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United States Patent	12385547
Kind Code	B2
Date of Patent	August 12, 2025
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Shock absorption assembly

Abstract

Shock absorption assemblies are provided. A shock absorption assembly includes an air shock that has a valve body. An air spring tube defines an air spring chamber. A piston rod extends through the air spring chamber to an oil piston head. An air piston head movably coupled to the piston rod. An oil damper tube is coupled to the piston head and is movable relative to the piston rod and the air spring tube. The shock absorption assembly further includes a mechanical spring disposed radially outward from, and that annularly surrounds, at least a portion of the air shock.

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Appl. No.: **17/542097**

Filed: **December 03, 2021**

Prior Publication Data

Document Identifier	Publication Date
US 20230175573 A1	Jun. 08, 2023

Publication Classification

Int. Cl.: **F16F13/00** (20060101); **B62K25/08** (20060101); **B62K25/28** (20060101)

U.S. Cl.:

CPC **F16F13/002** (20130101); B62K25/08 (20130101); B62K25/286 (20130101); F16F2222/126 (20130101); F16F2228/001 (20130101); F16F2232/08 (20130101); F16F2234/02 (20130101)

Field of Classification Search

CPC: F16F (9/062); F16F (9/063); F16F (9/065); F16F (9/0209); F16F (9/3214); F16F (9/3235); F16F (9/366); F16F (9/437); F16F (9/49); F16F (13/002); F16F (2222/126); F16F (2228/001); F16F (2232/08); F16F (2234/02); F16F (9/06); F16F (9/067); F16F (9/22); F16F (9/32); F16F (9/34); F16F (9/36); F16F (9/44); F16F (9/54); F16F (9/56); F16F (9/461); F16F (9/486); B62K (25/04); B62K (25/08); B62K (25/28); B62K (25/286); B62K (3/02); B62K (25/06); B62K (25/10); B62K (25/283); B62K (2025/044); B62K (2025/045); B62K (2025/048); B60G (15/12); B60G (15/065); B60G (15/066); B60G (17/021); B60G (2202/30); B60G (2202/312); B60G (2202/314); B60G (2500/10)

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Background/Summary

FIELD OF THE INVENTION
(1) The present disclosure relates generally to shock absorption systems for use with a bicycle. In particular, the present disclosure relates to a shock absorption system having a hybrid spring assembly.
BACKGROUND OF THE INVENTION
(2) The increased popularity in recent years of off-road cycling, particularly on mountains and cross-country, has made a shock absorbing system in many instances of biking necessity. A bicycle with a properly designed suspension system is capable of traveling over extremely bumpy, uneven terrain and up or down very steep inclines. Suspension bicycles are less punishing, reduce fatigue and reduce the likelihood of injury to the rider, and are much more comfortable to ride. For off-road cycling in particular, a suspension system greatly increases the rider's ability to control the bicycle because the wheels remain in contact with the ground as they ride over rocks and bumps in the terrain instead of being bounced into the air as occurs on conventional non-suspension bicycles. Over the last several years the number of bicycles now equipped with suspension systems has dramatically increased.
(3) Known shock absorbing systems typically include an oil damper operating in conjunction with a singular spring element (such as an air spring or a mechanical spring). However, issues exist with the use of know shock absorbing systems. For example, systems that utilize mechanical springs lack bottom out resistance or end stroke support, and systems utilizing air springs have harsh entry stroke support and a generally unsupportive or flat mid-stroke. Accordingly, an improved shock absorbing systems is desired and would be appreciated in the art.
BRIEF DESCRIPTION OF THE INVENTION
(4) Aspects and advantages of the invention will be set forth in part in the following description, or may be obvious from the description, or may be learned through practice of the invention.
(5) In accordance with one embodiment of the present disclosure, a shock absorption assembly is provided. The shock absorption assembly includes an air shock that has a valve body. An air spring tube defines an air spring chamber. A piston rod extends through the air spring chamber to an oil piston head. An air piston head movably coupled to the piston rod. An oil damper tube is coupled to the piston head and is movable relative to the piston rod and the air spring tube. The shock absorption assembly further includes a mechanical spring disposed radially outward from, and that annularly surrounds, at least a portion of the air shock.
(6) In accordance with another embodiment of the present disclosure, a shock absorption assembly is provided. The shock absorption assembly includes an air shock that has a valve body. An air spring tube defines an air spring chamber. A piston rod extends through the air spring chamber to an oil piston head. An air piston head movably coupled to the piston rod. An oil damper tube is coupled to the piston head and is movable relative to the piston rod and the air spring tube. The shock absorption assembly further includes a mechanical spring disposed radially outward from, and that annularly surrounds, at least a portion of the air shock. The mechanical spring extends between a first end coupled to the air spring tube and a second end coupled to the oil damper tube.
(7) These and other features, aspects and advantages of the present invention will become better understood with reference to the following description and appended claims. The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) A full and enabling disclosure of the present invention, including the best mode thereof, directed to one of ordinary skill in the art, is set forth in the specification, which makes reference to the appended figures, in which:
(2) FIG. **1** illustrates a schematic view of a vehicle in accordance with embodiments of the present disclosure;
(3) FIG. **2** illustrates a perspective view of a shock absorption assembly in accordance with embodiments of the present disclosure;
(4) FIG. **3** illustrates a perspective view of a shock absorption assembly in accordance with embodiments of the present disclosure;
(5) FIG. **4** illustrates a cross-sectional view of the shock absorption assembly from along the line **4**-**4** shown in FIG. **2** in accordance with embodiments of the present disclosure;
(6) FIG. **5** illustrates a cross-sectional view of a shock absorption assembly in a compressed position in accordance with embodiments of the present disclosure;
(7) FIG. **6** illustrates a cross-sectional view of the shock absorption assembly from along the line **6**-**6** shown in FIG. **2** in accordance with embodiments of the present disclosure;
(8) FIG. **7** illustrates an enlarged view of a shock absorption assembly in accordance with embodiments of the present disclosure;
(9) FIG. **8** illustrates a cross-sectional view of a shock absorption assembly in accordance with embodiments of the present disclosure;
(10) FIG. **9** illustrates a perspective view of a shock absorption assembly in accordance with embodiments of the present disclosure;
(11) FIG. **10** illustrates a cross-sectional view of the shock absorption assembly shown in FIG. **9** from along the line **10**-**10** in accordance with embodiments of the present disclosure; and
(12) FIG. **11** is a graph of stroke force versus stroke distance for three separate shock absorption devices in accordance with one or more exemplary aspects of the present disclosure.
(13) Repeat use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the present technology.

