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(54) **VEHICLE STEERING APPARATUS AND VEHICLE INCLUDING SAME**

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(57) **ABSTRACT**

A vehicle steering apparatus comprises an input shaft, an output shaft, and a torsion restoring member. The input shaft includes an insertion portion on the bottom end, the insertion portion having a space axially defined therein, and is coupled at the top end to a steering shaft to transmit a steering rotational force. The output shaft is coupled at the top end to the insertion portion and at the bottom end to a rack bar to transmit the steering rotational force to the rack bar. The torsion restoring member is coupled between the inner surface of the insertion portion and the top end of the output shaft to elastically deform upon rotation of the input shaft.

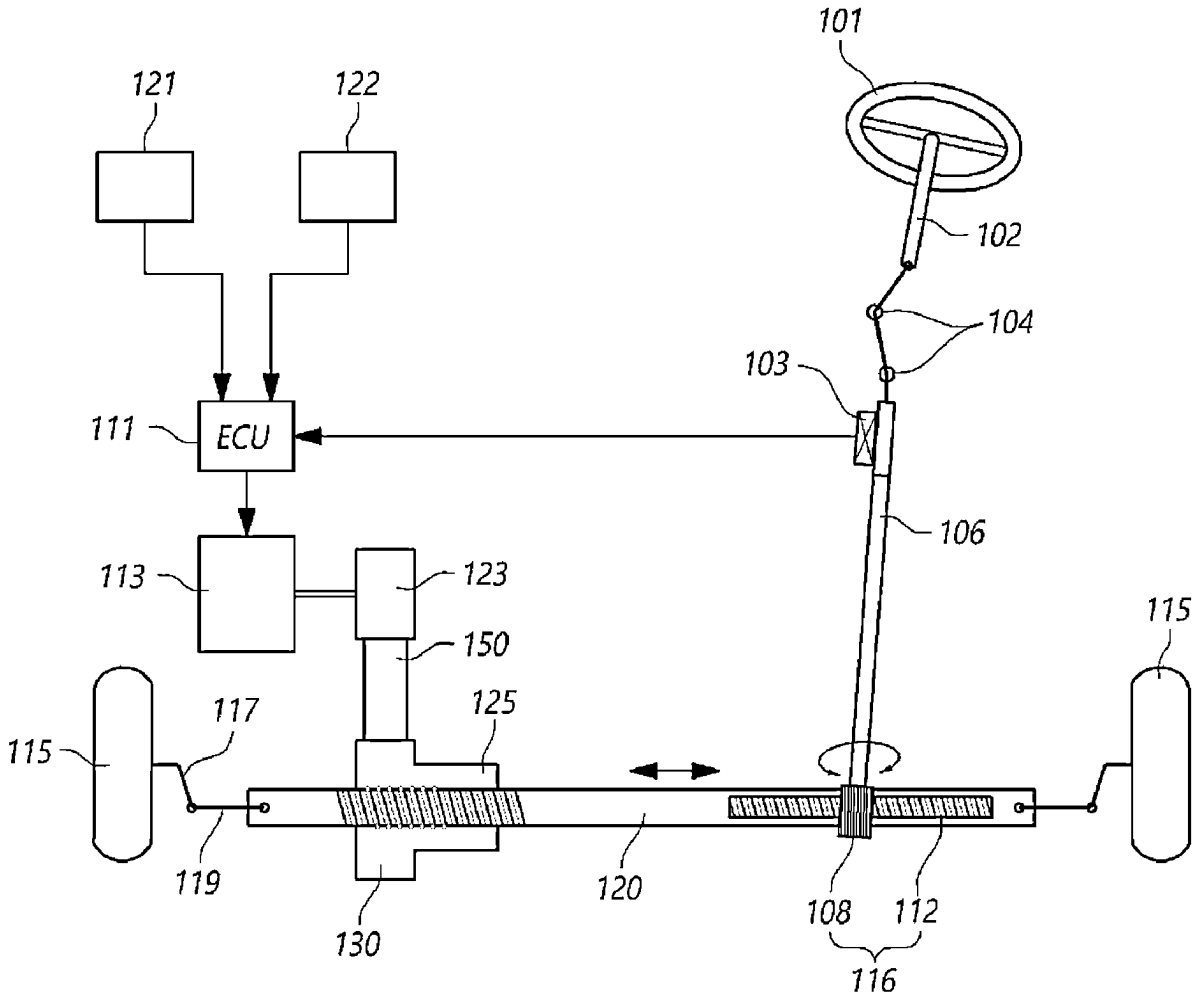
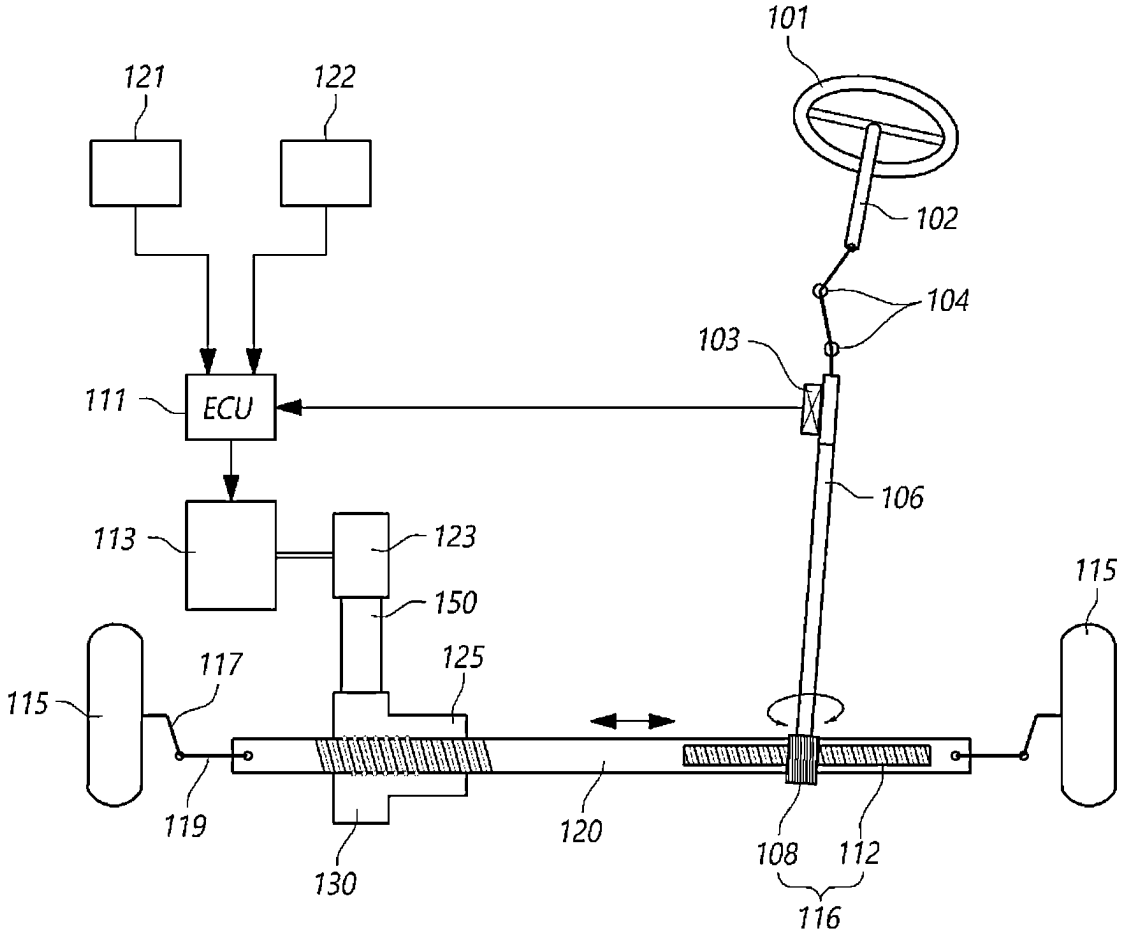


FIG. 1


101
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122
102
104
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130

