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(54) **REMOTE ELECTRONIC SHOCK ADJUSTER**

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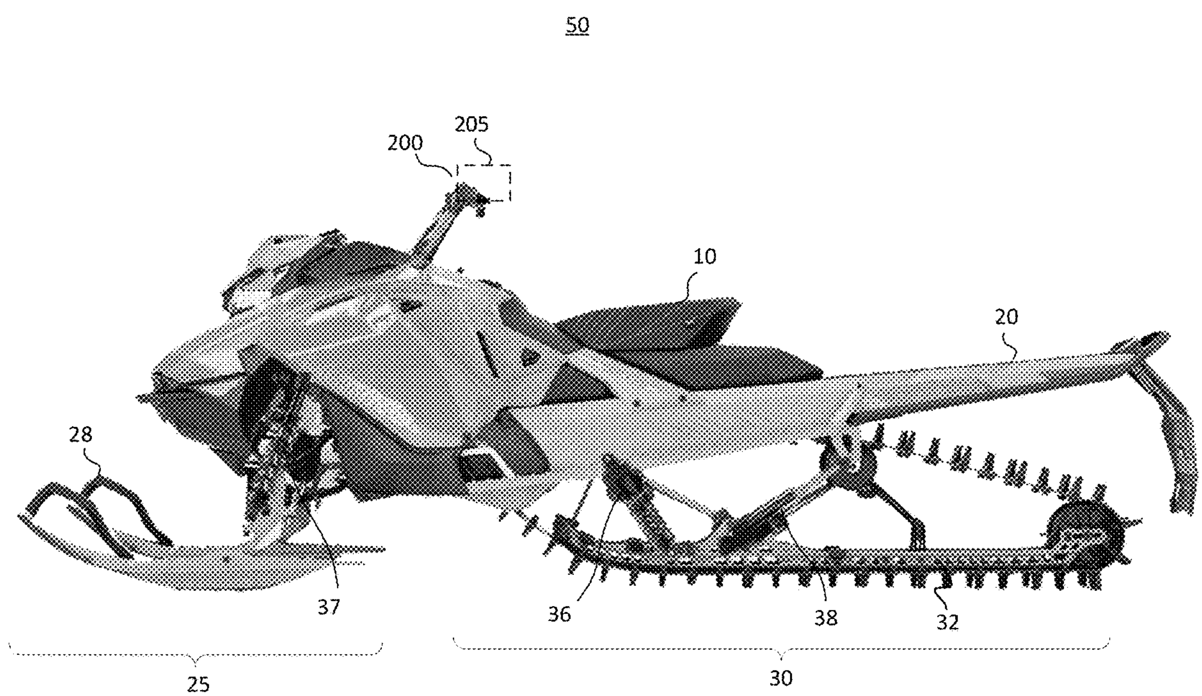
(57) **ABSTRACT**

An remote electronic shock adjuster is disclosed. The shock assembly with the electronic shock adjuster includes an electronic valve, the electronic valve configured to adjust a compression stiffness of the shock assembly. A switch is communicatively coupled with the electronic valve and configured to provide a signal to the electronic valve to lockout the shock assembly or return the shock assembly to a pre-lockout configuration.