DETAILED DESCRIPTION OF THE INVENTION

(14) Reference now will be made in detail to embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment can be used with another embodiment to yield a still further embodiment. Thus, it is intended that the present invention covers such modifications and variations as come within the scope of the appended claims and their equivalents.

(15) The detailed description uses numerical and letter designations to refer to features in the drawings. Like or similar designations in the drawings and description have been used to refer to like or similar parts of the invention. As used herein, the terms “first”, “second”, and “third” may be used interchangeably to distinguish one component from another and are not intended to signify location or importance of the individual components.

(16) As used herein, the term “radially” refers to the relative direction that is substantially perpendicular to an axial centerline of a particular component, the term “axially” refers to the relative direction that is substantially parallel and/or coaxially aligned to an axial centerline of a particular component and the term “circumferentially” refers to the relative direction that extends around the axial centerline of a particular component. terms of approximation, such as “generally,” or “about” include values within ten percent greater or less than the stated value. When used in the context of an angle or direction, such terms include within ten degrees greater or less than the stated angle or direction. For example, “generally vertical” includes directions within ten degrees of vertical in any direction, e.g., clockwise or counter-clockwise.

(17) Referring now to the drawings, FIG. **1** illustrates a schematic diagram of a vehicle **10**. In various embodiments, the vehicle **10** may be non-motor assisted, such as a bicycle or other human-powered vehicle. In other embodiments, the vehicle may be motor-assisted, such as a motorcycle or moped. In many embodiments, as shown, the vehicle **10** may include a frame **12**. The frame **12** may include a first frame portion **14** and a second frame portion **16** pivotably coupled to one another (e.g., via one or more pins **15** or other rotatable couplings). As shown, a first wheel **18** may be coupled to the first frame portion **14**, and a second wheel **20** may be coupled to the second frame portion **16**. Additionally, as shown, the vehicle **10** may include one or more shock absorption assemblies **50** for dampening or reducing impulses experienced during operation of the vehicle **10**. For example, the vehicle **10** may include a front shock absorption assembly **52** and a rear shock absorption assembly **54**. In exemplary embodiments, the rear shock absorption assembly **54** may extend between, and couple to, the first frame portion **14** and the second frame portion **16** of the frame **12**.

(18) FIG. **2** and FIG. **3** each illustrate a perspective view of a shock absorption assembly **50** in accordance with embodiments of the present disclosure. As shown, the shock absorption assembly **50** may extend along an axial centerline **60** from a first end **46** to a second end **48**. The shock absorption assembly **50** may define a cylindrical coordinate system relative to the axial centerline **60**. The cylindrical coordinate system may include an axial direction A extending along the axial centerline **60**, a radial direction R extending perpendicularly to the axial centerline **60**, and a circumferential direction C extending about or around the axial centerline **60**.

