AU9228591

(12) PATENT ABRIDGMENT (11) Document No. AU-B-28591/92
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 643631

(54) Title
POWER STEERING-GEAR PERMITTING SEPARATE MECHANICAL AND HYDRAULIC BALANCING

International Patent Classification(s)
(51)[5] **B62D 005/083**

(21) Application No. : **28591/92** (22) Application Date : **25.11.92**

(30) Priority Data

(31) Number	(32) Date	(33) Country
801200	**02.12.91**	**US UNITED STATES OF AMERICA**

(43) Publication Date : **03.06.93**

(44) Publication Date of Accepted Application : **18.11.93**

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(56) Prior Art Documents
US 5046574
US 4966192
US 4768604

(57) Claim

1. A detent mechanism in a hydraulically-assisted power steering-gear for an automotive vehicle, the power steering-gear being of the type having an input member with a first end and a second end, rotatable about a steering-gear axis and connected to a steering wheel; an output member rotatable about the steering-gear axis, connected to a pair of steerable road wheels, and proximate to the second end of the input member; a rotary valve including a valve sleeve rotatable as a unit with the output member and a valve spool portion rotatable as a unit with the input member, said valve having a hydraulically-balanced position between the valve sleeve and the valve spool portion; and a torsion rod aligned on the steering-gear axis with a first end of the torsion rod disposed within the first end of the input member and a second end of the torsion rod attached to the output member, the detent mechanism comprising: a tubular stub shaft having a first end and a second end, which stub shaft is aligned with the steering-gear axis, has a detent recess on the second end, has the first end thereof radially interposed

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between the first end of the input member and the first end of the torsion rod, and has the second end thereof extending beyond the second end of the input member; a detent-engaging element rotating with the output member, and accommodated in the output member by a socket alignable with the detent recess; a spring urging the detent-engagement element into the detent recess, thereby rotatively aligning the tubular stub shaft with the output member to a mechanically-balanced position therebetween; and a pin passing through, and thereby rotatively linking together, the input member, the first end of the tubular stub shaft, and the first end of the torsion rod so that the tubular stub shaft is rotatively aligned with the output member in the mechanically-balanced position, simultaneous with the rotary valve being in the hydraulically-balanced position, simultaneous with the torsion rod being in a neutral position.

AUSTRALIA

Patents Act

643631

COMPLETE SPECIFICATION
(ORIGINAL)

Class Int. Class

Application Number:
Lodged:

Complete Specification Lodged:
Accepted:
Published:

Priority

Related Art:

Name of Applicant:

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Invention Title:

POWER STEERING-GEAR PERMITTING SEPARATE MECHANICAL AND HYDRAULIC BALANCING

Our Ref : 311643
POF Code: 1221/1695

The following statement is a full description of this invention, including the best method of performing it known to applicant(s):

6006

POWER STEERING-GEAR PERMITTING SEPARATE MECHANICAL AND HYDRAULIC BALANCING

This invention relates to hydraulically-assisted power steering-gears with detent mechanisms.

A hydraulically-assisted power steering-gear with a detent mechanism typically has a steering-gear input member and a steering-gear output member. As vehicle speed increases, the detent mechanism tends to mechanically engage the output member to the input member with increasing force, mechanically positioning the output member with the input member to a mechanically-balanced position. The relative orientation between the input member and the output member in the mechanically-balanced position is typically determined by plungers or spheroids, rotating with the output member, being pressed into detent recesses in the input member.

In such a steering-gear, a rotary hydraulic valve has a spool portion integral with the input member and a sleeve rotatively fixed to the output member. The hydraulic valve is trying to position the output member relative to the input member simultaneous with the detent mechanism trying to position the output member relative to the input member. If the valve spool portion is not in a hydraulic "on-centre" position, that is, not in a hydraulically-balanced position, with respect to the valve sleeve, the valve supplies fluid to a bi-directional actuator which causes the output member, and hence the valve sleeve, to rotate back towards the hydraulically-balanced position.

Because both the valve spool portion and the recesses in the input member are integral with the input member, the hydraulically-balanced position cannot be

selectively aligned with the mechanically-balanced position by rotating the valve spool portion relative to the recesses.