FIG.2

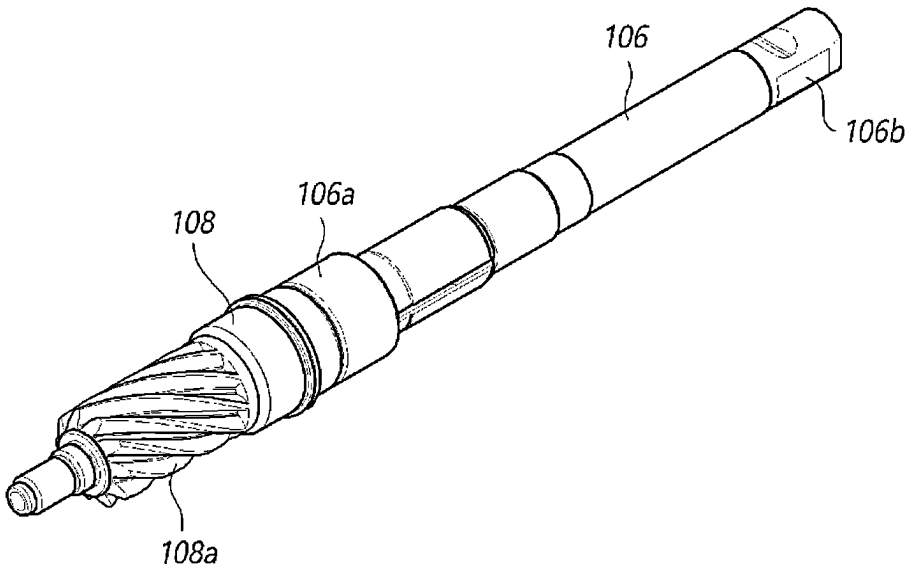


FIG.3

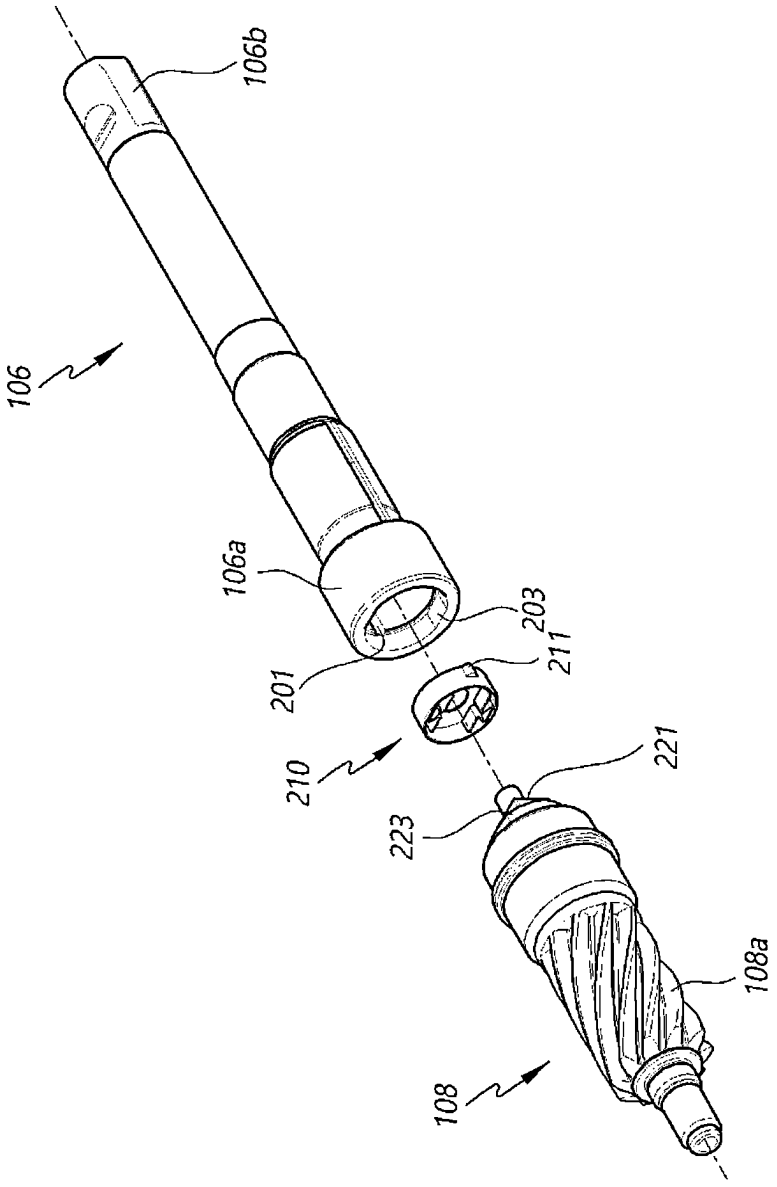


FIG. 4

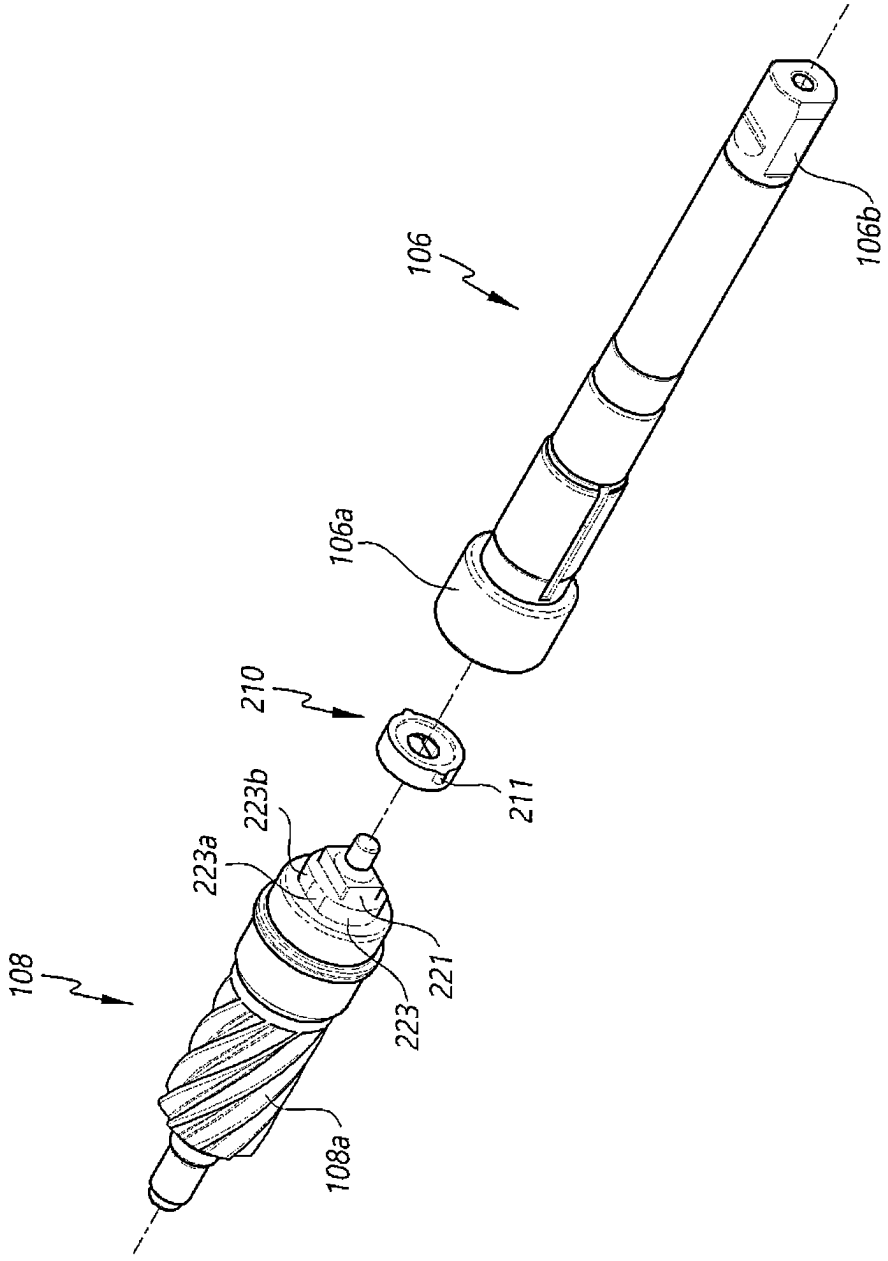
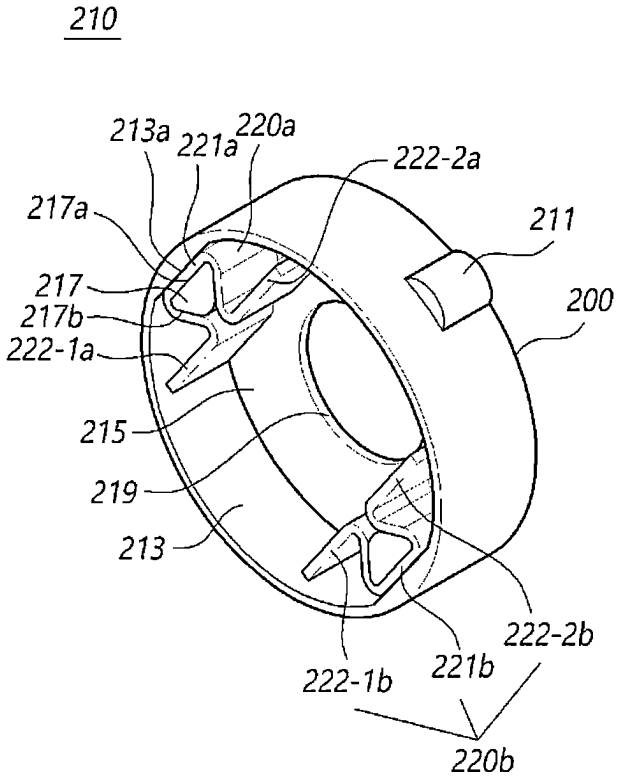