(19) In exemplary embodiments, the shock absorption assembly **50** may include an air shock **56** and a mechanical spring **58** disposed radially outward from the air shock **56**. The mechanical spring **58** may annularly surround at least a portion of the air shock **56**. In various embodiments, the mechanical spring **58** may be a helical spring, a coil spring, a wave spring, or other suitable mechanical springs. For example, in exemplary embodiments, the mechanical spring **58** may be a helical spring. The air shock **56** and the mechanical spring **58** may be coaxial. For example, the air shock **56** and the mechanical spring **58** may be coaxially aligned, such that they share a common axial centerline (e.g., the axial centerline **60** of the entire shock absorption assembly **50**), which may advantageously ensure an equal distribution of reactive forces from the air shock **56** and the mechanical spring **58**. The air shock **56** and the mechanical spring **58** may work in conjunction with one another to dampen shocks, vibrations, or other impulses experienced by the vehicle **10** during operation thereof.

(20) The air shock **56** may include a valve body **62**, an air spring tube **64** coupled to the valve body **62**, and an oil damper tube **66** coupled to the air spring tube **64**. As discussed below, the air spring tube **64** may define an air spring chamber **65**, and the oil damper tube **66** may define an oil chamber **67** (FIGS. **3** and **4**). In many embodiments, the oil damper tube **66** may be movably or slidably coupled to the air spring tube **64**, such that the oil damper tube **66** is movable in the axial direction A relative to the air spring tube **64**.

(21) The valve body **62** may include various knobs, switches, levers, or adjusters that may alter the dampening output (or resistance) of the air shock **56**. For example, the valve body **62** may include damping adjusters **68** for adjusting the resistance of the air shock **56**. Additionally, the valve body **62** may include an air valve **70** in fluid communication with the air spring chamber **65**. The air valve **70** may be used for filling the air spring chamber **65** with air or other fluids. In some embodiments, a reservoir **72** may be coupled to the valve body **62**. The reservoir **72** may extend generally axially alongside the mechanical spring **58**, such that at least a portion of the mechanical spring **58** is disposed radially between the air spring tube **64** and the reservoir **72**.

(22) In many embodiments, the shock absorption assembly **50** may include a top end eye **76** disposed at the first end **46** of the shock absorption assembly **50** and a bottom end eye **78** disposed at the second end **48** of the shock absorption assembly **50**. The top end eye **76** and the bottom end eye **78** may couple the shock absorption assembly **50** to the frame **12** of the vehicle **10**. Particularly, in embodiments where the shock absorption assembly **50** is a rear shock absorption assembly **54** (or in other embodiments not shown), the top end eye **76** may couple to one of the first frame portion **14** or the second frame portion **16** of the frame **12**, and the bottom end eye **78** may couple to the other of the first frame portion **14** or the second frame portion **16**.

(23) In exemplary embodiments, the top end eye **76** may be defined by the valve body **62**, such that the top end eye **76** forms a portion of the valve body **62**. In this way, the top end eye **76**, the valve body **62**, and the air spring tube **64** may be moveable together (e.g., as a unit) in the axial direction A relative to the oil damper tube **66**. Similarly, the bottom end eye **78** may be defined by the oil damper tube **66**, such that the bottom end eye **78** forms a portion of the oil damper tube **66**. In this way, the bottom end eye **78** and the oil damper tube may be movable together (e.g., as a unit) in the axial direction A relative to the air spring tube **64**.

(24) FIG. **4** illustrates a cross-sectional view of the shock absorption assembly **50** from along the line **4-4** shown in FIG. **2**, which is in an uncompressed position. FIG. **5** illustrates a cross-sectional view of the shock absorption assembly **50** in an at least partially compressed position, in accordance with embodiments of the present disclosure. Additionally, FIG. **6** illustrates a cross-sectional view of the shock absorption assembly **50** from along the line **5-5** shown in FIG. **2**. As discussed above and illustrated by comparing FIG. **4** and FIG. **5**, the shock absorption assembly **50** may be axially compressible or movable. Specifically, the air spring tube **64** may be coupled to the valve body **62**, and both the air spring tube **64** and the valve body **62** may be axially movable or slidable together relative to the oil damper tube **66**.

(25) As shown in FIGS. **4** through **6**, the air spring tube **64** may define an air spring chamber **65**, and the oil damper tube **66** may define an oil chamber **67**. For example, the air spring chamber **65** may be filled with air or another suitable fluid (or gas), and the oil chamber **67** may be filled with oil or other suitable fluid (such as a lubricant or other fluid).

