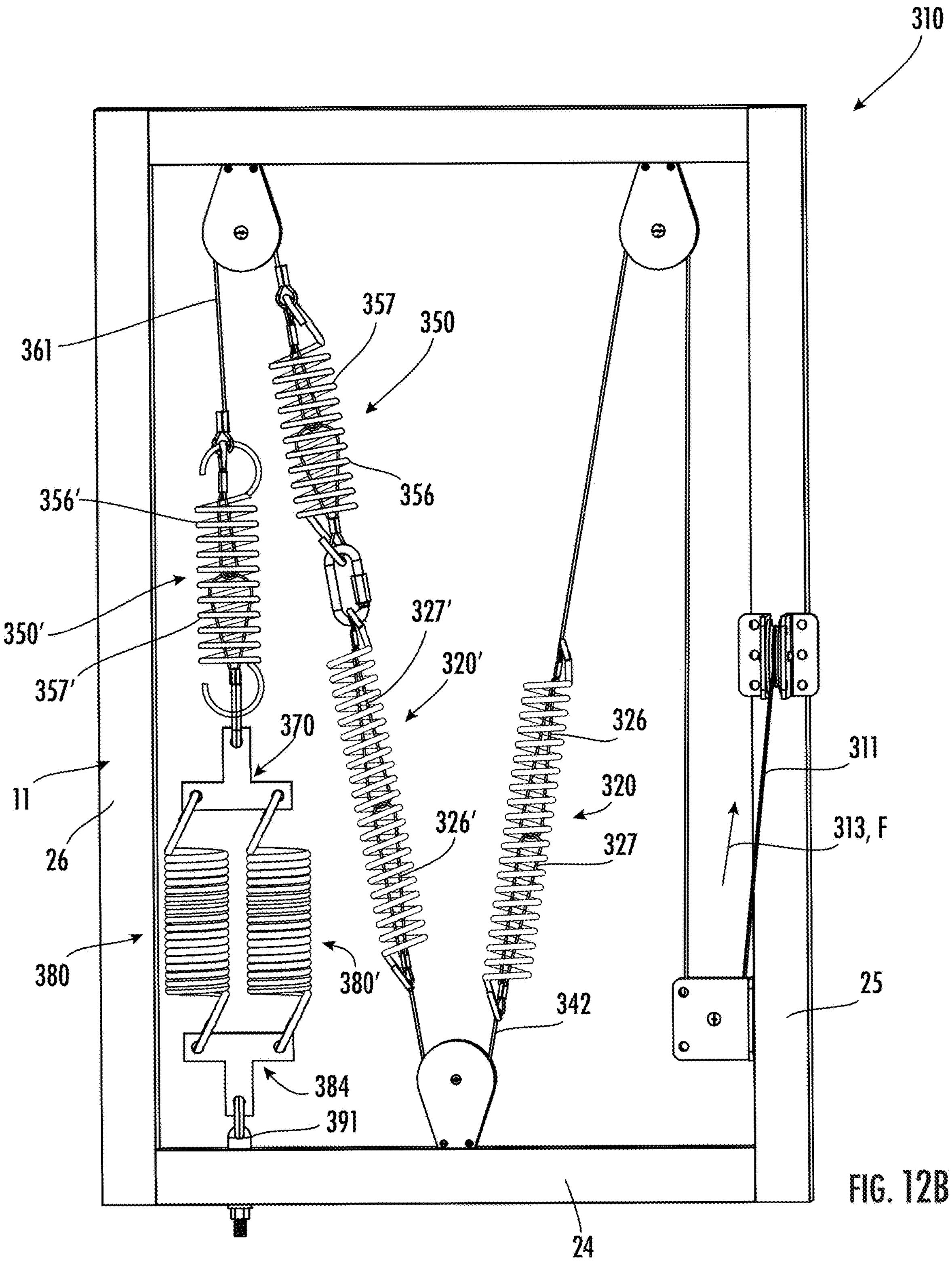
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FIG. 12B