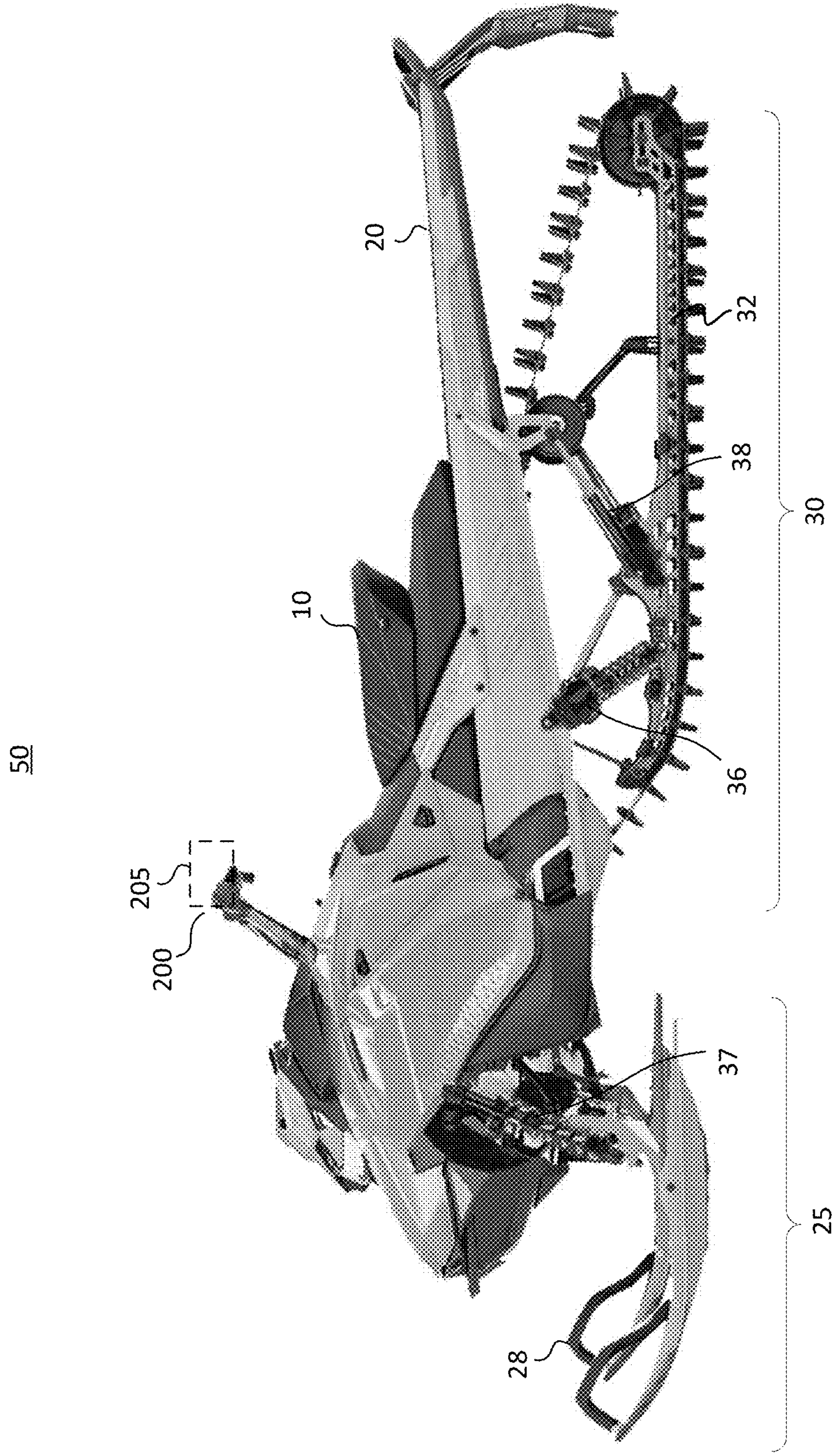


FIG. 1

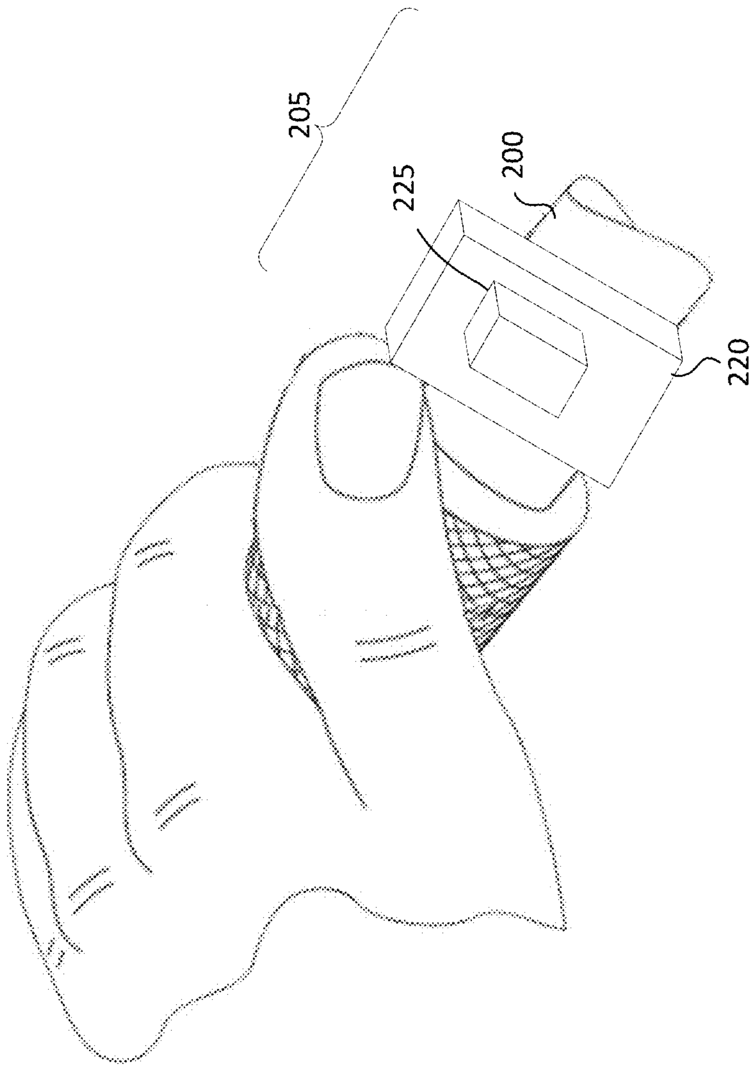


FIG. 2

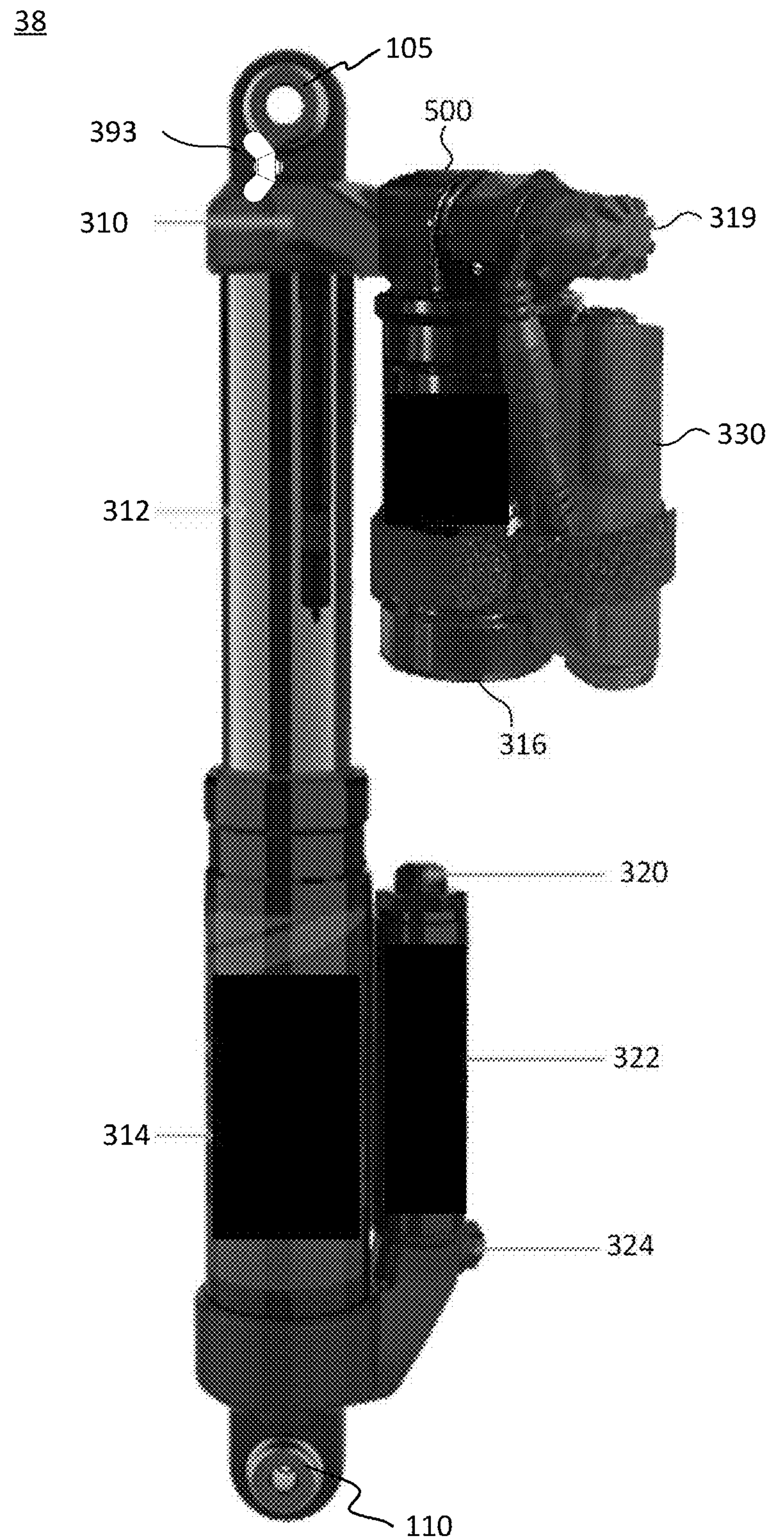


FIG. 3

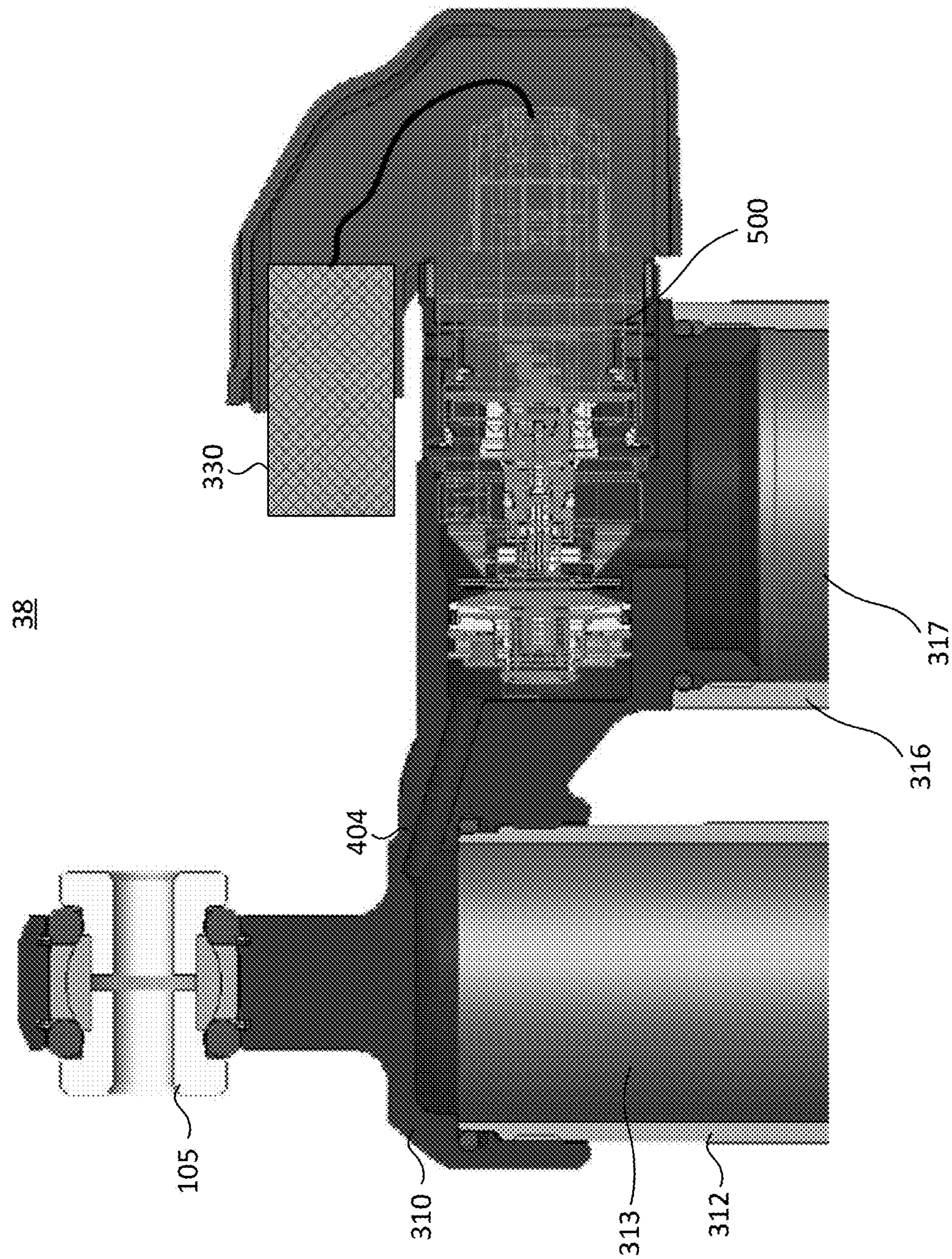


FIG. 4A

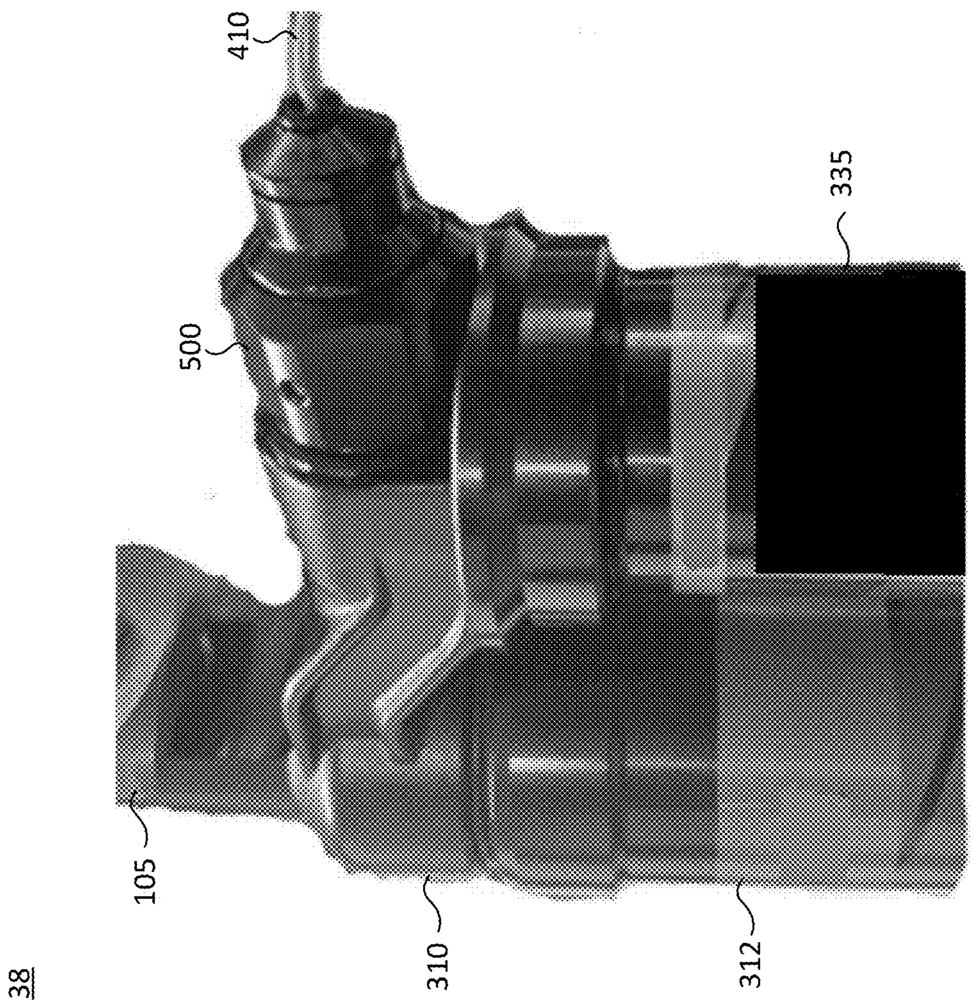


FIG. 4B

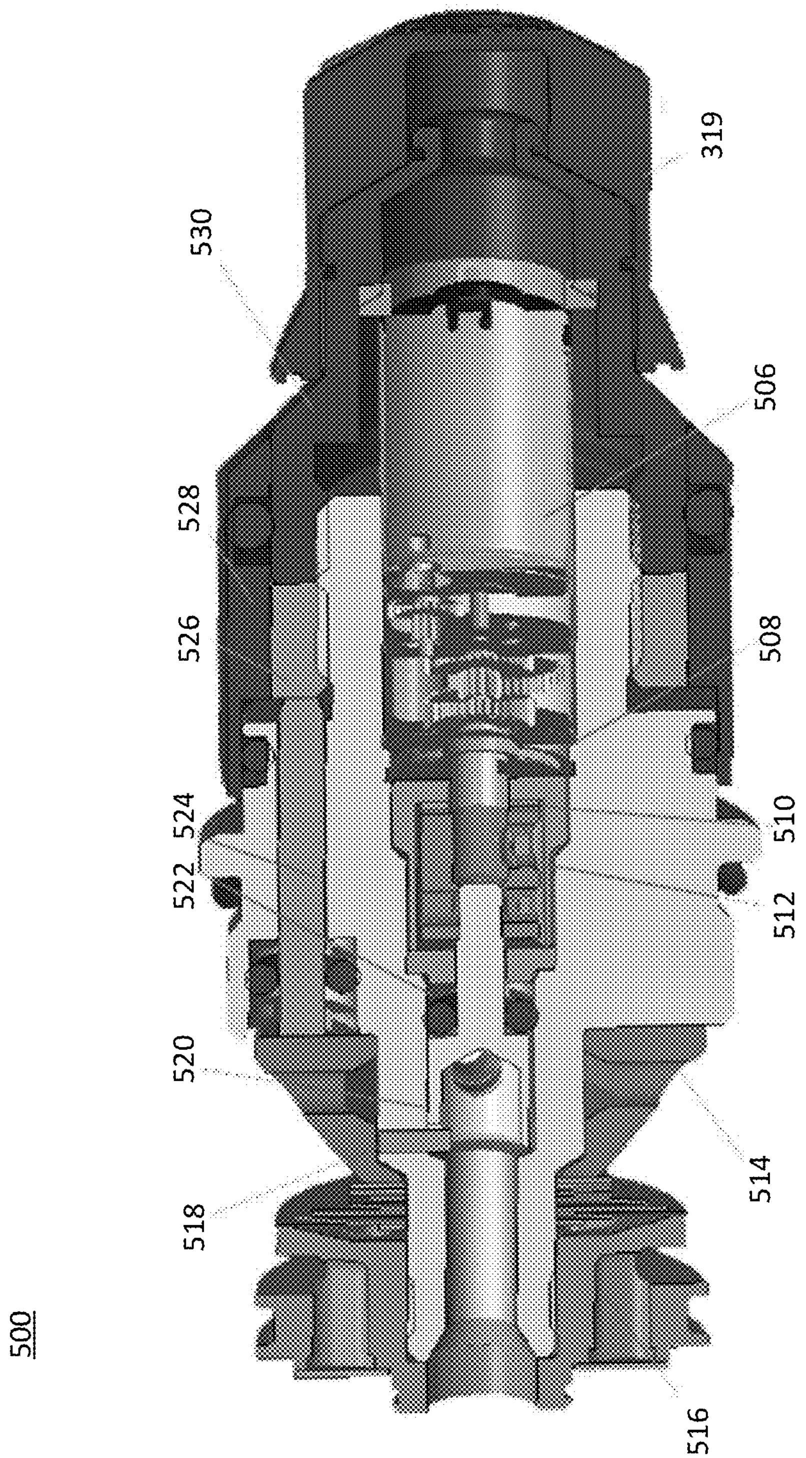


FIG. 5A

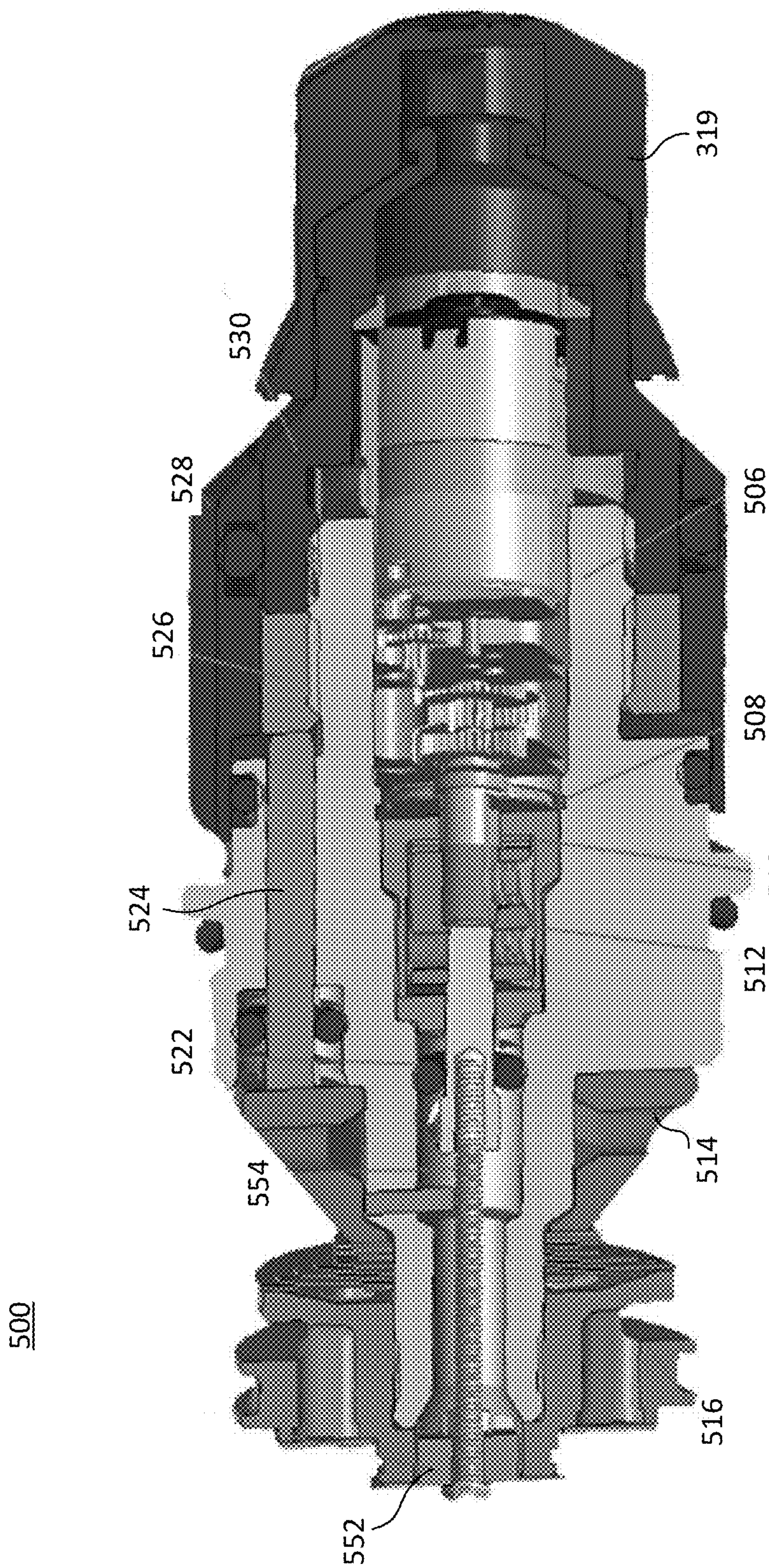


FIG. 5B

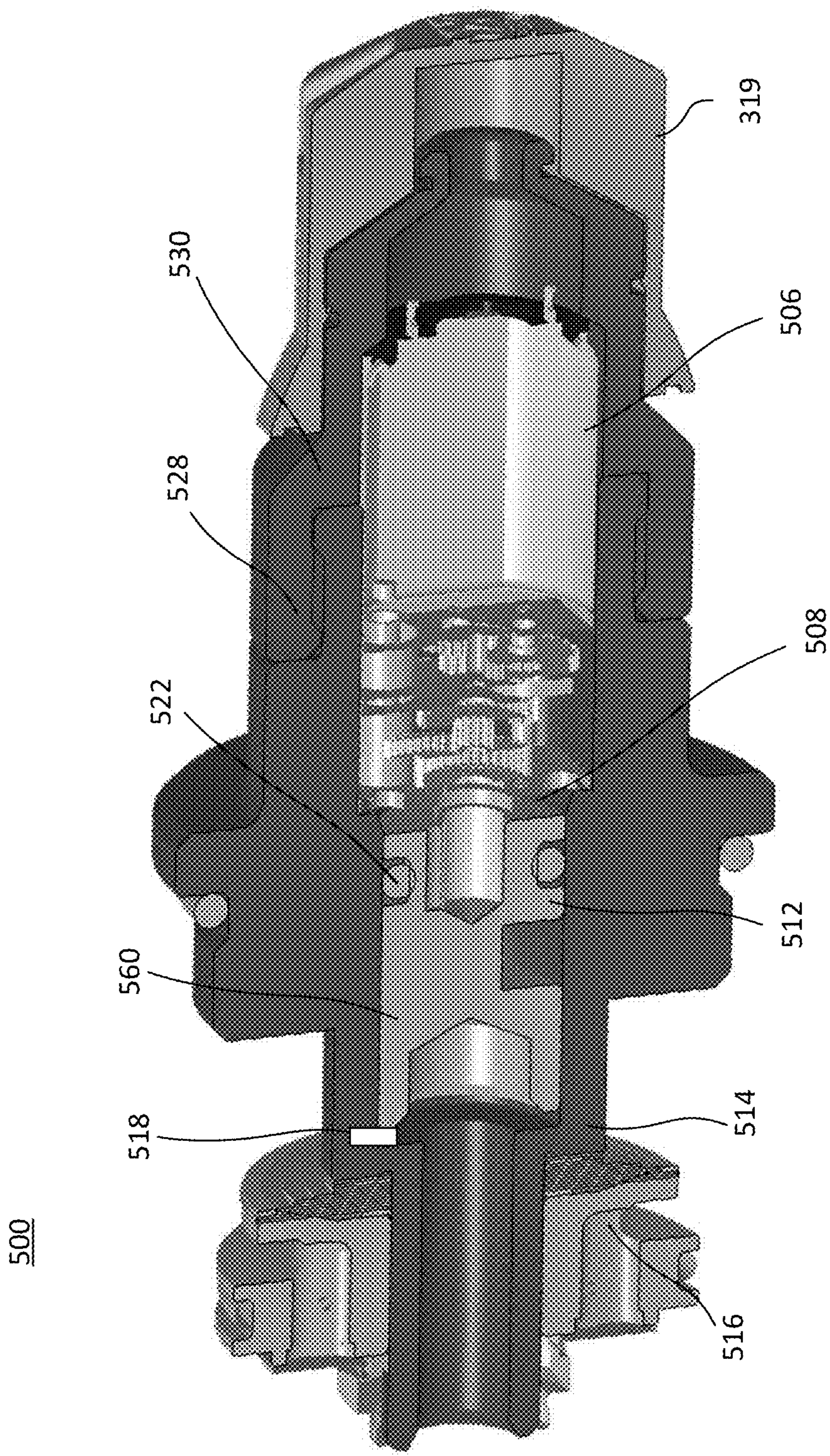


FIG. 5C

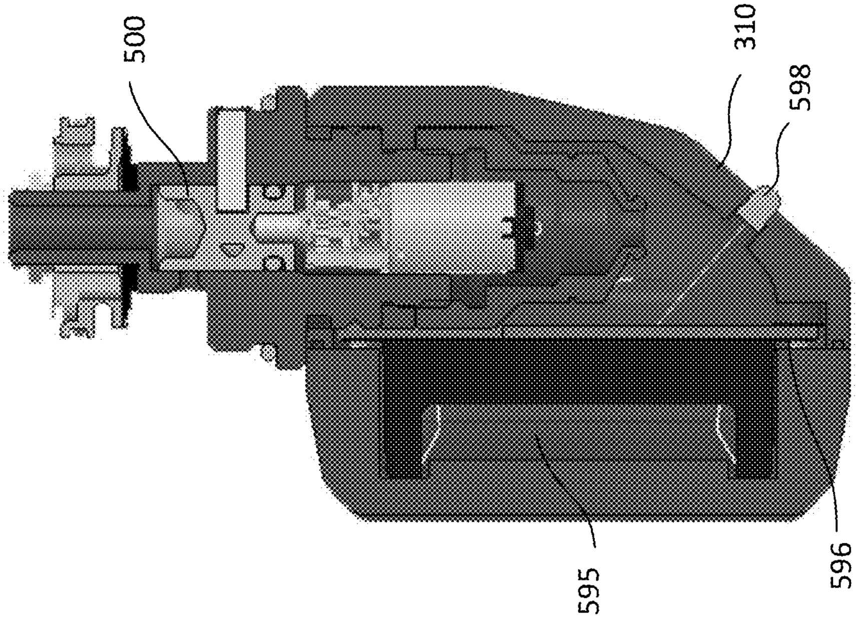


FIG. 6

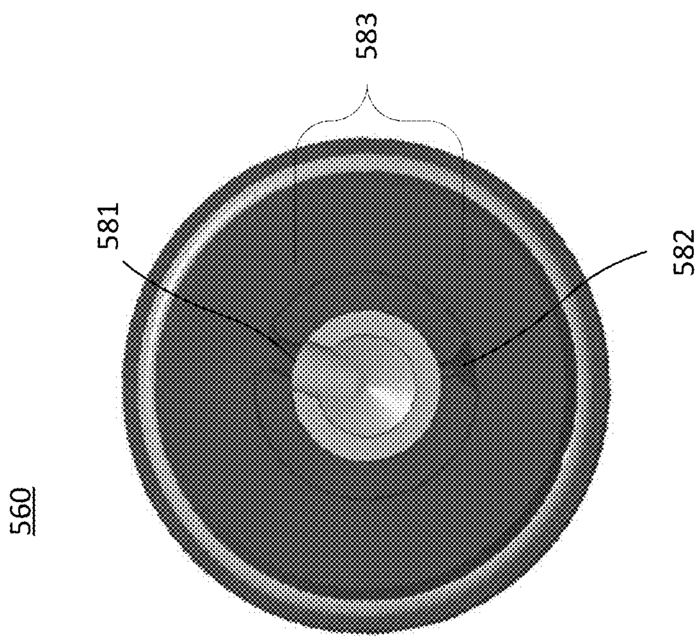


FIG. 5D

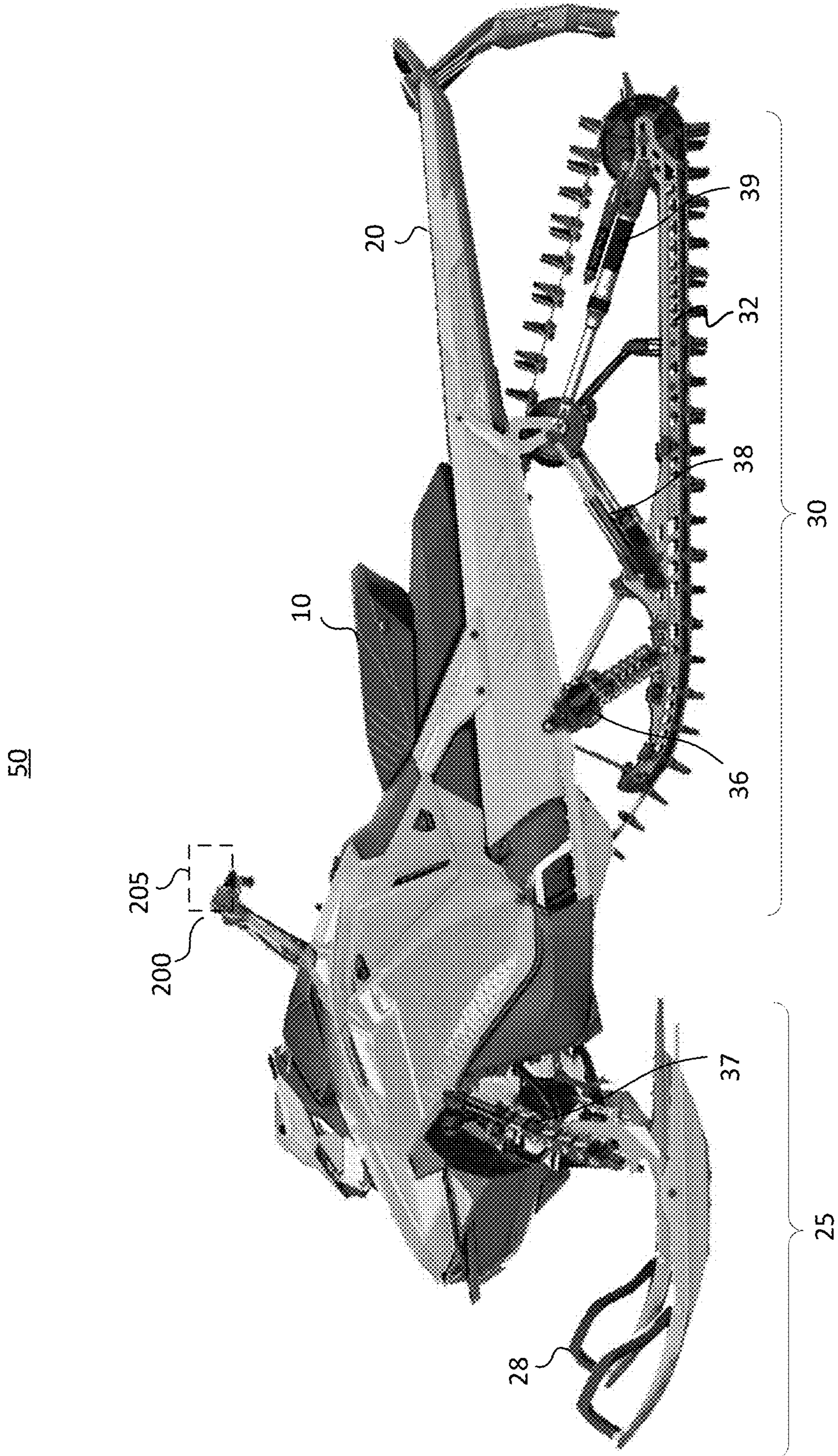


FIG. 7

REMOTE ELECTRONIC SHOCK ADJUSTER

FIELD OF THE INVENTION

[0001] Embodiments of the invention generally relate to an electronically adjustable shock assembly.

BACKGROUND

[0002] Shock assemblies are used in numerous different vehicles and configurations to absorb some or all of a movement that is received at a first portion of a vehicle before it is transmitted to a second portion of the vehicle. For example, when a front ski of a snowmobile hits a rough spot, the encounter will cause an impact force on the ski. However, by utilizing suspension components including one or more dampers, the impact force can be significantly reduced or even absorbed completely before it is transmitted to a user holding the handlebars of the vehicle.

[0003] Conventional shock assemblies provide a constant damping rate during compression or extension through the entire length of the stroke. As various types of recreational and sporting vehicles continue to become more technologically advanced, what is needed in the art are improved techniques for varying the performance characteristics of the shock assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Aspects of the present invention are illustrated by way of example, and not by way of limitation, in the accompanying drawings, wherein:

[0005] FIG. **1** is a perspective view of a snowmobile including a rear track shock assembly with an electronic valve, in accordance with an embodiment.

[0006] FIG. **2** is a perspective view of a user interface for the electronic valve of the rear track shock assembly, in accordance with an embodiment.

[0007] FIG. **3** is a perspective view of the rear track shock assembly with an electronic valve, in accordance with an embodiment.

[0008] FIG. **4**A is a cross-section view of a portion of the rear track shock assembly with the electronic valve illustrating the location of the electronic valve, in accordance with an embodiment.

[0009] FIG. **4**B is a perspective view of the rear track shock assembly with a wired electronic valve, in accordance with an embodiment.

[0010] FIG. **5**A is a cross-section view of a rotary spool style electronic valve, in accordance with an embodiment.

[0011] FIG. **5**B is a cross-section view of a check shim style electronic valve, in accordance with an embodiment.