(26) In exemplary embodiments, a piston rod **80** may be disposed within air spring chamber **65**. For example, the piston rod **80** may be coupled to the valve body **62** and may extend along an axial centerline of the shock absorption assembly **50** within the air spring chamber **65**, such that the piston rod **80** is spaced apart from the air spring tube **64**. In this way, the piston rod **80** may be at least partially surrounded (e.g., annularly) by the air spring chamber **65**. Particularly, the piston rod **80** may extend from a first end **82** coupled to the valve body **62**, through the air spring chamber **65**, to a second end **84** coupled to an oil piston head **86**. In particular embodiments, as shown in FIG. **7**, a piston rod extension **85** may couple to the second end **84** of the piston rod **80** (e.g., via an interference fit, welding, or other coupling means). The piston rod extension **85** may be disposed within the oil chamber **67** and may fluidly couple the oil chamber **67** to the piston rod **80**. The oil piston head **86** may annularly surround the piston rod extension **85** of the piston rod **80** and rigidly coupled thereto.

(27) The oil piston head **86** may be disposed within the oil chamber **67** and may at least partially define a boundary (e.g., an axial boundary) of the

oil chamber **67**. The oil piston head **86** may be axially movable relative to the oil damper tube **66**, and thus movable within the oil chamber **67** to compress the oil therewithin. In exemplary embodiments, the piston rod **80** may be a generally hollow body (such as a hollow cylinder). For example, the piston rod **80** and the piston rod extension **85** may define a channel **88** that fluidly couples the oil chamber **67** to the reservoir chamber **73**. In operation, compression of the shock absorption assembly **50** may force oil from the oil chamber **67** to flow into the channel **88** and the reservoir chamber **73**, and decompression of the shock assembly may force the oil to travel from the reservoir chamber **73** back through the channel **88** to the oil chamber **67**.

(28) In various embodiments, the shock absorption assembly **50** may further include an air piston head **90** coupled to the oil damper tube **66** and movably (or slidably) coupled to the piston rod **80**. Stated otherwise, the oil damper tube **66** may be coupled to the air piston head **90**, such that the oil damper tube **66** and the air piston head **90** are movable together relative to the piston rod **80** and the air spring tube **64**. For example, the air piston head **90** may annularly surround the piston rod **80**, such that the air piston head **90** is restricted to axial movement relative to the piston rod **80**.

(29) As should be appreciated, the valve body **62**, the air spring tube **64**, the piston rod **80**, and the oil piston head **86** may all be rigidly, fixedly, or otherwise non-movably coupled to one another, such that the components move together as a unit in the shock absorption assembly **50**. Similarly, the oil damper tube **66** and the air piston head **90** may be rigidly, fixedly, or otherwise non-movably coupled to one another, such that the components move together as a unit in the shock absorption assembly **50**.

(30) In many embodiments, the mechanical spring **58** may be disposed radially outward from and annularly surround at least a portion of the air shock **56**. For example, the mechanical spring **58** may annularly surround the air spring tube **64** and the oil damper tube **66**. Particularly, the mechanical spring **58** may extend between a first end **92** coupled to the air spring tube **64** and a second end **94** coupled to the oil damper tube **66**. In this way, compression of the air shock **56** causes a compression of the mechanical spring **58**.

(31) In some embodiments, as shown in FIG. **6**, a radial clearance **74** may be defined between the air spring tube **64** and the reservoir **72**. The radial clearance **74** is particularly important because, as the air shock **56** and mechanical spring **58** compress, a width **59** of the mechanical spring **58** may increase (which must be accounted for in the radial clearance **74** to avoid damage-causing friction to the surrounding components). For example, the radial clearance may be between about 105% and about 200% of a diameter **61** of the mechanical spring **58**, or such as between about 110% and about 180% of a diameter **61** of the mechanical spring **58**, or such as between about 120% and about 160% of a diameter **61** of the mechanical spring **58**, or such as between about 130% and about 150% of a diameter **61** of the mechanical spring **58**.

(32) In exemplary embodiments, the air shock **56** may further include a first platform **96** in contact with the first end **92** of the mechanical spring **58** and a second platform **98** in contact with the second end **94** of the mechanical spring **58**. In particular, the first end **92** of the mechanical spring **58** may be coupled to the first platform **96** (e.g., via frictional contact, welding, or other suitable coupling means), and the second end **94** of the mechanical spring **58** may be coupled to the second platform **98** (e.g., via frictional contact, welding, or other suitable coupling means). In this way, the mechanical spring **58** may be disposed between (e.g., axially between) the first platform **96** and the second platform **98**. More specifically, the first platform **96** may define a first annular surface **97** in contact with the first end **92** of the mechanical spring **58**, and the second platform **98** may each define a second annular surface **99** in contact with the second end **94** of the mechanical spring **58**. Both the first annular surface **97** and the second annular surface **99** may be generally flat, radially-extending, surfaces. This may be advantageous over, e.g., a curved or slanted surface, as the flat, radially-extending, annular surfaces **97**, **99** provide the supporting surfaces for the mechanical spring to be positioned therebetween.

