

US Patent & Trademark Office

Patent Public Search | Text View

United States Patent	12391085
Kind Code	B2
Date of Patent	August 19, 2025
Inventor(s)	Randall; Connor

Motorized adjustment of a damper bleed

Abstract

A powered bleed adjuster is disclosed. The powered bleed adjust includes a barrel valve located at least partially within a bleed fluid pathway of a shaft. The barrel valve includes an internal fluid path formed along a longitudinal axis of the barrel valve, an opening of the internal fluid path at a first end of the barrel valve, and at least one bleed port through a wall of the barrel valve to provide a second opening for the internal fluid path. The powered bleed adjust also includes a motor coupled with the barrel valve, the motor configured to rotate the barrel valve to control a fluid flow through the bleed fluid pathway.

Inventors:	Randall; Connor (Salida, CO)
Applicant:	Fox Factory, Inc. (Duluth, GA)
Family ID:	1000008765444
Assignee:	Fox Factory, Inc. (Duluth, GA)
Appl. No.:	18/533949
Filed:	December 08, 2023

Prior Publication Data

Document Identifier	Publication Date
US 20240308288 A1	Sep. 19, 2024

Related U.S. Application Data

us-provisional-application US 63431618 20221209

Publication Classification

Int. Cl.: B60G17/015 (20060101); F16F9/46 (20060101)

U.S. Cl.:

CPC **B60G17/0152** (20130101); B60G2202/24 (20130101); B60G2202/312 (20130101);
B60G2202/42 (20130101)

Field of Classification Search

CPC: B60G (17/0152); B60G (2202/24); B60G (2202/31); B60G (2202/312); B60G (2202/42);
B60G (2202/442)

USPC: 280/124.16

References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
5129488	12/1991	Furuya	188/317	F16F 9/5126
5383679	12/1994	Nakamura	318/400.41	B60G 15/067
7374028	12/2007	Fox	N/A	N/A
7484603	12/2008	Fox	N/A	N/A
8616351	12/2012	Roessle	188/266.5	F16F 15/023
8838335	12/2013	Bass et al.	N/A	N/A
8857580	12/2013	Marking	N/A	N/A
8955653	12/2014	Marking	N/A	N/A
8991832	12/2014	Tetzlaff	280/6.151	B60G 17/04
9303712	12/2015	Cox	N/A	N/A
10060499	12/2017	Ericksen et al.	N/A	N/A
10433671	12/2018	Surface	N/A	N/A
10737546	12/2019	Tong	N/A	N/A
10933710	12/2020	Tong	N/A	N/A
2021/0339594	12/2020	Wang	N/A	B60G 17/0152

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
111196116	12/2019	CN	B60G 13/08
111853133	12/2020	CN	B60G 13/08
3290738	12/2017	EP	B60G 13/06
WO-2018061726	12/2017	WO	F16F 9/19

OTHER PUBLICATIONS

Description Translation for CN 111853133 from Espacenet (Year: 2021). cited by examiner

Primary Examiner: Shanske; Jason D

Assistant Examiner: Keck; Daniel M.

Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS (PROVISIONAL (1) This application claims priority to and benefit of U.S. Provisional Patent Application No. 63/431,618 filed on Dec. 9, 2022, entitled “DC Motor Bleed Adjust” by Connor Randall and assigned to the assignee of the present application, the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

(1) Embodiments of the invention generally relate to methods and apparatus for use in a vehicle suspension.

BACKGROUND OF THE INVENTION

(2) Shock assemblies are used in numerous different systems to absorb some or all of a movement that is received at a first portion of the system before it is transmitted to a second portion of the system. Tunable shock assemblies can include a manual bleed adjuster which is often located on or about the eyelet of the shock assembly and is used to modify the rebound and/or compression characteristics of the shock assembly.

(3) In general, a bleed is a fluid pathway that traverses the main piston without using the main piston valving. A bleed valve is used to control the amount of bleed (or working fluid flow) that utilizes the bleed to traverse the main piston. The manual bleed adjuster is coupled with the bleed valve such that a user input to the adjuster will cause the bleed valve to change the working fluid flow rate through the bleed which will modify the damping performance/characteristics of the shock assembly. By providing an external manual bleed adjuster, these adjustments can be made without requiring disassembly of the shock assembly.

(4) In some electronic shock assemblies, a stepper motor is used instead of the manual bleed adjuster. Often, the stepper motor is located on or about the eyelet of the shock assembly and in operation, it will cause a needle to move (e.g., up/down) with respect to the bleed to adjust the working fluid flow rate therethrough. However, stepper motor performance is dependent upon a driver circuit (or control system). Thus, using a stepper motor in place of the manual bleed adjuster will incur increased manufacturing costs beyond merely the cost of the stepper motor (due to the control system and mounting needs) and also increase the dead length (and therefore the packaging space requirements) of the shock assembly.

(5) Another electronic control system solution utilizes a solenoid valve is used instead of the manual bleed adjuster. Often, the solenoid valve is located on or about the main piston and is fluidly coupled with the bleed. While a solenoid valve does not necessarily require additional control circuitry, its addition to the main piston will increase the dead length (and therefore the packaging space requirements) of the shock assembly. Of course, the increase in dead length will deleteriously limit the amount of applications within which the shock assembly is able to fit.

(6) Thus, what is needed is an electronic control system that is able to act as a bleed adjust without adding dead length to the shock assembly.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) Aspects of the present invention are illustrated by way of example, and not by way of limitation, in the accompanying drawings, wherein:

(2) FIG. 1 is a perspective view of a shock assembly with a powered bleed adjust assembly, in accordance with an embodiment.