[0012] FIG. **5**C is a cross-section view of a multi-state rotary spool style electronic valve, in accordance with an embodiment

[0013] FIG. **5**D is a front cut-away view of the multi-state rotary spool of FIG. **5**C, in accordance with an embodiment.

[0014] FIG. **6** is a cut-away view of a portion of rear track shock assembly with electronic valve, in accordance with an embodiment.

[0015] FIG. **7** is a perspective view of a snowmobile including a plurality of rear shock assemblies with electronic valves, in accordance with an embodiment.

[0016] The drawings referred to in this description should be understood as not being drawn to scale except if specifically noted.

DESCRIPTION OF EMBODIMENTS

[0017] The detailed description set forth below in connection with the appended drawings is intended as a description of various embodiments of the present invention and is not intended to represent the only embodiments in which the present invention is to be practiced. Each embodiment described in this disclosure is provided merely as an example or illustration of the present invention, and should not necessarily be construed as preferred or advantageous over other embodiments. In some instances, well known methods, procedures, and objects have not been described in detail as not to unnecessarily obscure aspects of the present disclosure.

Terminology

[0018] In the following discussion, a number of terms and directional language is utilized. Although the technology described herein is useful on a number of different suspension systems that use a shock assembly, a snowmobile (e.g., snowmachine, etc.) is used in the following description for purposes of clarity.

[0019] In general, a suspension system for a vehicle provides a motion modifiable connection between a portion of the vehicle that is in contact with a surface (e.g., an unsprung portion) and some or all of the rest of the vehicle that is not in contact with the surface (e.g., a suspended portion). For example, the unsprung portion of the vehicle that is in contact with the surface can include one or more wheel(s), skis, tracks, hulls, etc., while some or all of the rest of the vehicle that is not in contact with the surface include suspended portions such as a frame, a seat, handlebars, engines, cranks, etc.

[0020] In one embodiment, there may be times where specific changes to one, or some, but not all of the suspension component are desired during a given ride/drive. For example, a user of a snowmobile (or other rear-suspended vehicle) that is performing a hill climb, traversing a section of deep snow, loose fresh snow, or the like, would benefit by being able to proficiently firm up and/or lockout a shock assembly coupled with the rear track without necessarily modifying the damping characteristics of any other shock assemblies of the machine. Similarly, a bike rider in a sprinting scenario would often want to firm up or possibly even lockout the suspension component to remove the opportunity for rider induced pedal bob.

[0021] The term "active", as used when referring to a valve or shock assembly component, means adjustable, manipulatable, etc., during typical operation of the valve. For example, an active valve can have its operation changed to thereby alter a corresponding shock assembly characteristic damping from a "soft" setting to a "firm" setting (or a stiffness setting somewhere therebetween) by, for example, adjusting a switch in a passenger compartment of a vehicle. Additionally, it will be understood that in some embodiments, an active valve may also be configured to automatically adjust its operation, and corresponding shock assembly damping characteristics, based upon, for example, operational information pertaining to the vehicle and/or the suspension with which the valve is used.

[0022] Similarly, it will be understood that in some embodiments, an active valve may be configured to automatically adjust its operation, and corresponding shock assembly damping characteristics, based upon received user input settings (e.g., a user-selected “comfort” setting, a user-selected “sport” setting, and the like). In many instances, an “active” valve is adjusted or manipulated electronically (e.g., using a powered solenoid, electric motor, poppet, or the like) to alter the operation or characteristics of a valve and/or other component. As a result, in the field of suspension components and valves, the terms “active”, “electronic”, “electronically controlled”, and the like, are often used interchangeably.

[0023] The term “manual” as used when referring to a valve or shock assembly component means manually adjustable, physically manipulatable, etc., without requiring disassembly of the valve, damping component, or shock assembly which includes the valve or damping component. In some instances, the manual adjustment or physical manipulation of the valve, damping component, or shock assembly which includes the valve or damping component, occurs when the valve is in use. For example, a manual valve may be adjusted to change its operation to alter a corresponding shock assembly damping characteristic from a “soft” setting to a “firm” setting (or a stiffness setting somewhere therebetween) by, for example, manually rotating a knob, pushing or pulling a lever, physically manipulating an air pressure control feature, manually operating a cable assembly, physically engaging a hydraulic unit, and the like. For purposes of the present discussion, such instances of manual adjustment/physical manipulation of the valve or component can occur before, during, and/or after “typical operation of the vehicle”.

[0024] It should further be understood that a vehicle suspension may also be referred to using one or more of the terms “passive”, “active”, “semi-active” or “adaptive”. As is typically used in the suspension art, the term “active suspension” refers to a vehicle suspension which controls the vertical movement of the wheels relative to vehicle. Moreover, “active suspensions” are conventionally defined as either a “pure active suspension” or a “semi-active suspension” (a “semi-active suspension” is also sometimes referred to as an “adaptive suspension”). In a conventional “pure active suspension”, a motive source such as, for example, an actuator, is used to move (e.g. raise or lower) a wheel with respect to the vehicle. In a “semi-active suspension”, no motive force/actuator is employed to adjust move (e.g. raise or lower) a wheel with respect to the vehicle.

[0025] Rather, in a “semi-active suspension”, the characteristics of the suspension (e.g. the firmness of the suspension) are altered during typical use to accommodate conditions of the terrain and/or the vehicle. Additionally, the term “passive suspension”, refers to a vehicle suspension in which the characteristics of the suspension are not changeable during typical use, and no motive force/actuator is employed to adjust move (e.g. raise or lower) a wheel with respect to the vehicle. As such, it will be understood that an “active valve”, as defined above, is well suited for use in a “pure active suspension” or a “semi-active suspension”.

[0026] In the following discussion, an electronically adjustable component (or electronic valve) may be active and/or semi-active. In general, the electronic valve will have one or more electronically adjustable features controlled by a motive component such as a power resistor, solenoid, stepper motor, electric motor, or the like. In operation, the electronic valve will receive an input command which will cause the motive component to move, modify, or otherwise change one or more aspects of one or more electronically adjustable features.

[0027] In one embodiment, the electronic valve includes a manual command lockout capability. In one embodiment, a manual command lockout capability is provided by a rotary spool type base valve. In one embodiment, the manual command lockout capability is provided by a check shim type base valve architecture. In one embodiment, the manual command lockout capability is provided by a stand-alone valve. In one embodiment, the manual command lockout capability is added to a quick switch base valve architecture.

[0028] With respect to the term lockout, for purposes of the following discussion, lockout refers to the most restricted flow state attainable or desirable. Thus, in one embodiment, lockout refers to a stoppage of all fluid flow through a given flow path. However, in another embodiment, lockout does not stop all the fluid flow through a given flow path. For example, a manufactured component may not be able to stop all fluid flow due to tolerances, or a manufacturer (designer, etc.) may not want to stop all fluid flow for reasons such as lubrication, cooling, etc. Similarly, a lockout state could be a “perceived lockout”; that is, the flow area through a flow path of the adjustable shock assembly has been reduced to a minimum size for a given adjustable shock assembly, machine, environment, speed, performance requirement, etc. For example, in one “perceived lockout” most, but not all, of the fluid flow is minimized while in another “perceived lockout” the fluid flow is reduced by only half (or a third, quarter, three-quarters, or the like).

[0029] In another embodiment, lockout does not stop all the fluid flow through a given flow path but instead refers to the firmest compression setting available to a shock assembly. For example, if an electronic valve is locked out (or placed in its most restricted position), in one embodiment, the fluid flow would be reduced through some portion of the valving, but there would remain other flow paths such as blow-off paths, and the like. As such, in one embodiment, the lockout of an electronic valve would be similar to placing the valve in its firmest compression configuration.

Operation

[0030] Referring now to FIG. **1**, a perspective view of a snowmobile **50** with a shock assembly having an electronic valve (e.g., rear track shock assembly **38** with electronic valve **500**) is shown in accordance with an embodiment. Although a snowmobile **50** is used in the discussion, the electronic valve disclosed herein is also suited for use in one or more shock assemblies on other vehicles such as, but not limited to a bicycle, an electric bike (e-bike), a hybrid bike, a snowbike, a scooter, a motorcycle, an ATV, a personal water craft (PWC), a vehicle with three or more wheels (e.g., a UTV such as a side-by-side, a car, truck, etc.), an aircraft, and the like. In one embodiment, the electronic valve disclosed herein is also suited for use in one or more shock assemblies of a suspension inclusive device such as, but not limited to, an exoskeleton, a seat frame, a prosthetic, a suspended floor, and the like. However, in the following discussion, and for purposes of clarity, a snowmobile **50** is utilized as the example vehicle.

[0031] In general, snowmobile **50** includes a frame **5**, seat **10**, tail section **20**, handlebars **200**, front steering assembly

25, rear suspension assembly **30**, and a track **32** driven by the engine of snowmobile **50** and supported by the rear suspension assembly **30**.

[0032] In one embodiment, front steering assembly **25** includes front skis **28** and front shock assemblies **37**. In one embodiment, rear suspension assembly **30** includes a front track connection with front track shock assembly **36**, and a rear track connection with a rear track shock assembly **38**.

[0033] In one embodiment, snowmobile **50** will only include a limited number of the electronically actuated components, interactive components, and/or control features. For example, a snowmobile **50** might only include user interface **205** and rear track shock assembly **38** where the only setting that is electronically adjustable is the lockout setting.

[0034] In one embodiment, there may be times where specific changes to one, or some, but not all of the suspension component are desired during a given ride/drive. For example, a user of a snowmobile **50** (or other rear-suspended vehicle) that is performing a hill climb, traversing a section of deep snow, loose fresh snow, or the like, would benefit by being able to proficiently firm up and/or lockout rear track shock assembly **38** without necessarily modifying the damping characteristics of any other shock assemblies (e.g., front shock assemblies **37** and front track shock assembly **36**) of snowmobile **50**.

[0035] For example, when the snowmobile **50** is normally operating, each of the shock assemblies (e.g., front shock assemblies **37**, front track shock assembly **36**, and rear track shock assembly **38**) of the suspension are working to provide the best ride for a given scenario. They are absorbing bumps, reducing and/or removing the energy from impacts before that energy reaches the user, keeping the snowmobile components in contact with the surface, etc.

[0036] Thus, for many parts of a ride, the suspension settings are a compromise to obtain the desired performance. However, during a ride, when a user encounters a hill climb, deep and/or loose snow, or the like, the normal rear track shock assembly **38** settings can allow the rear suspension assembly **30** and track **32** to close toward the tail section **20** causing the snowmobile **50** to take on a nose high attitude.

[0037] Although during such events the rear suspension assembly **30** (and specifically rear track shock assembly **38** and track **32**) to close toward the tail section **20**, the other suspension assemblies (e.g., front shock assemblies **37** and front track shock assembly **36**) are not similarly affected. In contrast, the remaining suspension assemblies (e.g., front shock assemblies **37** and front track shock assembly **36**) are best suited to continue to provide the established damping and rebound characteristics to absorb events thereby keeping the snowmobile **50** from bouncing around too much, jarring the user, or otherwise causing a reduction and/or loss of control.

[0038] For example, in a hill climbing scenario, as the hill climb commences, normal rear track shock assembly **38** settings can allow the rear suspension assembly **30** and track **32** to close toward the tail section **20** causing the snowmobile **50** to take on a nose high attitude, as the hill climb continues, this nose high attitude will often result in loop-out, rolling over backwards, loss of forward momentum and/or drive, etc.

[0039] Similarly, in a deep powder scenario, as the traverse commences, normal rear track shock assembly **38** settings can allow the rear suspension assembly **30** and track **32** to close toward the tail section **20** causing the snowmobile **50** to take on a nose high attitude, as the traverse continues, the nose high attitude will result in trenching, tunneling, loss of forward momentum and/or drive, a crash, etc.

[0040] One embodiment utilizes the user interface **205** (in one embodiment, a two position switch) coupled to the rear track shock assembly **38** of the snowmobile **50** to provide this quick and easy tail hardening. For example, when the user encounters an environment (such as discussed above), the user would simply manipulate user interface **205** (e.g., flip it, push it, turn it, etc. to the firm position) which would cause the rear track shock assembly **38** to move to a firmer, firmest, and/or lockout state. In so doing, the firming of the rear track shock assembly **38** would remove an amount of flex from the rear suspension assembly **30** which would stop and/or reduce the rear suspension assembly **30** from closing toward the tail section **20** thereby stopping the snowmobile **50** from taking on a nose high attitude, and in so doing, reduce or remove loop-out, sinking, tunneling, or the like, while allowing the machine to maintain the connection between the terrain and the tread.

[0041] In one embodiment, after the terrain had been traversed, the hill had been climbed, or as the user desires, the user would then manipulate the user interface **205** (e.g., flip it, push it, turn it, switch it, etc. to the not firm position) which would cause the rear track shock assembly **38** to unlock and return to its regular compression damping settings.

[0042] In one embodiment, snowmobile **50** includes one or more electronically actuated components, interactive components, and/or control features such as one or more of a user interface **205**, active and/or semi-active shock assemblies (e.g., front track shock assembly **36**, rear track shock assembly **38**, and front shock assemblies **37**), a controller, one or more sensor(s), a display, a power source, smart components, and the like.

[0043] In general, the one or more sensor(s) could be used to monitor and/or measure things such as temperature, voltage, current, resistance, noise (such as when a motor is actuated, fluid flow through a flow path, engine knocks, pings, etc.), positions of one or more components of snowmobile **50** (e.g., shock positions, ride height, pitch, yaw, roll, etc.), and the like. In one embodiment, the one or more sensor(s) could be forward looking terrain, vibrations, bump, impact event, angular measurements, and the like.

