US010385930B2

(12) **United States Patent**
Magnus et al.

(10) **Patent No.: US 10,385,930 B2**
(45) **Date of Patent: Aug. 20, 2019**

(54) **BALL COUPLING ASSEMBLY FOR STEERING COLUMN ASSEMBLY**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 243 days.

(21) Appl. No.: **15/438,109**

(22) Filed: **Feb. 21, 2017**

(65) **Prior Publication Data**

US 2018/0238400 A1 Aug. 23, 2018

(51) **Int. Cl.**

B62D 1/16	(2006.01)
B62D 1/183	(2006.01)
F16D 15/00	(2006.01)
F16D 28/00	(2006.01)
F16D 11/16	(2006.01)

(Continued)

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

CPC ***F16D 15/00*** (2013.01); ***B62D 1/16*** (2013.01); ***B62D 1/183*** (2013.01); ***F16D 11/16*** (2013.01); ***F16D 23/12*** (2013.01); ***F16D 28/00*** (2013.01); *B60R 25/0222* (2013.01); *F16D 2300/24* (2013.01)

(58) **Field of Classification Search**

CPC F16D 15/00; F16D 23/14; F16D 11/16; B62D 1/183; B62D 1/16; B62D 1/20; B60R 25/0222

See application file for complete search history.

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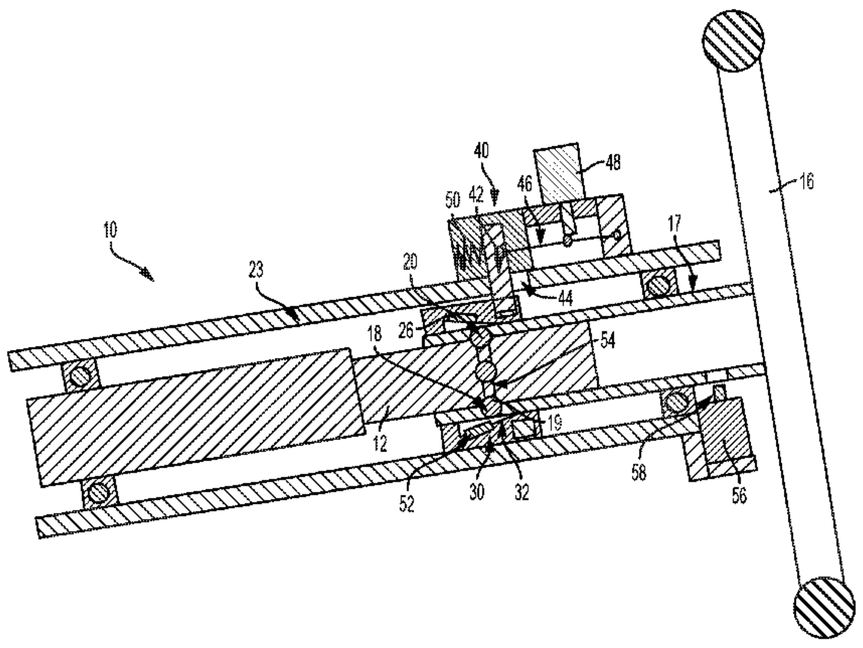
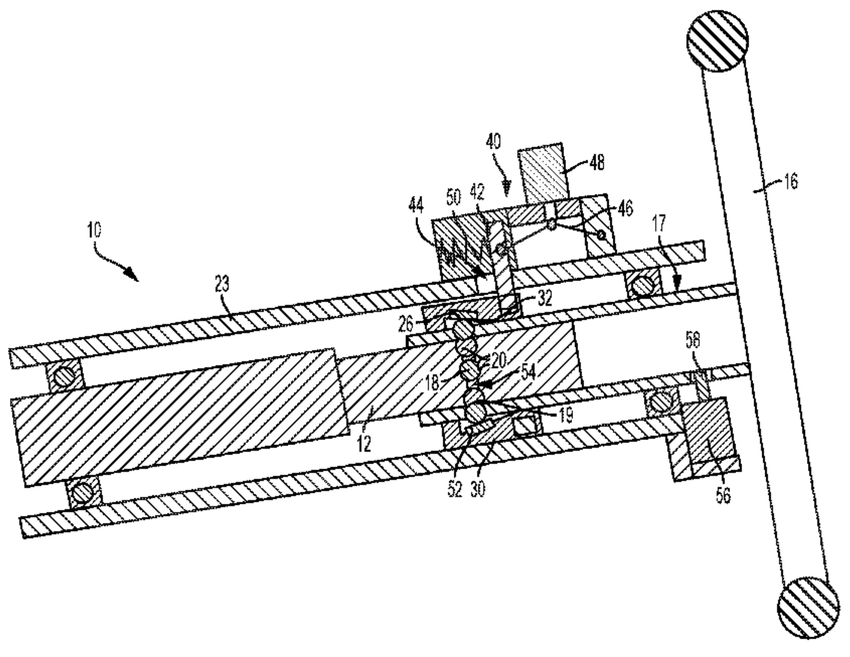
Primary Examiner — Barry Gooden, Jr.

(57) **ABSTRACT**

A steering column assembly for an autonomous or semi-autonomous vehicle includes a steering wheel and an upper steering shaft rigidly coupled to the steering wheel. Also included is a lower steering shaft operatively coupled to the upper steering shaft. Further included is a ball coupling assembly comprising balls retained within the upper steering shaft, the balls disposed in a first radial position that engages the balls with the upper steering shaft and the lower steering shaft to place the steering shafts in a coupled condition, the balls disposed in a second radial position that disengages the balls from at least one of the upper steering shaft and the lower steering shaft to place the steering shafts in a decoupled condition.