(3) FIG. 2 is a cross sectional view of the shock assembly with powered bleed adjust assembly, in accordance with an embodiment.

(4) FIG. 3 is a side perspective view of the powered bleed adjust assembly, in accordance with an embodiment.

(5) FIG. 4 is a perspective view of the barrel valve, in accordance with an embodiment.

(6) FIG. 5 is a cross section view of the barrel valve of the powered bleed adjust assembly in a closed position, in accordance with an embodiment.

(7) FIG. 6 is a cross section view of the barrel valve of the powered bleed adjust assembly in an open position, in accordance with an embodiment.

(8) FIG. 7 is a graph of the performance for a shock assembly with the powered bleed adjust assembly versus a shock assembly with a mechanical bleed adjust system, in accordance with an embodiment.

DETAILED DESCRIPTION OF THE EMBODIMENTS

(9) 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 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.

(10) 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.

(11) Often, the suspension system will include one or more shock assemblies which are used to reduce feedback from the unsprung portion of the vehicle before that feedback is transferred to the suspended portion of the vehicle, as the vehicle traverses an environment. However, the language used by those of ordinary skill in the art to identify a shock assembly used by the suspension system can differ while referring to the same (or similar) types of components. For example, some of those of ordinary skill in the art will refer to the shock assembly as a shock absorber, while others of ordinary skill in the art will refer to the shock assembly as a damper (or damper assembly), or the like.

(12) The term “dead length” refers to a given length of the shock assembly that does not contribute to available shock assembly travel. In other words, the dead length of a shock assembly would be a measurement of the shock assembly's overall length while in its most compressed state. For example, a shock assembly has a dead length of 10 inches. This would mean that it cannot fit into any space that is less than 10 inches in length.

(13) The term “travel” refers to the length of the operational portion of the shock, e.g., from its most compressed state to its most extended state. For example, the shock assembly will have a travel of 3 inches.

(14) The term “maximum working length” refers to the overall length of the shock assembly at its maximum extended state. In other words, the combination of the dead length and the travel.

Therefore, in the continuing example, the shock assembly with a dead length of 10 inches and a travel of 3 inches will have a maximum working length of 13 inches. Thus, the exemplary shock would fit within a suspension with more than 10 and no more than 13 inches of available packaging space.

(15) Embodiments disclosed herein provide a powered bleed adjust assembly that utilizes a motor such as a micro type DC motor (approximately $\frac{1}{4}$ inch in diameter) to provide electronic rebound and/or compression bleed adjust capabilities. In one embodiment, the motor is current limited so it will rotate until it hits an end stop in each direction. Another embodiment uses the motor to turn a lead screw and drive a needle up/down with respect to the bleed to adjust the working fluid flow

rate therethrough. In another embodiment, the powered bleed adjust assembly utilizes a motor such as, but not limited to, a servo, stepper, piezo, and the like.

(16) The motor is coupled with the barrel valve such that the rotation of the motor shaft will rotate the barrel valve. When the barrel valve is rotated to an open position, the through holes in the barrel valve will align with the ports in the rebound shaft to open the bleed. In contrast, when the barrel valve is rotated to the closed position, the through holes in the barrel valve will no longer be aligned with the ports in the rebound shaft effectively closing the bleed. When the barrel valve is rotated to a position somewhere between the opened and closed positions, the through holes in the barrel valve will partially align with the ports in the rebound shaft to partially open (or partially close) the bleed.

(17) In one embodiment, the components of the powered bleed adjust assembly are all located in a chamber that runs axially within a hollow shaft of the shock assembly. By including the components of the powered bleed adjust assembly within the hollow shaft, no dead length is added to shock assembly.

(18) In addition, any shock assembly with a mechanical rebound adjuster that utilizes a hollow shaft can be converted to an electronically tunable configuration by removing any unnecessary components of the mechanical rebound adjuster from within the shaft and installing the powered bleed adjust assembly in their place. As such, the converted electronically tunable shock assembly will not incur any increase in the packaging space.

(19) Moreover, as long as the motor is used as a modal adjust (e.g., it is current limited and does not require a controller), the converted electronically tunable shock assembly will not incur any additional controller costs.

(20) However, if a more advanced feedback system/controller was desired. Although it would incur additional cost, the controller would not need to be added to the shock assembly such that it increased the dead space (or the packing space) of the shock assembly. For example, in one embodiment the controller could fit within the hollow shaft along with the other components of the powered bleed adjust assembly. In another embodiment, the controller could be located on the shock assembly (such as in an external housing) and be communicatively coupled with the motor via the wiring. In another embodiment, the controller could be located remote from the shock assembly and be communicatively coupled with the motor via the wiring.

(21) With reference now to FIG. 1, a perspective view of a shock assembly **100** with a powered bleed adjust assembly **300** (of FIGS. 2 and 3) is shown in accordance with one embodiment. In one embodiment, shock assembly **100** includes a helical spring **115**, a damper housing **120**, a shaft **130** having a piston coupled therewith and located within a chamber of the damper housing **120**, an upper eyelet **105**, a lower eyelet **110**, and end cap **135**, and an external reservoir **125**.

(22) In one embodiment, shaft **130** is coupled with end cap **135**. In one embodiment, end cap **135** includes a spring seat and lower eyelet **110**.

(23) The upper eyelet **105** and lower eyelet **110** are used for mounting one end of the shock assembly to a static portion of a system and the other end of the shock assembly to a dynamic portion of the system. Although eyelets are shown, it should be appreciated that the mounting systems may be bolts, welds, or the like, the use of eyelets is provided as one embodiment and for purposes of clarity.