[0044] Additional information for vehicle suspension systems, sensors, and their components as well as adjustment, modification, and/or replacement aspects including manually, semi-actively, semi-actively, and/or actively controlled aspects and wired or wireless control thereof is provided in U.S. Pat. Nos. 8,838,335; 9,353,818; 9,682,604; 9,797,467; 10,036,443; 10,415,662; the content of which are incorporated by reference herein, in their entirety.

Wired

[0045] In one embodiment, there is a wired communication connection (such as via a wiring harness or the like) between the one or more electronically actuated components, interactive components, and/or control features. For example, in one embodiment, the user interface **205** has a wired connection with the electronic valve in the rear track shock assembly **38** via a wiring harness and any adjustable aspect inputs received at the electronic valve (e.g., the manual lockout) would be received over the wired connection.

[0046] In one embodiment, power might also be received over the wired connection. For example, the motor (solenoid, or the like) that operates electronic valve would receive its power from a power source coupled with the wiring harness (e.g., the snowmobile power supply, a power supply incorporated with user interface **205**, a power supply coupled with another component, a reserve or extra power supply for auxiliary components, or the like).

[0047] Although shown in certain locations in FIG. **1**, in accordance with one embodiment, in other embodiments, one, some, or all of the components shown in FIG. **1** could be located in other locations. For example, one, some, or all of the components could be located on the sides of components, at the handlebars, at a foot peg (or footwell), carried by the rider if it is wireless, located on a mount attached to a portion of the snowmobile **50**, etc. Thus, the use of the locations of components as shown in FIG. **1** is indicative of one embodiment, which is provided for purposes of clarity.

Wireless

[0048] In one embodiment, the electronic valve of rear track shock assembly **38** will be in wireless communication with user interface **205** without requiring a wiring harness and any adjustable aspect inputs received at the electronic valve (e.g., the manual lockout) would be received over the wireless connection.

[0049] In one embodiment, the electronic valve and/or rear track shock assembly **38** would include its own power source and the motor (solenoid, or the like) that operates the electronic valve would receive its operating power therefrom. In other words, the electronic valve and/or rear track shock assembly **38** would be a self-contained unit which would be able to receive and carry out changes transmitted from user interface **205**.

Hybrid Wired and Wireless

[0050] In one embodiment, the communications between the one or more components are a combination of wired and wireless connectivity.

[0051] For example, in one embodiment, electronic valve of rear track shock assembly **38** is in wireless communication with user interface **205** and any adjustable aspect inputs would be received over the wireless connection. However, the motor (solenoid, or the like) that operates the electronic valve of rear track shock assembly **38** would receive its power from a power source via a wiring harness.

[0052] In one embodiment, the electronic valve and/or rear track shock assembly **38** would include its own power source and the motor (solenoid, or the like) that operates the electronic valve of rear track shock assembly **38** would receive its operating power therefrom.

[0053] With reference now to FIG. **2**, a perspective view of a user interface **205** is shown in accordance with an embodiment. In one embodiment, user interface **205** is provided in a location convenient for user manipulation during vehicle operation. In one embodiment, user interface **205** is provided on the handlebar **200** of the snowmobile **50** (or other part of snowmobile **50** that is reachable during use). In one embodiment, user interface **205** is coupled with handlebar **200** via a clip or other retaining device. In one embodiment, user interface may be, but is not limited to, a voice activation device, a GPS device having stored map, a smart phone, smart device, lever, button, or the like. Moreover, although the user interface **205** is shown coupled with handlebar **200**. In another embodiment, the user interface **205** could be located elsewhere, such as, but not limited to, on another portion of the snowmobile frame **119**, on a mount coupled with the snowmobile **50**, worn as a smart device, carried by the rider, or the like.

[0054] In one embodiment, such as when snowmobile **50** is minimally upgraded with the electronic valve of rear track shock assembly **38**, user interface **205** will only include manual lockout communications component **220** with a manually operated button **225** (or switch, knob, lever, trigger, or the like) the operation of which allows the user to remotely lock/unlock the rear track shock assembly **38** at will. It should be understood that in an embodiment, there may be only a single control, or in an embodiment there may be a set of controls.

[0055] In one embodiment, when the user interacts the user interface **205**, a signal is sent from the user interface **205** to the electronic valve of rear track shock assembly **38**. For example, when button **225** is operated by a user, manual lockout communications component **220** will send a signal to the electronic valve of rear track shock assembly **38**. In one embodiment, the signal will either cause the electronic valve of rear track shock assembly **38** to transition to a locked out state, thereby locking out the rear track shock assembly **38**, or it will cause the electronic valve of rear track shock assembly **38** to transition to a non-locked out state, thereby releasing the rear track shock assembly **38** from being manually locked out and returning it to its normal damping performance settings.

[0056] In one embodiment, communications component **220** will provide wireless communications between the user interface **205** and the electronic valve of rear track shock assembly **38**. In one embodiment, communications component **220** will provide a wired communication between the user interface **205** and the electronic valve of rear track shock assembly **38**.

[0057] In one embodiment, such as, for example, when snowmobile **50** has a fully (or partially) active suspension setup with the electronic valve of rear track shock assembly **38**, user interface **205** will include an iQS switch and manual lockout communications component **220** with button **225** (or switch, knob, lever, etc.).

[0058] In one embodiment, when the lockout mode is manually selected, each of the front shock assemblies **37** and the front track shock assembly **36** would remain in their given configuration while the rear track shock assembly **38** would be locked out.

[0059] Referring now to FIG. **3**, a perspective view of the rear track shock assembly **38** with an electronic valve **500** is shown in accordance with one embodiment. In one embodiment, the rear track shock assembly **38** is a FOX load optimizing air technology (FLOAT) air shock assembly with a reservoir (hereinafter "air shock assembly"). In general, the air shock assembly is a high-performance shock assembly that use air as springs, instead of heavy steel coil springs or expensive titanium coil springs.

[0060] In general, rear track shock assembly **38** includes attachment features such as, in one embodiment, a chassis mount (e.g., upper eyelet **105**) and a rear suspension mount (e.g., lower eyelet **110**) which allow the rear track shock assembly **38** to be coupled between the unsprung portion of the suspension (e.g., the framework and components of the rear suspension between track **22** and the terrain) and the frame **5**.

[0061] In one embodiment, rear track shock assembly **38** includes body **312**, an expansion component (e.g., main air chamber **314**) providing some type of expansive (or spring) force on rear track shock assembly **38**, and a main air valve **324** for adding or removing air from main air chamber **314**. In one embodiment, the rear track shock assembly **38** also includes body cap **310**, and a reservoir **316** fluidly coupled with the body **312**.

[0062] In one embodiment, rear track shock assembly **38** optionally includes an adjustable rebound damping valve **393**. In one embodiment, rear track shock assembly **38** optionally includes a compression adjuster knob **319**.

[0063] In one embodiment, rear track shock assembly **38** includes an optional extra volume (Evol) chamber **322** with an Evol air valve **320** (similar in function to main air valve **324** described herein). In one embodiment, the Evol chamber **322** allows the available air volume of main air chamber **314** of rear track shock assembly **38** to be changed on the fly, e.g., while the vehicle is in operation. In one embodiment, the change in available air volume can be performed by a user manually adjusting a lever (turning a knob, or the like) on rear track shock assembly **38** or in another location that is communicatively coupled with, but possibly remote from, the rear track shock assembly **38** such that it is easier for a user to reach while operating the vehicle.

[0064] In one embodiment, the change in available air volume is controlled by a user. In one embodiment, the change is controlled automatically by a control system on or connected with the vehicle. In one embodiment, the change to the air volume can be controlled by an automated system, while also receiving control inputs from the user manually and/or electronically.

[0065] In one embodiment, by using a main air chamber **314** and the Evol chamber **322**, the air spring style rear track shock assembly **38** is lightweight and progressive. The progressive aspect occurs during the increase in spring force and travel. For example, as the air shock is compressed in a compression stroke, the spring force increase is provided by the body **312** reducing the volume of the main air chamber **314** which compresses the air therein. As the air shock is further compressed (such as during the second half of the shock travel or wherever the tuned air shock assembly is set to begin using the Evol chamber), the Evol chamber can be used to add to the spring force increase being generated by the additional compression of the air in the main air chamber **314**. Thus, as the air shock travel through its compression range, the spring force will build progressively, such that any harsh bottoming of the suspension is virtually eliminated thereby providing a "bottomless" feel.

[0066] Moreover, because the main air chamber **314** and Evol chamber **322** are separated, they can be independently tuned. However, since they also work together in the described progressive fashion, the range of the combined tuning is greater than that of either alone. Thereby providing adjustability for performance across a wide variety of terrain, riding style, and user weights.

[0067] In general, adjusting the pressure in the main air chamber **314** is similar to changing a tender, and/or secondary springs, and/or the crossover spacers on a coil-over shock. Thus, adjusting the pressure in the main air chamber **314** will adjust ride height. In contrast, adjusting the pressure in the Evol chamber **322** is similar to changing a main spring on a coil-over shock, that is, it will help control bottom out and chassis roll.

[0068] Although the rear track shock assembly **38** in one embodiment is an air shock style shock assembly. In another embodiment, the rear track shock assembly **38** is a coil-over shock assembly, such as, for example, a FOX 2.0 zero QS3-R shock assembly with a velocity-sensitive shimmed damping system, one or more coil-over springs, a spring preload adjuster, and a reservoir. In another embodiment, the rear track shock assembly **38** may be another type of shock assembly such as, but not limited to, a stand-alone fluid damper assembly, a coil sprung adjustable shock assembly, an air sprung fluid damper assembly, a strut shock, or the like.

[0069] Referring still to FIG. **3**, in one embodiment, rear track shock assembly **38** includes a wireless controller **330** which receives data transmissions from user interface **205**. In one embodiment, wireless controller **330** signals a motive component coupled with the control valve (or electronic valve **500**). In one embodiment, wireless controller **330** is part of the motive component coupled with the control valve (or electronic valve **500**). In one embodiment, the motive component causes the control valve to adjust a compression stiffness of the shock assembly.

[0070] In one embodiment, the electronic valve **500** is electronically actuated. For example, user interface **205** provides a signal to the motive component to stiffen and/or lockout said shock assembly or return said shock assembly to a pre-stiffened and/or non-locked out configuration. In one embodiment, the electronic valve **500** is mechanically actuated. In one embodiment, the electronic valve **500** is both mechanically and electronically actuated.

[0071] Referring now to FIG. **4**A, a cross-section view of the top portion of the rear track shock assembly **38** with the electronic valve **500** of FIG. **3**, illustrating the location of the electronic valve **500** and an optional location for wireless controller **330** is shown in accordance with an embodiment. In one embodiment, the cross-sectional view also shows a portion of the chamber **313** of body **312** that holds the working fluid, a portion of the reservoir chamber **317** of reservoir **316** that holds the working fluid, and the flow path **404** in the body cap **310** therebetween. In addition, the electronic valve **500** for controlling the flow rate is shown within flow path **404**.

[0072] Referring now to FIGS. **3** and **4**A, in one embodiment, body **312** has an internal chamber **313** filled with a working fluid (e.g., high viscosity index shock oil, etc.), an expansion component (e.g., main air chamber **314**) providing some type of expansive (or spring) force on rear track shock assembly **38**, a main air valve **324** for adding or removing air from main air chamber **314**, and a piston coupled with a piston shaft, where the piston is located somewhere within the internal chamber **313** of body **312**. In one embodiment, when installed, the resting length of the mounted rear track shock assembly **38** is maintained in compression by the weight of the body it is suspending (e.g., the sprung portion of snowmobile **50**), and in expansion by the "spring" force produced by the expansion component (e.g., main air chamber **314**).

[0073] In one embodiment, reservoir **316** is fluidly coupled with the body **312** via a flow path(s) **404** through body cap **310**. In one embodiment, the reservoir **316** has a reservoir chamber **317** that is divided by an internal floating piston (IFP). In one embodiment, one side of the IFP divided reservoir chamber **317** is filled with a pressurized gas (e.g., nitrogen, or the like) and the other side of reservoir chamber **317** is fluidly coupled with chamber **313** of body **312** via flow path **404** and contains working fluid. In general, the IFP keeps the pressurized gas from mixing with the working fluid and/or reaching the flow path **404**.

[0074] In operation, when the vehicle encounters a bump, rear track shock assembly **38** is compressed causing the piston and piston shaft to move further into chamber **313** of body **312** (e.g., the compression stroke). After the compression stroke, the expansion component (e.g., main air chamber **314**) which was compressed by body **312** moving thereinto, acts to push body **312** back out of the chamber **314**, causing the piston and piston shaft to move back toward their original location within the chamber **313** of body **312** (e.g., the rebound stroke).

[0075] During the compression stroke, some of the working fluid in chamber **313** of body **312** is displaced (due to the reduced volume within chamber **313** of body **312** caused by the incursion of the piston shaft). This displaced working fluid will flow from chamber **313** of body **312** through the flow path **404** in the body cap **310** to the reservoir chamber **317**. As the working fluid fills the reservoir chamber **317**, it will cause the IFP to move further into reservoir chamber **317** causing the pressurized gas to be further compressed, and in so doing, ensure consistent, fade-free damping in most riding conditions.

[0076] In one embodiment, the electronic valve **500** is located in the body cap **310** flow path **404** between the chamber **313** of body **312** and the reservoir **316**. In one embodiment, electronic valve **500** is used to control the flow of the working fluid through the flow path **404** during the compression stroke. For example, in a most basic configuration, electronic valve **500** will either allow the working fluid to flow through flow path **404** (e.g., allowing the rear track shock assembly **38** to operate in its established envelope), or it will affectively close flow path **404** causing a lockout or maximum firmness setting of the rear track shock assembly **38** during the compression stroke.

