United States Patent Application Publication 20250249807
Kind Code A1
Publication Date August 07, 2025
Inventor(s) Stover; Dale A. et al.

GROUNDS MAINTENANCE VEHICLE WITH ADJUSTABLE SUSPENSION SYSTEM

Abstract

Suspension systems and grounds maintenance vehicles incorporating the same are disclosed. The suspension system may include biasing elements or springs that may be adjusted to vary the preload and thus change the spring and dampening characteristics of the suspension system. In some embodiments, the system may include an adjustment mechanism that permits simultaneous adjustment of two springs via a single action. In other embodiments, features adapted to assist an operator with mounting/dismounting the vehicle are disclosed.

Inventors: **Stover; Dale A. (Plymouth, MN), Hoy; Alexander E. (Lake Elmo, MN), Duchscherer; Derek S. (Eden Prairie, MN), Shaver; Patrick J. (Woodbury, MN)**

Applicant: **THE TORO COMPANY** (Bloomington, MN)

Family ID: **66096896**

Appl. No.: **19/189858**

Filed: **April 25, 2025**

Related U.S. Application Data

parent US continuation 18205770 20230605 parent-grant-document US 12311818 child US 19189858
parent US continuation 17983199 20221108 parent-grant-document US 11712984 child US 18205770
parent US continuation 17095453 20201111 parent-grant-document US 11498464 child US 17983199
parent US continuation 16157506 20181011 parent-grant-document US 10864832 child US 17095453
us-provisional-application US 62572814 20171016

Publication Classification

Int. Cl.: **B60N2/50** (20060101); **A01D34/64** (20060101); **A01D34/82** (20060101); **A01D67/04** (20060101); **A01D101/00** (20060101); **B60N2/54** (20060101); **B62D21/03** (20060101); **B62D24/04** (20060101); **B62D27/04** (20060101)

U.S. Cl.:

CPC **B60N2/505** (20130101); **A01D34/64** (20130101); **A01D34/82** (20130101); **A01D67/04** (20130101); **B60N2/548** (20130101); **B62D21/03** (20130101); **B62D24/04** (20130101); **B62D27/04** (20130101); A01D2101/00 (20130101)

Background/Summary

[0001] This application claims the benefit of U.S. Provisional Pat. App. No. 62/572,814, filed Oct. 16, 2017, the content of which is incorporated herein by reference in its entirety. [0002] Embodiments of the present disclosure are directed generally to riding grounds maintenance vehicles (e.g., turf care vehicles such as lawn mowers) having an adjustable suspension system, and, in other embodiments, vehicle access features to assist with mounting and dismounting the vehicle.

BACKGROUND

[0003] Operators of grounds maintenance vehicles, such as zero-turn-radius (ZTR) mowers, often operate the vehicle for extended periods of time. Accordingly, mowers incorporating some type of suspension system have become more common in recent years. However, there may be significant variability in what operators consider desirable with regard to specific suspension system characteristics (e.g., stiffness/spring rate and dampening). Further, even the same operator may wish to adjust these characteristics over time (or even over the course of a single work day).

[0004] While configurations vary, some known suspension systems are complex and ill-suited to providing the variability in spring rate and/or dampening characteristics needed to satisfy a wide range of operators and terrain types. Moreover, some of these suspension systems are complicated, which may not only increase the cost of manufacture, but may require correspondingly complicated repairs and/or maintenance.

[0005] In addition to ride comfort, convenient access to the mower's operator platform (e.g., seat) is also desirable. Typically, to reach the operator seat, the operator first steps onto the mower's floor pan or foot area, which is generally located immediately forward of the seat. The foot area is usually accessed via the side or the front of the mower.

[0006] When the mower has one or more large cutting decks (or other side or front attachments), mounting the mower may present challenges for some operators (e.g., those of shorter stature and/or those having certain physical limitations). For example, for mowers having relatively wide cutting decks, the operator may be required (when mounting from the side) to extend his or her leg across a relatively large distance in order to step over the cutting deck (if the deck is not suited to bearing the operator's weight).

[0007] In other mowers, various components (e.g., out-front cutting decks) may be located at or near the front end of the mower or, as is common with ZTR mowers, the front of the mower may include a continuous, transverse, and upwardly angled foot rest. Such a configuration may also present challenges for some operators when mounting/dismounting the mower from the front. Due to their unique configuration, ZTR mowers may also lack grab handles or similar structure that may be used by the operator during mounting/dismounting of the mower.

SUMMARY

[0008] Embodiments described herein may provide a grounds maintenance vehicle including: a chassis having a front end, a rear end, and a longitudinal axis extending between the front and rear ends; a support platform extending along the longitudinal axis, wherein the support platform includes a seat support portion; and a suspension system. The suspension system includes a first suspension apparatus operatively acting between the chassis and the seat support portion of the support platform. The first suspension apparatus has first and second torsion springs, wherein the torsion springs are adapted to elastically deflect when the support platform is displaced relative to the chassis. The suspension system further includes: a second suspension apparatus longitudinally spaced-apart from the torsion springs, wherein the second suspension apparatus is operatively connected to both the support platform and the chassis; and an adjuster adapted to simultaneously adjust a preload applied to both of the first and second torsion springs.

[0009] In another embodiment, a grounds maintenance vehicle is provided that includes: a chassis having a front end, a rear end, and a longitudinal axis extending between the front and rear ends. The vehicle also includes a support platform extending along the longitudinal axis, wherein the support platform has a seat support portion, a foot support portion, and a connecting structure connecting the seat support portion to the foot support portion. Moreover, the vehicle includes a suspension system having a first suspension apparatus adapted to bias the support platform away from the chassis. The first suspension apparatus includes first and second torsion springs spaced-apart from one another in a direction transverse to the longitudinal axis, wherein the torsion springs are adapted to elastically deflect when the support platform is displaced toward the chassis. The suspension system also includes: a second suspension apparatus longitudinally spaced-apart from the first suspension apparatus, wherein the second suspension apparatus is also adapted to bias the support platform away from the chassis; and an adjuster adapted to simultaneously alter a preload applied to both of the first and second torsion springs.

[0010] In yet another embodiment, a riding lawn mower is provided that includes: a chassis having a front end, a rear end, and a longitudinal axis extending between the front and rear ends; and a support platform extending along the longitudinal axis. The support platform includes: a seat support portion supporting an operator seat; a foot support portion; and a connecting structure connecting the seat support portion to the foot support portion. The mower also includes a pivot member defining a transverse first pivot axis and a transverse second pivot axis, wherein the pivot member is: pivotally coupled to the chassis at the first pivot axis; and pivotally coupled to the support platform at the second pivot axis. A suspension system is also provided and includes first and second torsion springs positioned about the second pivot axis. The torsion springs operatively bias the support platform upwardly and away from the chassis and elastically deflect when the support platform is displaced toward the chassis. The torsion springs are located longitudinally near the seat support portion. The suspension system also includes: a coil-over shock absorber positioned longitudinally forward from the first and second torsion springs, wherein the shock absorber is operatively connected to the platform and to the chassis; and an adjuster adapted to simultaneously alter a preload applied to both of the first and second torsion springs.

[0011] The above summary is not intended to describe each embodiment or every implementation. Rather, a more complete understanding of illustrative embodiments will become apparent and appreciated by reference to the following Detailed Description of Exemplary Embodiments and claims in view of the accompanying figures of the drawing.