(24) Although the eyelets are labeled as upper eyelet **105** and lower eyelet **110**, this is providing as one embodiment, and for purposes of defining a relative direction of motion of one or more of the components of shock assembly **100**. It should be appreciated that in one embodiment, (such as an inverted scenario) the mounting of shock assembly **100** could be with the upper eyelet **105** being at a lower point (such as closer to a wheel retaining assembly) while the lower eyelet **110** would actually be at a higher point on a vehicle than upper eyelet **105** (e.g., such as at the frame of the vehicle).

(25) In one embodiment, external reservoir **125** includes an internal floating piston (IFP) fluidly

dividing the external reservoir into a working fluid side and a pressurized gas side. Where the pressurized gas side is able to compress to compensate for the shaft displaced fluid that enters the reservoir. In general, shaft displaced fluid refers to the fluid that is displaced from the damper chamber due to a reduction in available fluid volume within the damper chamber due to the additional volume of shaft **130** as it moves into the damper housing **120** during a compression stroke. Fluid communication between the main chamber of the damper and the external reservoir **125** may be via a flow channel including an adjustable needle valve. Additional detail and description of an external reservoir is described in U.S. Pat. No. 7,374,028 which is entirely incorporated herein by reference.

(26) In one embodiment, there is no external reservoir **125** and instead a base valve and IFP are located within the damper housing to separate the working fluid portion from the pressurized gas portion, wherein the base valve is used to compensate for the reduction in available volume of the damper housing **120** of the shock assembly **100** due to the shaft displaced volume.

(27) Although shock assembly **100** is a coil sprung shock assembly, this is provided as one embodiment and for purposes of clarity. In another embodiment, the shock assembly **100** could be a different type such as, but not limited to, an air sprung fluid damper assembly, a stand-alone fluid damper assembly, and the like. It should also be appreciated that the powered bleed adjust discussed herein could be used in an assortment of apparatus and vehicles such as, but not limited to, a bicycle, motorcycle, ATV, jet ski, car, snow mobile, side-by-side, door, hatch, hood, tailgate, exoskeleton, seat frame, prosthetic, orthotic, and the like.

(28) Referring now to FIG. 2, a cross sectional view of the shock assembly **100** with powered bleed adjust assembly **300** is shown in accordance with an embodiment. In one embodiment, shock assembly **100** includes damper housing **120**, a damping piston **208** coupled with shaft **130**, and powered bleed adjust assembly **300** (shown in further detail in FIG. 3). Damper housing **120** includes a main chamber **205** within which damping piston **208** is located. Damping piston **208** operationally divides main chamber **205** into a compression side **204** and a rebound side **206**.

(29) In operation, the damping piston **208** and shaft **130** are axially movable within the main chamber **205** of damper housing **120** toward or away from upper eyelet **105** (of FIG. 1). For example, during a compression stroke the damping piston **208** and shaft **130** move axially through the main chamber **205** toward upper eyelet **105**. In contrast, during a rebound stroke, the damping piston **208** and shaft **130** move axially through the main chamber **205** away from upper eyelet **105**.

(30) In one embodiment, main chamber **205** will include one or more fluid bypasses that allow fluid within the main chamber **205** to flow around damping piston **208** to move between the compression side **204** and the rebound side **206** of the main chamber **205** during at least a portion of the compression and/or rebound stroke. Additional information regarding the configuration and operation of a bypass is described in U.S. Pat. No. 8,857,580 which is entirely incorporated herein by reference.

(31) In one embodiment, damping piston **208** is equipped with fluid paths therethrough (e.g., one or more ports **210**) to permit damping fluid within the main chamber **205** to pass therethrough during the compression and/or rebound movement of shock assembly **100**. In one embodiment, the ports **210** have shim stacks (or the like) to regulate fluid flow therethrough. In one embodiment, a compression shim stack **212** is used to meter the fluid flow through one or more of the ports **210** during a compression stroke.

(32) For example, during the compression stroke (e.g., when the shock assembly **100** encounters a compression event and the shaft **130** is driven further into the compression side of the main chamber **205** within damper housing **120**) some or all of the force imparted by the compression event is transferred to and/or controlled by one or a combination of the fluid moving through the different valving as it traverses via one or more of the ports **210** from the compression side **204** to the rebound side **206** (and/or to the external reservoir **125**) and the compression of the helical spring **115**. Thus, during a compression event, the damping characteristics (e.g., firmness, softness,

stiffness, etc.) of the shock assembly **100** are controlled by the compression valving and the spring force of the helical spring **115**.

(33) In contrast, during a rebound stroke, the rebound shim stack **214** is used to meter fluid flow through one or more of the ports **210**. For example, after the compression event passes, the compressed helical spring **115** (which surrounds or is mounted in parallel with the damper housing **120**) will impart a spring force that will extend the shock assembly **100** causing the shaft **130** and piston to be pulled back from the compression side of the chamber of the damper housing **120**.

(34) In one embodiment, the rebound characteristics (e.g., speed) of the rebound stroke are controlled by the rebound valving (e.g., rebound shim stack **214**) which controls the rate of the fluid flow through one or more of the ports **210** through damping piston **208** as the fluid moves from the rebound side **206** to the compression side **204** of the main chamber **205**. In one embodiment, the rebound characteristics of the rebound stroke are also controlled by the rebound valving that controls the rate of the fluid flow from the external reservoir **125** back to the main chamber **205** of the damper housing **120** (e.g., to replace the reduced shaft volume withdrawn from the chamber of the damper housing **120**).