[0077] In one embodiment, making an adjustment to the electronic valve **500** will change the flow rate of the working fluid flowing through flow path **404** causing a corollary adjustment of one or more damping characteristics of the rear track shock assembly **38** during the compression stroke.

[0078] In one embodiment, electronic valve **500** receives adjustment input(s) from user interface **205**. In one embodiment, electronic valve **500** receives adjustment input(s) from a compression adjuster knob **319**. In one embodiment, electronic valve **500** receives adjustment input(s) from user interface **205** and compression adjuster knob **319**.

[0079] With reference now to FIG. 4B, a perspective view of top portion of the rear track shock assembly **38** with the electronic valve **500** of FIG. **3**, having a wire **410** extending from the electronic valve **500** is shown in accordance with an embodiment.

[0080] In one embodiment, the wire **410** is the wired connection with user interface **205**.

[0081] In one embodiment, one, some, or all of front shock assemblies **37** and/or front track shock assembly **36** include the same or similar components as described in the rear track shock assembly **38** discussion provided herein. However, as previously stated, the discussion uses examples based on the rear track shock assembly **38** for purposes of clarity.

[0082] Moreover, although components of FIGS. **3**, **4**A, and **4**B, are shown in given locations in accordance with one embodiment, in other embodiments, one, some, or all of the components shown in FIGS. **3** **4**A, and **4**B could be located in other locations, one or more components could be separated into two or more pieces and dispersed, etc. The use of the locations of the components as shown in FIGS. **3**, **4**A, and **4**B are indicative of one embodiment, which is provided for purposes of clarity.

[0083] Referring now to FIG. **5**A, a cross-section view of a rotary spool style electronic valve **500** is shown in accordance with an embodiment.

[0084] In one embodiment, rotary spool style electronic valve **500** includes an end cap/preload ring stop **530**, preload knob **528**, threaded preload ring **526**, preload pins **524**, O-ring/Back up **522**, compression adjuster knob **319**, motive component **506**, coupled retaining ring **508**, PRFE thrust washers **510**, motive component coupler **512**, preload plate **514**, threaded piston **516**, rotary spool **520** (or control valve-which in one embodiment is pressure balanced), and rotary spool stop **518** (or control valve movement limiter).

[0085] In one embodiment, the rotary spool **520** is designed such that the angular rotation between the closed state and the start of flow (and/or the open state and the beginning of the closing of the flow) is minimized. In one embodiment, the flow path through rotary spool **520** is circular. In another embodiment, the flow path through rotary spool **520** is another shape or combination of shapes. In one embodiment, instead of using a single sized flow path through rotary spool **520**, a grid of holes are used as the flow path through rotary spool **520**.

[0086] In one embodiment, rotary spool **520** has a throw of approximate 90 degrees between its open and closed positions. In one embodiment, the rotary spool **520** is a short throw valve where the difference between the open and the closed position is approximately 180 degrees or less. In one embodiment, the rotary spool **520** is a single rotation valve where the difference between the open and the closed position is approximately 360 degrees or less.

[0087] In one embodiment, the electronic valve **500** includes rotary spool **520** and a rotary motive component **506**, such that all of the motion is rotary and as such, there is no need for any rotary to linear conversion. In other words, in one embodiment, there is no rotary to linear transmission required. E.g., there is no need to convert the rotating motion from a motor to linear actuation motion.

[0088] Therefore, in one embodiment, since electronic valve **500** relies only on rotational motion, no axial extension is needed other than the size of the electronic valve **500**. In one embodiment, to provide an even smaller axial footprint, the output shaft from motive component **506** is used as to drive rotary spool **520**.

[0089] In one embodiment, the feature of the rotary spool **520** that interfaces with rotary spool stop **518** is used to key the flow path through the rotary spool **520** to flow path **404**.

[0090] In one embodiment, the rotary spool **520** of electronic valve **500** is (effectively) a two-state valve. In other words, the rotary spool **520** is an on/off component.

[0091] In one embodiment, motive component **506** is a brushed DC motor with a gearbox. In one embodiment, motive component **506** is a stepper motor, brushless motor, coreless motor, solenoid, or the like. In one embodiment, a control process is employed which controls the motive component **506** ensuring it turn the rotary spool **520** the proper amount. In one embodiment, the control process does not require the use of visual indices, motion measurement tools, or the like.

[0092] With reference now to FIG. **6**, a cut-away view of a portion of rear track shock assembly **38** with electronic valve **500**, a power source **595**, and a PCB **596** (which in one embodiment includes a microcontroller and motor controller) are shown in accordance with an embodiment. In one embodiment, FIG. **6** includes an LED **598**.

[0093] With reference now to FIGS. **5**A and **6**, in one embodiment, the control process utilizes the wireless radio (at the user interface **205**), a microcontroller and a motor controller (in one embodiment, both the microcontroller and the motor controller are located other than user interface **205** and closer (if not physically coupled with) motive component **506**). In one embodiment, microcontroller and motor controller are located on the same PCB **596**. In one embodiment, the wireless radio senses an actuation signal from the trigger unit (e.g., the user pushing one of the buttons or the like on user interface **205**) which, in one embodiment, is mounted at handlebar **200**. As described herein, the pushing of the button is used to indicate a desired change to the shock assembly tune. When the actuation signal is received from the user interface **205** to the microcontroller, the microcontroller sends a signal to the motor controller. In one embodiment, the motor controller allows power from the power source (such as **595** or the like) to be applied to the DC motive component **506**. In one embodiment, full voltage from the power source is supplied to the motive component **506**. In one embodiment, full voltage from the power source is supplied such that the motive component **506** is spun as quickly as possible. In one embodiment, less than full voltage from the power source is supplied to the motive component **506**. In one embodiment, one or more components of the control process (e.g., microcontroller, motor controller, or the like) then monitor for a condition that occurs during the operation of motive component **506** (e.g., current, proxy current, time, resistance, voltage, temperature, other sensors input, or the like) that satisfies a predetermined criteria. When the condition is met, the power to the motive component **506** is removed.

[0094] For example, in one embodiment, as power is provided to the motive component **506**, the motor controller senses the current provided to the motive component **506** using a circuit integrated into the motor controller. In general, the current (or other measurable aspect) varies over time (e.g., initially spiking to get the motor turning, then dropping while the valve moves, then spiking again when the valve is hits a hard stop). In one embodiment, the operating current provided to the motive component **506** is compared to one or more pre-determined values (or current thresholds) stored in the memory of the microcontroller. In one embodiment, when the sensed current meets the predetermined threshold (e.g., a current threshold that represents motor stall), the microcontroller sends a signal to the motor controller to shut off the power to the motive component **506**. In one embodiment, this would complete an "closed" portion of the control strategy (e.g., closing the rotary spool **520**) and lockout the shock assembly. In one embodiment, as long as the user depresses the button on user interface **205**, this is all that occurs. That is, power is not required to keep the rotary spool **520** in its closed position.

[0095] In one embodiment, when the user selects a different suspension tune button on user interface **205**, the reverse operation occurs to open rotary spool **520**. That is, the wireless radio senses that new button being pushed. The microcontroller sends a signal to the motor controller to once again allow power to be provided to the motive component **506**, (however, in one embodiment, it is provided in an opposite polarity from that provided in the rotary spool **520** close operation to cause the motive component **506** to rotate in the opposite direction). Once again, the current is sensed until the current threshold criteria is met, at which point the microcontroller sends a signal to the motor controller to shut off the power to the motive component **506**. In one embodiment, this would complete the "unlock" portion of the control strategy (e.g., opening the rotary spool **520**). Once again, power is not required to hold the rotary spool **520** in its opened position.

[0096] In one embodiment, such as when the wireless control only utilizes the lockout feature, when the user interacts the user interface **205**, a signal is sent from the user interface **205** to the electronic valve **500**. As described in detail herein, the signal causes motive component **506** to rotate the rotary spool **520** within the electronic valve **500**. The rotation of the rotary spool **520** causes the opening and/or closing of flow path **404** between body **312** and reservoir **316** at the location of the electronic valve **500** causing the rear track shock assembly **38** to either be put into a lockout condition or removed from a lockout condition.

[0097] In one embodiment, the use of the control process described herein to monitor and analyze the sensed current greatly reduces the complexity associated with the opening and closing of conventional electronically-actuated valves. For example, in one embodiment only two wires are required to be coupled to motive component **506**. In general, the two wires provide the power to motive component **506**, (e.g., completing a circuit between the power source and motive component **506**). In one embodiment, the microcontroller and/or motor controller would also be included in the circuit to control the flow of power from the power source to the motive component **506**.

[0098] In one embodiment, the current (or other measurable aspect) can be sensed at any desired location of the circuit. For example, in various embodiments, the current may be sensed at, but not limited to, any of the following locations, at or very near motive component **506**, at a location remote from motive component **506**, at the same location as the power source for motive component **506**, at a control unit (such as microcontroller and/or motor controller) which controls motive component **506**, at a control unit which controls other features on the vehicle (e.g., in one embodiment, the control unit is not required to control motive component **506**), and the like.

[0099] In one embodiment, there is a feature (such as a cutout, lip, arm, etc.) in a portion of the rotary spool **520** that interfaces with the rotary spool stop **518** to create a hard stop (or bump stop, or the like). In various other embodiment, other aspects, features, or the like maybe used as the stopping feature of the rotation of the rotary spool **520** (such as open, closed, or the like) which would cause a current threshold to be reached. In one embodiment, the hard stop is used to control the endpoint or endpoints of motive component **506** with respect to moving/translating/rotating of some portion of rotary spool **520**. Once the hard stop has restricted further moving/translating/rotating of rotary spool

520, the controller will sense a corresponding change in current (e.g., a current spike, a current drop, or other change in current) through motive component **506**. In one embodiment, based upon sensing the current change, the controller stops power from being provided to motive component **506**, or otherwise alters the power received by motive component **506**.

[0100] In one embodiment, instead of (or in addition to) the measuring and/or monitoring of a current threshold of the motive component **506** to determine rotary spool **520** has reached a stopping point, other measuring devices such as timers, filters, thermometer, other sensors, and the like, may be used to measure time, resistance, voltage, temperature, noise, or the like. Here again, the control process is looking for a condition (e.g., current, proxy current, time, resistance, voltage, temperature, other sensors input, or the like) supplied to the motive component **506** that satisfies a predetermined criteria.

[0101] For example, if the motive component **506** rotational rate for a given power is known, and the amount of desired rotation of the rotary spool **520** is also known, a timer or the like could be used to control the time the power is supplied to motive component **506**. For example, if motive component **506** spins at a rate of 200 rpm and the rotary spool **520** needs to be rotated 180 degrees, then the timer would let the motive component **506** operate for 0.15 seconds. In one embodiment, the timer and/or filters disclosed herein could also be used as back-up or confirmation settings to ensure against faults/transients such as where the stall current threshold is reached before the rotary spool **520** is completely open or completely closed. Thus, using any and/or all of these methods, there is no need to measure the position of the motive component **506** directly.

[0102] As a significant advantage over conventional approaches, the various sensing embodiments, are not required to use visual indices, motion measurement tools, or the like, to determine that motive component **506** has completed a desired movement/translation/rotation of rotary spool **520**. As a result, embodiments do not require the additional complex features, additional wires (e.g., additional control wires between motive component **506** and a controller dedicated and/or used to control motive component **506**). Instead, one embodiment is able to control motive component **506** using the wires providing power to motive component **506**, or otherwise altering the power received by motive component **506**. Additionally, as physical space tends to be constrained in various vehicles, such as, for example, in the rear suspension of snowmobile **50**, fewer wires and components will occupy far less physical space than is required by conventional electronically actuated suspension assemblies. Moreover, although the discussion above is provided in light of controlling a rear track shock assembly **38**, other embodiments are well suited to being utilized in conjunction with different components such as, but not limited to, each of the front shock assemblies **37**, the front track shock assembly **36**, and various other vehicle components/features.

[0103] In one embodiment, although a wired connection between the motor controller and motive component **506** is disclosed as one method for monitoring and or controlling the power to motive component **506**, other embodiments are well suited to using a wireless communication to communicate between, for example, the controller and motive component **506**.

[0104] With reference now to FIG. **5**B, a cross-section view of a check shim style electronic valve **500** is shown in accordance with an embodiment. In general, a number of the components of check shim style electronic valve **500** are similar to those of rotary spool style electronic valve **500** FIG. **5**A, and as such, only the different components are discussed herein. The discussion of the components of FIG. **5**B that are similar to those of FIG. **5**A is not repeated for purposes of clarity, but is instead incorporated by reference in its entirety.

[0105] In the check shim style electronic valve **500** instead of having rotary spool **520** (which in one embodiment is pressure balanced), and rotary spool stop **518**, in one embodiment, check shim style electronic valve **500** uses a lead screw **554** (control valve) and a check shim/guide **552** (or control valve movement limiter) to open or close the flow path **404**.

[0106] With reference now to FIGS. **5**B and **6**, in one embodiment, when the user interacts the user interface **205**, a signal is sent from the user interface **205** to the electronic valve **500**. As described in detail herein, the signal causes motive component **506** to move the lead screw **554** within the electronic valve **500**. The movement of the lead screw **554** causes the opening and/or closing of flow path **404** between body **312** and reservoir **316** at the location of the electronic valve **500**, thereby causing the rear track shock assembly **38** to either be put into a lockout condition or removed from a lockout condition.