(33) Additionally, as shown, the mechanical spring **58** may define a first flat surface **102** at the first end **92** and a second flat surface **104** at the second end **94**. The first flat surface **102** may flushly and/or continuously contact the first annular surface **97** onto which the first flat surface **102** is seated. Similarly, the second flat surface **104** may flushly and/or continuously contact the second annular surface **99** onto which the second flat surface **104** is seated.

(34) In exemplary embodiments, as shown, the first platform **96** may be defined by the air spring tube **64**. For example, the air spring tube **64** may define a generally cylindrical main body **106**, and the first platform **96** (e.g., and the first annular surface **97**) may extend radially outwardly from the cylindrical main body **106** of the air spring tube **64**. As discussed above, the first annular surface **97** may be entirely radially oriented, such that it does is not slanted, curved, or contoured, in order to allow the mechanical spring **58** to make sufficient contact therewith.

(35) In many embodiments, the second platform **98** may be threadably coupled to the oil damper tube **66**, such that rotation of the second platform **98** adjusts an axial position of the second platform, thereby adjusting a preload of the mechanical spring **58**. In particular, the second platform **98** may be movable or adjustable along the axial centerline **60** of the shock absorption assembly **50** to adjust a preload of the mechanical spring **58**. For example, the second platform **98** may define internal threads **108**, and the oil damper tube **66** may define external threads **110** corresponding with the internal threads **108** of the second platform **98**. In exemplary embodiments, the oil damper tube **66** may be generally shaped as a hollow cylinder. More particularly, the oil damper tube **66** may extend from a first end **112** coupled to the air piston head **90** to the bottom end eye **78** at a second end **114**. The oil damper tube **66** may define a first portion **116** having a first thickness **117** and as second portion **118** having a second thickness **119**. The first portion **116** may extend from the first end **112** to the second portion **118**, and the second portion **118** may extend from the first portion **116** to the bottom end eye **78**.

(36) In various embodiments, as shown, the second platform **98** may be threadably coupled to the second portion **118** of the oil damper tube **66**. Additionally, as shown, the second thickness **119** of the second portion **118** may be greater than the first thickness **117** of the first portion **116**. The second thickness **119** may advantageously provide additional structural support to the second platform **98**, which may experience a variety of forces during operation, thereby prolonging the hardware life of the overall shock absorption assembly **50**.

(37) As discussed above, the entire shock absorption assembly **50** may be movable between an uncompressed position (FIG. **4**) and a compressed position (FIG. **5**). Additionally, the air shock **56** and the mechanical spring **58** may be movable between a compressed position and an uncompressed position, which may or may not be the same as the entire shock absorption assembly **50**. For example, because the second platform **98** is axially adjustable to modify a preload of the mechanical spring **58**, the mechanical spring **58** may be at least partially compressed when the air shock **56** is in an uncompressed position, which may place the air shock **56** in tension. Thus, in such a configuration, the required force for engagement of the air shock **56** may be modified by adjusting a preload of the mechanical spring **58** (e.g., adjusting a position of the second platform **98**), which may be advantageous.

(38) In some embodiments, a spring constant of the mechanical spring **58** may be between about 100 lbs/inch (e.g., pounds per inch) and about 800 lbs/inch. In other embodiments, a spring constant of the mechanical spring **58** may be between about 200 lbs/inch and about 700 lbs/inch. In many embodiments, a spring constant of the mechanical spring **58** may be between about 300 lbs/inch and about 600 lbs/inch. In particular embodiments, a spring constant of the mechanical spring **58** may be between about 400 lbs/inch and about 500 lbs/inch.

(39) Additionally, in many embodiments, the air spring chamber **65** may have a nominal pressure between about 0 lbs/inch and about 350 lbs/inch. In other embodiments, the air spring chamber **65** may have a nominal pressure between about 0 lbs/inch and about 300 lbs/inch. In various embodiments, the air spring chamber **65** may have a nominal pressure between about 0 lbs/inch and about 250 lbs/inch. In certain embodiments, the air spring chamber **65** may have a nominal pressure between about 0 lbs/inch and about 200 lbs/inch. In particular embodiments, the air spring chamber **65** may have a nominal pressure between about 0 lbs/inch and about 100 lbs/inch.