(35) In one embodiment, powered bleed adjust assembly **300** (described in further detail with respect to FIG. 3) includes a central port **216**, cross ports **218**, motor **220**, control wires **232**, metering rod **222**, barrel valve **224**, end cap **135**, motor coupler **230**, jet **234**, and end stop **236**. In one embodiment, motor **220** is a DC motor. In one embodiment, motor **220** is a piezo motor, servo motor, stepper motor, or the like.

(36) In one embodiment, the central port **216** is formed within shaft **130** and traverses the entire length thereof. In one embodiment, central port **216** has a fluid opening at a portion of shaft **130** that is above damping piston **208** (e.g., on the compression side **204** of the main chamber **205** as divided by the damping piston **208**). In one embodiment, the fluid opening of the central port is located at the distal end of shaft **130**.

(37) In one embodiment, the cross ports **218** are formed approximately perpendicular to the central port **216** to provide openings through the wall of shaft **130** and thus openings for the central port **216**. The cross ports **218** are located below damping piston **208** (e.g., on the rebound side **206** of the main chamber **205** as divided by the damping piston **208**) and work in conjunction with the central port **216** to provide a novel fluid flow path through the damping piston **208** that is not regulated by either the compression shim stack **212** or the rebound shim stack **214**.

(38) In one embodiment, jet **234** is located at least partially within the central port **216** between the compression side **204** opening of central port **216** and the cross ports **218**. In one embodiment, jet **234** is located completely within the central port **216**. Jet **234** is used to modify the diameter of the central port **216** and thereby tune the parameters of the powered bleed adjust assembly **300**. In one embodiment, jet **234** has a protrusion that acts as an end stop **236** for the barrel valve **224**. In one embodiment, jet **234** includes a check valve to limit fluid flow to a single direction. This check valve may limit fluid flow only during a compression stroke, or only during a rebound stroke.

(39) In one embodiment, motor **220**, motor coupler **230**, metering rod **222**, and barrel valve **224** are all located at least partially within central port **216**. In one embodiment, motor **220**, motor coupler **230**, metering rod **222**, and barrel valve **224** are all located completely within central port **216**. In one embodiment, one or more of motor **220**, motor coupler **230**, metering rod **222**, and barrel valve **224** are located at least partially within central port **216**, while the remainder of the components are all located completely within central port **216**.

(40) Barrel valve **224** is located within central port **216** such that the bleed ports of the barrel valve are capable of aligning with the cross ports **218** of shaft **130**. In so doing, barrel valve **224** is able to open, partially impede, or block fluid flow through the cross ports **218** (and therefore through central port **216**) depending on the rotational position thereof.

(41) In one embodiment, the rotational position of barrel valve **224** is dictated by the motor **220**. For example, the rotational output of motor **220** will be passed along the transmission chain

resulting in the rotation of barrel valve **224**.

(42) With reference now to FIG. **3**, a side perspective view of the powered bleed adjust assembly **300** is shown in accordance with an embodiment. In the following discussion, the description of the components of FIG. **3** that are similar to those described in FIG. **2** are not repeated for purposes of clarity but are incorporated herein by reference in their entirety.

(43) In one embodiment, the metering rod **222** is located between the barrel valve **224** and the motor coupler **230** and connectively couples the barrel valve **224** with the motor coupler **230**. In one embodiment, motor coupler **230** is located between metering rod **222** and motor **220** and connectively couples the metering rod **222** with the motor **220**. In one embodiment, motor **220** is located closest to end cap **135** and wires **232** extend from motor **220** out of shaft **130** (as shown in FIG. **2**).

(44) In one embodiment, a connection ring **338** is used to couple the metering rod **222** with the barrel valve **224**. In one embodiment, an O-rings **340** is used to stop any working fluid from flowing past the connection ring **338** (or the top portion of the metering rod **222**) and down toward the motor **220**. In one embodiment, a thrust washer **342** is provided between the barrel valve **224** and the connection ring **338** (or the top portion of the metering rod **222**).

(45) In one embodiment, motor coupler **230** and motor **220** are a single component. For example, motor coupler **230** may be the shaft of motor **220**. In another embodiment, there may be other components located between motor coupler **230** and motor **220**.

(46) In one embodiment, metering rod **222** and motor coupler **230** are a single component. In another embodiment, there may be one or more other components located between metering rod **222** and motor coupler **230**.

(47) In one embodiment, metering rod **222**, motor coupler **230**, and motor **220** are a single component. For example, metering rod **222** and motor coupler **230** may be the shaft of motor **220**. In another embodiment, there may be one or more other components located between any or all of metering rod **222**, motor coupler **230**, and motor **220**.

(48) In one embodiment, metering rod **222** and barrel valve **224** are a single component. In another embodiment, there may be one or more other components located between metering rod **222** and barrel valve **224**.

(49) In one embodiment, barrel valve **224**, metering rod **222**, and motor coupler **230** are a single component. In another embodiment, there may be one or more other components located between any or all of barrel valve **224**, metering rod **222**, and motor coupler **230**.

(50) In one embodiment, barrel valve **224**, metering rod **222**, motor coupler **230**, and motor **220** are a single component. For example, barrel valve **224**, metering rod **222**, and motor coupler **230** may be the shaft of motor **220**. In another embodiment, there may be one or more other components located between any or all of barrel valve **224**, metering rod **222**, motor coupler **230**, and motor **220**.

(51) Referring now to FIG. **4**, a perspective view of the barrel valve **224** is shown in accordance with an embodiment. In the following discussion, the description of the components of FIG. **4** that are similar to those described in FIG. **2** are not repeated for purposes of clarity but are incorporated herein by reference in their entirety. In one embodiment, barrel valve **224** is a gate valve. In one embodiment, barrel valve **224** is a rotary spool.

(52) In one embodiment, barrel valve **224** includes guide needle **442**, bleed ports **448**, stopper **444**, and pressure balance ports **446**.