[0107] In one embodiment, the operation of lead screw **554** with respect to the check shim/guide **552** is similar to that described with respect to the rotary flow operation of FIG. **5**A. That is, check shim/guide **552** is used by a control system operating motive component **506** as part of a current limit type feedback system to control the operation and rotation of lead screw **554**. For example, in one embodiment, when the motive component **506** is activated, it will run in one of two directions to turn lead screw **554** (either to open or close flow path **404**). In one embodiment, when a feature on the lead screw **554** encounters check shim/guide **552** for a given direction of rotation, the lead screw **554** will stop rotating. This will cause a current increase in motive component **506** as it increases current to try to move the stopped lead screw **554**.

[0108] As discussed above, in one embodiment, there is a pre-established current threshold that is based on motive component **506** continuing to try to rotate the lead screw **554** after the lead screw **554** has been stopped by check shim/guide **552**. In one embodiment, when the control system operating motive component **506** determines the current threshold or current limit is met by the current requirements of motive component **506**, the control system will shut off the power to motive component **506**. In so doing, the check valve type electronic valve **500** is able to quickly rotate the lead screw **554** without requiring any additional controllers, inputs, etc.

[0109] In one embodiment, lead screw **554** of electronic valve **500** is (effectively) a two-state valve. In other words, the lead screw **554** is an on/off component. In one embodiment, the lead screw **554** of electronic valve **500** may have intermediate states (to limit flow, such as a high flow, a medium flow, a slow flow, etc., but not at zero flow). For example, the lead screw **554** of electronic valve **500** could have intermediate settings to control flow. In one embodiment, there may be a control system (an encoder on motive component **506** with different settings thereon, etc.) to control/adjust the rotational location of the lead screw **554** into one or more intermediate states, (e.g., between on and off), to provide a regulated flow.

[0110] In one embodiment, the motive component **506** (e.g., solenoid, electric motor, stepper motor, or the like) of the electronic valve **500** receives power from a power source located locally with respect to rear track shock assembly **38**. In one embodiment, the power source is integrated with the wireless controller **330**. In one embodiment, the power source is located at user interface **205**.

[0111] In one embodiment, electronic valve **500** may include a mechanical actuator (e.g., a cable, hydraulic line, etc.) for mechanically actuating one or more components of the electronic valve **500**. In general, the operation of electronic valve **500** would be similar to the operation described above, except for the change from a motive component **506** to electronically drive one or more components of the electronic valve **500**, a mechanical actuator would be used to mechanically actuate one or more components of the electronic valve **500**.

[0112] In one embodiment, the mechanical actuator **481** would provide a control capability such that a user input on a user interface **205** (or similar type device) would provide a mechanical actuation of the electronic valve **500** to change the lockout state of rear track shock assembly **38**.

[0113] Referring now to FIG. **5**C, a cross-section view of a multi-state rotary spool **560** of electronic valve **500** is shown in accordance with an embodiment. In general, multi-state rotary spool **560** of electronic valve **500** has a number of intermediate states (to limit flow, such as a high flow, a medium flow, a slow flow, etc.) between the closed state and the full-open state. In general, a number of the components of multi-state rotary spool **560** of electronic valve **500** are similar to those of rotary spool style electronic valve **500** FIG. **5**A, and as such, only the different components are discussed herein. The discussion of the components of FIG. **5**C that are similar to those of FIG. **5**A is not repeated for purposes of clarity, but is instead incorporated by reference in its entirety.

[0114] In one embodiment, multi-state rotary spool **560** of electronic valve **500** includes one or more intermediate settings in addition to the softest and the lockout positions to control flow.

[0115] With reference now to FIG. **5**D, a front cut-away view of the multi-state rotary spool **560** is shown in accordance with an embodiment. In one embodiment, multi-state rotary spool **560** has a soft setting **581** feature, a lockout setting **582** feature, and a firmness range **583** that becomes increasingly firmer as the multi-state rotary spool **560** is rotated from the soft setting **581** to the lockout setting **582**. In one embodiment, soft setting **581** feature is on one end stop and lockout setting **582** feature is on another end stop.

[0116] In one embodiment, soft setting **581** feature and lockout setting **582** feature are set 150 degrees apart. In another embodiment, they may be set at a different range. The use of 150 degrees is one embodiment and provided for purposes of clarity in the following examples.

[0117] With reference now to FIGS. **5**C-**6**, one embodiment of a control process is disclosed. In general, the control process for the valve of FIG. **5**C is similar to that of the discussion of the control and operation of FIG. **5**A. As such, it is not repeated for purposes of clarity.

[0118] In general, during operation, the controller may overshoot to each end stop to change between the soft setting **581** and lockout setting **582** of multi-state rotary spool **560** using the control and operation description provided in the discussion of FIG. **5**A. In one embodiment, instead of (or in addition to) the measuring and/or monitoring of a current threshold of the motive component **506** to determine multi-state rotary spool **560** has reached a stopping point, other measuring devices such as timers, filters, thermometer, other sensors, and the like, may be used to measure time, resistance, voltage, temperature, noise, or the like. Here again, the control process is looking for a condition (e.g., current, proxy current, time, resistance, voltage, temperature, other sensors input, or the like) supplied to the motive component **506** that satisfies a predetermined criteria.

[0119] In one embodiment, to obtain a middle firmness setting, a timer is used to time the operation of the motor such that it moves approximately half way between the soft setting **581** feature and lockout setting **582** feature in the firmness range **583**. For example, if the motive component **506** rotational rate for a given power is known, and the amount of desired rotation of the multi-state rotary spool **560** is also known, a timer or the like could be used to control the time the power is supplied to motive component **506**. For example, if motive component **506** spins at a rate of 200 rpm and the multi-state rotary spool **560** needs to be rotated approximately 75 degrees, then the timer would let the motive component **506** operate for 0.06 seconds. Thus, using any and/or all of these methods, there is no need to measure the position of the motive component **506** directly to put the multi-state rotary spool **560** in a softest position, a middle firmness position, or a firmest (or locked out) position.

[0120] In one embodiment, the rebound valve can use similar valving as disclosed in FIGS. **5**A-**6**. In one embodiment, if the rebound valve is on the same shock assembly as the compression valve, the two valves may share one or more of the control components such as the power source, the microcontroller, and the like. In one embodiment, each active valve may have its own motor controller.

[0121] As stated above a significant advantage over conventional approaches, the various sensing embodiments, are not required to use visual indices, motion measurement tools, or the like, to determine that motive component **506** has completed a desired movement/translation/rotation of multi-state rotary spool **560**. As a result, embodiments do not require the additional complex features, additional wires (e.g., additional control wires between motive component **506** and a controller dedicated and/or used to control motive component **506**). Instead, one embodiment is able to control motive component **506** using the wires providing power to motive component **506**, or otherwise altering the power received by motive component **506**. Additionally, as physical space tends to be constrained in various vehicles, such as, for example, in the rear suspension of snowmobile **50**, fewer wires and components will occupy far less physical space than is required by conventional electronically actuated suspension assemblies. Moreover, although the discussion above is provided in light of controlling a rear track shock assembly **38**, other embodiments are well suited to being utilized in conjunction with different components such as, but not limited to, each of the front shock assemblies **37**, the front track shock assembly **36**, and various other vehicle components/features.

[0122] In one embodiment, although a wired connection between the motor controller and motive component **506** is disclosed as one method for monitoring and or controlling the power to motive component **506**, other embodiments are well suited to using a wireless communication to communicate between, for example, the controller and motive component **506**.

[0123] In one embodiment, the microcontroller/Radio is a Feather M0 with RFM69HCW packet radio (433 MHz). In one embodiment, the motor controller is a DRV8833 2 channel controller with current limiting capabilities.

[0124] In one embodiment, the user interface **205** microcontroller/Radio is a Feather MO with RFM69HCW packet radio (433 MHz). In one embodiment, user interface **205** includes a voltage regulator such as TSR-12450. In one embodiment, the buttons on user interface **205** are momentary switches.

[0125] In one embodiment, the status of power source **595** is displayed by LED **598**. For example, in one embodiment, if power source **595** is running low, LED **595** may flash. Similarly, in one embodiment, user interface **205** may include an LED that provides status information such as which mode is selected, power source information, wireless connectivity status between user interface **205** and the one or more suspension components, and the like.

[0126] Referring now to FIG. **7**, a perspective view of a snowmobile **50** with a plurality of rear shock assemblies having an electronic valve (e.g., rear track shock assembly **38** and rear track roller shock assembly **39**) is shown in accordance with an embodiment. In general, a number of the components of snowmobile **50** of FIG. **7** are similar to those of snowmobile **50** of FIG. **1**, and as such, only the different components are discussed herein. The discussion of the components of FIG. **7** that are similar to those of FIG. **1** is not repeated for purposes of clarity, but is instead incorporated by reference in its entirety.

[0127] In one embodiment, rear suspension assembly **30** includes a front track connection with front track shock assembly **36**, a rear track connection with a rear track shock assembly **38**, and a rearmost track connection with a rear track roller shock assembly **39**.

[0128] In one embodiment, snowmobile **50** will only include a limited number of the electronically actuated components, interactive components, and/or control features. For example, a snowmobile **50** might only include user interface **205**, rear track shock assembly **38**, and rear track roller shock assembly **39** where the only setting that is electronically adjustable is the lockout setting.

[0129] In one embodiment, as discussed herein, there are times when specific changes to one, or some, but not all of the suspension component are desired during a given ride/drive. For example, a user of a snowmobile **50** (or other rear-suspended vehicle) that is performing a hill climb, traversing a section of deep snow, loose fresh snow, or the like, would benefit by being able to proficiently firm up and/or lockout rear track shock assembly **38** without necessarily modifying the damping characteristics of any other shock assemblies (e.g., front shock assemblies **37** and front track shock assembly **36**) of snowmobile **50**.

[0130] In one embodiment, depending upon the terrain being traversed, the length and/or overall flexibility of the rear suspension assembly **30**, and the like, there is a need for an additional shock assembly (e.g., rear track roller shock assembly **39**) to be locked out to limit any folding (or movement toward tail section **20**) of the last portion of the rear suspension assembly **30** (and therefore track **32**).

[0131] For example, in one embodiment, when a user encounters a hill climb, deep and/or loose snow, or the like, a locked out rear track shock assembly **38** setting will stop the rear suspension assembly **30** and track **32** from closing toward the tail section **20** causing the snowmobile **50** to take on a nose high attitude. However, it is possible that the portion of the rear suspension assembly **30** and track **32** that extend behind the connection of the locked out rear track shock assembly **38** will obtain an amount of flex that will allow the rear portion of the rear suspension assembly to move toward tail section **20**.

[0132] One embodiment utilizes the user interface **205** (in one embodiment, a two position switch) coupled to the rear track shock assembly **38** and the rear track roller shock assembly **39** of the snowmobile **50** to provide a quick and easy complete tail hardening. For example, when the user encounters an environment (such as discussed above), the user would simply manipulate user interface **205** (e.g., flip it, push it, turn it, etc. to the firm position) which would cause both rear track shock assembly **38** and rear track roller shock assembly **39** to move to a firmer, firmest, and/or lockout state. In so doing, the firming of the rear track shock assembly **38** and rear track roller shock assembly **39** would remove an amount of flex from the rear suspension assembly **30** which would stop and/or reduce the rear suspension assembly **30** from closing toward the tail section **20**, and in so doing, reduce or remove loop-out, sinking, tunneling, or the like, while allowing the machine to maintain the connection between the terrain and the tread.

[0133] In one embodiment, after the terrain had been traversed, the hill had been climbed, or as the user desires, the user would then manipulate the user interface **205** (e.g., flip it, push it, turn it, switch it, etc. to the not firm position) which would cause the rear track shock assembly **38** and rear track roller shock assembly **39** to unlock and return to its regular compression damping settings.

Communications Protocol

[0134] In one embodiment, one or more components of snowmobile **50** use a wireless network selected from one or more of: a wireless personal area network (WPAN), a low power network (LPAN), Internet of things (IoT) connectivity, or the like. In one embodiment, the wireless communication protocol could be, but is not limited to, Bluetooth, WiFi, Bluetooth Low Energy (BLE), near field communication (NFC), UHF radio signal, Worldwide Interoperability for Microwave Access (WiMax), long-term evolution (LTE), industrial, scientific, and medical (ISM) band, IEEE 802.15.4 standard communicators, Zigbee, ANT, ISA100.11a (wireless systems for industrial automation: process control and related applications) wireless highway addressable remote transducer protocol (HART), MiWi, IPv6 over low-power wireless personal area networks (6LoWPAN), thread network protocol, subnetwork access protocol (SNAP), and the like.

[0135] In one embodiment, one or more components of snowmobile **50** form a wireless mesh, such as a snowmobile area network (SAN) or the like. In one embodiment, one or more components of the SAN could interact with the user/rider in any number of ways such as via touch, sound, vision, radio, wearable, and the like.

[0136] In one embodiment, the wireless mesh may include protocols such as an auxiliary or propriety private network encryption such as AES 128. In one embodiment, the AES-128 block cipher is operated in the Authenticated Encryption with Associated Data (AEAD) scheme, which allows encrypting the given plaintext, and authenticating associated plain text data. The AEAD scheme requires a 13-byte nonce value, referred to herein as AEADNonce. When the AES-128symmetric key, and AEADNonce are unique for every packet, the connection is secured.

[0137] In one embodiment, the AEADNonce is constructed by concatenating the nonce of each device with the sequence number of the particular packet, for a total of 12 bytes, with the 13th byte padded with 00. This ensures the AEADNonce is unique, and the connection is therefore secure.