This invention permits rotative re-positioning of the hydraulically-balanced position of the valve to the mechanically-balanced position by rotatively separating the detent recesses of the input member from the valve portion of the input member. Detent recesses, normally on the input member, are placed on an end of a tubular stub shaft. The tubular stub shaft is largely disposed within the input member except for the end with the detent recesses which extends beyond the input member. The valve spool portion remains integral with the input member.

The output member and tubular stub shaft are first oriented to the mechanically-balanced position. The input member is then rotated to the hydraulically-balanced position. The tubular stub shaft and the input member are then rotatively fixed to one another.

~~It is an object of this invention to provide a~~ power steering-gear having a tubular stub shaft with detent recesses, having an input member with a valve spool portion, having a hydraulically-balanced position controlled by the rotative position of the input member relative to an output member, and having a mechanically-balanced position controlled by the rotative position of the tubular stub shaft relative to the output member, the input member being selectively fixed to the tubular stub shaft to align the hydraulically-balanced position ~~with the mechanically-balanced position.~~

According to an aspect of this invention there is provided a detent mechanism in a hydraulically-assisted power steering-gear for an automotive vehicle, the power steering-gear being of the type having an input member with a first end and a second end, rotatable about a steering-gear axis and connected to a steering wheel; an output member rotatable about the steering-gear axis, connected to a pair of steerable road wheels, and proximate to the second end of the input member; a rotary valve including a valve sleeve rotatable as a unit with the output member and a valve spool portion rotatable as a unit with the input member, said valve having a hydraulically-balanced position between the valve sleeve and the valve spool portion; and a torsion rod aligned on the steering-gear axis with a first end of the torsion rod disposed within the first end of the input member and a second end of the torsion rod attached to the output member, the detent mechanism comprising: a tubular stub shaft having a first end and a second end, which stub shaft is aligned with the steering-gear axis, has a detent recess on the second end, has the first end thereof radially interposed between the first end of the input member and the first end of the torsion rod, and has the second end thereof extending beyond the second end of the input member; a detent-engaging element rotating with the output member, and accommodated in the output member by a socket alignable with the detent recess; a spring urging the detent-engagement element into the detent recess, thereby rotatively aligning the tubular stub shaft with the output member to a mechanically-balanced position therebetween; and a pin passing through, and thereby rotatively linking together, the input member, the first end of the tubular stub shaft, and the first end of the torsion rod so that the tubular stub shaft is rotatively aligned with the output member in the mechanically-balanced position, simultaneous with the rotary valve being in the hydraulically-balanced position, simultaneous with the torsion rod being in a neutral position.

It is an object of this invention to provide an improved detent mechanism in an hydraulically-assisted power steering-gear.

This and other objects and advantages will be more apparent from the following description and the accompanying drawings, in which:.

Figure 1 shows a side sectional view of a steering-gear according to the present invention;

Figure 2 shows an enlarged view of a portion of Figure 1 where a tubular stub shaft and an input member of the steering-gear are axially linked by a retaining ring; and

Figure 3 shows a partially-exploded isometric view of the input member, the tubular stub shaft and a torsion rod.

A hydraulically-assisted power-steering rack and pinion steering-gear 10 has a main housing 12 with a cylindrical rotary valve portion 14 and an integral rack support portion 16. The steering-gear 10 provides a link between a steering wheel 18 and a pair of steerable road wheels (not shown). The steering wheel 18 is rotatively connected to a first end 20 of an input member 22. An output member 24 is connected to the pair of steerable road wheels through a steering-gear rack 26 disposed within the integral rack support portion 16 of the main housing 12. The input member 22 and the output member 24 are both disposed within the cylindrical rotary valve portion 14 of the housing and are rotatable about a steering-gear axis 28 coincident with a centre 30 of the cylindrical rotary valve portion 14 of the main housing 12. A rotary valve 32 is disposed between the output member 24 and the input member 22. A suitable rotary valve is described in U.S. Patent No.3,022,772, issued to Zeigler et al. on Feb. 27, 1962.