(53) In one embodiment, barrel valve **224** includes an internal fluid path **516** formed within the barrel valve **224** and extending along a longitudinal axis (the axis along the length of the barrel valve **224** body and guide needle **442**) of the barrel valve **224** (shown in further detail in FIG. **5**). The internal fluid path **516** is open at a top end of the barrel valve **224** (opposite the guide needle **442**) to provide an unencumbered flow path from the compression side opening of the central port **216** of shaft **130**. Barrel valve **224** also includes a guide needle **442** allowing it to be align and/or

coupled with the metering rod **222** (or another component of the powered bleed adjust assembly **300**) at a bottom end thereof.

(54) In one embodiment bleed ports **448** are formed approximately perpendicular to the internal fluid path **516** and provide openings through the wall of barrel valve **224** thereby providing a fluid flow path that extends from the top of barrel valve **224** through the bleed ports **448**.

(55) When barrel valve **224** is properly installed within the central port **216** of shaft **130**, the bleed ports **448** will be on the same plane as the cross ports **218**. Thus, when barrel valve **224** is rotated to an open state (as shown in FIG. **6**), the bleed ports **448** will be aligned with the cross ports **218** and will allow the working fluid to flow through the bleed. E.g., between the compression side **204** (via jet **234**, the internal chamber of barrel valve **224**, bleed ports **448**, and cross ports **218**) and the rebound side **206** via the powered bleed adjust assembly **300**.

(56) In contrast, when barrel valve **224** is rotated to a closed state (as shown in FIG. **5**), the bleed ports **448** will not be aligned with the cross ports **218** and will reduce and/or stop the ability of the working fluid to flow through the bleed.

(57) In one embodiment, there are a plurality of bleed ports **448**. In one embodiment, there are a plurality of bleed ports **448** on different planes. In one embodiment, there are a plurality of bleed ports **448** with one or more varying diameters.

(58) Stopper **444** is used to limit the rotational freedom of barrel valve **224**. For example, when barrel valve **224** is rotating, as it reaches its fully open (or fully closed position) stopper **444** will contact the end stop **236** (e.g., a protrusion from jet **234** of FIG. **2**) which will stop the directional rotation of barrel valve **224**. This stopper **444** will both provide a limit to the rotational range of the barrel valve **224** and also act as an indicator of the actual position of barrel valve **224**. In one embodiment, the stopper **444** is larger, smaller, of a different geometric design, slope, angle, or the like, to allow different degrees of rotational freedom for barrel valve **224**.

(59) In one embodiment, within the body of barrel valve **224** one or more pressure balance ports **446** are formed approximately perpendicular to the longitudinal axis of barrel valve **224** (e.g., approximately perpendicular to internal fluid path **516**) and provide openings through the wall of barrel valve **224** (similar to the bleed ports **448** discussed herein). In one embodiment, pressure balance ports **446** cause barrel valve **224** to be a pressure balanced valve. Further discussion of the pressure balance ports **446** is provided in the description of FIG. **5**.

(60) With reference now to FIG. **5**, a cross section view of the barrel valve **224** of the powered bleed adjust assembly **300** in a closed position is shown in accordance with an embodiment. In the following discussion, the description of the components of FIG. **5** that are similar to those described in FIGS. **2-4** are not repeated for purposes of clarity but are incorporated herein by reference in their entirety.

(61) In one embodiment, when barrel valve **224** is in a closed position the bleed ports **448** are not aligned with the cross ports **218** thereby reducing and/or stopping the flow of working fluid between the compression side **204** (via jet **234**, the internal fluid path **516** of barrel valve **224**, bleed ports **448**, and cross ports **218**) and the rebound side **206** via the powered bleed adjust assembly **300**.

(62) However, some amount of working fluid is able to flow through the pressure balance ports **446** and into chamber **510**. In so doing, the fluid around the barrel valve **224** will all remain at the same pressure and the barrel valve **224** will remain pressure balanced. Moreover, the thrust washer **342** located between the barrel valve **224** and the connection ring **338** (or the top portion of the metering rod **222**) will stop any working fluid from flowing out of the chamber **510** and down into metering rod **222** or further to motor **220**. In one embodiment, O-rings **340** will also stop any working fluid from flowing past the connection ring **338** (or the top portion of the metering rod **222**) and down toward the motor **220**.

(63) With reference now to FIG. **6**, a cross section view of the barrel valve **224** of the powered bleed adjust assembly **300** in an open position is shown in accordance with an embodiment. In the

following discussion, the description of the components of FIG. 6 that are similar to those described in FIGS. 2-4 are not repeated for purposes of clarity but are incorporated herein by reference in their entirety.

(64) In one embodiment, when barrel valve **224** is in the open position, the bleed ports **448** will be aligned with the cross ports **218**. This alignment of ports will allow the working fluid to flow between the compression side **204** (via jet **234**, the internal chamber of barrel valve **224**, bleed ports **448**, and cross ports **218**) and the rebound side **206** via the powered bleed adjust assembly **300**.

(65) Dashed arrows **605** show the fluid flow direction during a compression stroke while solid arrows **610** show the fluid flow during a rebound stroke.

(66) In one embodiment, as the shock assembly **100** is in a rebound stroke and nearing a fully extended position, cross ports **218** may become at least partially obstructed by the surrounding shock assembly **100** architecture to limit the amount of working fluid that can exit the rebound side **206** via the powered bleed adjust assembly **300**. This restriction of fluid flow assists in the shock topping out and damaging itself.

(67) In one embodiment, the powered bleed adjust assembly **300** is utilized in a base valve to reduce bottom out.