FIG.5


210
213a
221a
220a
222-2a
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200
217b
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222-2b
222-1b
221b
220b

FIG. 6

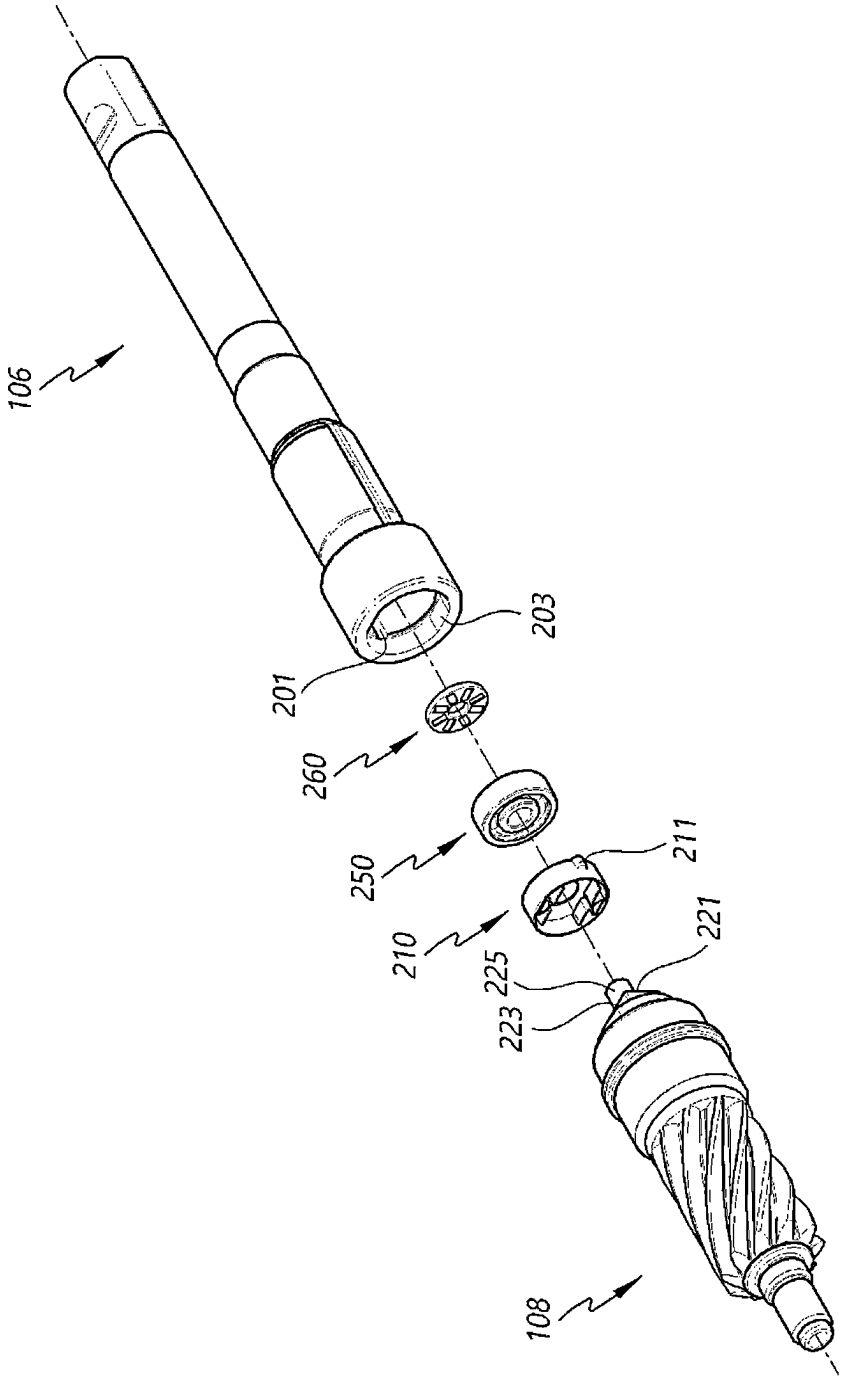


FIG. 7

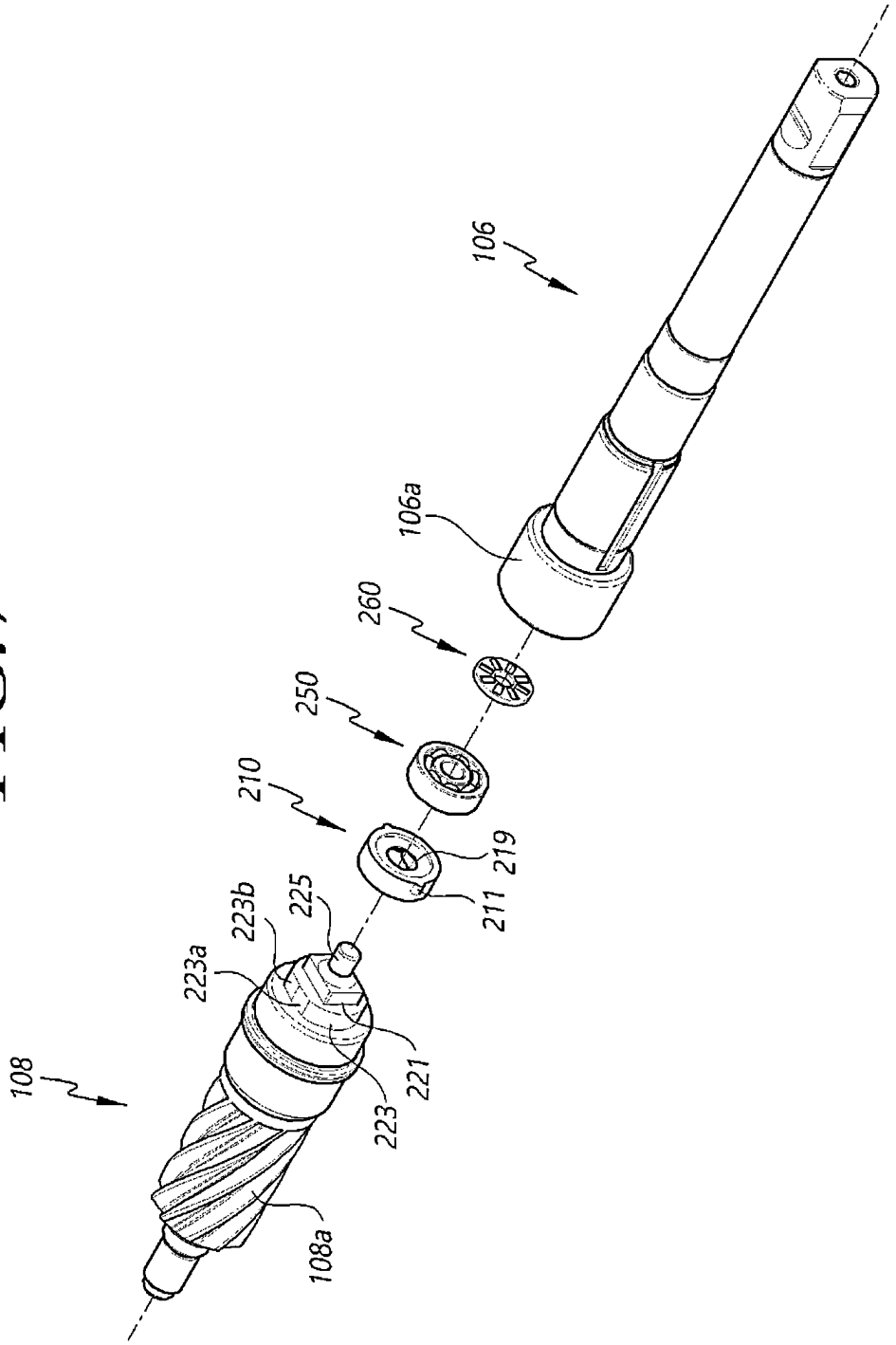


FIG. 8

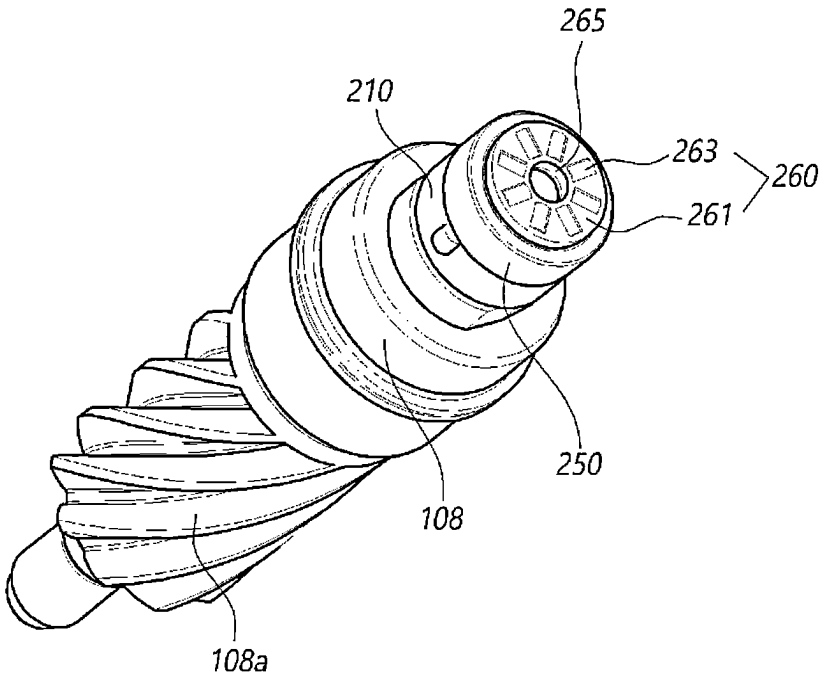


FIG.9

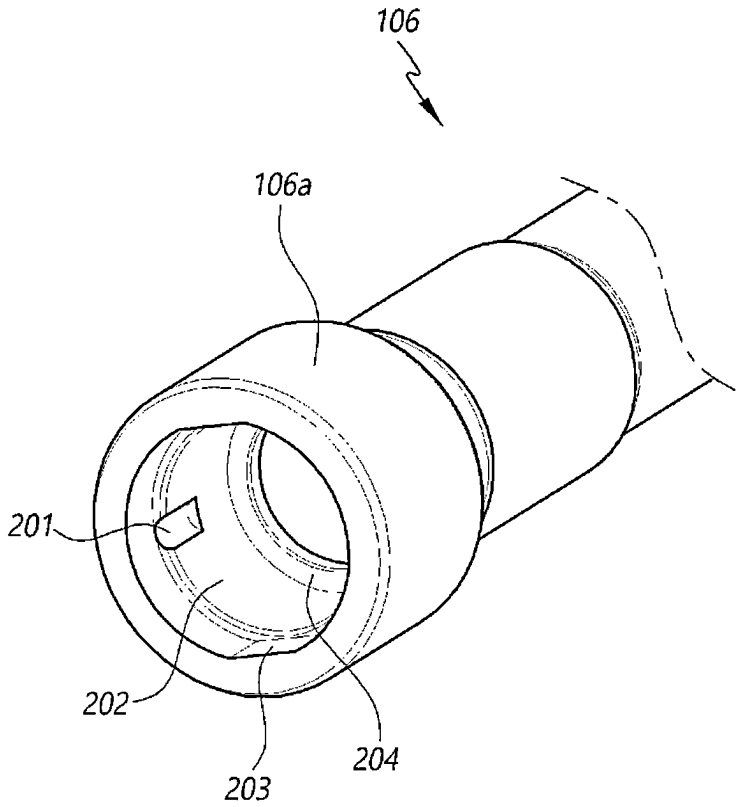