A detent mechanism 34 is interposed between the output member 24 and a tubular stub shaft 36. The tubular stub shaft 36, rotatable about the steering gear

axis 28, is disposed within the input member 22. The input member 22 has a first end 20 and a second end 40, and the tubular stub shaft 36 has a first end 38 and a second end 42. The first end 38 of the tubular stub shaft 36 is within the first end 20 of the input member 22. The second end 42 of the tubular stub shaft 36 extends beyond the second end 40 of the input member 22.

Detailed descriptions of similar steering gears having detent mechanisms interposed directly between the output member and the input member are found in U.S. Patent No. 4,768,604 to Schipper on Sept. 6, 1988, and U.S. Patent No. 4,759,420 to Schipper, Jr. et al. on July 26, 1988.

A retaining ring 44 is disposed between the tubular stub shaft 36 and the input member 22. The ring 44 is formed of wire 46 with a constant diameter 47. A centre 48 of the wire 46 forms a diameter D equal to an outside diameter 50 of the tubular stub shaft 36 as best seen in Figure 2. The ring 44 is split to allow radial expansion and contraction thereof. The tubular stub shaft 36 accommodates the ring 44 within a retaining ring groove 52 circumscribed about the outside diameter 50 of the tubular stub shaft with a minimum depth equal to the wire diameter 47. The input member 22 accommodates the ring 44 within a retaining ring groove 54 circumscribed about an inside diameter 56 of the input member 22, with a depth of about one half the wire diameter 47.

A torsion rod 58 with a first end 60 and a second end 62 is disposed within the tubular stub shaft 36 such that the first end 60 of the torsion rod 58 is axially aligned with the first end 20 of the input member 22 and the first end 38 of the tubular stub shaft 36. The first end 60 and the second end 62 of the

torsion rod 58 are larger in diameter than a centre portion 64 of the torsion rod 58.

The second end 62 of the torsion rod 58 extends beyond the second end 42 of the tubular stub shaft 36 and into the output member 24. The second end 62 of the torsion rod 58 is rotatively fixed to the output member 24. The torsion rod 58 rotatively supports the second end 42 of the tubular stub shaft 36.

The second end 42 of the tubular stub shaft 36 has detent recesses 66 between radial splines 68, as best seen in Figure 3. The second end 42 of the tubular stub shaft 36 has a ~~block~~ tooth 70 extending beyond the detent recesses 66 towards the first end 38 of the tubular stub shaft 36, also best seen in Figure 3. The input member 22 has a ~~block tooth~~ tooth-shaped groove 72 accommodating the ~~block~~ tooth 70. With the block tooth 70 inserted in the ~~block tooth~~ tooth-shaped groove 72, the relative rotation between the input member 22 and the second end 42 of the stub shaft 36 is limited to 7°.

A valve spool portion 74 of the input member 22, proximate to the second end 40 of the input member 22, co-operates with an encircling valve sleeve 76 to function as the rotary valve 32. The valve sleeve 76 is rotatively fixed to the output member 24. The valve sleeve 76 and the output member 24 axially overlap to accommodate a drive pin 77 passing between the valve sleeve 76 and the output member 24. The cylindrical rotary valve portion 14 of the housing 12 serves as a valve housing to the rotary valve 32, aiding in the routing of fluid between the valve 32 and a steering actuator, or steering piston within a cylinder (not shown).

The valve sleeve 76 and the valve spool portion 74 have a hydraulically-balanced position

relative to each other where fluid is ported equally to both sides of the steering piston. The torsion rod 58, when fixed at its first end 60 to the first end 20 of the input member 22, maintains the valve spool portion 74 and valve sleeve 76 in the hydraulically-balanced position in an absence of steering wheel torque. An application of torque to the steering wheel 18 by the vehicle operator tends to torsionally deflect the centre portion 64 of the torsion rod 58, producing relative rotative displacement between the valve sleeve 76 and the valve spool portion 74. A torsional stiffness of the centre portion 64 controls a steering effort required by a vehicle operator to steer the road wheels.

Displacement away from the hydraulically-balanced position results in fluid being ported principally to a selected side of the steering piston. Porting pressurized fluid to one side of the steering piston results in the steering piston being movably displaced. The steering piston in turn axially displaces the rack 26, thereby rotating the output member 24 and the valve sleeve 76 until the hydraulically-balanced position is again achieved. Determination of the orientation of the input member 22 relative to the output 24 member corresponding to the hydraulically-balanced position is usually done on a flow bench by varying the orientation of the input member 22 relative to the output member 24 until flow to both sides of the piston is equalized.