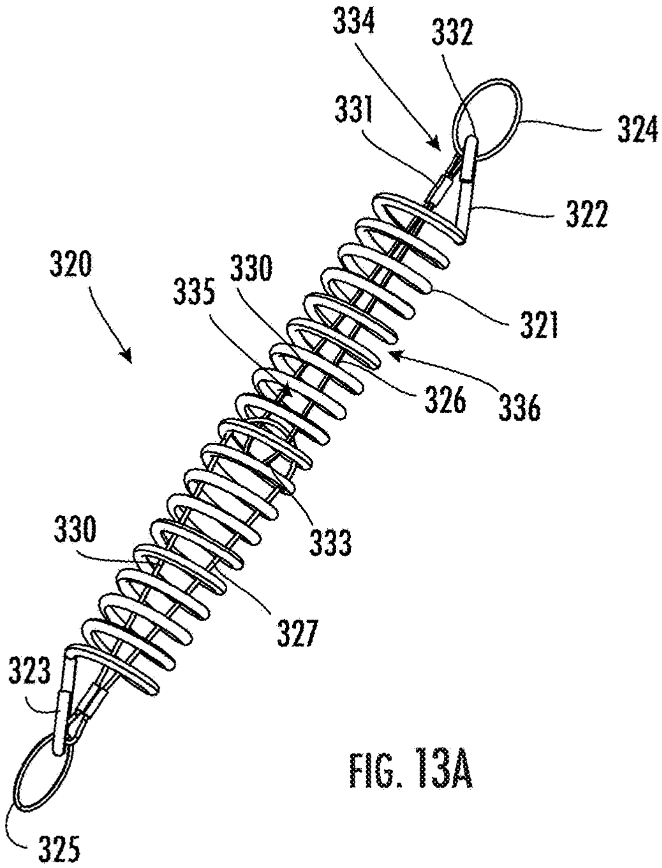

FIG. 13A

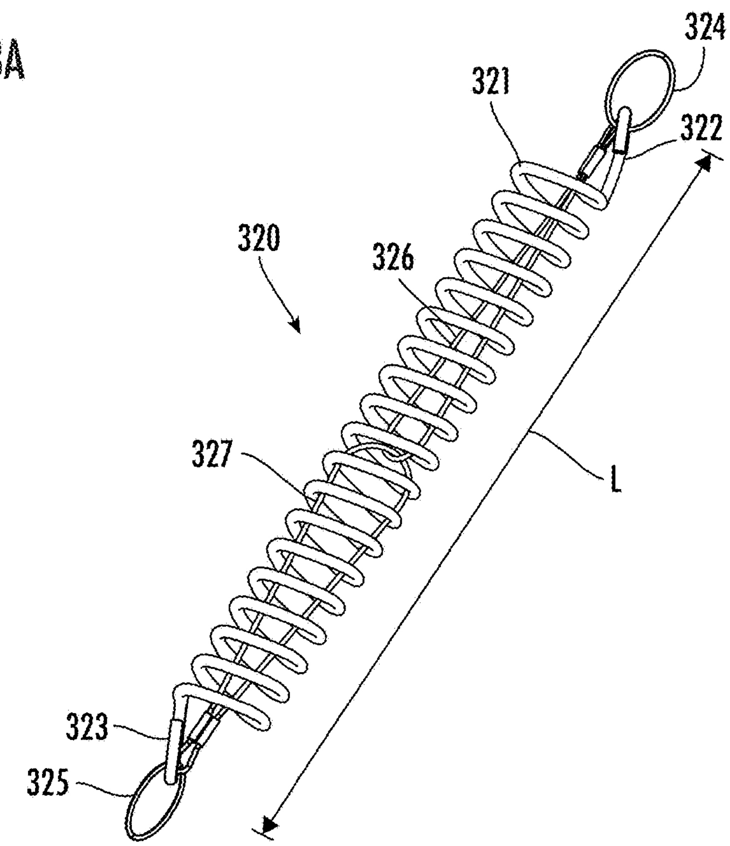

FIG. 13B