(40) Referring now to FIG. **7**, an enlarged view of the outlined detail shown in FIG. **4** is illustrated in accordance with embodiments of the present disclosure. As described above, the air spring tube **64**, the piston rod **80**, and the oil piston head **86** may all be rigidly, fixedly, or otherwise non-movably coupled to one another, such that the components move together as a unit in the shock absorption assembly **50**. Similarly, the oil damper tube **66** and the air piston head **90** may be rigidly, fixedly, or otherwise non-movably coupled to one another, such that the components move together as a unit in the shock absorption assembly.

(41) As shown in FIG. **7**, the oil piston head **86** may form an interference fit with an internal diameter of the oil damper tube **66**, but the oil piston head **86** may be slidably coupled to the oil damper tube **66**, in order to compress the fluid within the oil chamber **67** during a compression cycle. In some embodiments, as shown, the oil piston head **86** may further include a piston band **120** annularly surrounding the oil piston head **86**. The piston band **120** may advantageously prolong the hardware life of the oil piston head **86** and prevent fluid from leaking out of the oil chamber **67**.
(42) In certain embodiments, as discussed above, the air piston head **90** may be rigidly coupled to the oil damper tube **66**, such that the air piston head **90** moves with the oil damper tube **66**. For example, in some embodiments, the air piston head **90** may form an interference fit with the oil damper tube **66**. In other embodiments, the air piston head **90** may be welded or otherwise fixedly coupled to the oil damper tube **66**. Additionally, as shown, the air piston head **90** may extend into the air spring chamber **65**. In exemplary embodiments, a seal ring **122** may annularly surround the air piston head **90**. For example, the seal ring **122** may be disposed radially between the air piston head **90** and an internal surface **69** of the air spring tube **64**. The seal ring **122** may form a seal between the air piston head **90** and the internal surface **69** of the air spring tube **64**. In some embodiments, the air piston head **90** may further include a scraper seal **124** annularly surrounding the air piston head **90** within the air spring chamber **65**. For example, the scraper seal **124** may be disposed radially between the air piston head **90** and the internal surface **69** of the air spring tube **64**.
(43) FIG. **8** illustrates a cross-sectional view of a shock absorption assembly **50** in an uncompressed position, in accordance with embodiments of the present disclosure. As shown, the shock absorption assembly **50** may include a negative air spring chamber **126**. The negative air spring chamber **126** may be defined between the air spring tube **64** and the oil damper tube **66**. Specifically, the negative air spring chamber may be defined between an internal surface of the air spring tube **64** and an external surface of the oil damper tube **66**. Additionally, the negative air spring chamber may be in fluid communication with the air spring chamber **65** during portions of the stroke of the shock absorption assembly **50**, but the negative air spring chamber **126** may otherwise be fluidly isolated from the air spring chamber **65**. For example, an interior surface of the air spring tube **64** may define a recess **128**. In such embodiments, the air piston head **90** (and/or the seal ring **122** and the scraper seal **124**) may come out of contact with the internal surface of the air spring tube **64** when the air piston head **90** is passing over the recess **128**, such that the recess **128** may fluidly couple the negative air spring chamber **126** and the air spring chamber **65** when the air piston head **90** is passing thereover during the stroke of the shock absorption assembly **50**. The negative air spring chamber **126** may advantageously balance the initial force generated by the air spring chamber **65**. Additionally, the negative air spring chamber **126** shown in FIG. **8** may advantageously be defined between the generally concentric cylinder arrangement of the air spring tube **64** and the oil damper tube **66**, which allows for the negative air spring chamber **126** to be utilized alongside the mechanical spring **58**. For example, the concentric cylinder arrangement of the air spring tube **64** and the oil damper tube **66** may define the negative air spring chamber **126** without requiring a large protrusion, which could otherwise impede the mechanical spring **58**.
(44) FIG. **9** illustrates a perspective view of a shock absorption assembly **150** in accordance with an alternative embodiment of the present disclosure. As shown in FIG. **9** and described below in more detail, the shock absorption assembly **150** may include an oil damper tube **166** and an air spring tube **164** in an opposite configuration as the oil damper tube **66** and air spring tube **64** described above with reference to FIGS. **1** through **8**. The shock absorption assembly **150** may extend along an axial centerline **160** from a first end **146** to a second end **148**.
(45) In exemplary embodiments, the shock absorption assembly **150** may include an air shock **156** and a mechanical spring **158** disposed radially outward from the air shock **56**. The mechanical spring **158** may annularly surround at least a portion of the air shock **156**. The air shock **156** and the mechanical spring **158** may be coaxial. For example, the air shock **156** and the mechanical spring **158** may be coaxially aligned, such that they share a common axial centerline (e.g., the axial centerline **160** of the entire shock absorption assembly **150**), which may advantageously ensure an equal distribution of reactive forces from the air shock **156** and the mechanical spring **158**. The air shock **156** and the mechanical spring **158** may work in conjunction with one another to dampen shocks, vibrations, or other impulses experienced by the vehicle **10** during operation thereof.