16 Claims, 4 Drawing Sheets





(51) **Int. Cl.**
F16D 23/12 (2006.01)
B60R 25/022 (2013.01)

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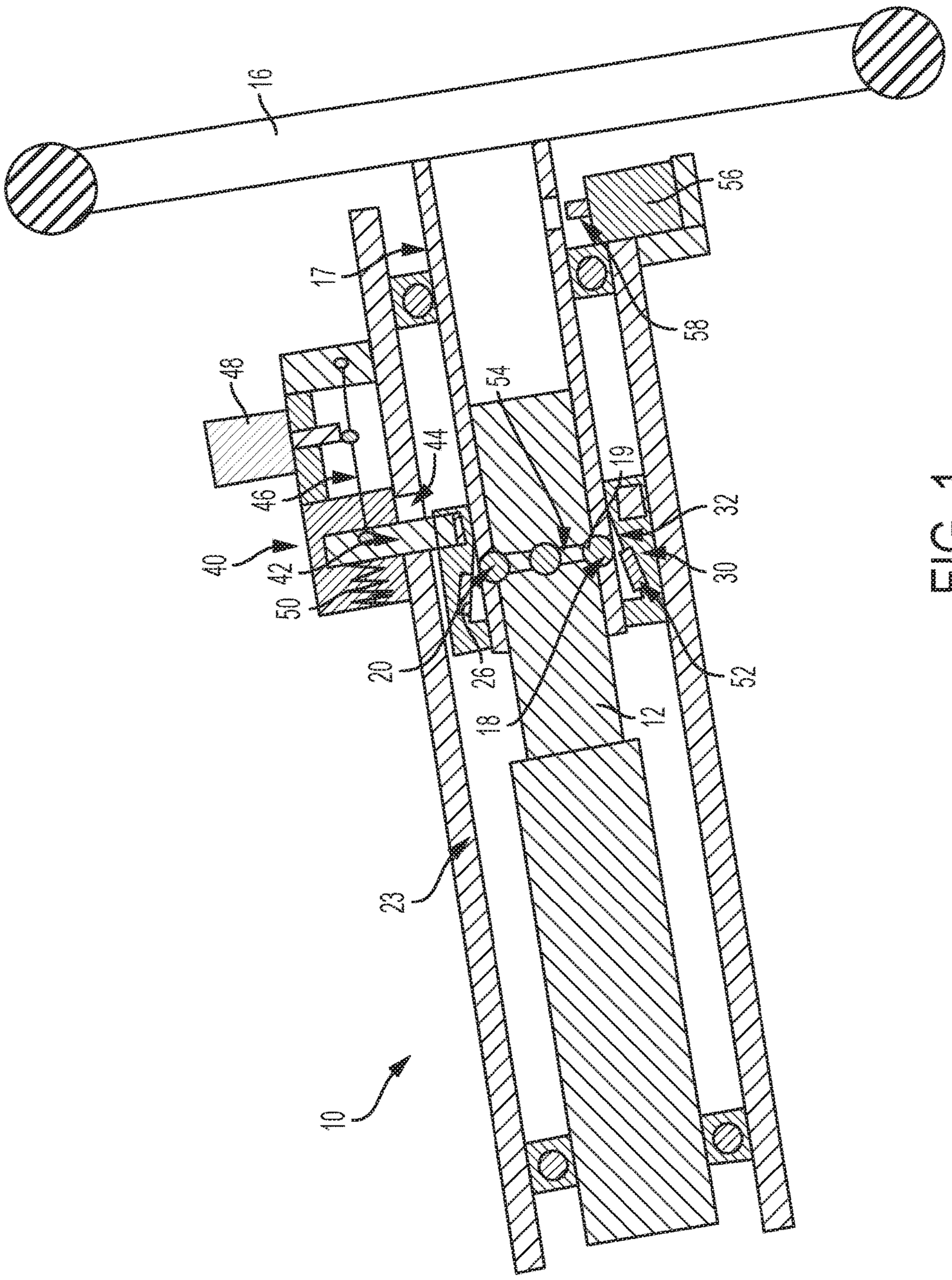