Description

BRIEF DESCRIPTION OF THE VIEWS OF THE DRAWING

[0012] Exemplary embodiments will be further described with reference to the figures of the

drawing, wherein:
[0013] FIG. **1** illustrates a grounds maintenance vehicle, e.g., riding lawn mower, incorporating an adjustable suspension system in accordance with embodiments of the present disclosure;
[0014] FIG. **2** is a partial perspective view of the mower of FIG. **1** illustrating portions of the exemplary suspension system;
[0015] FIG. **3** is another partial perspective view of the mower of FIG. **1** with components (e.g., the seat and seat frame) shown exploded from a platform of the mower;
[0016] FIG. **4** is a view similar to FIG. **2**, but with a support platform removed to better illustrate aspects of the exemplary suspension system;
[0017] FIG. **5** is an enlarged partial perspective view of a portion (e.g., first suspension apparatus) of the suspension system of FIGS. **1-4**;
[0018] FIG. **6** is a torsion spring that forms an exemplary biasing element of the first suspension apparatus;
[0019] FIG. **7** is a section view taken along line **7-7** of FIG. **5** illustrating the suspension system when the support platform is unloaded and a preload adjustment mechanism of the system is set for a minimal (“least-stiff”) preload of the biasing elements;
[0020] FIG. **8** is a bottom perspective view of portions of an exemplary suspension system in isolation;
[0021] FIG. **9** is a side elevation view of a lever-operated preload adjustment mechanism in accordance with embodiments of the present disclosure, the preload adjustment mechanism adapted to alter the preload of biasing elements of the suspension system;
[0022] FIG. **10** is a section view similar to FIG. **7** (i.e., the support platform shown unloaded), but with the preload adjustment mechanism set to provide an intermediate preload to the biasing elements;
[0023] FIG. **11** is a partial perspective view of a preload adjustment mechanism in accordance with another embodiment of the present disclosure, the mechanism including a two-step adjustment procedure;
[0024] FIG. **12** is bottom perspective view of the preload adjustment mechanism of FIG. **11**;
[0025] FIG. **13** is section view taken along line **13-13** of FIG. **11** showing a lever lock in a closed position;
[0026] FIG. **14** is a section view similar to FIG. **13**, but illustrating the lever lock in an open position;
[0027] FIG. **15** is a partial perspective view of a suspension system in accordance with another embodiment of the present disclosure, wherein the preload adjustment mechanism includes a threaded screw;
[0028] FIG. **16** is another perspective view of the suspension system of FIG. **15**;
[0029] FIG. **17** is a section view taken along line **17-17** of FIG. **16** illustrating the suspension system when the support platform is unloaded and the preload adjustment mechanism is set for a minimal preload of the biasing elements;
[0030] FIG. **18** is a perspective view of the section shown in FIG. **17**;
[0031] FIG. **19** is a section view similar to FIG. **17**, but shown with the support platform loaded;
[0032] FIG. **20** is a section view similar to FIG. **17** (i.e., the support platform shown unloaded), but with the preload adjustment mechanism set to provide an intermediate preload to the biasing elements;
[0033] FIG. **21** is a partial, perspective section view of a suspension system in accordance with another embodiment of the present disclosure, wherein the first suspension apparatus is configured as a single coil-over shock absorber;
[0034] FIG. **22** is a direct section view of the suspension system of FIG. **21**;
[0035] FIG. **23** is a partial perspective view of mount/dismount assist bar in accordance with embodiments of the present disclosure;

[0036] FIG. **24** is a side elevation view of the assist bar of FIG. **23** in both a deployed position (solid lines) and a stowed position (broken lines);

[0037] FIG. **25** is a perspective view of a grounds maintenance vehicle (e.g., riding lawn mower) in accordance with another embodiment of the present disclosure, the mower shown incorporating low, step-through front access; and

[0038] FIG. **26** is a partial, isolated view of a chassis of the mower of FIG. **25**.

[0039] The figures are rendered primarily for clarity and, as a result, are not necessarily drawn to scale. Moreover, various structure/components, including but not limited to fasteners, electrical components (wiring, cables, etc.), and the like, may be shown diagrammatically or removed from some or all of the views to better illustrate aspects of the depicted embodiments, or where inclusion of such structure/components is not necessary to an understanding of the various exemplary embodiments described herein. The lack of illustration/description of such structure/components in a particular figure is, however, not to be interpreted as limiting the scope of the various embodiments in any way.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0040] In the following detailed description of illustrative embodiments, reference is made to the accompanying figures of the drawing which form a part hereof. It is to be understood that other embodiments, which may not be described and/or illustrated herein, are certainly contemplated.

[0041] All headings provided herein are for the convenience of the reader and should not be used to limit the meaning of any text that follows the heading, unless so specified. Moreover, unless otherwise indicated, all numbers expressing quantities, and all terms expressing direction/orientation (e.g., vertical, horizontal, parallel, perpendicular, etc.) in the specification and claims are to be understood as being modified in all instances by the term “about.” The term “and/or” (if used) means one or all of the listed elements or a combination of any two or more of the listed elements. “I.e.” is used as an abbreviation for the Latin phrase id est, and means “that is.” “E.g.” is used as an abbreviation for the Latin phrase exempli gratia, and means “for example.”

[0042] It is noted that the terms “comprises” and variations thereof do not have a limiting meaning where these terms appear in the accompanying description and claims. Further, “a,” “an,” “the,” “at least one,” and “one or more” are used interchangeably herein. Moreover, relative terms such as “left,” “right,” “front,” “fore,” “forward,” “rear,” “aft,” “rearward,” “top,” “bottom,” “side,” “upper,” “lower,” “above,” “below,” “horizontal,” “vertical,” and the like may be used herein and, if so, are from the perspective of one operating the vehicle (e.g., mower **100** of FIG. **1**) while it is in an operating configuration, e.g., while the mower **100** is positioned such that wheels **106** and **108** rest upon a generally horizontal ground surface **105**. These terms are used only to simplify the description, however, and not to limit the interpretation of any embodiment described.

[0043] Still further, the suffixes “a” and “b” may be used throughout this description to denote various left-and right-side parts/features, respectively. However, in most pertinent respects, the parts/features denoted with “a” and “b” suffixes are substantially identical to, or mirror images of, one another. It is understood that, unless otherwise noted, the description of an individual part/feature (e.g., part/feature identified with an “a” suffix) also applies to the opposing part/feature (e.g., part/feature identified with a “b” suffix). Similarly, the description of a part/feature identified with no suffix may apply, unless noted otherwise, to both the corresponding left and right part/feature.

[0044] While various embodiments are possible within the scope of this disclosure, some embodiments are directed to grounds maintenance vehicles that include a chassis supported by one or more ground contact members. The vehicle also includes an operator support platform adapted to support a riding operator, and a suspension system operatively acting between the chassis and the support platform. The suspension system may attenuate forces, e.g., travel-induced forces, which may otherwise be transmitted to the support platform during vehicle operation. Stated another way, the support platform, and thus the operator, may be partially isolated from forces imparted to the chassis as a result of vehicle operation. Moreover, in some embodiments, the suspension system may permit adjustment of spring rate and/or dampening of the suspension system to, for example, better accommodate a range of operator riding preferences. Some embodiments may provide a single adjuster that alters the spring rate and/or dampening characteristics of multiple suspensions units simultaneously. Such a configuration may be beneficial when, for example, symmetric adjustment of multiple suspension units is desired.

[0045] Still further, illustrative suspension systems may provide a low profile, permitting components of the suspension system (e.g., the suspension units) to be contained within an envelope generally defined by the remainder of the vehicle.

[0046] In other embodiments, operator assistance features may be provided to assist with mounting and dismounting the vehicle. For instance, vehicles may include assist handles that may be deployed during mounting and dismounting of the vehicle, and then stowed during operation. Yet other embodiments may provide a step-through chassis that provides low-step height access when mounting and dismounting the vehicle.

[0047] FIG. **1** illustrates an exemplary grounds maintenance vehicle **100** that incorporates a suspension system **200** (see FIG. **2**) in accordance with embodiments of the present disclosure. As stated above, the suspension system **200** may operatively connect a chassis **102** of the vehicle with an operator support platform **103**. As a result, the support platform **103** may “float” relative to the chassis **102** via compliance of the suspension system **200**. That is, the suspension system **200** may allow for relative motion between the support platform **103** and the chassis **102**.