[0138] In one embodiment, one or more components within the wireless mesh may include communication protocols for one or more peers, such as an out-of-SAN wireless device that doesn't want to share its network. In this case, the out-of-SAN wireless device can provide a hardware interface and it can be piped into the SAN. Thus, in one embodiment, the wireless mesh network can be used to connect and/or control almost any wireless aspect, as the network, topology, and features thereof are well suited to interacting with basic device operating structures.

[0139] In one embodiment, information broadcast from a given component will include a unique identifier (ID) that identifies the specific component that made the broadcast. Thus, even when a number of different components are operating in the same environment, each component will be able to identify which component sent the signal based on the unique ID. In one embodiment, the unique ID is used during the programming/pairing of the components with the network.

[0140] In one embodiment, the unique ID is used to validate the sending component. Although a unique ID is used in one embodiment, in another embodiment, a different identification methodology may be used to identify the different components in the network. In one embodiment, the wireless network is an intra-vehicle wireless network (such as a SAN). In one embodiment, the intra-vehicle wireless network is a wireless mesh network. In one embodiment, the intra-vehicle wireless network includes an intra-vehicle transmission authentication and encryption protocol.

[0141] In one embodiment, the broadcast information or data (e.g., message payload) will include additional information/data comprising the wireless network which is passed to and from peripheral devices in the network. Thus, in one embodiment, the wireless network communication and/or wireless mesh network will allow for information/data to be exchanged between adjacent vehicles, vehicle networks, etc.

[0142] In one embodiment, the wireless network includes an inter-vehicle communication (IVC) wireless network for data transmission between the vehicle and at least another vehicle, between the vehicle and a mobile communications device distinct from the vehicle, between the vehicle and an infrastructure component (such as a traffic light, beacon on a stop sign, road mile marker, a benchmark, or the like). In one embodiment, the IVC wireless network is a wireless mesh network. In one embodiment, the IVC wireless network includes an IVC transmission authentication and encryption protocol.

[0143] The IVC transmission authentication and encryption protocol can be distinct and different from the intra-vehicle transmission authentication and encryption protocol, such that a device receiving a communication can determine the origin of the communication. Often, the origin of the communication is important depending upon the data provided in the communication. For example, a transmission that includes sensor provided information might only be verified and acted upon if it includes the intra-vehicle transmission authentication and encryption protocol (such as for security purposes or the like).

[0144] In one embodiment, the IVC transmission authentication and encryption protocol can include levels of trust. For example, a vehicle used by a friend may have a "trusted" IVC transmission authentication and encryption protocol that allows a sensor from the friend's vehicle to provide information to a component on the user's machine, information that is verified and acted upon as sensor data from a "trusted" peripheral. In contrast, when an IVC transmission includes sensor provided information but it does not have a "trusted" IVC transmission authentication and encryption protocol it would not be verified and acted upon. However, other information such as stop sign warnings, terrain changing information, or the like from IVC transmissions would be evaluated by one or more components of the user's machine and may be used depending upon context, or the like.

[0145] In one embodiment, communication protocol is designed for low latency and long battery life. In one embodiment, the network implements the proprietary low-latency low-power radio protocol to provide an effective transport for communication between electronic valve **500** and user interface **205**.

[0146] In one embodiment, the wireless signal is a "telegram" or the like that includes the unique identifier (ID) that identifies the component that broadcast the telegram signal. Thus, even when several devices are operating in the same environment, the telegram signal will identify which device sent the signal. Although the unique ID is used in one embodiment, in another embodiment, a different portion of the telegram signal is used to identify the transmitting device.

[0147] In one embodiment, one or more components will periodically send a heartbeat (e.g., check-in message), to inform one or more of the other components that they are still active. In one embodiment, the heartbeat is sent at a 1 Hz communication rate. In one embodiment, the component that received, but did not send, the heartbeat will provide a response message to confirm that there is a wireless connection therebetween.

[0148] In one embodiment, a timer is used to count down a check-in or heartbeat time period. In one embodiment, the time period measured by the timer is preset by the manufacturer. In one embodiment, the time period measured by the timer is adjustably set by the manufacturer, by the user, by a mechanic, based on the vehicle location, terrain type, or the like.

[0149] In one embodiment, when the timer expires, the heartbeat is sent. In one embodiment, once the wireless communication is confirmed, the timer will be restarted.

[0150] In one embodiment, if there is no response to the heartbeat with a predefined period of time, another heartbeat will be sent. In one embodiment, if there is still no response received, an additional pre-defined number of heartbeat signals will be sent.

[0151] In one embodiment, one or more of the components can be in a number of different energy states to conserve battery life. Although a number of states are discussed, in one embodiment there may be more, fewer, or a different combination or variation of the described energy states. The use of the disclosed energy states is provided herein as one embodiment and for purposes of clarity.

[0152] One state is referred to as the operating state. This is the highest battery power consumption state. In the operating state, the component is transmitting and/or receiving data.

[0153] In a standby state, the component is awake and there is a connection therebetween. For example, in the standby state, the user interface **205** is waiting to receive input from the user. When the user provides an input, user interface **205** will move into the operating state and transmit the data to electronic valve **500**.

[0154] In one embodiment, when electronic valve **500** responds to the transmission from user interface **205**, it will be known to both devices that there is a connection therebetween, that the signal has been received by electronic valve **500**, and that one or both the electronic valve **500** and/or the user interface **205** can return to the standby state until the next time the user provides an input to user interface **205**.

[0155] In one embodiment, the electronic valve **500** may not provide a response to the transmission from user interface **205**. In one embodiment, user interface **205** may not expect a response from electronic valve **500** after user interface **205** sends the transmission.

[0156] In one embodiment, the electronic valve **500** may only provide the heartbeat message to the user interface **205** at pre-defined intervals to evidence the connection between user interface **205** and electronic valve **500**.

[0157] In one embodiment, if user interface **205** expected but did not receive a response from electronic valve **500**, user interface **205** will include a programmed pre-defined number of attempts at transmitting the signal to electronic valve **500** before making the determination that there is a disconnection in the communication between the user interface **205** and the electronic valve **500**.

[0158] In one embodiment, such as after a period of inaction, or the user interface **205** determines that the snowmobile is not being ridden (e.g., based on a user input, a sensor input, or the like), such as for example, in one embodiment, a vibration sensor will determine that the snowmobile is stationary, the user interface **205** will send a standby message to inform electronic valve **500** and/or any active components that the snowmobile is not being ridden. In one embodiment, the electronic valve **500** and/or any active components will transition to a low-power mode or sleep mode when the standby message is received.

[0159] In one embodiment, once the electronic valve **500** and/or any active components user interface **205** is turned off (or otherwise not responding), electronic valve **500** and/or any active components will enter a no-heartbeat standby state (e.g., an intermediate battery power consumption state), where electronic valve **500** and/or any active components is awake and listening but is not sending any transmissions (e.g., heartbeat transmissions, etc.).

[0160] In one embodiment, electronic valve **500** and/or any active components will remain in the no-heartbeat standby state until the connection with user interface **205** is re-established. In one embodiment, when electronic valve **500** and/or any active components receives a message from user interface **205**, it will know that the connection with user interface **205** is established (or re-established) and electronic valve **500** and/or any active components will transition from the no-heartbeat standby state to a heartbeat standby state.

[0161] In a dormant state, the snowmobile is stationary. For instance, the snowmobile is in storage or otherwise parked and not being ridden. In one embodiment, when in the dormant state, active components such as the user interface **205**, electronic valve **500**, and/or any other active (or power consuming) components, will go into low-power mode. In one embodiment, while in the dormant state, electronic valve **500** and/or any active components will periodically wake up to transmit a signal to user interface **205**. If no response is received, electronic valve **500** and/or any active components will return to the dormant state, e.g., go back to sleep.

[0162] In contrast, if electronic valve **500** and/or any active components receives a response from user interface **205** during the periodic wakeup, in one embodiment, electronic valve **500** and/or any active components will change from the dormant state into the standby state.

[0163] In one embodiment, while in the dormant state, when motion is detected, the vibration sensor will wake the microcontroller on the user interface **205** (or in another embodiment, on the shock assembly, on another active component, or the like) which will then transmit a wake-up signal to the other components. In one embodiment, the wake-up signal will be transmitted a number of times over a given time period (e.g., a time period longer than the periodic wakeup time period to ensure the other components receive the wake-up transmission.

[0164] In one embodiment, while in the dormant state, when motion is detected, the vibration sensor will wake the microcontroller on a number of components such as user interface **205**, the shock assembly, and/or another active component. In one embodiment, a user may interact with a component such as a button on user interface **205** (or turning a key to an on position, pushing a start button, operating the throttle, bouncing the suspension, or the like) which will cause the components to wake from the dormant state.

[0165] Thus, in one embodiment, the electronic valve **500**, any active components, and/or the user interface **205** can move between the different states fluidly using the model described above. In one embodiment, the electronic valve **500**, any active components, and/or the user interface **205** will try to remain in (or return to) the lowest powered state for the specific situation.

[0166] In one embodiment, the power draw for each state is approximated as an average of 150 microamp draw during the active state, an average of 32 microamp draw during either standby state, and an average of 1 microamp draw during the dormant state.

[0167] In one embodiment, for example when the power source is a battery such as a CR2032, the capacity is approximately 173 mAh. As such, and based on the power draw for each state, the expected battery life of the battery of the electronic valve **500**, any active components, and/or the user interface **205** is a number of months. In one embodiment, depending upon the duty cycle, the lifespan of the battery will be different.

[0168] The foregoing Description of Embodiments is not intended to be exhaustive or to limit the embodiments to the precise form described. Instead, example embodiments in this Description of Embodiments have been presented in order to enable persons of skill in the art to make and use embodiments of the described subject matter. Moreover, various embodiments have been described in various combinations. However, any two or more embodiments can be combined. Although some embodiments have been described in a language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed by way of illustration and as example forms of implementing the claims and their equivalents.

What is claimed is:

1. A shock assembly comprising:

a valve coupled with a power resistor, wherein said power resistor causes said valve to adjust a compression stiffness of said shock assembly; and

a switch communicatively coupled with said valve, said switch configured to provide a signal, via a relay, to said valve to lockout said shock assembly or return said shock assembly to a non-lockout configuration.

2. The shock assembly of claim **1**, wherein said switch is located remote from said shock assembly.

3. The shock assembly of claim **2**, wherein said switch is wirelessly coupled with said valve.

4. The shock assembly of claim **2**, wherein said switch is coupled with said valve via a wired connection.

5. The shock assembly of claim **1**, wherein said valve is a rotary spool valve.

6. The shock assembly of claim **1**, wherein said valve is a check shim valve.

7. The shock assembly of claim **1**, wherein said valve is a two-state valve.

8. The shock assembly of claim **1**, wherein said valve is further configured to adjust a stiffness of said shock assembly to a firmest setting.

9. A suspension system comprising:

at least one front shock assembly;

at least one rear shock assembly comprising an electronic valve, wherein said electronic valve is configured to adjust a stiffness of said at least one rear shock assembly; and

a user interface communicatively coupled with said electronic valve, said user interface configured to provide a signal to said electronic valve to increase a firmness of said at least one rear shock assembly or return said at least one rear shock assembly to a pre-increased firmness configuration.

10. The suspension system of claim **9**, wherein said user interface is located remote from said at least one rear shock assembly.

11. The suspension system of claim **10**, wherein said user interface is wirelessly coupled with said at least one rear shock assembly.

12. The suspension system of claim **10**, wherein said user interface is coupled with said at least one rear shock assembly via a wired connection.

13. The suspension system of claim **9**, wherein said control valve is selected from a group consisting of: a rotary spool valve, a check shim valve, and a two-state valve.

14. The suspension system of claim **9**, wherein said control valve adjusts said stiffness of said at least one rear shock assembly to a firmest compression setting.

15. The suspension system of claim **9**, wherein said control valve adjusts said stiffness of said at least one rear shock assembly to a lockout compression setting.

16. The suspension system of claim **9**, further comprising:

a plurality of rear shock assemblies, wherein at least two of said plurality of rear shock assemblies comprise: said electronic valve, wherein said electronic valve is configured to adjust said stiffness of said at least two rear shock assemblies.

17. The suspension system of claim **16**, wherein said user interface is communicatively coupled with each of said at least two of said plurality of rear shock assemblies.

18. A snowmobile comprising:

an engine;

a frame;

a front steering assembly comprising at least one front shock assembly coupled between said frame and at least one ski, wherein said at least one front shock assembly does not require any electronic inputs;

a rear suspension assembly coupled with a track driven by said engine, said rear suspension assembly comprising:

a front track connection with a front track shock assembly; and

a rear track connection with a rear track shock assembly, said rear track shock assembly comprising: an electronic valve, wherein said electronic valve is configured to adjust a stiffness of said at least one rear shock assembly; and

a user interface communicatively coupled with said rear track shock assembly, said user interface configured to provide a signal to said electronic valve to lockout said rear track shock assembly or return said rear track shock assembly to a pre-lockout configuration.

19. The snowmobile of claim **18**, wherein said user interface is located remote from said rear track shock assembly.

20. The snowmobile of claim **18**, wherein said rear suspension assembly further comprises:

a rear track roller connection with a rear track roller shock assembly, said rear track roller shock assembly comprising: an electronic valve, wherein said electronic valve is configured to adjust a stiffness of said rear track roller shock assembly; and

said user interface communicatively coupled with said rear track roller shock assembly, wherein said user interface provides said signal to said electronic valve to lockout said rear track roller shock assembly or return said rear track roller shock assembly to a pre-lockout configuration.

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