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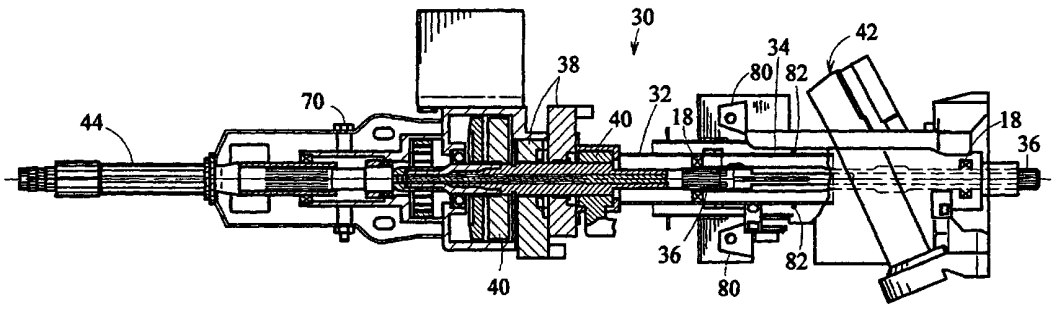

(57) Abstract: A steer-by-wire system for a motor vehicle that utilizes a mechanical back-up device that enables the motor vehicle to be steered mechanically in the event of a failure of the steer-by-wire function includes a steering column having an upper end and a lower end, a hand steering device disposed on the upper end of the steering column, a lower shaft disposed on the lower end of the steering column, the mechanical backup device configured to be in mechanical communication with the lower shaft, and a rack configured to steer at least one steerable wheel of the motor vehicle in mechanical communication with the backup device. The mechanical backup device includes a pinion lashedly engaged to the lower shaft to provide communication between the rack and the steering column. The mechanical communication of the pinion and the lower shaft may be through a pinion shaft. The lashed engagement of the pinion and the pinion shaft may be effectuated by the positioning of engaging sets of splines disposed on the pinion and the pinion shaft.

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STEER-BY-WIRE STEERING SYSTEM WITH MECHANICAL BACK-UP

TECHNICAL FIELD

This disclosure relates to steer-by-wire steering systems, and, more particularly, to a steer-by-wire system having a mechanical backup device.

BACKGROUND

In a typical "steer-by-wire" system of a motor vehicle, the angular displacement of a hand steering device is detected by sensors and converted into an electronic signal. This electronic signal is processed and applied to a servo motor that controls the angular positioning of the steerable wheels of the motor vehicle with respect to the direction of travel of the body of the motor vehicle. The prior art steer-by-wire systems all rely solely on the use of electronic signals. More modern steer-by-wire systems employ dual wiring systems in which one wiring system assumes control of the steering functions of a motor vehicle in the event the other wiring system fails.

SUMMARY

Disclosed herein is a steer-by-wire system for a motor vehicle that utilizes a mechanical back-up device that enables the motor vehicle to be steered by mechanical means in the event of a failure of the steer-by-wire function. The steer-by-wire system includes a steering column having an upper end and a lower end, a hand steering device disposed on the upper end of the steering column, a lower shaft depending from the lower end of the steering column, the mechanical backup device in mechanical communication with the steering column through the lower shaft, and a rack configured to steer at least one steerable wheel of the motor vehicle in mechanical communication with the mechanical backup device. The mechanical

backup device includes a pinion lashedly engaged to the lower shaft to provide mechanical communication between the steering column and the rack. The mechanical communication of the pinion and the lower shaft may be through a pinion shaft. The lashed engagement of the pinion and the pinion shaft may be effectuated by the positioning of engaging sets of splines disposed on the pinion and the pinion shaft.

The steer-by-wire system may also be configured to allow the hand steering device to be adjusted in a vertical direction relative to an operator of the motor vehicle. Furthermore, the steering column may be telescopically adjustable, or it may have an energy absorbing function incorporated therein to absorb the energy of an impact of the operator of the motor vehicle.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a partial cutaway plan view of a steering column of steer-by-wire system having a mechanical back-up device, and tilt-wheel, telescopic, and energy-absorbing functions.

Figure 2 is a cutaway side elevation view of a rack and pinion assembly incorporated into a steer-by-wire system.

Figure 3 is a sectional view along line 4-4 of Figure 2 illustrating the intermeshing of splines within the rack and pinion assembly.

Figure 4 is a side elevation view of a steering column of a steer-by-wire system having a mechanical backup function and tilt-wheel, telescopic, and energy-absorbing functions.