[0048] While the vehicle is shown and described herein as a self-propelled ride-on lawn mower (also referred to herein simply as a “mower” or “vehicle”), such a configuration is not limiting. That is, those of skill in the art will realize that embodiments of the present disclosure may find application to other types of ride-on (e.g., sit-on or stand-on) grounds maintenance vehicles including skid-steer vehicles, aerators, material spreader/sprayers, dethatchers, snow throwers, and debris management systems, to name a few.

[0049] As shown in FIG. **1**, the mower **100**/chassis **102** may define front and rear ends **125**, **126**, respectively, with a longitudinal or travel axis **101** extending between the front and rear ends (i.e., the longitudinal axis being the axis of mower travel when the mower is traveling in a straight line). As used herein, a transverse axis or plane is any laterally extending axis or plane that is normal to the longitudinal axis **101**.

[0050] The chassis **102** may support a prime mover (e.g., internal combustion engine **104**), which may, in one embodiment, be located at or near the rear end **126** of the mower **100**. Left and right ground-engaging drive members (e.g., rear drive wheels **106***a*, **106***b*) may be coupled to left and right sides, respectively, of the chassis **102**. Each drive wheel may be powered to rotate, relative to the chassis **102**, about an axis such that simultaneous and equal rotation of the two drive wheels causes the mower **100** to move parallel to (i.e., along) the longitudinal axis **101**. In some embodiments, the mower **100** may be configured as a ZTR vehicle, wherein the drive wheels **106** are independently driven by the engine **104** (e.g., via one or more hydraulic motors/pumps, hydrostatic transmissions, or the equivalent). While described herein as an internal combustion engine **104**, other embodiments could utilize other prime movers, e.g., an electrical motor, to power the drive wheels **106**, or utilize separate prime movers for propulsion and for implement (cutting deck) power. Moreover, while illustrated as wheels **106**, other embodiments may utilize other drive members (e.g., tracks or the like) without departing from the scope of this disclosure.

[0051] The mower **100** may additionally include one or more, e.g., two, support members or wheels **108***a*, **108***b*. In the illustrated embodiment, the support wheels **108** are caster wheels and are located forward of the drive wheels **106** (e.g., during normal forward travel of the mower) and are thus referred to herein simply as “front” wheels. Together, the wheels **106** and **108** support the mower **100** in rolling engagement with the ground surface **105**. While described herein as utilizing two rear drive wheels and two front castering wheels, such a configuration is merely exemplary.

For example, other embodiments may use more or less wheels (e.g., a tri-wheel configuration), while still other embodiments may provide different drive wheel configurations (e.g., front-wheel drive or all-wheel drive) or different steering configurations (e.g., a vehicle with conventional Ackermann-type steering).
[0052] The mower **100** may further include one or more controls, e.g., left and right drive control levers **110***a*, **110***b*. The drive control levers **110** may be pivotally coupled to the mower **100** (e.g., to the chassis **102**) such that the levers may independently pivot forwardly and rearwardly (e.g., about a transverse axis) under the control of an operator located at an operator station that, in one embodiment, is configured as an operator seat **112**. Via incremental pivoting, the drive control levers **110** are operable to control the speed and direction of their respective drive wheels **106** (e.g., the left lever **110***a* may control speed and rotational direction of the left drive wheel **106***a*, while the right lever **110***b* may control speed and rotational direction of the right drive wheel **106***b*) via manipulation of the mower's drive system. While illustrated herein as incorporating separate drive control levers **110**, other controls, e.g., single or multiple joysticks or joystick-type levers, touchpads, steering wheels, foot pedals, etc. could also be used to control one or both of mower speed and direction.
[0053] An implement, e.g., lawn mower cutting deck **114**, may be mounted to the lower side of the chassis **102**, e.g., generally between the rear drive wheels **106** and the front wheels **108**. The cutting deck **114** may include a housing forming a cutting chamber partially surrounding one or more rotatable cutting blades (not shown) as is known in the art. While shown as a mid-or belly-mount deck, other embodiments may position the deck in other locations, e.g., forward of the front wheels **108**, aft of the rear wheels **106**, lateral to the chassis **102**, etc.
[0054] During operation, power is selectively delivered (by the prime mover **104**) to the cutting deck **114** and the drive wheels **106**, whereby the cutting blades rotate at a speed sufficient to sever grass and other vegetation as the deck passes over the ground surface **105**. Typically, the cutting deck **114** has an operator-selectable height-of-cut system to allow deck height adjustment relative to the ground surface **105**.
[0055] The mower **100** may also include one or more side shells or fenders **116** located relatively close to the operator seat. The fenders **116** provide not only storage areas for the operator, but also cover a variety of vehicle controls and components, such as the fuel tank. The mower **100** may include a fender on both the left (fender **116***a*) and right (fender **116***b*) side of the operator seat **112** as shown in FIG. **1**.
[0056] In some embodiments, the fenders are constructed of plastic (but could be made of metallic and other non-metallic materials). Each fender may include several cutouts for storage of items. For example, a cup holder may be provided on one or both of the fenders. As stated above, each fender may also accommodate a variety of machine controls, such as the drive control levers, engine throttle, ignition, PTO engagement, etc.
[0057] As illustrated in the partial view of FIG. **2**, a suspension system, e.g., suspension system **200**, may be operatively connected between the chassis **102** and the support platform **103**. In one embodiment, the suspension system **200** includes, among other components, a first suspension apparatus **202** and, optionally, a second suspension apparatus **204**.
[0058] The first suspension apparatus **202** may be longitudinally positioned (i.e., positioned along the longitudinal axis **101**) at or near a rear end of the support platform **103** (e.g., at or near the seat support portion), while the second suspension apparatus **204** may be longitudinally spaced-apart from the apparatus **202** such that it is located more toward an intermediate or central portion of the support platform **103**. While such placement may position the suspension apparatus **202**, **204** near a center of the unsprung mass of the support platform **103**, other suspension apparatus locations are also contemplated.
[0059] While the exact placement may vary, the seat **112** is generally located mid-ship on the chassis (forward of the engine **104**). One or more isolators (not shown) may be provided between

the seat **112** and a seat frame **111**, the latter attached to the support platform **103**. The isolator(s) may include elastomeric elements that absorb multidirectional forces resulting from engine and/or mower operation. Once again, while shown as a seat **112**, operator stations adapted to support a standing operator are also contemplated within the scope of this disclosure.

[0060] One turf vehicle suspension system that provides adjustable spring and dampening characteristics is described in U.S. Pat. No. 9,499,204 (the "'204 Patent"). Embodiments described in the '204 Patent utilize an operator platform that is supported, relative to a chassis of the vehicle, by a first and second suspension apparatus. In some embodiments, the first suspension apparatus includes first and second shock absorbers laterally offset from one another, wherein the first and second shock absorbers are pivotable in a vertical plane. Pivoting of the shock absorbers alters the characteristics of the suspension system as explained in the '204 Patent.

[0061] While the suspension system **200** of the present disclosure has elements in common with systems described in the '204 Patent (e.g., a chassis, platform, and suspension system with a centered, forward suspension apparatus), the system **200** does not utilize multiple, pivoting rear shock absorbers. Instead, the first suspension apparatus **202** is, in some embodiments, formed by one or more compact-height suspension units located primarily beneath the seat elevation. For instance, as shown in the partial perspective views of FIGS. **3** and **4**, the suspension apparatus **202** may include first and second biasing elements (e.g., torsion springs **206**) as described in more detail below. In some embodiments, the two torsion springs are spaced-apart from one another in a transverse direction.