(68) Referring now to FIG. 7, a graph **700** of the performance for a shock assembly with the powered bleed adjust assembly **300** versus a shock assembly with a legacy mechanical bleed adjust system **710** is shown in accordance with an embodiment.

(69) In graph **700**, dyno curve testing data is shown over the operation range of each of the powered bleed adjust assembly **300** and the legacy mechanical bleed adjust system **710** in both the open bleed and closed bleed configurations. As shown in graph **700**, the powered bleed adjust assembly **300** has approximately twice the range as the legacy mechanical bleed adjust system **710**. Further, the operational range of the powered bleed adjust assembly **300** can be further tuned by modifying the size of the jet **234**, the diameter of the bleed ports **448**, the diameter of the cross ports **218**, a combination thereof, and the like.

(70) Motor

(71) In one embodiment, motor **220** is a geared motor **220**. In one embodiment, motor **220** is brushless. In one embodiment, motor **220** is a brushed motor. In one embodiment, motor **220** is a non-stepper geared motor **220**. In one embodiment, the geared motor is smaller than a stepper motor. In one embodiment the motor **220** is powered by a wireless battery.

(72) In one embodiment, the motor **220** is a micro type DC motor (approximately ¼ inch in diameter). In one embodiment, the micro type DC motor has an axial length that is shorter than an equivalently rated stepper motor.

(73) In one embodiment, the motor **220** is current limited so it will rotate until it hits an end stop in each direction, and does not require a controller to operate. For example, to ensure the complete opening or closing of the barrel valve **224** the motor **220** is turned on for longer than rotationally necessary (for example, if it takes 100 milli seconds to open/close the barrel valve **224** then motor **220** will run for 250 ms). As the barrel valve **224** completes its rotation and hits the end stop **236**, the sudden resistance in movement will cause a current spike in the motor **220** as it continues to attempt to rotate the barrel valve **224**. When the current spike hits a predefined threshold value, the motor **220** will automatically turn off (e.g., current limited).

(74) In some operational environments, the motor **220** can experience small current spikes from changes in terrain that the vehicle is traversing. For example, when the shock assembly is compressing and/or rebounding while it is traversing terrain, the changing fluid pressure can affect the friction generated during the rotation of the barrel valve **224** which could cause smaller current spikes. Running the motor **220** for longer than rotationally necessary (for the rotational range barrel valve **224**) will also prevent the smaller current spikes from stopping the operation of the motor **220** before the barrel valve **224** is fully open or closed.

(75) In one embodiment, instead of a current limited motor **220**, a motor controller is used in conjunction with motor **220**. In one embodiment, the controller allows power from a power source (such as a battery, capacitor, or the like) to be applied to the motor **220**. In one embodiment, full voltage from the power source is supplied such that the motor **220** is spun as quickly as possible. In one embodiment, less than full voltage from the power source is supplied to the motor **220** to modify the speed of rotation of motor **220**. In one embodiment, one or more components of the control process (e.g., microcontroller, motor controller, or the like) will also monitor for a condition that occurs during the operation of motor **220** (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 motor **220** is removed. In one embodiment, there is a delay in cutting off power to motor **220**.

(76) In one embodiment, the motor **220** is controlled by a simple switch and relay system that a user or rider can control. In one embodiment, a control system sends commands to the motor **220** via wires **232**. In one embodiment, a rider or user provides inputs to the control system to influence how the control system operates the motor **220**.

(77) In one embodiment, the rider or user provides the input via a graphical user interface (GUI) and/or human machine interface (HMI) such as an infotainment system HMI/GUI (e.g., in-vehicle infotainment (IVI) system, or the like). In one embodiment, the IVI system may be integrated with the vehicle structure, suspension components, suspension component controller(s) and data processing system as described in U.S. Pat. Nos. 7,484,603; 8,838,335; 8,955,653; 9,303,712; 10,060,499; 10,443,671; 10,737,546; and 10,933,710 the content of each of which are incorporated by reference herein, in their entirety.

(78) In one embodiment, the motor **220** has a torque limiting/limited slip function. This functionality will provide some give/slip when the end stop **236** is hit to reduce motor **220** burnout. In one embodiment, the torque limiting/limited slip functionality can be used in place of the current limited methodology to control the motor **220** operation. For example, instead of waiting for a current spike to remove the power to (and thus stop the operation of) the motor **220**, the motor **220** will be powered down when the predefined torque limitation is met.

(79) In one embodiment, the composition of the gear box within the motor **220** is used to change the rotational speed of the barrel valve **224**. In one embodiment, the gear box is configured such that the motor **220** can turn at rotational speeds fast enough for the powered bleed adjust assembly **300** to operate as an active or semi active system.

(80) In one embodiment, an energy absorption component is included between (or is used by) one or more of the components of the powered bleed adjust assembly **300**. The energy absorption component could be an elastomers and/or a rotationally compliant part (such as a spring, a rotationally flexible material, and the like). The energy absorption component is used to reduce torque, vibration, and the like to reduce and/or prevent degradation and damage of the gear box of the motor **220** due to end stop impacts, frictional changes during the rotational operation of the barrel valve **224**, and the like. For example, the utilization of one or more energy absorption components would allow the current increase (e.g., as the barrel valve **224** hits the end stop **236**) to be gradual rather than a step function, which would help prevent damage to the motor **220**. In one embodiment, elastomers are included in coupling one, some, or all of the components of the powered bleed adjust assembly **300**. In one embodiment, metering rod **222** has built in rotational compliance. In one embodiment, one, some, or all of the components of the powered bleed adjust assembly **300** will have built in rotational compliance. This could be due to material choice, or designing a sectional metering rod with springs, or similar structures, or the like.