The output member 24 has a pinion portion 78 with teeth 80 engaging the rack 26. The output member 24 has a flange 82 proximate to the pinion portion 78. The flange 82 is circumferentially sealed with the cylindrical rotary valve portion 14 of the housing 12. Opposite the flange 82 from the pinion portion 80 is a

detent portion 88 of the output member. The detent portion 88 of the output member 24 is proximate to the second end 40 of the input member 22.

The output member 24 has a cavity 92 in the detent portion 88, centred about the steering-gear axis of rotation 28. The cavity 92 is sufficiently large to accommodate the insertion of the second end 42 of the tubular stub shaft 36. A blind hole 94 at a bottom 96 of the cavity 92 accommodates insertion of the second end 62 of the torsion rod 58 into the output member 24. The cavity 92 has radial splines 97 complementary to the splines 68 of the stub shaft 36 which limit relative rotation between the output member 24 and the stub shaft 36 to 3°.

The detent portion 88 of the output member 24 has sockets 98 corresponding in number and location to the detent recesses 66 in the tubular stub shaft 36. The sockets 98 lie in a plane perpendicular to the steering-gear axis of rotation 28 and are oriented radially about the steering-gear axis of rotation 28. Spheroids 100, i.e., detent-engaging elements, are disposed in the sockets 98, and protrude beyond the sockets 98 even when the spheroids 100 are pressed into the detent recesses 66. When the sockets 98 are aligned with the recesses 66 in the tubular stub shaft 36, the spheroids 100 simultaneously protrude uniformly beyond the detent portion 88 of the output member 24.

An annular piston 102 has a piloting portion 104 joined to a dish portion 106. The piloting portion 104 slides on the detent portion 88 of the output member 24. The piloting portion 104 of the annular piston 102 is slidably disposed between the sockets 98 and the output member flange 82. The piloting portion 104 is sealed against the output member 24. The dish portion

106 is sealed against the cylindrical rotary valve portion 14 of the housing 12. The dish portion 106 of the annular piston 102 has a chamfered side 112 facing the sockets 98. The chamfered side 112 contacts the spheroids 100.

A spring 114 between the output member flange 82 and the annular piston 102 provides a spring force pressing the chamfered side 112 of the annular piston 102 against the spheroids 100, in turn pressing the spheroids 100 into the detent recesses 66. Force from the spring 114 against the annular piston 102 seats the spheroids 100 in the detent recesses 66, thereby rotating the tubular stub shaft 36 to a mechanically-balanced position relative to the output member 24. A detent-apply chamber 116 between the output member flange 82 and the annular piston 102 is supplied with fluid at a pressure which increases with vehicle speed. The pressure increases the force against the annular piston 102, increasing the force against the spheroids 100. A means for supplying fluid at a pressure which increases with vehicle speed is provided by an auxiliary pump 115 to the chamber 116 through a detent-pressure port 117, as described in United States Patent No. 4,768,604 and United States Patent No.4,759,420.

Alignment of the mechanically-balanced position with the hydraulically-balanced position is achieved in the following manner. The steering gear 10 is completely assembled except for fixing the first ends 20, 38, 60 of the input member 22, the stub shaft 36, and the torsion rod 58 together. The output member 24 is held in place during the alignment procedure. The spring 114 acting against the annular piston 102 forces the detent mechanism 34, and consequently the stub shaft

36 and the output member 24, into the mechanically-balanced position.

After mounting the steering gear 10 on a flow bench, with the stub shaft 36 and the output member 24 remaining in the mechanically-balanced position, the input member 22 is rotated relative to the output member 24 until the hydraulically-balanced position is reached. The torsion rod 58, rotatively fixed at its second end 62 to the output member 24, remains in a neutral position, uncoupled at its first end 60. The torsion rod 58 has no residual torsion within it in the neutral position. With the stub shaft 36 and the input member 22 and the torsion rod 58 being simultaneously so aligned, their first ends, 20, 38, 60 are cross-drilled accommodating a locking pin 118 rotatively fixing the first ends 20, 38, 60 of the three members 22, 36, 58 to each other. This done, torque induced in the torsion rod 58 by rotatively displacing the first ends 20, 38, 60 relative to the output member 24 restores the steering gear 10 to both the hydraulically-balanced and the mechanically-balanced positions simultaneously when the steering wheel 18 is released.