FIG. 1

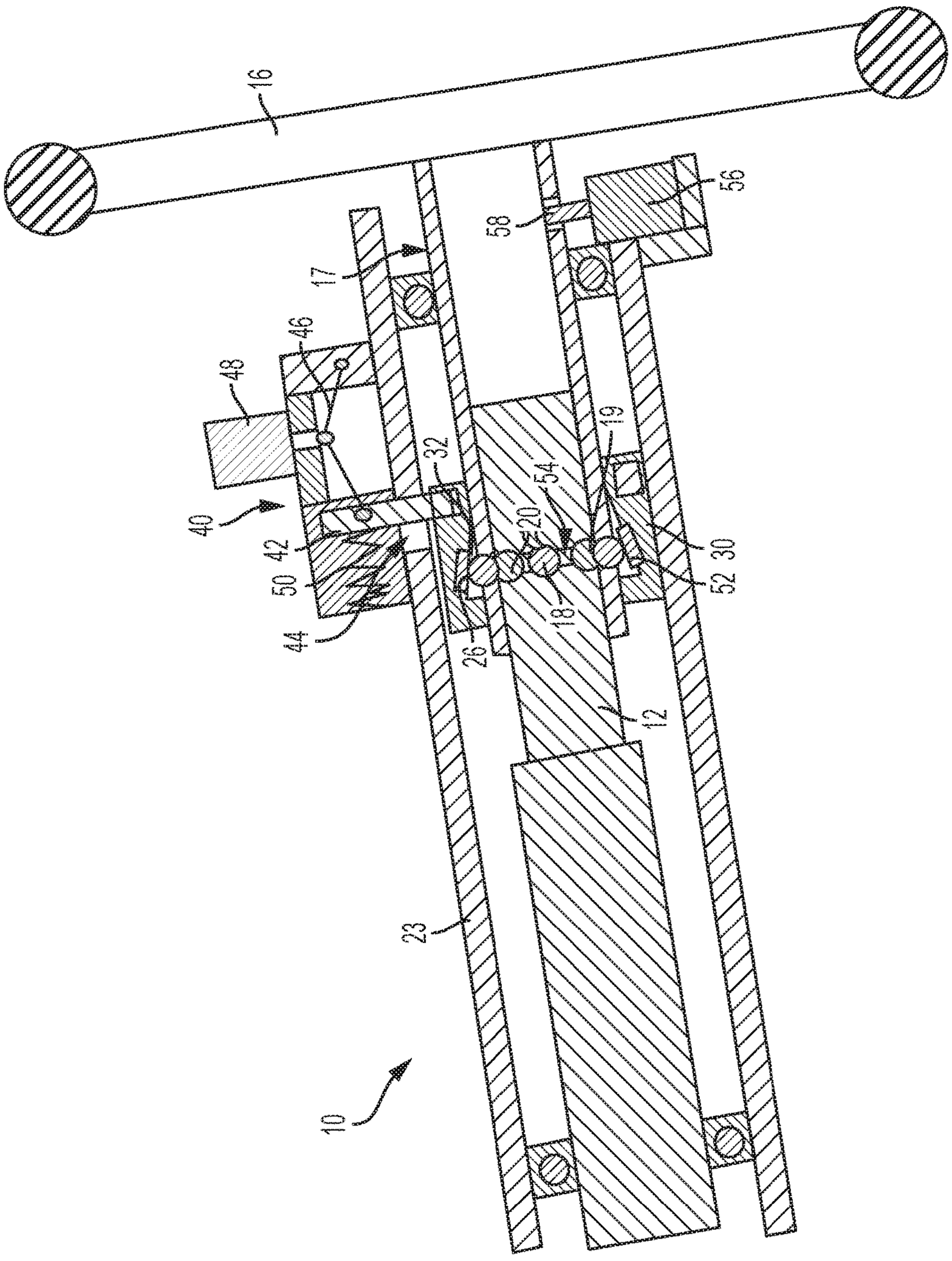
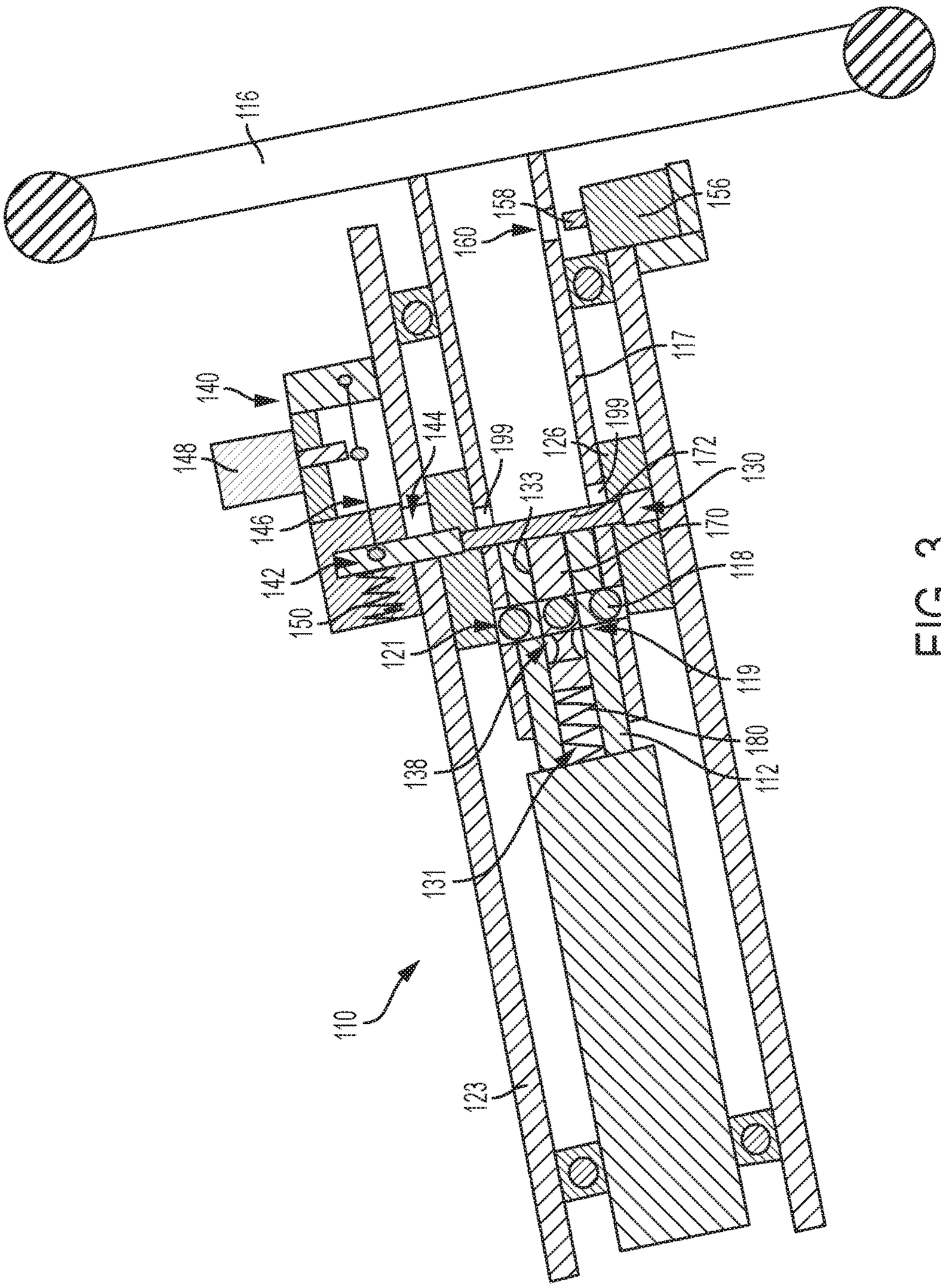