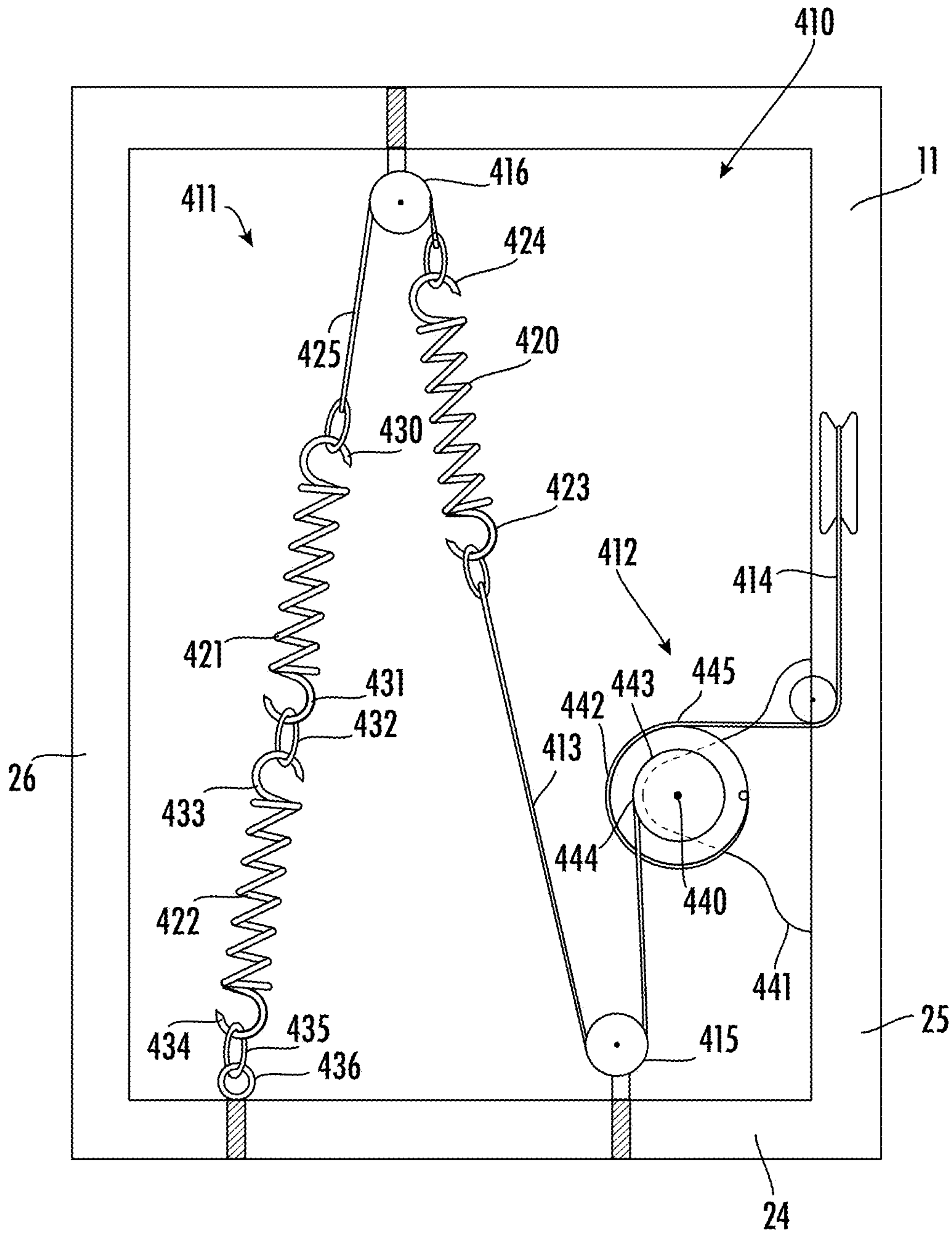
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FIG. 14