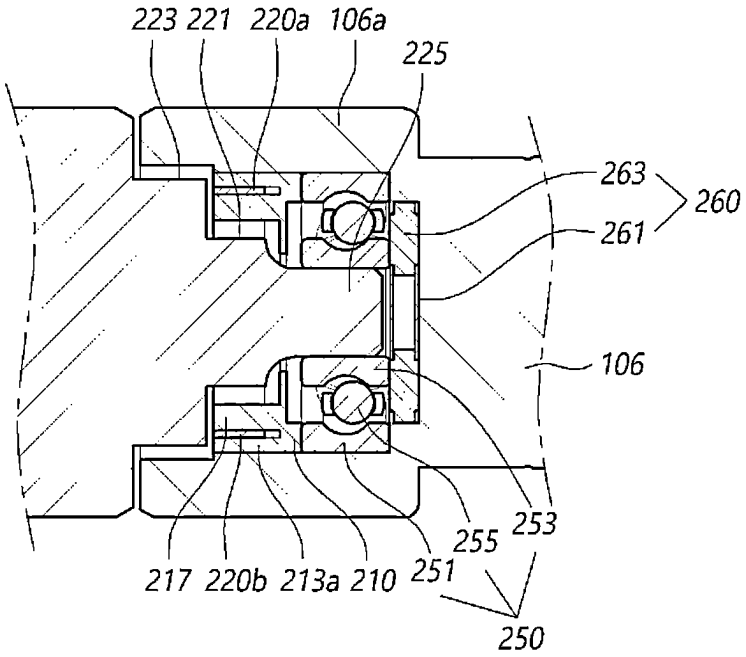


FIG. 10


223
221
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220b
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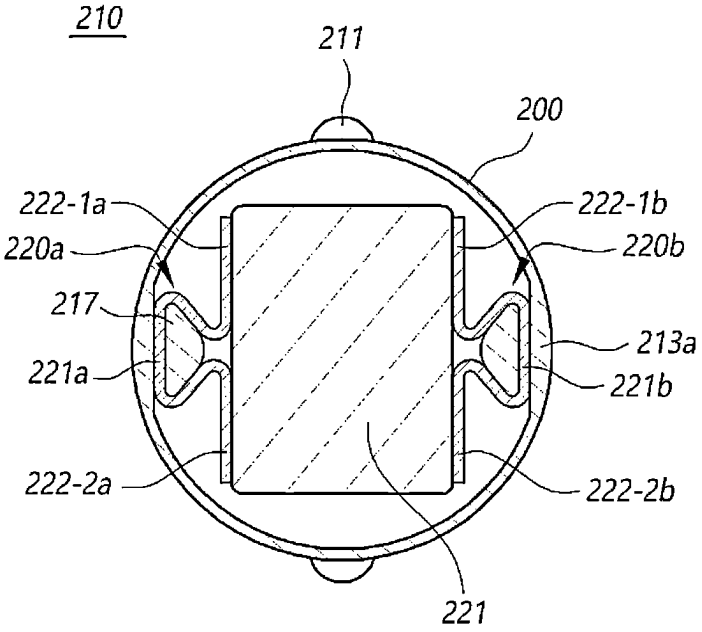
FIG. 11


210
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221b
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222-2b
221