DETAILED DESCRIPTION

Referring to Figure 1, a steering wheel actuator for a steer-by-wire system of a motor vehicle is shown generally at 30. Steering wheel actuator 30 comprises a tube portion 32, a sleeve 34 that coaxially and slideably engages tube portion 32, an upper shaft 36 coaxially inserted through sleeve 34 and rotatably positioned between bearings 18, and position sensors 38 and torque sensors 40 operably connected to upper shaft 36. Upper shaft 36 is operably connected to a hand steering device (not shown), which may be a hand steering wheel. An ignition switch

housing 42 is operably connected to steering wheel actuator 30. The angular displacement of the hand steering device is detected by sensors 38, 40, processed, and applied to a servo motor (not shown) to move steerable wheels of the motor vehicle. A lower shaft 44 is axially disposed on an end of upper shaft 36 to provide a mechanical link between upper shaft 36 and a steer-by-wire mechanical backup device (shown below with reference to Figure 2).

In Figure 2, the backup device is shown generally at 50. In the event of a failure of the electrical system controlling the steer-by-wire function, rotation of the hand steering device will continue to move the steerable wheels of the motor vehicle. The hand steering device causes the axial rotation of the upper shaft and the lower shaft. The lower shaft may be connected on its lower end to an intermediate shaft 52, which may be rotatably connected to a pinion shaft 54 in such a manner so as to permit play in the steering column and thereby accommodate the movement of the suspension system of the motor vehicle.

The steering column, a lower end of which is connected to pinion shaft 54, is rotatably disposed in a housing 56. Bearings 58, such as needle bearings, are positioned to enable pinion shaft 54 to freely spin within housing 56. Pinion shaft 54 is in mechanical communication with a pinion 60, which is likewise positioned within a housing 96 and is rotatable therewithin. Pinion 60 typically includes a threaded portion 62 that engages a rack 64 in a rack and pinion relationship. Ball bearings 66 are positioned intermediate the ends of pinion 60 to enable pinion 60 to freely rotate within housing 96. Pinion shaft 54 is not tightly connected to pinion 60 but is, however, in lashed engagement with pinion 60, thereby allowing pinion shaft 54 to rotate freely through a limited range of motion relative to pinion 60 in the event of a mechanical failure of the steer-by-wire function. After the rotation of pinion shaft 54, pinion 60 is driven by pinion shaft 54 and drives rack 64, which is positioned in a coaxial relationship with a steering rod (not shown) controllable by the steer-by-wire function, and which is fixedly connected to rack 64 to form a rack/pinion assembly 57. The ends of rack 64 and the steering rod are ultimately connected to each wheel of a pair of steerable wheels. Lateral movement of rack/pinion assembly 57 effectuates the movement of the steerable wheels in and out of the plane of travel of the motor vehicle in order to steer the motor vehicle.

Referring now to Figure 3, a first set of splines 68 engages a second set of splines 69 to allow the free axial rotation of pinion shaft 54 within housing 56 over the above-mentioned limited range in the event of a failure of the steer-by-wire function. First set of splines 68 is disposed longitudinally along the outer surface of pinion shaft 54, and a second set of splines 69 is disposed longitudinally along the inner surface of a recess formed in pinion 60. When pinion shaft 54 is inserted into the recess in pinion 60, first set of splines 68 and second set of splines 69 intermesh to permit the free rotation of pinion shaft 54 through about a fifteen degree angle, thereby resulting in lash in the system. The splines may be dimensioned so as to allow for the lash to be less than about fifteen degrees. For example, the free rotation of pinion shaft 54 may be about ten or five degrees. The actual amount of lash will generally depend on the steer-by-wire system and may be selected to ensure that the pinion shaft 54 will not engage the pinion so long as the steer-by-wire function is operational.

Referring back to Figure 1 an optional tilt function for a steer-by-wire system is shown in which the hand steering device may be adjusted in a vertical direction relative to an operator of the motor vehicle. Such a tilt function comprises a bolt 70 extending laterally through the steering column. Bolt 70 allows for the pivotal motion of an upper part of the steering column thereabout, while lower shaft 44 remains in operable communication with the steerable wheels of the vehicle.

Referring now to Figure 4, there is also shown an optional telescopic steering column. In a steer-by-wire system utilizing steering wheel actuator 30, the telescopic feature is embodied by steering wheel actuator 30 being slideably engaged by a bracket 99, bolt 70, and a tensioning mechanism 74. Tensioning mechanism 74 is manually articulated in one direction about a pivot point 76 to loosen upper sleeve 34, thereby allowing upper sleeve 34 to transverse the length of a slot 78 in sleeve 34 in order to be adjusted to the preferences of a driver. Manual articulation of tensioning mechanism 74 in the opposite direction as the previous articulation allows upper sleeve 34 to be secured in the position preferred by the driver.