(46) The air shock **156** may include a valve body **162**, an oil damper tube **166** coupled to the valve body **162**, and an air spring tube **164** coupled to oil damper tube **166**. As discussed below, the air spring tube **164** may define an air spring chamber **165**, and the oil damper tube **166** may define an oil chamber **167** (FIG. **10**). In many embodiments, the oil damper tube **166** may be movably or slidably coupled to the air spring tube **164**, such that the oil damper tube **166** is movable in the axial direction A relative to the air spring tube **164**. In many embodiments, the shock absorption assembly **150** may include a top end eye **176** disposed at the first end **146** of the shock absorption assembly **150** and a bottom end eye **178** disposed at the second end **148** of the shock absorption assembly **150**. The top end eye **176** may be defined by the valve body **162**, and the bottom end eye **178** may be defined by a base **179**.
(47) FIG. **10** illustrates a cross-sectional view of the shock absorption assembly **150** from along the line **10**-**10** shown in FIG. **9**. As shown, the oil damper tube **166** may be coupled to the valve body **162**, and both the oil damper tube **166** and the valve body **162** may be axially movable or slidable together relative to the air spring tube **164**.
(48) As shown in FIG. **10**, the air spring tube **164** may define an air spring chamber **165**, and the oil damper tube **166** may define an oil chamber **167**. For example, the air spring chamber **165** may be filled with air or another suitable fluid (or gas), and the oil chamber **167** may be filled with oil or other suitable fluid (such as a lubricant or other fluid).
(49) In exemplary embodiments, a piston rod **180** may be disposed within air spring chamber **165**. For example, the piston rod **180** may be coupled to the base **179** and may extend along an axial centerline of the shock absorption assembly **150** within the air spring chamber **165**, such that the piston rod **180** is spaced apart from the air spring tube **164**. In this way, the piston rod **180** may be at least partially surrounded (e.g., annularly) by the air spring chamber **165**. Particularly, the piston rod **180** may extend from a first end **182** coupled to the valve body **62**, through the air spring chamber **165**, to a second end **184** coupled to an oil piston head **186**.
(50) In various embodiments, the shock absorption assembly **150** may further include an air piston head **190** coupled to the oil damper tube **166** and movably (or slidably) coupled to the piston rod **180**. Stated otherwise, the oil damper tube **166** may be coupled to the air piston head **190**, such that the oil damper tube **166** and the air piston head **190** are movable together relative to the piston rod **180** and the air spring tube **164**. For example, the air piston head **190** may annularly surround the piston rod **180**, such that the air piston head **190** is restricted to axial movement relative to the piston rod **180**.
(51) In many embodiments, the mechanical spring **158** may be disposed radially outward from and annularly surround at least a portion of the air shock **156**. For example, the mechanical spring **158** may annularly surround the air spring tube **164** and the oil damper tube **166**. Particularly, the mechanical spring **158** may extend between a first end **192** coupled to the oil damper tube **166** and a second end **194** coupled to the air spring tube **164**. In this way, compression of the air shock **156** causes a compression of the mechanical spring **158**.
(52) In exemplary embodiments, the air shock **156** may further include a first platform **196** defined by the base **179** and in contact with the second end **194** of the mechanical spring **158** and a second platform **198** in contact with the first end **192** of the mechanical spring **58**. The second platform **198** may be threadably coupled to the oil damper tube **166** (e.g., via threads **199**), such that rotation of the second platform **198** adjusts an axial position of the second platform, thereby adjusting a preload of the mechanical spring **158**. In particular, the second platform **198** may be movable or adjustable along the axial centerline **160** of the shock absorption assembly **50** to adjust a preload of the mechanical spring **158**.
(53) FIG. **11** is a graph **1100** of stroke force versus stroke distance (each expressed in terms of a percentage, e.g, 0% to 100%) for three separate shock absorption devices. For example, the graph **1100** shows a coil shock **1104**, an air shock **1102**, and a coil over air shock **1106**. The coil over air shock **1106** may be representative of the shock absorption assembly **50**, **150** described above with reference to FIGS. **1** through **10**. As shown, the coil shock **1104** includes a generally linear stroke force progression through the stroke distance. The air shock **1102** includes a large entry stroke force during the first half of the stroke distance (e.g., about 0% to about 50% of the stroke distance), such that a large amount of force may be required to engage the air shock **1102**. The air shock **1102** also includes a progressive force ramp at during the second half of the stroke distance (e.g., about 50% to about 100%). In this way, the air shock **1102** may generate a large amount of force at the beginning and end of the stroke. The

coil over air shock **1106** may advantageously include a low initiation force (e.g., low stroke force into the beginning of the stroke distance) and a supportive and progressive end of stroke force (e.g., at the end of the stroke distance).