FIG. 12

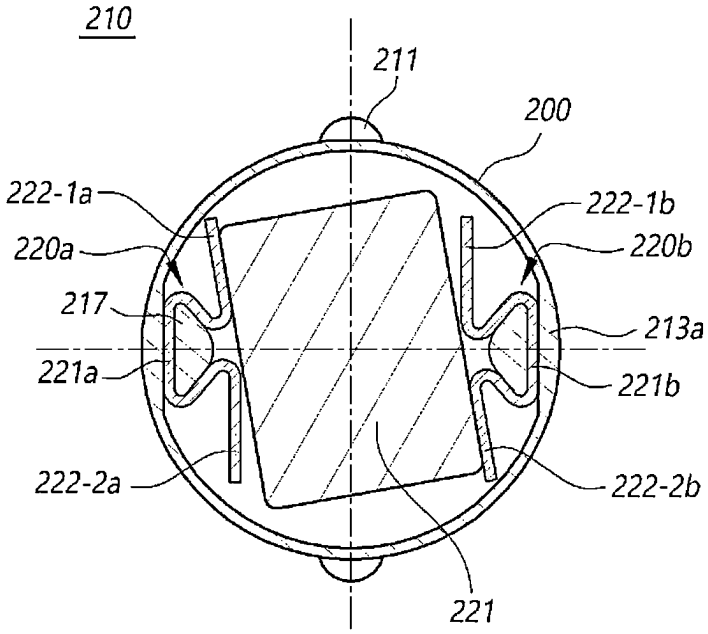
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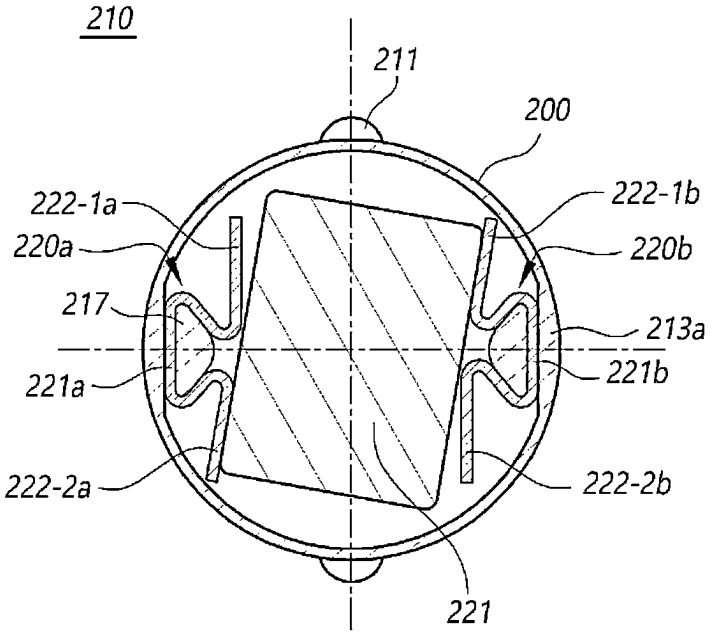
FIG. 13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222-2b
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VEHICLE STEERING APPARATUS AND VEHICLE INCLUDING SAME

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from Korean Patent Application No. 10-2024-0024630, filed on Feb. 20, 2024, which is hereby incorporated by reference for all purposes as if fully set forth herein.

BACKGROUND

Field

[0002] Embodiments relate to a vehicle steering apparatus and a vehicle including the same.

Description of Related Art

[0003] In a vehicle steering apparatus and a vehicle, a steering shaft includes a lower steering shaft and an upper steering shaft coupled thereto. The upper steering shaft is connected to a steering wheel and configured such that an input shaft of the lower steering is connected to an output shaft coupled to a rack bar to transmit a steering force of the steering wheel.

[0004] One end of the lower steering shaft is coupled to the input shaft, and is coupled to the input shaft and a torsion bar by a pin.

[0005] The torsion bar is coupled to the input shaft and the output shaft within the input shaft and the output shaft, and acts as a type of torsion spring that rotates and twists together with the input shaft as the steering shaft rotates. The relative amount of torsion between the input and output shafts is measured by a torque sensor and sent to an electronic controller, which in turn generates a control signal to control generation of an auxiliary steering force.

[0006] However, conventional torsion bars with such a structure and acting as torsion springs on steering shafts have suffered from difficulties in torsion bar manufacturing and machining processes and assembly processes such as pin-fixing to the input and output shafts. The need to manufacture torsion bars of different lengths depending on the vehicle type may reduce productivity and increase costs, and there are difficulties in tuning the stiffness of torsion bars.

[0007] Therefore, there is an increasing need for research on a vehicle steering apparatus that may minimize the cost increase and improve the assemblability by replacing and commonizing existing torsion bars.

BRIEF SUMMARY

[0008] Various aspects provide a vehicle steering apparatus that may minimize the cost increase and improve the assemblability by replacing and commonizing existing torsion bars.

[0009] According to embodiments, provided is a vehicle steering apparatus including an input shaft coupled to a steering shaft and including an insertion portion on a end of the input shaft, the insertion portion of the input shaft having an inner space formed in the insertion portion in an axial direction of the input shaft, an output shaft, wherein one end of the output shaft is coupled to the insertion portion of the input shaft and another end of the output shaft is coupled to a rack bar, and a torsion restoring member coupled between the inner surface of the insertion portion of the input shaft and the one end of the output shaft, and configured to be elastically deformable in response to rotation of the input shaft.

[0010] According to embodiments, also provided is a vehicle steering apparatus including an input shaft coupled to a steering shaft and including an insertion portion on an end of the input shaft, the insertion portion of the input shaft having an inner space formed, in the insertion portion in an axial direction of the input shaft, an output shaft, wherein one end of the output shaft is coupled to the insertion portion of the input shaft and another end of the output shaft is coupled to a rack bar, a torsion restoring member coupled between the insertion portion and the one end of the output shaft, coupled to be elastically deformable in response to rotation of the input shaft, and a rotational support member coupled to the one end of the output shaft and coupled between an inner surface of the insertion portion of the input shaft and the torsion restoring member to support rotation of the output shaft.

[0011] According to embodiments, also provided is a vehicle including a steering shaft connected to a steering wheel, an input shaft coupled to the steering shaft and including an insertion portion on an end of the input shaft, the insertion portion of the input shaft having an inner space formed in the insertion portion in an axial direction of the input shaft, an output shaft, wherein one end of the output shaft is coupled to the insertion portion of the input shaft and at another end of the output shaft is coupled to a rack bar, a rack driver coupled to the rack bar and configured to control movement of the rack bar, a torsion restoring member coupled between an inner surface of the insertion portion of the output shaft coupled and the one end of the output shaft, coupled to the insertion portion of the input shaft, and configured to be elastically deformable in response to rotation of the input shaft, a torque sensor configured to sense torque of the input shaft, and an electronic controller configured to output a control signal to the rack driver according to the torque of the input shaft.

[0012] According to embodiments, both minimizing the cost increase and improving the assemblability may be achieved by replacing and commonizing existing torsion bars.

DESCRIPTION OF DRAWINGS

[0013] The above and other objects, features, and advantages of the present disclosure will be more clearly understood from the following detailed description, taken in conjunction with the accompanying drawings, in which:

[0014] FIG. **1** is a schematic view illustrating a vehicle according to embodiments;

[0015] FIG. **2** is a perspective view illustrating portions of a vehicle steering apparatus according to embodiments;

[0016] FIGS. **3** and **4** are exploded perspective views illustrating portions of the vehicle steering apparatus according to embodiments;

[0017] FIG. **5** a perspective view illustrating portions of the vehicle steering apparatus according to embodiments;

[0018] FIGS. **6** and **7** are exploded perspective views illustrating portions of the vehicle steering apparatus according to embodiments;

[0019] FIGS. **8** and **9** are perspective views illustrating portions of the vehicle steering apparatus according to embodiments; and

[0020] FIGS. **10** to **13** are cross-sectional views illustrating portions of the vehicle steering apparatus according to embodiments.

DETAILED DESCRIPTION

[0021] In the following description of examples or embodiments of the present disclosure, reference will be made to the accompanying drawings in which it is shown by way of illustration specific examples or embodiments that can be implemented, and in which the same reference numerals and signs can be used to designate the same or like components even when they are shown in different accompanying drawings from one another. Further, in the following description of examples or embodiments of the present disclosure, detailed descriptions of well-known functions and components incorporated herein will be omitted when it is determined that the description may make the subject matter in some embodiments of the present disclosure rather unclear. The terms such as "including", "having", "containing", "constituting", "made up of", and "formed of" used herein are generally intended to allow other components to be added unless the terms are used with the term "only". As used herein, singular forms are intended to include plural forms unless the context clearly indicates otherwise.