FIG. 2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140
144
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172
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121
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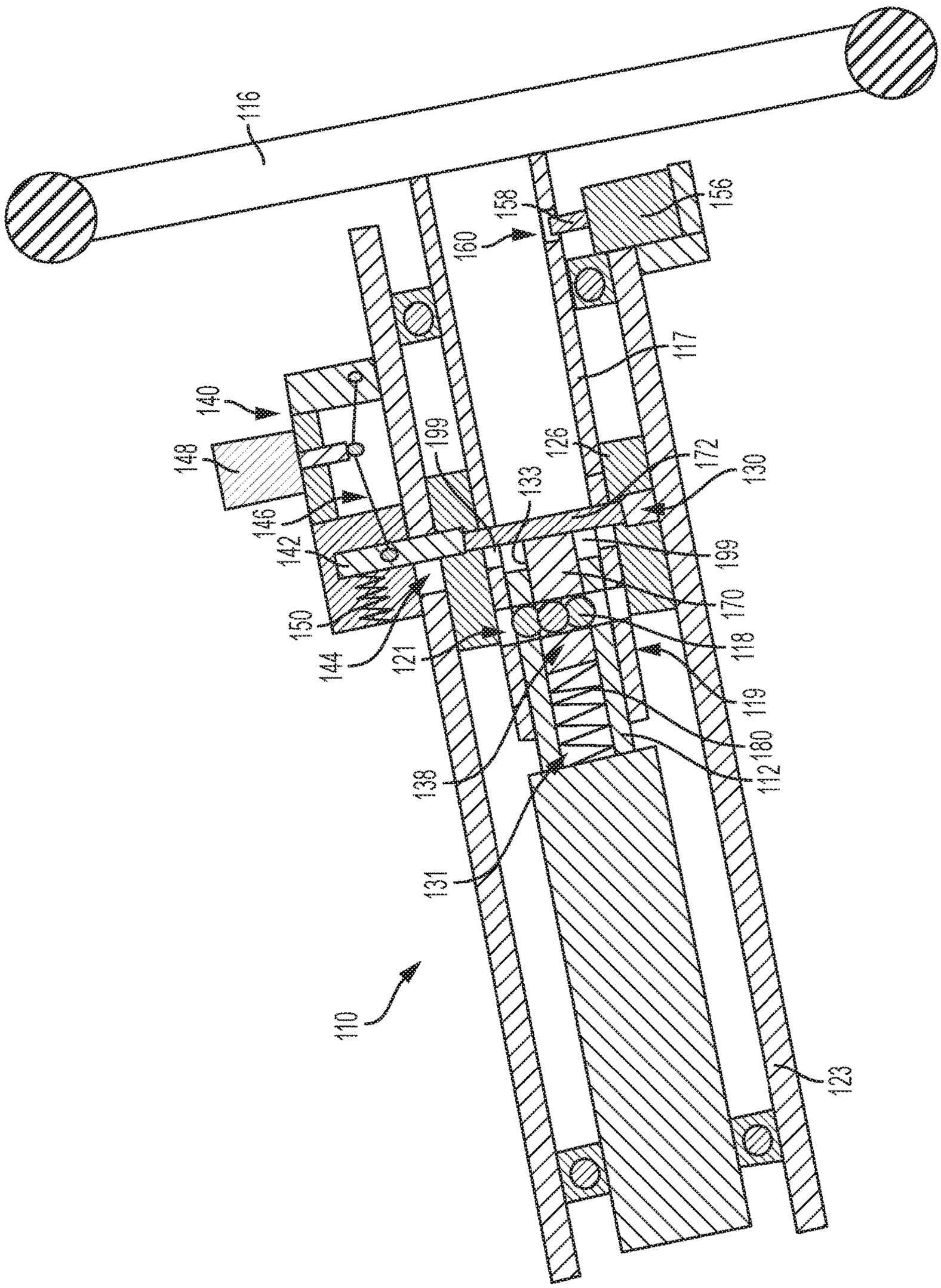
138
180
112
131
110
123

FIG. 3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110
123

FIG. 4

BALL COUPLING ASSEMBLY FOR STEERING COLUMN ASSEMBLY

BACKGROUND OF THE INVENTION

The invention described herein relates to steering column assemblies and, more particularly, to a ball coupling assembly for steering column assemblies implemented in autonomous or semi-autonomous vehicles.

As the automotive industry moves toward autonomously driven vehicles, there will be Advanced Driver Assist Systems (ADAS) that allow a vehicle to be autonomously controlled using sensing, steering, and braking technology. Implementing steering on ADAS vehicles may include decoupling the driver interface (e.g., steering wheel) from the steering actuator. However, a rotating driver interface may cause confusion, inconvenience or even harm to the driver during an autonomous driving mode. Addressing the issue of a moving interface will assist with the overall development of autonomous vehicle technology and feasibility.

SUMMARY OF THE INVENTION

According to an aspect of the invention, a steering column assembly for an autonomous or semi-autonomous vehicle includes a steering wheel. Also included is an upper column steering shaft rigidly coupled to the steering wheel. Further included is a lower column steering shaft operatively coupled to the upper column steering shaft. Yet further included is a ball coupling assembly for switching the upper column steering shaft and the lower column steering shaft between a coupled condition and a decoupled condition. The ball coupling assembly includes a plurality of balls retained within the upper column steering shaft. The ball coupling assembly also includes a plurality of pockets circumferentially spaced from each other and defined by the lower steering shaft, each of the pockets sized to receive a portion of one of the plurality of balls. The ball coupling assembly further includes a collar surrounding the balls, the collar having an angled portion of an inner wall disposed in contact with the balls. The ball coupling assembly yet further includes a collar actuating mechanism for selectively axially translating the collar between a coupled condition and a decoupled condition.

According to another aspect of the invention, a steering column assembly for an autonomous or semi-autonomous vehicle includes a steering wheel. Also included is an upper column steering shaft rigidly coupled to the steering wheel. Further included is a lower column steering shaft operatively coupled to the upper column steering shaft. Yet further included is a ball coupling assembly for switching the upper column steering shaft and the lower column steering shaft between a coupled condition and a decoupled condition. The ball coupling assembly includes a plurality of balls retained within respective holes defined by the lower column steering shaft in a single axial plane. The ball coupling assembly also includes a central pin disposed within a bore of the lower column steering shaft and axially translatable therein. The ball coupling assembly further includes an annular recess defined by the central pin. The ball coupling assembly yet further includes a central pin actuating mechanism for axially translating the central pin, the balls disposed at a first radial position that disposes the balls within the annular recess to place the upper and lower column steering shafts in a decoupled condition, the balls disposed at a second radial position that disposes the balls in abutment with a radially outer surface of the central pin and within the holes of the lower column steering shaft and holes of the upper column steering shaft to place the upper and lower column steering shafts in a coupled condition, the coupled condition providing common rotation of the upper and lower column steering shafts and the decoupled condition permitting independent rotation of the upper and lower column steering shafts.