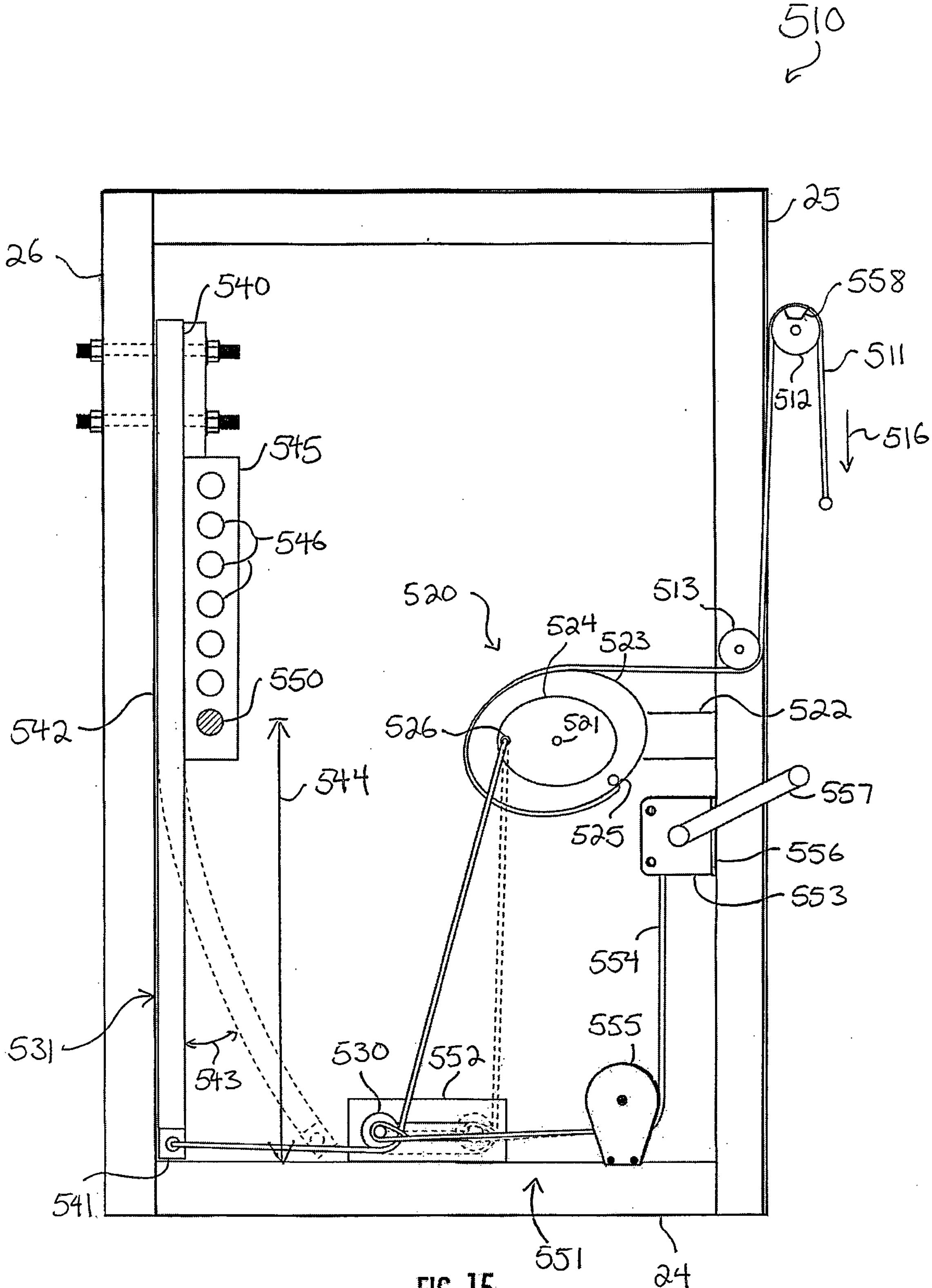
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FIG. 15