Referring again to Figure 1 an optional energy-absorbing feature for a steering column is also shown. In a steer-by-wire system utilizing the steering wheel actuator 30, sleeve 34, which coaxially receives upper shaft 36, is longitudinally

pressed on tube portion 32 in the event of an impact on the hand steering device that is oriented along the longitudinal axis of the steering column. At least one capsule 80 is positioned at a lower end of sleeve 34 to prevent the casual use of the energy-absorbing feature. In the event of a substantial impact on the steering wheel, capsules 80 disengage to allow sleeve 34 to be pressed onto tube portion 32. A plurality of tolerance ring springs 82 positioned between sleeve 34 and tube portion 32 provide frictional resistance as sleeve 34 moves over tube portion 32, thereby cushioning the body of the operator as it impacts the hand steering device.

While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustration only, and such illustrations and embodiments as have been disclosed herein are not to be construed as limiting to the claims.

CLAIMS

What is claimed is:

1. A steer-by-wire system for a motor vehicle, comprising:

a steering column having an upper end and a lower end, said upper end having disposed thereon a hand steering device and said lower end having a lower shaft depending therefrom;

a mechanical backup device in mechanical communication with said lower shaft, said mechanical backup device comprising a pinion in mechanical communication with and lashedly engaged to said lower shaft of said steering column; and

a rack in mechanical communication with said pinion of said mechanical backup device, said rack being configured to steer at least one steerable wheel of said motor vehicle.

2. The steer-by-wire system for a motor vehicle as in claim 1 wherein said lashed engagement of said pinion to said lower shaft is about 15 degrees.

3. The steer-by-wire system for a motor vehicle as in claim 2 wherein said lashed engagement of said pinion to said lower shaft is about 10 degrees.

4. The steer-by-wire system for a motor vehicle as in claim 3 wherein said lashed engagement of said pinion to said lower shaft is about 5 degrees.

5. The steer-by-wire system for a motor vehicle as in claim 1 wherein said mechanical backup device further comprises a pinion shaft, said pinion shaft providing mechanical communication between said pinion and said lower shaft.

6. The steer-by-wire system for a motor vehicle as in claim 5 wherein said pinion shaft is in lashed engagement with said pinion.

7. The steer-by-wire system for a motor vehicle as in claim 6 wherein said pinion shaft comprises a first set of splines disposed longitudinally thereon.

8. The steer-by-wire system for a motor vehicle as in claim 7 wherein said pinion has disposed therein a second set of splines configured and positioned to longitudinally engage said first set of splines disposed on said pinion shaft.

9. The steer-by-wire system for a motor vehicle as in claim 8 wherein said longitudinal engagement of said first set of splines and said second set of splines defines a lash therebetween.

10. The steer-by-wire system for a motor vehicle as in claim 9 wherein said lash is about 15 degrees.

11. The steer-by-wire system for a motor vehicle as in claim 10 wherein said lash is about 10 degrees.

12. The steer-by-wire system for a motor vehicle as in claim 11 wherein said lash is about 5 degrees.

13. The steer-by-wire system for a motor vehicle as in claim 5 further comprising an intermediate shaft connecting said lower shaft to said pinion shaft.

14. The steer-by-wire system for a motor vehicle as in claim 13 wherein said intermediate shaft is in lashed mechanical communication with said pinion shaft so as to accommodate movement of a suspension system of said motor vehicle.

15. The steer-by-wire system for a motor vehicle as in claim 1 further comprising:

at least one sensor configured to sense an angular position of said steering column and to sense torque applied to said steering column and to generate signals indicative of said angular position and said torque; and

one or more actuators adapted to steer said at least one of said steerable wheels in response to said position signals and said torque signals.

16. The steer-by-wire system for a motor vehicle as in claim 1 wherein said steering column is configured to allow said hand steering device to be adjusted in a vertical direction relative to an operator of said motor vehicle.

17. The steer-by-wire system for a motor vehicle as in claim 1 wherein said steering column is configured to allow said hand steering device to be telescopically adjusted.

18. The steer-by-wire system for a motor vehicle as in claim 1 wherein said steering column is configured to absorb the energy of an impact of an operator of said motor vehicle against said hand steering device.

19. A steering system for a motor vehicle, comprising:

a steering column in lashed engagement with a pinion;

a mechanical device for steering at least one steerable wheel of said motor vehicle in response to a movement of said pinion; and

a steer-by-wire device for steering said at least one steerable wheel of said motor vehicle in response to a movement of said steering column.