According to yet another aspect of the invention, a steering column assembly for an autonomous or semi-autonomous vehicle includes a steering wheel. Also included is an upper column steering shaft rigidly coupled to the steering wheel. Further included is a lower column steering shaft operatively coupled to the upper column steering shaft. Yet further included is a ball coupling assembly comprising a plurality of balls retained within the upper column steering shaft, the balls disposed in a first radial position that engages the balls with the upper column steering shaft and the lower column steering shaft to place the upper and lower column steering shafts in a coupled condition, the balls disposed in a second radial position that disengages the balls from at least one of the upper column steering shaft and the lower column steering shaft to place the upper and lower column steering shafts in a decoupled condition.

These and other advantages and features will become more apparent from the following description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a partial cross-sectional view of a steering column assembly in a coupled condition according to an aspect of the disclosure;

FIG. **2** is a partial cross-sectional view of the steering column assembly of FIG. **1** in a decoupled condition;

FIG. **3** is a partial cross-sectional view of a steering column assembly in a coupled condition according to another aspect of the disclosure; and

FIG. **4** is a partial cross-sectional view of the steering column assembly of FIG. **3** in a decoupled condition.

DETAILED DESCRIPTION

Referring now to the Figures, where the invention will be described with reference to specific embodiments, without limiting same, various features of a steering column assembly for an autonomous vehicle are illustrated. As described herein, the embodiments provide a reliable and efficient assembly that allows a driver to decouple a steering wheel from a lower steering shaft for use of the vehicle in an autonomous mode, while maintaining the steering wheel in a stationary position.

The steering column assembly is part of an advanced driver assist system (ADAS) that is able to steer as well as control other parameters of the vehicle to operate it without direct driver involvement. Autonomous or semi-autonomous driving refers to vehicles that are configured to perform operations without continuous input from a driver (e.g., steering, accelerating, braking etc.) and may be equipped

with technology that allows the vehicle to be autonomously or semi-autonomously controlled using sensing, steering, and/or braking technology.

Referring to FIGS. **1** and **2**, a portion of a steering column assembly **10** is shown according to an embodiment. The steering column assembly **10** includes a lower column steering shaft **12** (also referred to herein as a lower steering shaft) that is operatively coupled to road wheel control structures (not shown), thereby allowing a driver to input road wheel controls and to receive feedback in response to road wheel movement. A column jacket surrounds a portion of the lower steering shaft **12**. A steering input device, such as the illustrated steering wheel **16**, is operatively coupled to the lower steering shaft **12** via an upper column steering shaft **17** (also referred to herein as an upper steering shaft) to allow the user to control the vehicle in a manual driving mode. The upper steering shaft **17** is rigidly fixed to the steering wheel **16** with a splined connection, or the like, to ensure common rotation of the steering wheel **16** and the upper steering shaft **17**.

The steering column assembly **10** is shown in the manual driving mode in FIG. **1**. In the manual driving mode, the upper steering shaft **17** is coupled to the lower steering shaft **12**, also referred to as being rotationally coupled. The coupled (or rotationally coupled) condition of the upper steering shaft **17** and the lower steering shaft **12** results in common rotation of the steering wheel **16** and the lower steering shaft **12**, such that rotation of the components is dependent upon each other. Conversely, a decoupled condition (FIG. **2**) of the upper steering shaft **17** and the lower steering shaft **12** may be present during an autonomous driving mode. The decoupled (or rotationally decoupled) condition results in independent rotation of the steering wheel **16** and the lower steering shaft **12**, such that rotation of the lower steering shaft **12** in response to road wheel angular movement does not require or result in rotation of the steering wheel **16**. The steering column assembly **10** disclosed herein provides a driver the ability to switch between the coupled and decoupled condition in conjunction with switching between manual and autonomous driving modes.

In contrast to a continuously fixed relationship between the lower steering shaft **12** and the steering wheel **16** that is achieved with a splined mating assembly, the embodiments described herein employ at least one, but typically a plurality of balls **18** to establish the coupled or decoupled conditions. The plurality of balls **18** are part of a ball coupling assembly and are fixed within a ball retaining structure, such as a plurality of respective holes **19**, defined by the upper steering shaft **17** in a one-to-one relationship. The holes **19** are circumferentially spaced from each other and are each sized to axially and circumferentially retain one of the balls **18** therein.

The lower steering shaft **12** defines a plurality of pockets **20** disposed in a common axial plane and that are circumferentially spaced from each other. The plurality of pockets **20** extend to a radial depth of the lower steering shaft **12** that allows the balls to be partially disposed therein, but with a portion of the balls **18** protruding radially outwardly therefrom. The balls **18** are positioned within the pockets **20** in the coupled condition of the lower steering shaft **12** with the upper steering shaft **17** and the steering wheel **16**. The balls protrude radially from the pockets **20** to engage both the pocket surfaces and the walls defining the holes **19** of the upper steering shaft **17**. Therefore, when the balls **18** are positioned with the pockets **20** of the lower steering shaft **12**, torque transmission between the steering wheel **16** and the lower steering shaft **12** is established.

To retain the balls **18** within the pockets **20** and prevent radial movement of the balls **18**, an inner wall **26** of a collar **30** is disposed in contact with the balls **18**. More specifically, an innermost location of an angled portion **32** of the inner wall **26** is in contact with the balls **18**. The collar **30** is disposed between the upper steering shaft **17** and a column housing structure **23**. Due to the angled portion **32** of the inner wall **26**, a portion of the inner wall **26** is spaced from the balls **18** to allow the balls **18** to move radially outwardly in some conditions, as described in detail herein.

A collar actuating mechanism **40** is provided to selectively axially translate the collar **30** in order to control the portion of the angled portion **32** that is adjacent the balls **18**, as this positioning determines whether the balls **18** are radially retained within the pockets **20** or free to move radially outwardly. A driving structure **42**, such as a pin or shift fork is engaged with the collar **30**. The driving structure **42** extends through an aperture **44** of the column housing structure **23** in the illustrated embodiment. The aperture **44** is large enough to accommodate axial travel by the driving structure **42**. A linkage **46** is coupled to the driving structure **42** at one end and to the column housing structure **23** at an opposing end. Different positioning of the linkage **46** axially translates the driving structure **42** and therefore the collar **30** between two axial positions. Manipulation of the linkage **46** may be accomplished with any suitable actuator, such as an electric solenoid **48** having a pin engageable with the linkage **46**.