[0022] Terms, such as "first", "second", "A", "B", "(A)", or "(B)" may be used herein to describe elements of the disclosure. Each of these terms is not used to define essence, order, sequence, or number of elements etc., but is used merely to distinguish the corresponding element from other elements.

[0023] When it is mentioned that a first element "is connected or coupled to", "contacts or overlaps" etc. a second element, it should be interpreted that, not only can the first element "be directly connected or coupled to" or "directly contact or overlap" the second element, but a third element can also be "interposed" between the first and second elements, or the first and second elements can "be connected or coupled to", "contact or overlap", etc. each other via a fourth element. Here, the second element may be included in at least one of two or more elements that "are connected or coupled to", "contact or overlap", etc. each other.

[0024] When time relative terms, such as "after", "subsequent to", "next", "before", and the like, are used to describe processes or operations of elements or configurations, or flows or steps in operating, processing, manufacturing methods, these terms may be used to describe non-consecutive or non-sequential processes or operations unless the term or "directly" "immediately" is used together.

[0025] In addition, when any dimensions, relative sizes etc. are mentioned, it should be considered that numerical values for an elements or features, or corresponding information (e.g., level, range, etc.) include a tolerance or error range that may be caused by various factors (e.g., process factors, internal or external impact, noise, etc.) even when a relevant description is not specified. Further, the term "may" fully encompasses all the meanings of the term "can".

[0026] FIG. **1** is a schematic view illustrating a vehicle according to embodiments, FIG. **2** is a perspective view illustrating portions of a vehicle steering apparatus according to embodiments, FIGS. **3** and **4** are exploded perspective views illustrating portions of the vehicle steering apparatus according to embodiments, FIG. **5** a perspective view illustrating portions of the vehicle steering apparatus according to embodiments, FIGS. **6** and **7** are exploded perspective views illustrating portions of the vehicle steering apparatus according to embodiments, FIGS. **8** and **9** are perspective views illustrating portions of the vehicle steering apparatus according to embodiments, and FIGS. **10** to **13** are cross-sectional views illustrating portions of the vehicle steering apparatus according to embodiments.

[0027] First, embodiments will be described with reference to FIGS. **1** to **5**.

[0028] According to the present embodiments, provided may be a vehicle steering apparatus including: an input shaft **106** coupled to a steering shaft **102** and including an insertion portion **106***a* on an end of the input shaft **106**, the insertion portion **106***a* of the input shaft **106** having an inner space formed in the insertion portion **106***a* in an axial direction of the input shaft **106**, an output shaft **108**, wherein one end of the output shaft **108** is coupled to the insertion portion **106***a* of the input shaft **106** and another end of the output shaft **108** is coupled to a rack bar **120**, and a torsion restoring member **210** coupled between an inner surface of the insertion portion **106***a* of the input shaft **106** and the one end of the output shaft **108**, coupled to the insertion portion **106***a* of the input shaft **106**, and configured to be elastically deformable in response to rotation of the input shaft **106**.

[0029] Referring to FIG. **1** the vehicle of the present embodiments is configured such that the steering shaft **102** connected to a steering wheel **101** is coupled to the input shaft **106** through a universal joint **104**, and an electronic controller **111**, such as an electronic control unit (ECU), sends a control signal to a motor **113** to steer two wheels **115** through tie rods **119** based on information received from a torque sensor **103** detecting torque on the input shaft in response to the driver operating the steering wheel **101**, a steering angle sensor **121**, a speed sensor **122**, and the like.

[0030] In the present embodiments, the steering shaft **102** at the top is connected to the input shaft **106** at the bottom through the universal joint **104** and allows steering to be performed by a rack-and-pinion device **116** including a pinion **108** and a rack gear **112**.

[0031] Here, the driving force of the motor **113** driven by the electronic controller **111** is transmitted from the motor **113** to a ball nut **125** through the belt **150**, thereby causing the rack bar **120** coupled to the ball nut **125** by a ball to slide axially. The tie rods **119** are coupled to the opposite ends of the rack bar **120**. The tie rods **119** are coupled to knuckle arms **117** connected to the wheels **115** to steer the wheels **115**.

[0032] A motor pulley **123** connected to the shaft of the motor **113** and a nut pulley **130** connected to the ball nut **125** are arranged in parallel. A belt **150** is coupled to the motor pulley **123** and the nut pulley **130** to transmit the rotational force of the motor **113** to the rack bar **120** through the ball nut **125**. The rack bar **120** may be moved from side to side by the motion of the ball nut **125** to generate a steering assist force.

[0033] An electrical signal generated by the torque sensor **103** is sent to the electronic controller **111**, and the electronic controller **111** controls the motor **113** based on an electrical signal transmitted by the torque sensor **103** and electrical signals transmitted by the steering angle sensor **121**, the speed sensor **122**, and the like mounted on the vehicle.

[0034] Referring to FIG. **2**, the bottom end of the input shaft **106** is provided with the insertion portion **106***a* having a space axially defined therein, and the top end of the input

shaft **106** is provided with a coupling portion **106***b* that is coupled to the steering shaft **102** to transmit the steering rotational force as the steering shaft **102** rotates.

[0035] The top end of the output shaft **108** is coupled to the insertion portion **106***a* of the input shaft **106**, and the output shaft **108** is provided with a pinion gear **108***a* on the bottom end and is coupled to the rack gear **112** of the rack bar **120** to transmit the steering rotational force of the input shaft **106** to the rack bar **120**.

[0036] As shown in FIGS. **3** and **4**, the torsion restoring member **210** is coupled between the inner surface of the insertion portion **106***a* and the top end of the output shaft **108** to elastically deform and generate an elastic restoring force upon rotation of the input shaft **106**.

[0037] Referring to FIG. **5**, the torsion restoring member **210** includes a fixed housing **200** fixed to the insertion portion **106***a* and elastic members **220***a* and **220***b* each having a first end and a second end supporting the output shaft **108**, wherein a portion of the elastic member **220***a* between the first and second ends of the elastic member **220***a* is fixed to the fixed housing **200** of the torsion restoring member **210**.

[0038] As shown in FIG. **4**, the output shaft **108** is provided with an axially protruding support end **223** protruding from the one end of the output shaft **108** coupled to the insertion portion **106***a* of the input shaft **106**, and the support end **223** is provided with stopper surfaces **223***a* and **223***b* formed as incised planes on the radially opposite sides of the support end **223**.

[0039] In addition, the insertion portion **106***a* is provided with a support surface **203** on the inner circumferential surface of the end of the input shaft **106**, the stopper surfaces **223***a* and **223***b* of the output shaft **108** being supported on the support surface **203** upon rotation of the input shaft **106**.

[0040] The stopper surfaces **223***a* and **223***b* are configured such that the first stopper surface **223***a* and the second stopper surface **223***b* are connected at an angle. The first stopper surface **223***a* is supported and stopped on the support surface **203** upon clockwise rotation of the input shaft **106**, and the second stopper surface **223***b* is supported and stopped on the support surface **203** upon counterclockwise rotation of the input shaft **106**.

[0041] In addition, the output shaft **108** is provided with protruding ends **221** on the top end, the protruding ends **221** axially protruding from the support end **223** and supported on first and second ends of the elastic members **220***a* and **220***b*. Upon rotation of the input shaft **106**, the protruding ends **221** are supported on the first and second ends of the elastic members **220***a* and **220***b*, thereby causing elastic deformation.

[0042] The protruding ends **221** are provided as a plane, in which the opposite sides in the radial direction about the central axis are parallel to each other.

[0043] In addition, the elastic members **220***a* and **220***b* are provided as a pair of elastic members symmetrically disposed on the opposite sides of the protruding ends **221** such that the elastic restoring force generated on the elastic members **220***a* and **220***b* by the protruding ends **221** upon rotation of the input shaft **106** is applied equally to the opposite sides of the protruding ends **221**.

[0044] Referring to FIG. **5** again in conjunction with FIGS. **3** and **4**, the fixed housing **200** includes a cylindrical portion **213** coupled to the inner circumferential surface of the insertion portion **106***a*, a vertical partition **215** extending from a first end of the cylindrical portion **213**, and fixing protrusions **217** each protruding axially from the vertical partition **215**, such that a portion between a first end and a second end of each of the elastic members **220***a* and **220***b* is coupled to one of the fixing protrusions **217**.