[0062] Similar to the vehicles described in the '204 Patent, the support platform **103** has a long dimension that extends along the longitudinal axis **101**. In addition to a seat support portion **120** to which the seat **112** may couple, the support platform **103** may further define a foot support portion **122**, and a connecting structure **124**, the latter which may connect the seat support portion to the foot support portion. As shown in FIG. **2**, the seat support portion **120** may form the rear end of the platform **103**, while the foot support portion **122** may form the front end.

[0063] The connecting structure **124** may be a separate component of the platform **103** or, alternatively, part of one or both of the seat support portion **120** and the foot support portion **122**. In general, the connecting structure **124** may be of most any configuration that connects the seat support portion **120** to the foot support portion **122** of the support platform **103**. For instance, in the illustrated embodiment, the foot support portion **122** is vertically spaced-apart from (e.g., below) the seat support portion **120** and, in at least one embodiment, the foot support portion **122** and the seat support portion **120** are in generally parallel planes. As a result, the connecting structure **124** may be oriented in a direction that is generally vertical, or at an incline from vertical. Regardless of its exact orientation, the connecting structure **124** may extend from a forward end of the seat support portion **120** downwardly to a rear end of the foot support portion **122**. As described and illustrated herein, the connecting structure **124**, the seat support portion **120**, and/or the foot support portion **124** may incorporate features (e.g., cutouts or openings) to accommodate the second suspension apparatus **204** (see FIG. **2**). While the support platform **103** is shown herein as a unitary (e.g., cast or welded) structure, those of skill in the art will realize that it could also be an assembly of multiple components that are rigidly connected (e.g., bolted, welded, clamped, pinned, etc.), or otherwise attached to one another.

[0064] Although shown as being vertically spaced-apart, the seat support portion **120** and the foot support portion **122** may, in other embodiments, both be on the same plane (i.e., forming a generally flat support platform **103**). In such a configuration, the connecting structure **124** is understood to be an intermediate portion of the support platform **103** that lies between the seat support portion **120** and the foot support portion **122**.

[0065] In the illustrated embodiments, the suspension system **200** includes the first suspension apparatus **202** and the second suspension apparatus **204**, each of which operatively supports the platform **103** relative to the chassis **102** (e.g., biases the support platform away from the chassis) as the platform moves through its range of motion. For purposes of this description, potential degrees of freedom of the platform **103**/seat **112**, relative to the chassis **102**, may be described as occurring in relation to three mutually perpendicular axes as shown in FIG. **1**: the longitudinal or fore-and-aft axis x; the transverse or side-to-side axis y; and the vertical axis z. In addition to potential translation along each of these three axes, the platform **103**/seat **112** may also potentially pivot, relative to the chassis **102**, about the x (e.g., "roll"), y (e.g., "pitch"), and z (e.g., "yaw") axes.

[0066] With reference to FIGS. **3** and **4**, the second suspension apparatus may be configured as a coil-over shock absorber **204** that defines a front connection of the platform **103** to the chassis **102**. As shown in these views, the shock absorber **204** may be pivotally connected to the chassis **102** at a frame pivot **210** and to the platform **103** (only partially shown in FIG. **4**) at a platform pivot **212**. The pivots **210**, **212** may define transverse, parallel axes **211**, **213**, respectively, about which the shock absorber **204** may pivot. Moreover, the shock absorber **204** may utilize spherical rod ends at each of the pivots **210**, **212** to allow limited side-to-side translation of the platform **103** relative to the chassis **102**. While shown herein as a linear shock absorber, the second suspension apparatus could be configured as most any suspension device including, for example, one or more elastomeric elements, torsion springs, extension springs, compression springs, gas-filled devices, etc. In fact, any device that is capable of providing elastic deflection could be used.

[0067] The suspension system **200** may further include a pivot member **250** that defines a rear connection of the platform **103** to the chassis **102**. The pivot member **250** may assist in reducing or even eliminating fore-and-aft and transverse (side-to-side) translation, as well as rolling and yawing, of the support platform **103** relative to the chassis **102**. In other words, the pivot member **250** may be configured to permit the support platform **103** to move generally up and down and pitch, while reducing or eliminating transverse and fore-and-aft translation, as well as rolling and yawing.

[0068] The pivot member **250** may define two transverse pivot axes: a first pivot axis **252** and a second pivot axis **254**. The pivot member **250** may be pivotally coupled to the chassis **102** at the first pivot axis **252**, and pivotally coupled to the support platform **103** at the second pivot axis **254**. In the illustrated embodiment, the first and second pivot axes **252**, **254** are parallel to one another and transverse to the longitudinal axis **101**. The second pivot axis **254** may pivotally couple to the support platform **103** along the seat support portion **120** as shown (e.g., under the center of mass of the operator). Moreover, while illustrated with the first pivot axis **252** being located aft of the second pivot axis **254**, other embodiments may place the first pivot axis forward of the second pivot axis.

[0069] As shown in FIG. **3**, the pivot member may include transverse lugs **258** (**258***a*, **258***b*) that define the first pivot axis **252**. Extending outwardly (forwardly) from the lugs **258** is at least one arm **260**. In the illustrated embodiments, the pivot member **250** includes two such arms **260***a*, **260***b* one extending from each of the lugs **258**. Forward or opposite ends of the arms **260** define coaxial features (e.g., openings, pins, etc.) that permit pivotal connection to the platform **103** at the second pivot axis **254**.

[0070] FIG. **5** illustrates a portion of the suspension system **200** with various vehicle structure removed to better illustrate the biasing elements of the first suspension apparatus **202**, e.g., the torsion springs **206**, one of which is illustrated in isolation in FIG. **6**. Each torsion spring includes a coiled body **209** and protruding legs **207** and **208**. The legs **207**, **208** may be generally equal in length, or may be different as shown in FIG. **6**, e.g., leg **208** may be longer that leg **207**. The torsion springs are adapted to elastically deflect when the support platform **103** is displaced relative to the chassis **102**.

[0071] The torsion springs **206** are positioned about a shaft **256** (via a supporting mandrel **257**) extending along the second pivot axis **254** such that the coiled body **209** of each torsion spring moves with the second pivot axis **254** during operation. A guide plate **262** is also pivotally attached to the shaft **256** such that it may move with the second pivot axis **254**, as well as pivot about the second pivot axis **254**.

[0072] FIG. **7** illustrates a section view taken along line **7-7** of FIG. **5**. As indicated in this view, the coiled body **209** of each torsion spring **206** is secured in place along the pivot axis **254**. The leg **208** may then bear directly against (abut) a load surface of either the guide plate **262** as shown (see also isolated perspective view of FIG. **8**) or against a shaft **288** (described below) associated with the guide plate, while the leg **207** bears against (abuts) a receiver **264** formed along an inner face of the adjacent arm **260**. Thus, the torsion springs **206** may directly act between the shaft **288**/guide plate **262** and the pivot member **250**, and indirectly between the chassis **102** and the platform **103**.

[0073] With reference to FIGS. **8** and **9**, the suspension system **200** may further include an adjustment mechanism or “adjuster” that permits a preload on the torsion springs **206** to be altered, thereby changing suspension system characteristics to best satisfy the preferences of a particular operator. In some embodiments, the adjuster may include a Bowden cable **266** having a first end **268** connected to a pulley (also referred to herein as a “cam”) of an adjustment lever **270** (see also FIG. **1**), and a second end **272** connected to the guide plate **262** or the shaft **288** as further described below. Such an adjuster may permit the action required to alter the preload (e.g., lever movement) to occur remotely from the torsion springs. That is to say, the lever **270** may be located at almost any location on the mower **100**, regardless of proximity to the support platform.