In a first state (i.e., powered or unpowered) of the electric solenoid **48**, the linkage **46** positions the driving structure **42**, and therefore the collar **30**, in an orientation that disposes the balls **18** in the pockets **20**. This provides the coupled condition (FIG. **1**), with the innermost location of the angled portion **32** in contact with, or in close proximity to, the balls **18** to radially retain the balls **18** within the pockets **20**. In second state (i.e., powered or unpowered) of the electric solenoid **48**, the driving structure **42** is biased with a spring **50** to move the collar **30** to a position that locates a radially outer region of the angled portion **32**, thereby allowing the balls **18** to move radially outwardly. Outward radial movement of the balls **18** is facilitated with one or more magnets **52** located on or in the collar **30** in some embodiments. The lower steering shaft **12** defines an annular recess **54** that is located at the same axial position as the pockets **20**, but the annular recess **54** extends to a radial depth that is less than the radial depth of the pockets **20**. This provides a continuous track for the balls to travel through when the balls **18** are at the outer radial position (i.e., decoupled condition), thereby rotationally decoupling the steering wheel from the lower steering shaft **12**.

The steering column assembly **10** also facilitates autonomous mode for the steering wheel **16** when the assembly in the decoupled condition. An autonomous mode refers to a rotationally stationary position and condition of the steering wheel **16**. Maintaining the steering wheel **16** in a stationary position reduces the likelihood of driver confusion, inconvenience and/or harm.

Placing the steering wheel in the stationary position occurs upon transition to the decoupled condition of the steering column assembly **10** shown in FIG. **2**. In the illustrated embodiment, an electric solenoid **56** includes a pin **58** extending therefrom. The electric solenoid **56** is switchable between a first state (i.e., powered or unpowered) and a second state (i.e., powered or unpowered), with one state disposing the pin **58** in a retracted position (FIG. **1**) and

the other state disposing the pin **58** in an extended position (FIG. **2**). The extended position of the pin **58** engages the pin **58** with a receiving hole **60** defined by the upper steering shaft **17** to rotationally lock the steering wheel **16** when the upper and lower steering shafts **12**, **17** are in the decoupled condition. The preceding example is merely illustrative of how the steering wheel **16** may be locked in the "quiet wheel" mode. Although the steering wheel **16** is rotationally locked, the lower steering shaft **12** is free to rotate due to the balls **18** being disposed in the outward radial position.

In operation, a user interacts with a user input device that switches the states of both electric solenoids **48**, **56**. The user input device may be a button, toggle switch, voice activated command, etc. These types of input devices are merely illustrative of the devices that may be employed to switch the states of the solenoids.

Referring now to FIGS. **3** and **4**, another aspect of the disclosure is illustrated. In particular, a portion of a steering column assembly **110** is shown according to an embodiment. The steering column assembly **110** includes a lower column steering shaft **112** (also referred to herein as a lower steering shaft) that is operatively coupled to road wheel control structures (not shown), thereby allowing a driver to input road wheel controls and to receive feedback in response to road wheel movement. A column jacket surrounds a portion of the lower steering shaft **112**. A steering input device, such as the illustrated steering wheel **116**, is operatively coupled to the lower steering shaft **112** via an upper column steering shaft **117** (also referred to herein as an upper steering shaft) to allow the user to control the vehicle in a manual driving mode. The upper steering shaft **117** is rigidly fixed to the steering wheel **116** with a splined connection, or the like, to ensure common rotation of the steering wheel **116** and the upper steering shaft **117**.

The steering column assembly **110** is shown in the manual driving mode in FIG. **3**. In the manual driving mode, the upper steering shaft **117** is coupled to the lower steering shaft **112**, also referred to as being rotationally coupled. The coupled (or rotationally coupled) condition of the upper steering shaft **117** and the lower steering shaft **112** results in common rotation of the steering wheel **116** and the lower steering shaft **112**, such that rotation of the components is dependent upon each other. Conversely, a decoupled condition (FIG. **4**) of the upper steering shaft **117** and the lower steering shaft **112** may be present during an autonomous driving mode. The decoupled (or rotationally decoupled) condition results in independent rotation of the steering wheel **116** and the lower steering shaft **112**, such that rotation of the lower steering shaft **112** in response to road wheel angular movement does not require or result in rotation of the steering wheel **116**. The steering column assembly **110** disclosed herein provides a driver the ability to switch between the coupled and decoupled condition in conjunction with switching between manual and autonomous driving modes.

In contrast to a continuously fixed relationship between the lower steering shaft **112** and the steering wheel **116** that is achieved with a splined mating assembly, the embodiments described herein employ at least one, but typically a plurality of balls **118** to establish the coupled or decoupled conditions. The plurality of balls **118** are part of a ball coupling assembly and are fixed within ball retaining structure, such as a plurality of respective holes **119** defined by the lower steering shaft **112** in a one-to-one relationship. The holes **119** are circumferentially spaced from each other and are each sized to axially and circumferentially retain one of the balls **118** therein. The upper steering shaft **117** also has a plurality of holes **121** that are circumferentially spaced from each other and are each sized to axially and circumferentially retain a portion of one of the balls **118** therein. The holes **121** of the upper steering shaft **117** and the holes **119** of the lower steering shaft **112** are equal in number and aligned in a common axial plane.

A central pin **170** is disposed within an axially extending bore **131** of the lower steering shaft **112**. The central pin **170** includes a grooved surface leading from a radially outer surface **133** of the central pin **170** to an annular recess **138** defined by the central pin **170**. In the coupled condition shown in FIG. **3**, the balls **118** are in abutment with the radially outer surface **133** of the central pin **170**. The balls **118** protrude radially to engage the walls defining the holes **119** of the lower steering shaft **112** and the holes **121** of the upper steering shaft **117**. Therefore, when the balls **118** are positioned as such, torque transmission between the steering wheel **116** and the lower steering shaft **112** is established.