[0045] The cylindrical portion **213** is provided with radially protruding support protrusions **211** protruding from the outer circumferential surface, and the insertion portion **106***a* is provided on the inner circumferential surface with seating recesses **201** into which the support protrusions **211** are inserted, so that the fixed housing **200** is fixed to the inner circumferential surface of the insertion portion **106***a* without idling.

[0046] The fixing protrusions **217** are spaced apart from the inner circumferential surface of the cylindrical portion **213**, and the portions between the first and second ends of the elastic members **220***a* and **220***b* are disposed between the inner circumferential surface of the cylindrical portion **213** and the fixing protrusions **217**.

[0047] One of the fixing protrusions **217** has a flat surface **217***a* that is provided as a plane at a position opposite the inner circumferential surface of the cylindrical portion **213**. The cylindrical portion **213** is provided with a flat surface **213***a* on the inner circumferential surface, the flat surface **213***a* of the cylindrical portion **213** is parallel to the flat surface **217***a* of the fixing protrusions **217**.

[0048] In addition, one of the fixing protrusions **217** includes inclined portions **217***b* extending radially from the ends of the flat surface **217***a* facing the inner circumferential surface of the cylindrical portion **213**.

[0049] Each elastic member **220***a* or **220***b* includes shaft support members **222-1***a* and **222-2***a* or **222-1***b* and **222-2***b* each having first and second ends bilaterally disposed on the same plane to support the outer circumferential portions of the output shaft **108** and fixing protrusions **221***a* and **221***b* bent at the inner ends of the shaft support members **222-1***a* and **222-2***a* or **222-1***b* and **222-2***b* to wrap around and fix the inclined portions **217***b* and the flat surface **217***a* of the fixing protrusion **217**.

[0050] Referring to FIGS. **6** to **13**, the vehicle steering apparatus according to the present embodiments includes: an input shaft **106** coupled to a steering shaft **102** and including an insertion portion **106***a* on an end of the input shaft **106**, the insertion portion **106***a* having an inner space formed in the insertion portion **106***a* in an axial direction, an output shaft **108**, wherein one end of the output shaft **108** is coupled to the insertion portion **106***a* and another end of the output shaft is coupled to a rack bar **120**, a torsion restoring member **210** coupled between an inner surface of the insertion portion **106***a* and the one end of the output shaft **108**, and configured to be elastically deformable in response to rotation of the input shaft **106**, and a first rotational support member **250** coupled to the one end of the output shaft **108** and coupled between the inner surface of the insertion portion **106***a* and the torsion restoring member **210** to support rotation of the output shaft **108**.

[0051] Here, the torsion restoring member **210** includes a fixed housing **200** fixed to the insertion portion **106***a* and elastic members **220***a* and **220***b* each having first and second ends supporting the output shaft **108**, in which a portion of the elastic member **220***a* and **220***b* between the first and second ends is fixed to the fixed housing **200**. These features are the same as those described above and therefore a detailed description thereof will be omitted below.

[0052] Referring to FIGS. **6** and **7**, the top end of the output shaft **108** is provided with protruding ends **221** axially protruding and supported on the first and second ends of the elastic members **220***a* and **220***b*, in which each of the protruding ends **221** is configured such that the opposite sides of the protruding ends **221** of the output shaft **108** in the radial direction about the central axis are parallel to each other.

[0053] In addition, the top end of the output shaft **108** is provided with a coupling protrusion **225** axially protruding from the protruding ends **221** to be coupled to the first rotational support member **250**.

[0054] Referring to FIGS. **8** to **10** together, the first rotational support member **250** includes an annular inner coupling member **253** coupled to the coupling protrusion **225** to rotate together with the output shaft **108**, an annular outer coupling member **251** axially supported by the fixed housing **200** of the torsion restoring member **210** and radially supported by and fixed to the inner circumferential surface of the insertion portion **106***a*, and a first rolling member **255** coupled between the inner coupling member **253** and the outer coupling member **251** to support rotation of the inner coupling member **253**.

[0055] In an embodiment, the first rolling member **255** may be implemented as a ball, and the inner circumferential surface of the insertion portion **106***a* is provided with a coupling surface **202** to which the first rolling member **255** is coupled.

[0056] The present embodiments may further include a second rotational support member **260** coupled between the inner surface **204** of the insertion portion **106***a* and the first rotational support member **250** to support the rotation of the inner coupling member **253**.

[0057] The second rotational support member **260** may include a support member **261** supporting the inner surface **204** of the insertion portion **106***a* and the inner coupling member **253** and second rolling members **263** rotatably coupled to the support member **261** to support rotation of the inner coupling member **253**.

[0058] In an embodiment, the second rolling members **263** may be implemented as rolls, and the inner surface **204** on which the second rolling members **263** are supported may be provided as a stepped portion having a decreasing inner diameter.

[0059] In an embodiment, an assembly process may be performed by the sequence of attaching the second rolling members **263** to the inner surface **204** of the insertion portion **106***a*, sliding the first cloud member **255** on the inner circumferential surface of the insertion portion **106***a* to be attached to the mating surface **202**, and then attaching the torsion restoring member **210** and the output shaft **108** to the input shaft **106**.

[0060] Referring to FIGS. **11** to **13**, the operation of the torsion restoring member will be described as follows.

[0061] First, FIG. **11** shows the steering wheel in a neutral state, i.e., a state in which the driver is not operating the steering wheel and the vehicle is traveling straight, with the opposite sides of the protruding ends **221** uniformly supported on the elastic members **220***a* and **220***b*.

[0062] FIG. **12** shows a state in which the steering wheel is operated to rotate the protruding ends **221** counterclockwise, at which time a first end **222-1***a* of the left elastic member **220***a* and a second end **222-2***b* of the right elastic member **220***b* are compressed, thereby applying an elastic restoring force to the protruding ends **221**.

[0063] In contrast to FIG. **12**, FIG. **13** shows a state in which the protruding ends **221** are rotated clockwise. Here, the second end **222-2***a* of the left elastic member **220***a* and the first end **222-1***b* of the right elastic member **220***b* are compressed, thereby applying an elastic restoring force to the protruding ends **221**.

[0064] In addition, referring to FIGS. **2** to **13** together with FIG. **1**, a vehicle according to the present embodiments includes a steering shaft **102** connected to a steering wheel **101**, an input shaft **106** coupled to the steering shaft **102** and including an insertion portion **106***a* on an end of the input shaft **106**, the insertion portion **106***a* having an inner space formed in the insertion portion **106***a* in an axial direction of the input shaft **106**, an output shaft **108**, wherein one end of the output shaft **108** is coupled to the insertion portion **106***a* and another end of the output shaft is coupled to a rack bar **120**, a rack driver **113**, **123**, **150**, **130**, and **125** coupled to the rack bar **120** and configured to control movement of the rack bar **120**, a torsion restoring member **210** coupled between the inner surface of the insertion portion **106***a* and the one end of the output shaft **108**, coupled to the insertion portion **106***a*, and configured to be elastically deformable in response to rotation of the input shaft **106**, a torque sensor **103** configured to sense torque of the input shaft **106**, and an electronic controller **111** configured to output a control signals to the rack driver according torque of the input shaft **106**.

[0065] The steering shaft **102**, the input shaft **106**, the output shaft **108**, and the torsion restoring member **210** are the same as described above and will not be described in detail below.

[0066] As shown in FIG. **1**, the rack driver **113**, **123**, **150**, **130**, and **125** coupled to the rack bar **120** to slide the rack bar **120** may include a motor **113** configured to driven in response to a control signal of the electronic controller **111**, a motor pulley **123** coupled to the motor **113**, a nut pulley **130** coupled to a ball nut **125** coupled to the rack bar **120**, and a belt **150** connecting the motor pulley **123** and the nut pulley **130**.

[0067] The torque sensor **103** is coupled to a first side of the input shaft **106** and is configured to sense the driver operating the steering wheel **101** and send an electrical signal to the electronic controller **111** to operate the motor **113**.

[0068] The electronic controller **111** controls the motor **113** based on an electrical signal transmitted by the torque sensor **103** and electrical signals transmitted by the steering angle sensor **121**, the speed sensor **122**, and the like mounted on the vehicle.