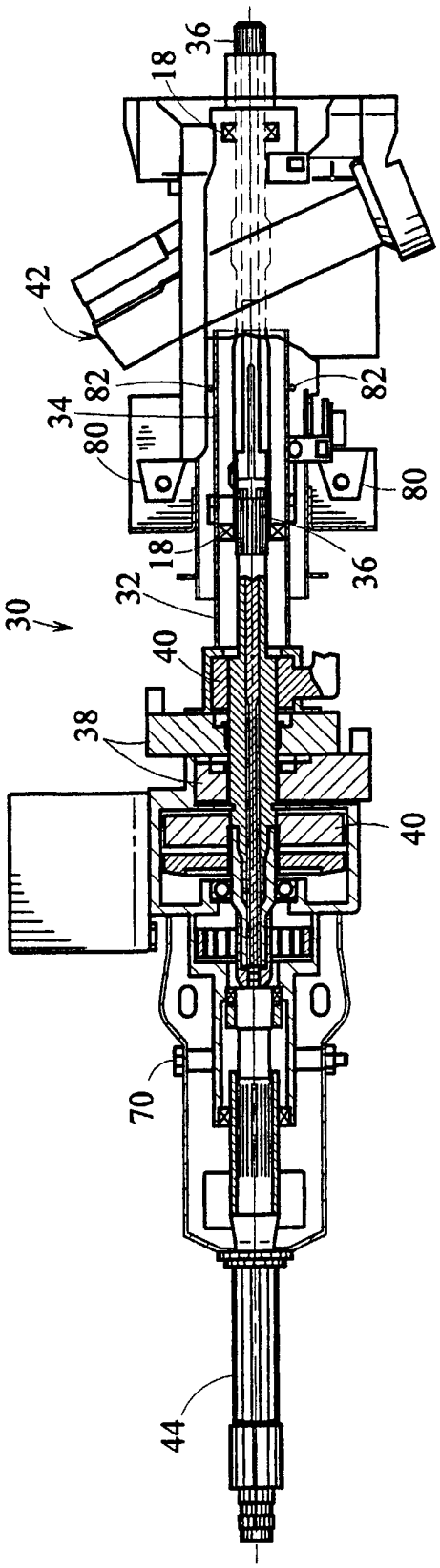


FIG. 1

FIG. 2

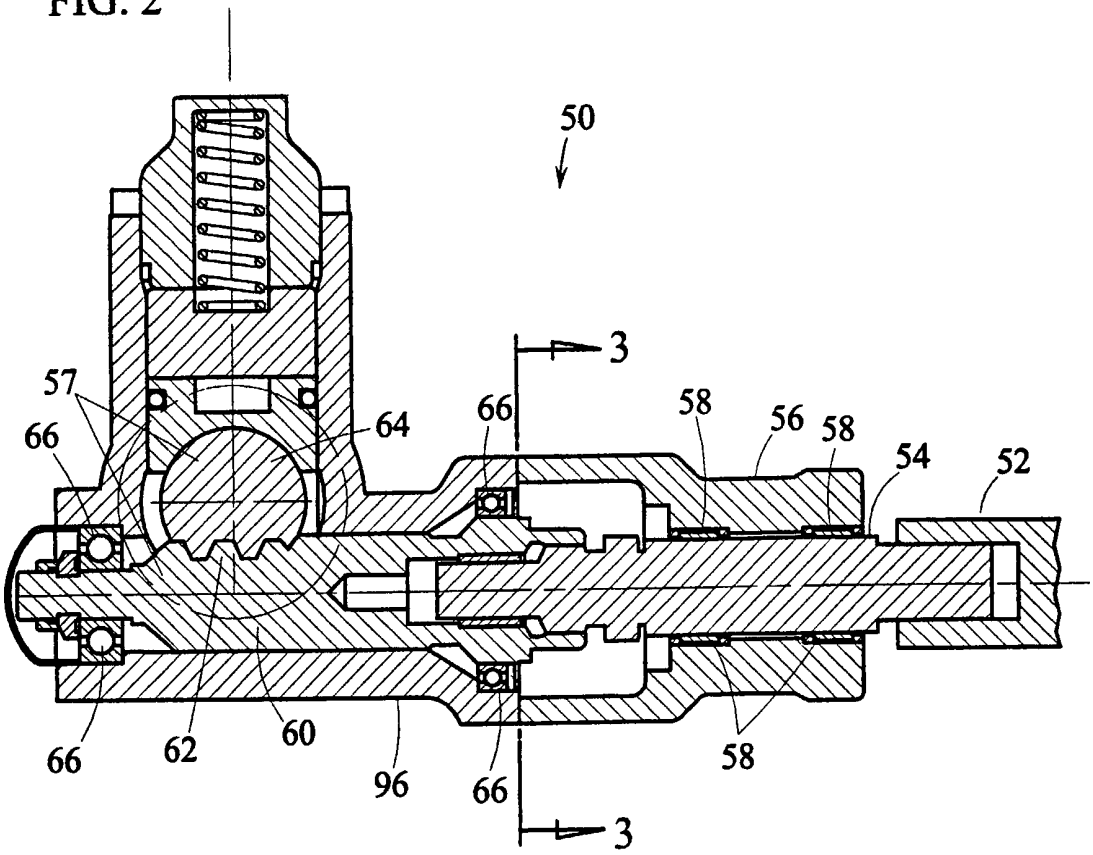