(81) Intermediate Settings

(82) In one embodiment, the barrel valve **224** can be placed in one or more intermediate settings in addition to the open and closed settings. In one embodiment, the intermediate settings would be the partial alignment of bleed ports **448** with cross ports **218** thereby providing a reduced flow rate via

the powered bleed adjust assembly **300**. In one embodiment, the intermediate settings would use different sets of bleed ports and/or cross ports on different planes from one another. In one embodiment, the different sets of bleed ports and/or cross ports would be of various diameters to allow for different fluid flow rates.

(83) In one embodiment, a ball-and-spring detent system (or the like) is utilized to monitor the rotational position of the barrel valve **224** with respect to the more or more intermediate settings. For example, a ball-and-spring with a detent is provided either on the barrel valve **224** or on the shaft **130**. In addition, one or more cross holes are located on the other of the barrel valve **224** or the shaft **130** and aligned such that during the full range of rotation of the barrel valve **224**, the ball-and-spring would encounter each of the one or more cross holes.

(84) As the barrel valve **224** is rotated, each time the ball-and-spring detent system encounters a cross hole it will cause an increase in the rotational friction of the barrel valve **224**. This increased friction will result in a torque spike occurring at the motor **220**. Since the location of the cross hole(s) are known, and as the torque spike is directly correlated with the increased friction caused by the cross hole encounter, tracking the torque spikes will provide a relatively accurate rotational location/orientation of the barrel valve **224**.

(85) For example, if there is a single cross hole located at the halfway point in the barrel valve's rotational range, an identified torque spike would indicate the barrel valve **224** is at the mid-point of its rotational range (e.g., halfway between open and closed).

(86) Similarly, if there are three cross holes, each located $\frac{1}{3}$ of the way along the barrel valve's rotational range, a first identified torque spike would indicate the barrel valve **224** being at a first third of its rotational range, a second identified torque spike would indicate the barrel valve **224** being at a second third of its rotational range, and a third identified torque spike would indicate the barrel valve **224** being at a final third of its rotational range. In conjunction with the information about whether the motor **220** was operating in the direction of closing the barrel valve **224** or opening the barrel valve **224**, the radial orientation of the barrel valve **224** is established/controlled. Moreover, this methodology could be interpolated and/or extrapolated to provide more or less radial orientation specificity based on the number and/or location of cross holes.

(87) In one embodiment, the ball-and-spring with a detent tracking system will include an indexing aspect (e.g., the barrel valve **224** contacting a stop in the open position and/or the barrel valve **224** contacting a stop in the closed position) to provide a reset to the tracking of the torque spikes.

(88) In operation, the powered bleed adjust assembly **300** could include different barrel valve **224** positions to provide different flow rates through the bleed to provide different damping characteristic adjustments to the shock assembly **100**. Thus, a firmer (but not firmest) setting would cause the barrel valve **224** to be opened only a third of the way. Similarly, a softer (but not softest) setting would cause the barrel valve **224** to be opened two-thirds of the way.

(89) In one embodiment, an encoder can be used to track/control the rotational location/orientation of the barrel valve **224** to provide one or more mid-settings.

(90) In one embodiment, motor **220** is coupled with a needle system instead of a metering rod **222** and barrel valve **224**.

(91) In one embodiment, the motor **220**, barrel valve **224**, and connecting components (together referred to as powered bleed adjust assembly **300**) fit within the same shaft **130** as one that previously housed a manual rebound adjuster. As such, embodiments are suitable to be used within legacy systems.

(92) For example, any shock assembly with a mechanical rebound adjuster that utilizes a hollow shaft can be converted to an electronically tunable configuration by removing any unnecessary components of the mechanical rebound adjuster from within the shaft and installing the powered bleed adjust assembly **300** in their place. As such, the converted electronically tunable shock assembly will not incur any increase in dead space or packaging space.

(93) Moreover, as long as the motor **220** is used as a modal adjust (e.g., it is current limited and

does not require a controller), the converted electronically tunable shock assembly will not incur any additional controller costs.

(94) However, if a more advanced feedback system/controller was desired. Although it would incur additional cost, the controller would not need to be added to the internals of the shock assembly **100** such that it increased the dead space (or the packing space) of the shock assembly **100**. For example, in one embodiment the controller could fit within the hollow shaft **130** along with the other components of the powered bleed adjust assembly **300**. In another embodiment, the controller could be located on the shock assembly **100** (such as in an external housing) and be communicatively coupled with the motor **220** via wires **232**. In another embodiment, the controller could be located remote from the shock assembly **100** and be communicatively coupled with the motor **220** via wires **232**.

(95) The foregoing Description of Embodiments is not intended to be exhaustive or to limit the embodiments to the precise form described. Instead, the examples set forth herein were presented in order to best explain, to describe particular applications, and to thereby enable those skilled in the art to make and use embodiments of the described examples. However, those skilled in the art will recognize that the foregoing description and examples have been presented for the purposes of illustration and example only. The description as set forth is not intended to be exhaustive or to limit the embodiments to the precise form disclosed. Rather, the specific features and acts described above are disclosed as example forms of implementing the Claims and their equivalents.