(54) This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they include structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal languages of the claims.

Claims

1. A shock absorption assembly comprising: an air shock comprising a valve body, an air spring tube defining an air spring chamber, a piston rod extending through the air spring chamber to an oil piston head, an air piston head movably coupled to the piston rod, and an oil damper tube coupled to the piston head and movable relative to the piston rod and the air spring tube, wherein a first platform extends form the air spring tube and a second platform extends from the oil damper tube; and a mechanical spring disposed radially outward from and annularly surrounding the air spring tube and the oil damper tube, the mechanical spring extending from a first end in contact with the first platform to a second end in contact with the second platform, wherein the shock absorption assembly is movable between an uncompressed position and a compressed position in which both the air shock and mechanical spring compress, wherein the air piston head is disposed closer to the first platform in the compressed position than in the uncompressed position, and wherein the oil piston head is disposed closer to the second platform in the compressed position than in the uncompressed position.
2. The shock absorption assembly as in claim 1, wherein the second platform is movable along an axial centerline of the shock absorption assembly to adjust a preload of the mechanical spring.
3. The shock absorption assembly as in claim 1, wherein the second platform is threadably coupled to the oil damper tube such that rotation of the second platform adjusts a preload of the mechanical spring.
4. The shock absorption assembly as in claim 1, wherein the air shock and the mechanical spring are coaxial.
5. The shock absorption assembly as in claim 1, wherein a spring constant of the mechanical spring is between about 100 lbs/inch and about 800 lbs/inch.
6. The shock absorption assembly as in claim 1, wherein the air spring chamber has a nominal pressure between about 0 lbs/inch and about 350 lbs/inch.
7. The shock absorption assembly as in claim 1, wherein the oil damper tube includes a first portion having a first thickness and a second portion having a second thickness, and wherein the second thickness is greater than the first thickness.
8. The shock absorption assembly as in claim 7, wherein the second platform is threadably coupled to the second portion of the oil damper tube.
9. The shock absorption assembly as in claim 1, further comprising a reservoir coupled to the valve body, wherein a radial clearance is defined between the reservoir and the air spring tube, wherein the mechanical spring is a coil spring that defines a width and a diameter, and wherein the radial clearance is larger than a diameter of the coil spring.
10. The shock absorption assembly as in claim 9, wherein the radial clearance is between about 105% and about 200% of the diameter of the coil spring.
11. The shock absorption assembly as in claim 1, wherein the oil damper tube defines an oil chamber filled with a first fluid, wherein the air spring tube defines an air spring chamber filled with a second fluid.
12. The shock absorption assembly as in claim 1, wherein the oil chamber is fluidly isolated from the air spring chamber.
13. A shock absorption assembly comprising: an air shock comprising a valve body, an air spring tube defining an air spring chamber, a piston rod extending through the air spring chamber to an oil piston head, an air piston head movably coupled to the piston rod, and an oil damper tube coupled to the piston head and movable relative to the piston rod and the air spring tube, wherein a first platform extends form the air spring tube and a second platform extends from the oil damper tube; and a mechanical spring disposed radially outward from and annularly surrounding the air spring tube and the oil damper tube, the mechanical spring extending between a first end coupled to the first platform and a second end coupled to the second platform, wherein the shock absorption assembly is movable between an uncompressed position and a compressed position in which both the air shock and mechanical spring compress, wherein the air piston head is disposed closer to the first platform in the compressed position than in the uncompressed position, and wherein the oil piston head is disposed closer to the second platform in the compressed position than in the uncompressed position.
14. The shock absorption assembly as in claim 13, wherein the second platform is movable along an axial centerline of the shock absorption assembly to adjust a preload of the mechanical spring.
15. The shock absorption assembly as in claim 13, wherein the second platform is threadably coupled to the oil damper tube such that rotation of the second platform adjusts a preload of the mechanical spring.
16. The shock absorption assembly as in claim 13, wherein the air shock and the mechanical spring are coaxial.
17. The shock absorption assembly as in claim 13, wherein the oil damper tube includes a first portion having a first thickness and a second portion having a second thickness, and wherein the second thickness is greater than the first thickness, wherein the air shock includes a first platform, and wherein a second platform is threadably coupled to the second portion of the oil damper tube.