[0074] The pulley is attached to an adjustment lever **270** that is pivotable, relative to the chassis **102** about an eccentric pivot axis **274**, between a plurality of discrete positions. The pulley defines a cam surface **276** along which an inner member **278** of the cable **266** may wrap as the lever/pulley is moved through its range of pivotal motion (full range represented by position “A” (corresponding to highest torsion spring preload) and position “B” (corresponding to lowest preload) in FIG. **9**). An outer housing **280** of the cable **266** may then have one end anchored to the chassis **102** as shown in FIG. **9**, and its opposite end anchored to a bracket **107** connected to the platform **103** as shown in FIG. **7**. As the lever **270** moves from position B toward position A in FIG. **9**, the inner member **278** may slide within the outer housing **280**, displacing the shaft **288**, and thus the guide plate **262**, from the position shown in FIG. **7**, to the position shown in FIG. **10**. As the shaft **288**/guide plate **262** is displaced in this direction, the legs **208** of the torsion springs **206** (which are in operative contact with the shaft **288**) are displaced, effectively twisting the coiled body **209**, which in turn increases the preload simultaneously (and generally equally) on each of the torsion springs. Similarly, the preload on the torsion springs may be simultaneously reduced by moving the lever **270** from position A back toward position B.

[0075] To secure the guide plate **262** and shaft **288** at any one of multiple, discrete positions corresponding to positions A, B, and positions of the lever **270** therebetween, the lever may engage one of several discrete notches **282** as shown in FIG. **9**. That is, the lever **270** may be moved along a slot **283** and, upon reaching the desired position, moved laterally into engagement with the appropriate notch **282**. As shown in FIG. **1**, each of the notches may include indicia (e.g., letters or numbers) that indicate a relative preload of the springs (e.g., a relative stiffness of the suspension system). Such indicia may indicate relative stiffness settings (for example, lever position B may be identified as stiffness setting “**1**,” while lever position A may be identified as stiffness setting “**5**,” wherein the intermediate notches **282** may be identified as stiffness settings **2-4**).

[0076] The profile of the cam surface **276** may be designed so that a relatively consistent actuation force moves the lever **270** through its range of travel. That is to say, the cam surface **276** provides increasing mechanical advantage as lever resistance (i.e., torsion spring preload) increases. To ensure that the change in deflection of the torsion springs **206** is generally equal between any two adjacent notches **282** (thus providing generally linear preload variation between stiffness settings), the angular distance between one pair of adjacent notches may differ from a spacing between another pair of adjacent notches as is evident in FIG. **11**. For example, the lever **270** may pivot (about the transverse pivot axis **274** of FIG. **9**) through a greater angular travel as it moves between settings **4** and **5** than it does when pivoting between settings **1** and **2**.

[0077] As shown in FIG. **9**, a lever spring **284** (tension spring) may be provided to bias the lever **270** and/or assist with moving the lever toward the higher preload positions. While the particular parameters (length, spring rate, attachment point (moment arm) on pulley, etc.) of the spring **284** may vary, the spring may, in one embodiment, be selected to provide lesser biasing torque to the lever (about the pivot axis **274**) as the lever **270** is moved toward positions corresponding to higher torsion spring **206** preloads, and greater biasing force as the lever is moved toward positions corresponding to lower torsion spring preloads. In some embodiments, the spring **284** may be selected to provide a biasing torque on the lever that is approximately equal and opposite to the torque applied by the torsion springs **206** (via the cable **266**) when the lever **270** is in an intermediate position (e.g., setting **3** as shown in FIG. **11**). As the handle **270** moves from the intermediate position toward a position corresponding to a higher preload on the torsion springs **206** (e.g., toward a preload setting that is higher than the intermediate setting such as setting **5** in FIG. **11**), the biasing torque provided by the spring **284** decreases. However, as the handle **270** moves from the intermediate position toward a position corresponding to a lower preload on the torsion springs (e.g., toward a preload setting that is lower than the intermediate setting such as setting **1** in FIG. **11**), the biasing torque provided by the spring **284** increases. As a result, the assist spring **284** may, along with the cam surface **276**, assist with maintaining a more consistent lever actuation force regardless of the lever's position along the slot **283**.
[0078] FIG. **8** illustrates attachment of the cable **266**, e.g., the inner member **278**, to the shaft **288**/guide plate **262**. In this embodiment, the plate may include an opening **285** through which a cable eye **286** (attached to second end **272** of the inner member **278**) may pass. The eye **286** may include an aperture adapted to receive the shaft **288** that is itself engaged with the guide plate by passing through openings **289** formed on the top of the guide plate. The opening **285** allows pivoting of the eye **286** about the shaft **288** as the shaft **288**/guide plate **262** moves through its range of motion (see, e.g., FIGS. **7** and **10**). As one can appreciate, the guide plate **262** may be used merely to stabilize the shaft **288**. That is to say, the adjustment mechanism (i.e., the cable **278**) may not even require the guide plate **262**. However, use of the guide plate **268** may ensure that the shaft **288** does not shift out of place during operation.
[0079] The illustrated construction allows the preload on the torsion springs **206** to be simultaneously (and generally equally) adjusted by manually moving the lever **270** between different notches **282** in the slot **283** of the chassis **102** (see FIG. **9**). As the lever moves, the cable **266** causes the shaft **288**/guide plate **262** to pivot about the second pivot axis **254**, effectively increasing or decreasing the preload on the torsion springs **206**. Although not acting directly between the platform **103** and the chassis **102**, the torsion springs **206** may resist pivoting of the pivot member **250** about the first pivot axis **252**, effectively biasing the platform relative to the chassis.
[0080] To limit travel of the support platform **103** relative to the chassis **102**, stops **290** and **292** may be provided as shown in FIG. **10**. The stop **290** (one located under each arm **260***a*, **260***b*) may limit downward movement of the platform **103** by contacting the arms **260** of the pivot member **250**, while the stop **292** (attached to the bracket **107**) may limit upward movement of the platform upon contact with the pivot member. In the illustrated embodiments, the stops **290**, **292** are formed of a resilient, compressible material such as rubber (e.g., neoprene) to effectively reduce hard, jarring impacts at the travel extremes of the platform **103**.
[0081] FIGS. **11-14** illustrate an adjustment mechanism **271** in accordance with another embodiment of the present disclosure. The adjustment mechanism illustrated in FIGS. **11-14** is similar in many respects to the that described above and thus like reference numerals are used where appropriate. For instance, the adjustment mechanism again includes the lever **270** movable along the slot **283** and, upon reaching the desired position, is movable laterally into engagement with the appropriate notch **282**. However, while the adjustment mechanism described previously required only a single step procedure (moving the lever from one notch to another), the adjustment

mechanism **271** requires a two-step procedure in order to change the torsion spring preload.

[0082] For example, in one embodiment, the adjustment mechanism may include a lever lock **273** as shown in FIGS. **11** and **12**. When the lever lock **273** is in a first or closed position (see FIG. **13**), the lever lock physically obstructs movement of the lever **270** out of the notches **282** and into the slot **283**. That is to say, the lever lock **273** may "lock" the lever **270** in any one of the available notches **282**.

[0083] While various lever lock configurations are contemplated, an exemplary construction is illustrated in FIGS. **11-13** (lever lock shown in the first or closed position in these figures). As indicated in these views, the lever lock **273** may be configured as a shaft **275** journalled for rotation about an axis **277** that extends generally parallel to the slot **283**. The shaft **275** may further define a radially extending protrusion or ear that forms the lever lock **273**.

[0084] The back end of the shaft **275** may have attached thereto a handle or knob **279** wherein rotation of the knob results in rotation of the shaft and, therefore, pivoting of the lever lock **273**. The shaft **275** may further include a leg **281** as shown in FIG. **12** for attachment of a spring or other biasing element (not shown) adapted to bias the lever lock **273** to the first or closed position as shown in FIGS. **11-12**.

[0085] FIG. **13** is a section view taken along line **13-13** of FIG. **11**. As shown in this view, the lever lock **273**, which is illustrated in the first or closed position, may again effectively obstruct or block movement of the lever **270** from the notch **282** into the slot **283**.