To radially retain the balls **118**, an inner wall **126** of a collar **130** is disposed in contact with an outer radial surface of the balls **118**. The collar **130** is disposed between the upper steering shaft **117** and a column housing structure **123**. The collar **130** is operatively coupled to the central pin **170** and the elements are axially translatable in a dependent manner. Operative coupling of the collar **130** and the central pin **170** may be achieved with a pin **172** that is disposed in forced contact with the central pin **170** and the collar **130** as a result of a preload reaction of spring **150** against driving pin **142**. The spring **150** is provided in some embodiments, but is not necessary to bias the driving pin **142** in some embodiments. In some embodiments, it is contemplated that the pin **172** and the central pin **170** are fixed to each other. The pin **172** extends through and axially moves within slots **199** defined by the upper steering shaft **117**.

A collar actuating mechanism **140** is provided to axially translate the collar **130** in order to control the axial position of the central pin **170**, as this positioning determines whether the balls **118** are located at a first radial position or a second radial position. In particular, the balls **118** may be located at a first radial position when the balls **118** are disposed radially inwardly within the annular recess **138** and at a second radial position when the balls **118** are disposed in abutment with the radially outer surface **133** of the central pin **170**. The radial position of the balls **118** is dependent upon the axial position of the central pin **170**.

The collar actuating mechanism **140** includes a driving structure **142**, such as a pin or shift fork is engaged with the collar **130**. The driving structure **142** extends through an aperture **144** of the column housing structure **123** in the illustrated embodiment. The aperture **144** is large enough to accommodate axial travel by the driving structure **142**. A linkage **146** is coupled to the driving structure **142** at one end and to the column housing structure **123** at an opposing end. Different positioning of the linkage **146** axially translates the driving structure **142** and therefore the collar **130** between two axial positions. Manipulation of the linkage **146** may be accomplished with any suitable actuator, such as an electric solenoid **148** having a pin engageable with the linkage **146**.

In a first state (i.e., powered or unpowered) of the electric solenoid **148**, the linkage **146** positions the driving structure **142**, and therefore the collar **130**, in an orientation that disposes the balls **118** in abutment with the radially outer surface **133** of the central pin **170**. This provides the coupled condition (FIG. **3**. In a second state (i.e., powered or unpowered) of the electric solenoid **148**, the driving structure **142** is biased with a spring **150** to move the collar **130** to a position that moves the balls **118** radially inwardly and

out of contact with the wall defining the holes **121** of the upper steering shaft **117**. In this position, the balls **118** are located within the annular recess **138** which provides a continuous track for the balls **118** to travel through when the balls **118** are at the inner radial position (i.e., decoupled condition), thereby rotationally decoupling the steering wheel **116** from the lower steering shaft **112**. A spring **180** located within the bore **131** of the lower steering shaft **112** biases the central pin **170** to the axial position that disposes the balls **118** in the annular recess **138**.

The steering column assembly **10** is also facilitates a rotationally stationary position and condition of the steering wheel **116**. Maintaining the steering wheel **116** in a stationary position reduces the likelihood of driver confusion, inconvenience and/or harm.

Placing the steering wheel **116** in the stationary position occurs upon transition to the decoupled condition of the steering column assembly **110** shown in FIG. **4**. In the illustrated embodiment, an electric solenoid **156** includes a pin **158** extending therefrom. The electric solenoid **156** is switchable between a first state (i.e., powered or unpowered) and a second state (i.e., powered or unpowered), with one state disposing the pin **158** in a retracted position (FIG. **3**) and the other state disposing the pin **158** in an extended position (FIG. **4**). The extended position of the pin **158** engages the pin **158** with a receiving hole **160** defined by the upper steering shaft **117** to rotationally lock the steering wheel **116** when the upper and lower steering shafts **112**, **117** are in the decoupled condition. The preceding example is merely illustrative of how the steering wheel **116** may be locked in the "quiet wheel" mode. Although the steering wheel **116** is rotationally locked, the lower steering shaft **112** is free to rotate due to the balls **118** being disposed in the inward radial position.

In operation, a user interacts with a user input device that switches the states of both electric solenoids **148**, **156**. The user input device may be a button, toggle switch, voice activated command, etc. These types of input devices are merely illustrative of the devices that may be employed to switch the states of the solenoids.

In some of the above-described embodiments, the overall steering system is monitored with an absolute position sensor and the system only allows switching between the driving modes (autonomous and manual) when the steering system is in an "on-center position" (e.g., straight ahead driving position). This facilitates a smooth transition between the driving modes.

The embodiments described herein provide a reliable and efficient way to transition between the coupled and decoupled conditions of the steering column assembly **10**. Additionally, the steering wheel **16** is desirably maintained in a stationary position (rotationally) while the assembly is in the decoupled condition and autonomous driving mode.

While the invention has been described in detail in connection with only a limited number of embodiments, it should be readily understood that the invention is not limited to such disclosed embodiments. Rather, the invention can be modified to incorporate any number of variations, alterations, substitutions or equivalent arrangements not heretofore described, but which are commensurate with the spirit and scope of the invention. Additionally, while various embodiments of the invention have been described, it is to be understood that aspects of the invention may include only some of the described embodiments. Accordingly, the invention is not to be seen as limited by the foregoing description.

Having thus described the invention, it is claimed:

1. A steering column assembly for an autonomous or semi-autonomous vehicle having a steering wheel, the assembly comprising:

an upper column steering shaft rigidly coupled to the steering wheel;

a lower column steering shaft operatively coupled to the upper column steering shaft; and

a ball coupling assembly for switching the upper column steering shaft and the lower column steering shaft between a coupled condition and a decoupled condition, the ball coupling assembly comprising:

a plurality of balls retained within the upper column steering shaft;

a plurality of pockets circumferentially spaced from each other and defined by the lower column steering shaft, each of the pockets sized to receive a portion of one of the plurality of balls;

a collar surrounding the balls, the collar having an angled portion of an inner wall disposed in contact with the balls; and

a collar actuating mechanism for selectively axially translating the collar between a coupled condition and a decoupled condition, the collar actuating mechanism further comprising:

a driving structure engaged with the collar; and

a linkage coupled to the driving structure to axially translate the collar.