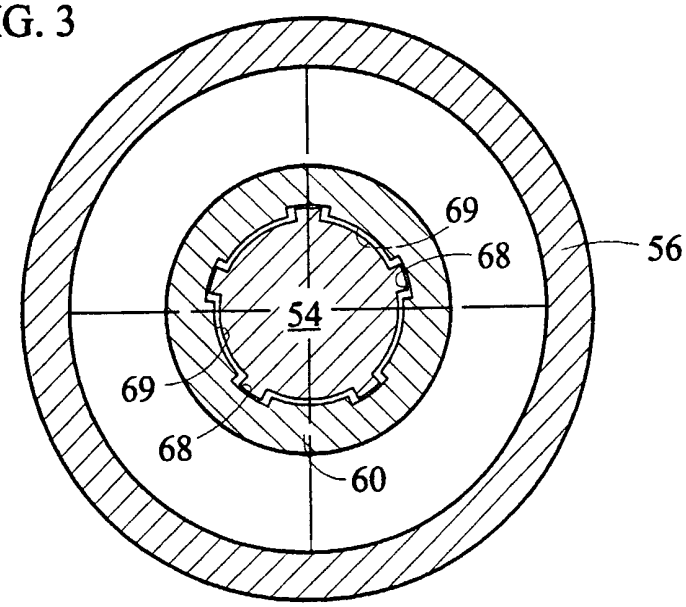


FIG. 3



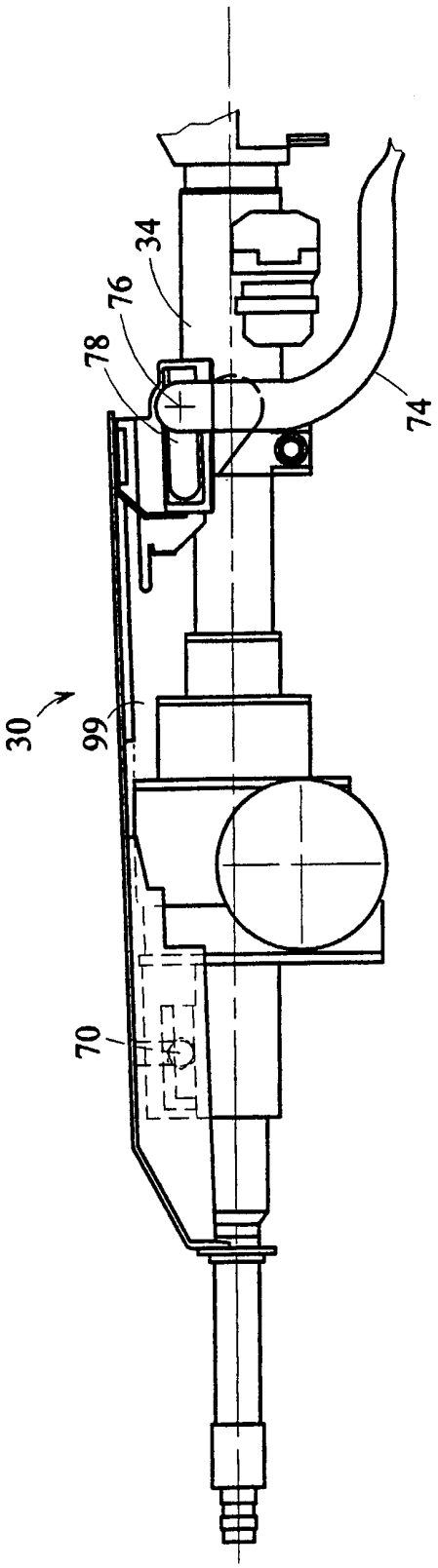


FIG. 4