[0086] When the operator wishes to adjust the position of the lever **270** (to change a preload on the torsion springs), he or she dismounts the mower (if already seated) and, standing to the side of the mower, rotates the knob **279** in the direction **269** (see FIG. **11**) with a first (e.g., left) hand. Such rotation of the knob **279** causes the shaft **275**, and thus the lever lock **273**, to move from the first or closed position shown in FIG. **13**, to a second or open position shown in FIG. **14**. In the open position, the lever **270** is free to move, under a displacing force provided by the operator's other (e.g., right) hand, from the notch **282** into the slot **283** (in the direction **267**), at which point the lever is moved until it aligns with another one of the notches. Once the lever **270** is placed into the newly-selected notch **282**, the knob **279** is released, allowing the bias applied to the shaft **275**/lever lock **273** (in a direction opposite the direction **269** in FIG. **13**) to return the lever lock to the closed position (see FIG. **13**), thereby locking the lever **270** in the newly-selected notch.

[0087] The adjustment mechanism **271** thus requires the operator to execute two discrete steps (while dismounted from the mower) in order to adjust the torsion spring preload. First, the knob **279** is rotated with one hand to move the lever lock **273** out of the closed position (see FIG. **13**) and into the open position (see FIG. **14**). While holding the knob **279** with one hand to maintain the open position of the lever lock, the operator, using his or her other hand, moves the lever **270** in the direction **267** (see FIG. **14**) to relocate the lever to a different notch **282**. At this point, the knob **279** is released, thereby locking the lever **270** in this newly-selected notch **282**.

[0088] FIGS. **15-20** illustrate a suspension system **300** in accordance with an alternative embodiment of the present disclosure. As is evident below, the system **300** is similar in many respects to the system **200** described above. For example, the system **300** may again include the second suspension apparatus **204** (not shown) and a first suspension apparatus including two torsion springs **306** positioned beneath the platform **103**. However, unlike the system **200**, the suspension system **300** may use an adjustment mechanism (adjuster) formed by a rotatable threaded adjuster or screw **370**, which may be located under and/or to the rear of the seat (see seat **112** in FIG. **1**). FIG. **16** is a view similar to FIG. **15**, but taken from a rear perspective.

[0089] A preload on the torsion springs **306** may be adjusted via rotation of the screw **370**. For example, rotation of the screw **370** in a clockwise direction simultaneously tightens (i.e., increases the preload of) the torsion springs **306**, which thereby increases the stiffness of the suspension system. Similarly, rotation of the screw **370** in a counterclockwise direction loosens (i.e., decreases the preload of) the torsion springs, thereby decreasing the stiffness of the suspension system. The system **300** may also include a transverse retention bar **392** to limit an upward position of the platform **103**.

[0090] In some embodiments, an indicator, e.g., vertical tab **372**, is provided. As the screw **370** is rotated, the tab **372** may rise or fall, relative to a slot **373** in the platform, in proportion to the preload applied to the torsion springs **306**. The tab **372** may include various indicia (parallel and horizontal letters, numbers, pictures, etc.) that correspond to various preload settings. As a result, the position of the tab **372**, with the corresponding indicia, enables the operator to gauge the degree of preload (stiffness) of the suspension system. While shown as a linear translating tab, the indicator could also be configured as a dial gauge, wherein a needle of the gauge would move as the screw **370** is rotated.

[0091] FIG. **17** is a section view of the vehicle suspension system **300** taken along line **17-17** of FIG. **16**. In this view, the suspension system is shown: adjusted to the lightest preload (least-stiff) setting; and in an uncompressed or unloaded state. FIG. **18** is a perspective view of this same section from a rear perspective. The transverse retention bar **392** is also visible in these views. The bar **392** may abut an elastomeric pad **393** operatively attached to the platform to effectively limit an upward position of the platform.

[0092] As shown in these views, the mower **100** incorporating the suspension system **300** may again include a frame or chassis **102**, operator support platform **103**, suspensions apparatus **204** (not shown), pivot member **350** (pivotally attached to the chassis **102** at a first transverse pivot axis **352**, and to the support platform at a second transverse pivot **354**), and torsion springs **306** that are configured as generally described herein in the context of the mower **100**/suspension system **200**. The torsion springs **306** may be similar or identical to the springs **206** already described herein, e.g., include in inner leg **307** that engages a receiver **364** (protruding stud) on the pivot member **350**, while the outer leg **308** engages an adjustment pad **368** that is vertically displaceable by the screw **370**.

[0093] During operation, the torsion springs **306**, like the springs **206**, may attenuate operating loads that may otherwise be transmitted to the platform **103**. For instance, FIG. **19** is a view similar to FIG. **17**, but with the suspension system in a fully compressed or fully loaded state. Similarly, FIG. **20** is a view similar to FIG. **17** (in the unloaded state), but with the adjuster configured to provide the suspension system **300** with a higher preload on the springs **306** (higher suspension system stiffness). That is, the screw **370** has been rotated to displace the pad **368** downwardly to deflect the leg **308** and effectively preload both springs **306**.

[0094] While illustrated herein as using either a pivoting guide plate/cable or a screw to form the adjuster, other embodiments are contemplated. In fact, most any device operable to apply a preload to the torsion springs (e.g., a lever, direct acting cam, etc.) is possible within the scope of this disclosure.

[0095] While shown as utilizing torsion springs to form the first suspension apparatus, other embodiments may utilize other suspension units also contained generally beneath the support platform **103** without departing from the scope of this disclosure. For example, FIGS. **21-22** illustrate a mower **100** (only partially shown) that incorporates a suspension system **400** in accordance with another embodiment of this disclosure. As is indicated below, the system **400** is similar in many respects to the systems **200** and **300** described above. For example, as shown in FIG. **21**, the system **400** may again include a frame or chassis **102**, operator support platform **103**, suspension apparatus **204**, and pivot member **450** configured as generally described herein with the same or similarly corresponding reference numerals in the context of the mower **100**/suspension system **200**. The pivot member **450** may again pivotally attached to the chassis **102** at a first transverse pivot axis **452**, and to the support platform at a second transverse pivot **454**. However, unlike the suspension systems **200** and **300**, the suspension system **300** replaces the torsion springs **206**, **306** with a suspension apparatus **402** that includes one or more coil-over shock absorbers **406** positioned in a horizontal or approximately horizontal orientation as shown.

[0096] With reference to FIG. **22**, the motion of the platform **103** relative to the chassis is again defined by the suspension apparatus **204** (e.g., the pivot member **450**). However, the suspension apparatus **400** also includes a bell-crank or pivot plate **416** that is fixed to a pivot shaft **418** such that the pivot plate may pivot, relative to the chassis **102**, about a transverse pivot axis **420**. The shock absorber **406** may have a first end pivotally coupled to the chassis at a frame pivot **422**, and a second end pivotally coupled to the pivot plate at a shock pivot **424**. The frame pivot **422** and the shock pivot **424** may both allow pivoting of the shock absorber about associated transverse pivot axes.

[0097] The suspension system **400** may further include an arm **426** having a first end pivotally connected to the platform **103** at a platform pivot **428**, and a second end defining a stub shaft **430** adapted to pivotally engage the pivot plate **416**. In some embodiments, the pivot plate **416** may define a slot **432** with two or more notches **434** in communication therewith.

[0098] During operation, the platform **103** may move, relative to the chassis **102**, via compliance of the suspension apparatus **204** and movement of the pivot member **450** as already described herein with respect to the suspension systems **200** and **300**. As the rear of the platform **103** is displaced downwardly during operation, the arm **426** may transfer downward forces to the pivot plate **416**, causing the pivot plate to pivot about the transverse pivot axis **420** defined by the pivot shaft **418** in the direction **436**. This pivoting of the pivot plate **416** is resisted by the shock absorber **406**, which provides a biasing force to the pivot plate in a direction opposite the direction **436**. As a result, downward motion of the platform **103** is influenced (resisted) by the suspension apparatus **204** and the shock absorber **406**.