[0069] The motor **113** may be coupled to a speed reducer to reduce the number of revolutions of the motor, and may slide the rack bar **120** from side to side by a belt **150** and a nut pulley **130** to steer both wheels **115** by tie rods **119** and knuckle arms **117**.

[0070] In the drawings of the present embodiments, for the sake of brevity, the torque sensor **103** provided on the input shaft **106**, the speed sensor **122** transmitting steering information to the electronic controller **190**, and the steering angle sensor **121** are illustrated by way of example, but other devices, such as an ultrasonic sensor, an image sensor, a

motor position sensor, and various radars and LiDARs, may be provided, and detailed descriptions thereof will be omitted.

[0071] According to embodiments of the present invention having the shapes and structures described above, both minimizing the cost increase and improving the assemblability may be achieved by replacing and commonizing existing torsion bars.

[0072] The above description has been presented to enable any person skilled in the art to make and use the technical idea of the present disclosure, and has been provided in the context of a particular application and its requirements. Various modifications, additions and substitutions to the described embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the present disclosure. The above description and the accompanying drawings provide an example of the technical idea of the present disclosure for illustrative purposes only. That is, the disclosed embodiments are intended to illustrate the scope of the technical idea of the present disclosure. Thus, the scope of the present disclosure is not limited to the embodiments shown, but is to be accorded the widest scope consistent with the claims.

What is claimed is:

1. A vehicle steering apparatus comprising:

an input shaft coupled to a steering shaft and including an insertion portion on an end of the input shaft, the insertion portion of the input shaft having an inner space formed in the insertion portion in an axial direction of the input shaft;

an output shaft, wherein one end of the output shaft is coupled to the insertion portion of the input shaft and another end of the output shaft is coupled to a rack bar; and

a torsion restoring member coupled between an inner surface of the insertion portion of the input shaft and the one end of the output shaft, coupled to the insertion portion of the input shaft, and configured to be elastically deformable in response to rotation of the input shaft.

2. The vehicle steering apparatus of claim **1**, wherein the torsion restoring member comprises:

a fixed housing fixed to the insertion portion of the input shaft; and

at least one elastic member having a first end and a second end supporting the output shaft, wherein a portion of the elastic member between the first and second ends of the elastic member is fixed to the fixed housing of the torsion restoring member.

3. The vehicle steering apparatus of claim **2**, wherein the output shaft comprises:

an axially protruding support end protruding from the one end of the output shaft coupled to the insertion portion of the input shaft, and

stopper surfaces at sides of the axially protruding support end of the output shaft.

4. The vehicle steering apparatus of claim **3**, wherein the insertion portion of the input shaft comprises a support surface on an inner circumferential surface of the end of the input shaft, the stopper surfaces of the output shaft supported by the support surface of the insertion portion of the input shaft.

5. The vehicle steering apparatus of claim **3**, wherein the output shaft comprises a protruding end axially protruding from the axially protruding support end of the output shaft, and supported by the first and second ends of the at least one elastic member of the torsion restoring member.

6. The vehicle steering apparatus of claim **5**, wherein opposite sides of the protruding end of the output shaft in a radial direction are parallel to each other.

7. The vehicle steering apparatus of claim **6**, wherein the at least one elastic member comprises a pair of elastic members symmetrically disposed on the opposite sides of the protruding end of the output shaft.

8. The vehicle steering apparatus of claim **2**, wherein the fixed housing of the torsion restoring member comprises:

a cylindrical portion coupled to the inner surface of the insertion portion of the input shaft;

a vertical partition extending from a first end of the cylindrical portion; and

fixing protrusions each protruding axially from the vertical partition such that the portion of the elastic member between the first end and the second end of the elastic member is coupled to one of the fixing protrusions.

9. The vehicle steering apparatus of claim **8**, wherein the cylindrical portion of the fixed housing of the torsion restoring member radially comprises protruding support protrusions protruding from an outer circumferential surface of the cylindrical portion, and the insertion portion of the input shaft comprises seating recesses on the inner surface of the insertion portion, wherein the radially protruding support protrusions are inserted into the seating recesses of the insertion portion of the input shaft.

10. The vehicle steering apparatus of claim **8**, wherein the fixing protrusions of the fixed housing of the torsion restoring member are spaced apart from an inner circumferential surface of the cylindrical portion, and the portion of the elastic member between the first and second ends of the elastic member is disposed between the inner circumferential surface of the cylindrical portion and one of the fixing protrusions of the fixed housing of the torsion restoring member.

11. The vehicle steering apparatus of claim **10**, wherein one of the fixing protrusions of the fixed housing of the torsion restoring member comprises a flat surface facing the inner circumferential surface of the cylindrical portion, the cylindrical portion comprises a flat surface on the inner circumferential surface of the cylindrical portion, the flat surface of the one of the fixing protrusions of the fixed housing of the torsion restoring member is parallel to the flat surface of the cylindrical portion.

12. The vehicle steering apparatus of claim **11**, wherein one of the fixing protrusions of the fixed housing of the torsion restoring member comprises inclined portions extending radially from ends of the flat surface facing the inner circumferential surface of the cylindrical portion.

13. A vehicle steering apparatus comprising:

an input shaft coupled to a steering shaft and comprising an insertion portion on an end of the input shaft, the insertion portion of the input shaft having an inner space formed in the insertion portion in an axial direction of the input shaft;

an output shaft, wherein one end of the output shaft is coupled to the insertion portion of the input shaft and another end of the output shaft is coupled to a rack bar;

a torsion restoring member coupled between an insertion portion and the one end of the output shaft, coupled to the insertion portion of the input shaft, and configured to be elastically deformable in response to rotation of the input shaft; and

a rotational support member coupled to the one end of the output shaft and coupled between an inner surface of the insertion portion of the input shaft and the torsion restoring member to support rotation of the output shaft.

14. The vehicle steering apparatus of claim **13**, wherein the torsion restoring member comprises:

a fixed housing fixed to the insertion portion of the input shaft; and

an elastic member having a first end and a second end supporting the output shaft, wherein a portion of the elastic member between the first and second ends is fixed to the fixed housing of the torsion restoring member.

15. The vehicle steering apparatus of claim **14**, wherein the output shaft comprises a protruding end axially protruding from the one end of the output shaft and supported by the first and second ends of the elastic member of the torsion restoring member, wherein opposite sides of the protruding end of the output shaft in a radial direction are parallel to each other.

16. The vehicle steering apparatus of claim **15**, wherein the output shaft comprises a coupling protrusion on the one end of the output shaft and axially protruding from the protruding end of the output shaft to be coupled to the rotational support member.

17. The vehicle steering apparatus of claim **16**, wherein the rotational support member comprises:

an inner coupling member coupled to the coupling protrusion of the output shaft to rotate together with the output shaft;

an annular outer coupling member axially supported by the fixed housing of the torsion restoring member and radially supported by and fixed to an inner circumferential surface of the insertion portion of the input shaft;

an outer coupling member axially supported by the fixed housing and radially supported by and fixed to the inner circumferential surface of the insertion portion of the input shaft; and

a first rolling member coupled between the inner coupling member and the outer coupling member to support rotation of the inner coupling member.

18. The vehicle steering apparatus of claim of **17**, further comprising another rotational support member coupled between the inner surface of the insertion portion of the input shaft and the rotational support member to support the rotation of the inner coupling member.

19. A vehicle comprising:

a steering shaft connected to a steering wheel;

an input shaft coupled to the steering shaft and comprising an insertion portion on an end of the input shaft, the insertion portion of the input shaft having an inner space formed in the insertion portion in an axial direction of the input shaft;

an output shaft, wherein one end of the output shaft is coupled to the insertion portion of the input shaft and another end of the output shaft is coupled to a rack bar;

a rack driver coupled to the rack bar and configured to control movement of the rack bar;

a torsion restoring member coupled between an inner surface of the insertion portion of the output shaft coupled and the one end of the output shaft, coupled to the insertion portion of the input shaft, and configured to be elastically deformable in response to rotation of the input shaft;

a torque sensor configured to sense torque of the input shaft; and

an electronic controller configured to output a control signal to the rack driver according to the torque of the input shaft.

20. The vehicle of claim **19**, wherein the rack driver comprises:

a motor configured to be driven in response to the control signal of the electronic controller;

a motor pulley coupled to the motor;

a nut pulley coupled to a ball nut coupled to the rack bar; and

a belt connecting the motor pulley and the nut pulley.

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