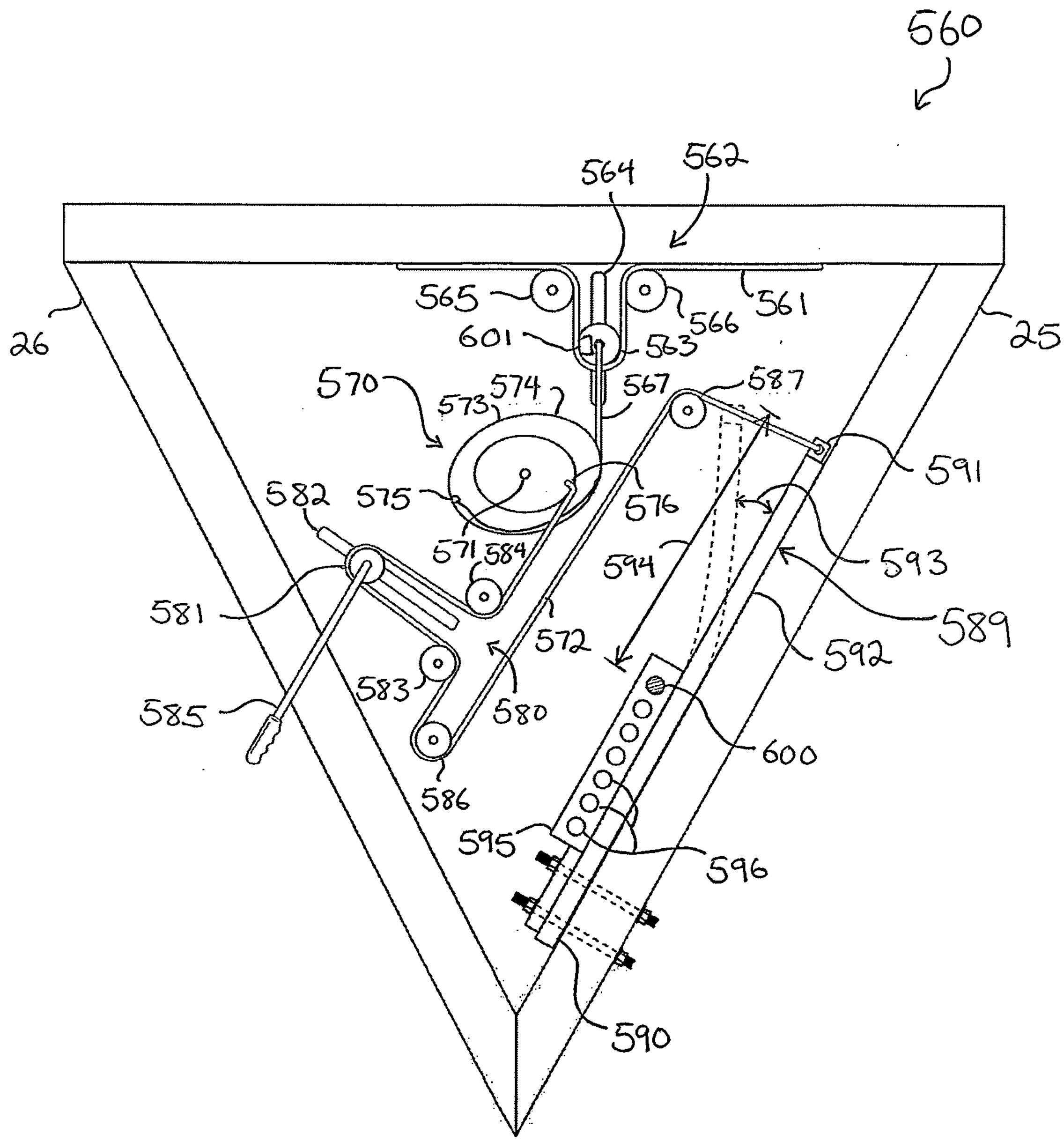
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FIG. 16

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 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.

[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. **3**A 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. **3**B 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. **4**A is a section view taken along the line **4-4** in FIG. **2**, showing pulley cassettes on the bodyweight unloading locomotive device;

[0025] FIGS. **4**B and **4**C 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. **8-10**B are enlarged, generalized diagrams illustrating alternative embodiments of the unloading assembly;

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

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

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

[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. **3**A and **3**B. 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. **3**A and **3**B show the right side **21** of the frame **11**. In FIG. **3**A, the panel **15** is removed so that the unloading assembly **14** is visible; FIG. **3**B 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. **3**A, in which the free end **54** is in a high position above the fixed end **53**, and second, loaded position as shown in FIG. **3**B, 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-arrowed line A in FIG. **3**B. 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 on 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. **4**A-**4**C 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. **4**C) and a rearward position (shown in solid line) along the double-arrowed arcuate line B in FIG. **4**C. FIG. **4**C 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. **4**A and **4**B.

[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. **4**A and **4**B, 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. **3**A: 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. **3**A and **3**B 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 horizonal configuration of FIG. **3**B. 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. **3**A: 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. **8-10**B 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 three 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. **10**A and **10**B 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 horizonal length of the main tube **24**. The free end **221** of the spring **211** is disposed toward the housing **24**. FIG. **10**A shows a first, "unloaded" position, and FIG. **10**B 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. **10**A and **10**B, 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. **11**A-**11**C 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. **11**A and **11**B, 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. **11**C. 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. **11**C, 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. **11**C. 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. **11**C. 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. **11**C. 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 inadvertently 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. **12**A and **12**B 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. **12**A. 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. **13**A and **13**B, in first and second conditions.

[0122] Turning to those FIGS. **13**A and **13**B, 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. **13**B. 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. **12**A, 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. **12**A 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. **12**A. 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. **12**A. 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. **12**A) 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 though-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. **12**A and **12**B, 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. **12**A, 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. **12**A and then through the pulleys **314** and **315** to the light spring assembly **320**. FIG. **12**A 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. **12**A, the stabilizing assembly **310** is in a first or unloaded position, and it moves into a second or loaded position, as shown in FIG. **12**B, 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. **12**A. This force F propagates through the entire stabilizing assembly **310**, causing the stabilizing assembly **310** to move into the loaded position shown in FIG. **12**B. 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. **12**B 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. **12**B 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 a 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 light-weight, 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-arrowed 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-arrowed 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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