[0099] As with the systems **200** and **300** described herein, the suspension system **400** may permit adjustment of the preload on the shock absorber **406** to permit altering suspension system characteristics. For example, in some embodiments, the stub shaft **430** may be moved to a different notch **434**. Such movement alters the distance between the pivot axis **418** and the force vector applied by the arm **426**, effectively increasing (or decreasing) the moment about the pivot axis resulting from loading of the platform **103**. In addition or alternatively to moving the stub shaft **430** to a different notch, the pivot plate **416** may include multiple, e.g., three, apertures **438**, each of which is spaced at a different distance from the pivot axis **418**. Accordingly, the shock pivot **424** may be located at correspondingly different distances from the pivot axis **418**, which may also alter the effective resistance or preload applied by the shock absorber **406**. The notches **434** and/or apertures **438** may also include indicia that may assist the operator in adjusting the preload on the shock absorber.

[0100] Adjustable positioning of the shock pivot **424** and/or the stub shaft **430** on the pivot plate **416** may allow significant range of resistance provided by the shock absorber **406**. As a result, adequate suspension variability may be achieved using only a single shock absorber **406** (in addition to the front shock absorber **204**). Such a construction may reduce system cost and complexity for some applications.

[0101] Moreover, the shock absorber **406** of the system **400** integrates a dampener (gas strut) therein, which may be beneficial in some instances, e.g., where dampening is desired. However, those of skill in the art will recognize that the torsion spring concepts described herein could also, if desired, incorporate a dampening element (in addition to the dampener provided in front shock absorber **204**) to control platform rebound motion without departing from the scope of this disclosure.

[0102] Suspension systems described herein thus allow for a compact vehicle suspension system that may be adjusted to provide the desired suspension characteristics. Moreover, exemplary suspension systems may include an adjustment mechanism that allows a preload on one or more biasing elements (e.g., on both torsion springs, or on the shock absorber **406**) to be altered. In some embodiments, the first suspension apparatus may include two suspension units (torsion springs **206**) and the adjustment mechanism may be adapted to adjust preload on both units simultaneously.

[0103] In addition to suspension systems, embodiments of the present disclosure may provide features that assist with mounting and dismounting the operator platform **103** (e.g., the seat **112**). For example, FIGS. **23-24** illustrate an assist bar **500** attached, directly or indirectly, to the mower chassis **102** of the mower **100**. While not wishing to be bound to any specific configuration, the assist bar **500** may extend upwardly from near a floor pan (e.g., foot support portion **122** of the platform **103**). The assist bar **500** may be positioned within easy reach as the operator is rising from the seat **112**, or as he/she is otherwise mounting or dismounting the mower. The upper end of the assist bar may include a handle portion **502**, which may have a soft, ergonomically-shaped surface that is comfortable to grip.
[0104] A lower end of the assist bar may be pivotally connected to the chassis **102** by any suitable means. For instance, in some embodiments, a mount or bracket **504** may be attached to a frame rail **109** of the frame **102** at a location in front of, and to the side of, the operator seat **112**. The bracket **504** may include a slot **506** while the assist bar **500** includes pins **508**, **510** that may move within the slot(s) to allow pivotal movement the assist bar between a collapsed or stowed position “B” and a raised or deployed position “A.”
[0105] The assist bar **500** is shown in both the deployed position A and the collapsed position B in FIG. **23** (such depiction is for illustration purposes only as the bar would be in either position A or position B (or some intermediate position) at any given time). The pivotal connection of the assist bar **500** to the chassis **102**, as further described below, may allow the assist bar to selectively lock or otherwise be secured in the deployed position A. With the assist bar in the deployed position, the operator may grasp the handle portion **502** during mounting/dismounting of the mower. That is to say, the assist bar **500** may provide an additional support to assist the operator as he/she mounts and dismounts the mower.
[0106] As stated above, the assist bar **500** may be designed to pivot to the stowed position B as shown in FIG. **23**. In the stowed position, the assist bar is generally positioned to minimize interference with machine steering controls and operator line-of-sight. Moreover, stowing the assist bar **500** may reduce inadvertent contact of the assist bar with surrounding bushes, trees, or other obstacles during use of the mower. In one embodiment, the assist handle **502** is located at or near the seat **112** when in the stowed position to allow convenient access during movement of the assist bar toward or away from the stowed position B.
[0107] As shown in FIG. **24**, pivotal attachment of the assist bar may be accommodated by the bracket **504**. The bracket includes the slot **506** having a vertical portion **512** rising to intersect with an arc-shaped portion **514**. As stated above, the assist bar **500** may include the two pins **508** and **510** that move within the slot **506**. Specifically, when the assist bar **500** is in the deployed position A as shown in solid lines in FIG. **24**, the two pins **508**, **510** are captured within the vertical portion **512** of the slot **506** such that the assist bar is held in place (against all but vertical displacement). When the operator wishes to move the assist bar **500** to the stowed position B shown in broken lines in FIG. **24**, the assist bar **500** may be displaced upwardly (e.g., in the direction **516**) until the upper pin **508** exits the vertical portion **512** of the slot **506** and enters the arc-shaped portion **514**. At this point, the bar **500** may be pivoted about the lower pin **510** in the direction **518** as the upper pin **508** moves along the arc-shaped portion until the assist bar reaches the stowed position B. Accordingly, the positions of the pins **508** and **510** may be located in the positions indicated as “A” when the assist bar **500** is in the deployed position A, and in the positions indicated as “B” when the assist bar is in the stowed position B.
[0108] In another embodiment, the assist bar extends above the foot plate in a substantially vertical orientation, and its upper end again includes a handle portion. However, instead of moving to a stowed position via pivotal movement, this alternative assist bar may have a telescoping construction to collapse its height when not in use. Such a telescoping assist bar is described in more detail in U.S. Pat. No. 8,794,660.
[0109] In other embodiments, other features may be provided to assist the operator with mounting

and dismounting the mower. For example, FIGS. **25-26** illustrate a ZTR mower **600** having a fixed foot support portion or floor pan **603** as opposed to the floating platform **103** described elsewhere herein.

[0110] The ZTR mower **600** includes a pair of caster wheels **608** at the front of the mower. In conventional ZTRs, the two front caster wheels are interconnected by a straight axle or “beam.” In order to accommodate the caster wheel diameter and the caster mechanism, this beam may be located at an elevation that creates a step-up height higher than what some operators may prefer when stepping onto, or off of, the mower. Moreover, in conventional ZTRs, an angled foot rest is commonly included and generally extends across the transverse width of the front of the mower. As a result, when mounting/dismounting such mowers from the front, the operator may be required to step not only to the height defined by the beam, but also sufficiently high to traverse the foot rest.

[0111] Mowers in accordance with embodiments of the present disclosure, however, may utilize a beam **616** that is, at least near a centerline of the mower **600**, at a lower elevation (e.g., at an elevation that is about 1.5-2 inches lower) than its elevation near the caster wheel mounts **624**. In fact, as shown in FIG. **25**, the beam **616** may be at the same elevation, e.g., flush with, the floor pan **603**.

[0112] Moreover, the mower **600** may further include a step-through foot rest **618**, which allows the operator to step on and off the machine easily via the mower's front end without obstruction from the foot rest. This feature, in combination with the front beam **616** being generally flush in elevation with the floor pan, provides a single, unobstructed step that is positioned more closely to the ground than may otherwise be possible with a conventional beam and footrest configuration.