2. The steering column assembly of claim **1**, wherein the linkage is secured to a column housing structure of the steering column assembly.

3. The steering column assembly of claim **1**, wherein the collar includes a magnet located proximate the inner wall to attract the balls radially outwardly to the second radial position.

4. The steering column assembly of claim **1**, wherein the upper and lower steering column shafts are switched between the coupled condition and the decoupled condition with a user input device.

5. The steering column assembly of claim **4**, wherein the user input device comprises one of a button, a switch and a voice prompt system.

6. A steering column assembly for an autonomous or semi-autonomous vehicle having a steering wheel, the assembly comprising:

an upper column steering shaft rigidly coupled to the steering wheel;

a lower column steering shaft operatively coupled to the upper column steering shaft; and

a ball coupling assembly for switching the upper column steering shaft and the lower column steering shaft between a coupled condition and a decoupled condition, the ball coupling assembly comprising:

a plurality of balls retained within the upper column steering shaft;

a plurality of pockets circumferentially spaced from each other and defined by the lower column steering shaft, each of the pockets sized to receive a portion of one of the plurality of balls;

a collar surrounding the balls, the collar having an angled portion of an inner wall disposed in contact with the balls; and

a collar actuating mechanism for selectively axially translating the collar between a coupled condition and a decoupled condition, wherein the balls are disposed at a first radial position that disposes the balls within the pockets to place the upper and lower column steering shafts in the coupled condition, the

balls disposed at a second radial position that removes the balls from the pockets to place the upper and lower column steering shafts in the decoupled condition, the coupled condition providing common rotation of the upper and lower column steering shafts and the decoupled condition permitting independent rotation of the upper and lower column steering shafts, the steering column assembly further comprising an annular recess defined by the lower column steering shaft, the annular recess extending to a radial depth that is less than a radial depth of the plurality of pockets, the balls free to rotate along the annular recess when the balls are in the second radial position, the collar actuating mechanism further comprising an actuator engaged with a linkage to actuate movement of the linkage.

7. The steering column assembly of claim **6**, wherein the actuator comprises an electric solenoid biasing the linkage in a first state of the solenoid to position the balls in the first radial position, the electric solenoid switchable to a second state to allow the balls to move to the second radial position.

8. The steering column assembly of claim **7**, wherein the collar actuating mechanism further comprises a spring axially biasing the driving structure to position the balls in the second radial position when the electric solenoid is in the second state.

9. A steering column assembly for an autonomous or semi-autonomous vehicle having a steering wheel, the assembly comprising:

an upper column steering shaft rigidly coupled to the steering wheel;

a lower column steering shaft operatively coupled to the upper column steering shaft; and

a ball coupling assembly for switching the upper column steering shaft and the lower column steering shaft between a coupled condition and a decoupled condition, the ball coupling assembly comprising:

a plurality of balls retained within the upper column steering shaft;

a plurality of pockets circumferentially spaced from each other and defined by the lower column steering shaft, each of the pockets sized to receive a portion of one of the plurality of balls;

a collar surrounding the balls, the collar having an angled portion of an inner wall disposed in contact with the balls; and

a collar actuating mechanism for selectively axially translating the collar between a coupled condition and a decoupled condition; and

an electric solenoid having a pin extending therefrom, the pin engageable with a receiving hole defined by the upper column steering shaft to rotationally lock the steering wheel when the upper and lower column steering shafts are in the decoupled condition.

10. A steering column assembly for an autonomous or semi-autonomous vehicle having a steering wheel, the assembly comprising:

an upper column steering shaft rigidly coupled to the steering wheel;

a lower column steering shaft operatively coupled to the upper column steering shaft; and

a ball coupling assembly for switching the upper column steering shaft and the lower column steering shaft between a coupled condition and a decoupled condition, the ball coupling assembly comprising:

a plurality of balls retained within respective holes defined by the lower column steering shaft in a single axial plane;

a central pin disposed within a bore of the lower column steering shaft and axially translatable therein;

an annular recess defined by the central pin; and

a central pin actuating mechanism for axially translating the central pin, the balls disposed at a first radial position that disposes the balls within the annular recess to place the upper and lower column steering shafts in a decoupled condition, the balls disposed at a second radial position that disposes the balls in abutment with a radially outer surface of the central pin and within the holes of the lower column steering shaft and holes of the upper column steering shaft to place the upper and lower column steering shafts in a coupled condition, the coupled condition providing common rotation of the upper and lower column steering shafts and the decoupled condition permitting independent rotation of the upper and lower column steering shafts.

11. The steering column assembly of claim **10**, further comprising an electric solenoid having a pin extending therefrom, the pin engageable with a receiving hole defined by the upper column steering shaft to rotationally lock the steering wheel when the upper and lower column steering shafts are in the decoupled condition.

12. The steering column assembly of claim **10**, wherein the central pin actuating mechanism further comprises:

a collar disposed between the upper column steering shaft and a column housing structure and operatively coupled to the central pin;

a driving structure engaged with the collar; and

a linkage coupled to the driving structure to axially translate the collar and the central pin.

13. The steering column assembly of claim **12**, wherein the linkage is secured to the column housing structure of the steering column assembly.

14. The steering column assembly of claim **12**, wherein the collar actuating mechanism further comprises an actuator engaged with the linkage to actuate movement of the linkage.

15. The steering column assembly of claim **14**, wherein the actuator comprises an electric solenoid biasing the linkage in an first state of the solenoid to position the balls in the first radial position, the electric solenoid switchable to a second state to allow the balls to move to the second radial position, the upper and lower steering column shafts switchable between the coupled condition and the decoupled condition with a user input device comprising one of a button, a switch and a voice prompt system.

16. The steering column assembly of claim **15**, wherein the collar actuating mechanism further comprises a spring axially biasing the driving structure to position the balls in the first radial position when the electric solenoid is in the first state.

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