Claims

1. A powered bleed adjust comprising: a barrel valve located at least partially within a bleed fluid pathway of a shaft, said barrel valve comprising: an internal fluid path formed along a longitudinal axis of said barrel valve, said internal fluid path extending completely through said barrel valve along said longitudinal axis of said barrel valve, a portion of said internal fluid path centrally formed within said barrel valve and extending axially within said barrel valve, wherein a compression flow of fluid occurs axially about said barrel valve and along said portion of said internal fluid path in a first direction, wherein a rebound flow of said fluid occurs axially about said barrel valve and along said portion of said internal fluid path in a second direction, wherein said compression flow of said fluid and said rebound flow of said fluid travel a same fluid path through said barrel valve, and wherein said first direction of said compression flow is opposite said second direction of said rebound flow of said fluid; an opening of said internal fluid path at a first end of said barrel valve; and at least one bleed port through a wall of said barrel valve to provide a second opening for said internal fluid path; and a motor coupled with said barrel valve, said motor configured to rotate said barrel valve to control a fluid flow through said bleed fluid pathway.
2. The powered bleed adjust of claim 1, wherein said at least one bleed port is approximately perpendicular to said internal fluid path.
3. The powered bleed adjust of claim 1, wherein said barrel valve is oriented with respect to a cross port of said bleed fluid pathway, such that a rotational position of said barrel valve will cause said at least one bleed port to not impede, partially impede, or block a fluid flow through said cross port.
4. The powered bleed adjust of claim 1, wherein said motor is selected from a group consisting of: a current limited motor and a torque limited motor.
5. The powered bleed adjust of claim 1, wherein said barrel valve further comprises: a pressure balanced port through a wall of said barrel valve for said internal fluid path, said pressure balanced port providing a fluid pathway to a fluid chamber within a portion of said bleed fluid pathway to pressure balance said barrel valve.
6. The powered bleed adjust of claim 1, further comprising: a metering rod coupled between said motor and said barrel valve.
7. The powered bleed adjust of claim 6, further comprising: a motor coupler coupled between an

output shaft of said motor and said metering rod.

8. The powered bleed adjust of claim 6, further comprising: a connection ring configured to couple said metering rod with said barrel valve.

9. A powered bleed adjust for a shock assembly comprising: a shaft coupled with and extending through a piston, said shaft comprising: a central port along a longitudinal axis of said shaft; an opening to said central port of said shaft on a first side of said piston; and a cross port through a wall of said shaft on an opposite side of said piston from said opening, wherein said opening, said central port, and said cross port form a bleed fluid pathway; a barrel valve located at least partially within said bleed fluid pathway, said barrel valve comprising: an internal fluid path formed along a longitudinal axis of said barrel valve, said internal fluid path extending completely through said barrel valve along said longitudinal axis of said barrel valve, a portion of said internal fluid path centrally formed within said barrel valve and extending axially within said barrel valve, wherein a compression flow of fluid occurs axially about said barrel valve and along said portion of said internal fluid path in a first direction, wherein a rebound flow of said fluid occurs axially about said barrel valve and along said portion of said internal fluid path in a second direction, wherein said compression flow of said fluid and said rebound flow of said fluid travel a same fluid path through said barrel valve, and wherein said first direction of said compression flow is opposite said second direction of said rebound flow of said fluid; an opening of said internal fluid path at a first end of said barrel valve; and at least one bleed port through a wall of said barrel valve to provide a second opening for said internal fluid path; and a motor coupled with said barrel valve, said motor configured to rotate said barrel valve to control a fluid flow through said bleed fluid pathway.

10. The powered bleed adjust for said shock assembly of claim 9, wherein said barrel valve is oriented with respect to said cross port of said bleed fluid pathway, such that a rotational position of said barrel valve will cause said bleed port to not impede, partially impede, or block a fluid flow through said cross port.

11. The powered bleed adjust for said shock assembly of claim 9, wherein said motor is selected from a group consisting of: a current limited motor and a torque limited motor.

12. The powered bleed adjust for said shock assembly of claim 9, wherein said barrel valve further comprises: a pressure balanced port through a wall of said barrel valve for said internal fluid path, said pressure balanced port providing a fluid pathway to a fluid chamber within a portion of said bleed fluid pathway to pressure balance said barrel valve.

13. The powered bleed adjust for said shock assembly of claim 9, further comprising: a metering rod coupled between said motor and said barrel valve.

14. The powered bleed adjust for said shock assembly of claim 13, further comprising: a motor coupler coupled between an output shaft of said motor and said metering rod.

15. The powered bleed adjust for said shock assembly of claim 13, further comprising: a connection ring configured to couple said metering rod with said barrel valve.

16. A powered bleed adjust that does not affect a dead space of a shock assembly, said powered bleed adjust comprising: a shaft coupled with and extending through a piston, said shaft comprising: a central port along a longitudinal axis of said shaft; an opening to said central port of said shaft on a first side of said piston; and a cross port through a wall of said shaft on an opposite side of said piston from said opening, wherein said opening, said central port, and said cross port form a bleed fluid pathway; a barrel valve located within said central port and at least partially within said bleed fluid pathway, said barrel valve comprising: an internal fluid path formed along a longitudinal axis of said barrel valve, said internal fluid path extending completely through said barrel valve along said longitudinal axis of said barrel valve, a portion of said internal fluid path centrally formed within said barrel valve and extending axially within said barrel valve, wherein a compression flow of fluid occurs axially about said barrel valve and along said portion of said internal fluid path in a first direction, wherein a rebound flow of said fluid occurs axially about said barrel valve and along said portion of said internal fluid path in a second direction, wherein said

compression flow of said fluid and said rebound flow of said fluid travel a same fluid path through said barrel valve, and wherein said first direction of said compression flow is opposite said second direction of said rebound flow of said fluid; an opening of said internal fluid path at a first end of said barrel valve; and at least one bleed port through a wall of said barrel valve to provide a second opening for said internal fluid path; and a motor located within said central port and coupled with said barrel valve, said motor configured to rotate said barrel valve to control a fluid flow through said bleed fluid pathway.