[0113] To provide this step-through path, the front of the mower uses two spaced-apart transverse foot rest members **618***a*, **618***b* (as opposed to a single continuous foot rest) secured to the front portion of the floor pan **603**. Each foot rest member is generally V-or U-shaped and presents an angled surface upon which the operator may rest his or her feet when sitting in the seat **612**. Each of the foot rest members **618***a*, **618***b* extends in a transverse direction near the front of the floor pan **603**. The step-through feature is then formed between the spaced-apart foot rest members **618**.

[0114] The step-through area may be configured to provide surfaces that minimize slipping and falls. Specifically, the surfaces of the foot rest members and step-through areas may have either an adhesive-backed textured decal, or may be stamped or embossed. Such surfaces may increase the operator's traction when mounting or dismounting the mower.

[0115] FIG. **26** depicts the chassis **602** with various structure removed to illustrate the shape of the transverse beam **616**. As shown in this view, the transverse beam **616** may include a flat center portion **620** near its center, and upwardly and outwardly extending portions **622** extending from the flat center portion transversely to the caster wheel mounts **624**. Stated another way, the beam **616** may appear as a flattened “V” shape when viewed from the front of the mower.

[0116] Operator mount/dismount access features (e.g., assist bar, step-through front) as described herein may find application to mowers with or without suspension systems. In fact, such features may be utilized with other non-mowing vehicles without departing from the scope of this disclosure.

[0117] The complete disclosure of the patents, patent documents, and publications cited herein are incorporated by reference in their entirety as if each were individually incorporated. In the event that any inconsistency exists between the disclosure of the present application and the disclosure(s) of any document incorporated herein by reference, the disclosure of the present application shall govern.

[0118] Illustrative embodiments are described and reference has been made to possible variations of the same. These and other variations, combinations, and modifications will be apparent to those skilled in the art, and it should be understood that the claims are not limited to the illustrative embodiments set forth herein.

Claims

1.-**25**. (canceled)
26. A grounds maintenance vehicle comprising: a chassis comprising a front end, a rear end, and a longitudinal axis extending between the front and rear ends; a support platform extending along the longitudinal axis, the support platform comprising a seat support portion; and a suspension system comprising: a first suspension apparatus operatively acting between the chassis and the seat support portion of the support platform, wherein the first suspension apparatus comprises at least one torsion spring, and wherein the at least one torsion spring is adapted to elastically deflect when the support platform is displaced relative to the chassis; a second suspension apparatus longitudinally spaced-apart from the at least one torsion spring, the second suspension apparatus operatively connected to both the support platform and the chassis; and an adjuster adapted to adjust a preload applied to the at least one torsion spring.
27. The vehicle of claim 26, wherein the suspension system further comprises a pivot member pivotally coupled to the chassis and to the support platform.
28. The vehicle of claim 27, wherein the pivot member defines a transverse first pivot axis and a transverse second pivot axis, and wherein the pivot member is: pivotally coupled to the chassis at the first pivot axis and pivotally coupled to the support platform at the second pivot axis, and wherein the at least one torsion spring is positioned about the second pivot axis.
29. The vehicle of claim 27, wherein the at least one torsion spring acts upon the pivot member.
30. The vehicle of claim 26, wherein the adjuster comprises a lever pivotable between a plurality of discrete positions relative to the chassis, wherein each of the plurality of discrete positions corresponds to a different preload applied to the at least one torsion spring.
31. The vehicle of claim 30, wherein the lever comprises a pulley pivotable about an eccentric pivot axis, and wherein a cable extends between the pulley and a shaft, the shaft in operative contact with a leg of the at least one torsion spring.
32. The vehicle of claim 30, wherein the plurality of discrete positions are defined by notches arranged along a slot, and wherein a spacing between a first pair of adjacent notches differs from a spacing between a second pair of adjacent notches.
33. The vehicle of claim 30, further comprising a lever spring adapted to provide a lever biasing torque to the lever, wherein the lever biasing torque decreases as the lever moves from an intermediate position to a position corresponding to a higher preload on the at least one torsion spring, and increases as the lever moves from the intermediate position to a position corresponding to a lower preload on the at least one torsion spring.
34. The vehicle of claim 31, wherein the lever is configured to provide a force vector acting upon the shaft at a radial distance from the eccentric pivot axis, wherein the radial distance from the eccentric pivot axis is adjustable by moving the lever into a different discrete position.
35. A grounds maintenance vehicle comprising: a chassis comprising a front end, a rear end, and a longitudinal axis extending between the front and rear ends; a support platform extending along the longitudinal axis, the support platform comprising: a seat support portion; a foot support portion; and a connecting structure connecting the seat support portion to the foot support portion; and a suspension system comprising: a first suspension apparatus adapted to bias the support platform away from the chassis, wherein the first suspension apparatus comprises at least one torsion spring, the at least one torsion spring adapted to elastically deflect when the support platform is displaced toward the chassis; a second suspension apparatus operatively acting between the chassis and the seat support portion of the support platform, the second suspension apparatus longitudinally spaced-apart from the first suspension apparatus, wherein the second suspension apparatus is also adapted to bias the support platform away from the chassis; and an adjuster adapted to alter a preload applied to the at least one torsion spring.

36. The vehicle of claim 35, further comprising a pivot member defining a transverse first pivot axis and a transverse second pivot axis, wherein the pivot member is: pivotally coupled to the chassis at the first pivot axis; and pivotally coupled to the support platform at the second pivot axis.
37. The vehicle of claim 36, wherein the at least one torsion spring is positioned about the second pivot axis.
38. The vehicle of claim 36, wherein the at least one torsion spring acts upon the pivot member.
39. The vehicle of claim 36, wherein the adjuster comprises a lever pivotable between a plurality of discrete positions relative to the chassis, wherein each of the plurality of discrete positions corresponds to a different preload applied to the at least one torsion spring.
40. The vehicle of claim 39, wherein the lever comprises a pulley pivotable about an eccentric pivot axis, and wherein a cable extends between the pulley and a shaft, the shaft in operative contact with a leg of the at least one torsion spring.
41. The vehicle of claim 39, wherein the plurality of discrete positions are defined by notches arranged along a slot, and wherein a spacing between a first pair of adjacent notches differs from a spacing between a second pair of adjacent notches.
42. The vehicle of claim 39, further comprising a lever spring adapted to provide a lever biasing torque to the lever, wherein the lever biasing torque decreases as the lever moves from an intermediate position to a position corresponding to a higher preload on the at least one torsion spring, and increases as the lever moves from the intermediate position to a position corresponding to a lower preload on the at least one torsion spring.
43. The vehicle of claim 40, wherein the lever is configured to provide a force vector acting upon the shaft at a radial distance from the eccentric pivot axis, wherein the radial distance from the eccentric pivot axis is adjustable by moving the lever into a different discrete position.
44. A riding lawn mower comprising: a chassis comprising a front end, a rear end, and a longitudinal axis extending between the front and rear ends; a support platform extending along the longitudinal axis, the support platform comprising: a seat support portion supporting an operator seat; a foot support portion; and a connecting structure connecting the seat support portion to the foot support portion; a pivot member defining a transverse first pivot axis and a transverse second pivot axis, wherein the pivot member is: pivotally coupled to the chassis at the first pivot axis; and pivotally coupled to the support platform at the second pivot axis; and a suspension system comprising: at least one torsion spring positioned about the second pivot axis, the at least one torsion spring operatively biasing the support platform upwardly and away from the chassis, wherein the at least one torsion spring elastically deflects when the support platform is displaced toward the chassis, the at least one torsion spring located near the seat support portion; a coil-over shock absorber positioned longitudinally forward from the at least one torsion spring, wherein the coil-over shock absorber is operatively connected to the support platform and to the chassis; and an adjuster adapted to alter a preload applied to the at least one torsion spring.
45. The riding lawn mower of claim 44, wherein the coil-over shock absorber is connected to the support platform at or near the connecting structure.