Obviously, many modifications and variations of the present invention are possible in light of the above disclosure. It is therefore to be understood, that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described.

The claims defining the invention are as follows:

1. A detent mechanism in a hydraulically-assisted power steering-gear for an automotive vehicle, the power steering-gear being of the type having an input member with a first end and a second end, rotatable about a steering-gear axis and connected to a steering wheel; an output member rotatable about the steering-gear axis, connected to a pair of steerable road wheels, and proximate to the second end of the input member; a rotary valve including a valve sleeve rotatable as a unit with the output member and a valve spool portion rotatable as a unit with the input member, said valve having a hydraulically-balanced position between the valve sleeve and the valve spool portion; and a torsion rod aligned on the steering-gear axis with a first end of the torsion rod disposed within the first end of the input member and a second end of the torsion rod attached to the output member, the detent mechanism comprising: a tubular stub shaft having a first end and a second end, which stub shaft is aligned with the steering-gear axis, has a detent recess on the second end, has the first end thereof radially interposed between the first end of the input member and the first end of the torsion rod, and has the second end thereof extending beyond the second end of the input member; a detent-engaging element rotating with the output member, and accommodated in the output member by a socket alignable with the detent recess; a spring urging the detent-engagement element into the detent recess, thereby rotatively aligning the tubular stub shaft with the output member to a mechanically-balanced position therebetween; and a pin passing through, and thereby rotatively linking together, the input member, the first

end of the tubular stub shaft, and the first end of the torsion rod so that the tubular stub shaft is rotatively aligned with the output member in the mechanically-balanced position, simultaneous with the rotary valve being in the hydraulically-balanced position, simultaneous with the torsion rod being in a neutral position.

2. A detent mechanism within a steering-gear according to claim 1, in which the detent mechanism further comprises: a plurality of sockets in ~~the~~ a detent portion of the output member, a corresponding plurality of detent-engaging elements, and a corresponding plurality of detent recesses in the tubular stub shaft.

3. A detent mechanism within a steering-gear according to claim 2, in which there is a ~~block~~ tooth-shaped groove in the second end of the input member, proximate to the second end of the tubular stub shaft; and there is a ~~block~~ tooth on the tubular stub shaft axially engaging the ~~block tooth~~ tooth-shaped groove of the input member so as to limit relative rotation between the tubular stub shaft and the input member.

4. A detent mechanism within a steering-gear according to claim 2 or 3, in which the tubular stub shaft has a retaining ring groove circumscribing an outside diameter of the tubular stub shaft; the input member has a retaining ring groove circumscribing an inside diameter of the input member; and a retaining ring, having a split therein allowing elastic expansion and contraction of the ring in a radial direction, is simultaneously disposed in both the input member retaining ring groove and the tubular stub shaft retaining ring groove.

5. A detent mechanism within a steering-gear according to any one of claims 2 to 4, which includes

means for supplying fluid at a pressure which increases with vehicle speed, said fluid urging the respective detent-engaging elements into the respective detent recesses.

6. A detent mechanism within a steering-gear according to claim 5, in which the detent-engaging elements are spheroids located in the respective sockets in the output member, the sockets permitting movement of the spheroids into and out of the respective detent recesses.

7. A detent mechanism within a steering-gear according to claim 6, in which an annular piston encircling the output member is urged along the steering-gear axis against the spheroids by both the spring and the fluid increasing in pressure with vehicle speed, the annular piston in turn urging the spheroids into the respective detent recesses, thereby aligning the tubular stub shaft with the output member to the mechanically-balanced position.

8. A detent mechanism within a steering-gear according to claim 7, in which the detent recesses in the tubular stub shaft are formed between radial splines; the detent portion of the output member has a cavity centred about the steering-gear axis which is able to accommodate insertion therein of the second end of the torsional stub shaft, which cavity has a plurality of radially-directed sockets formed therein, and has radial splines complementary to the radial splines on the tubular stub shaft limiting relative rotation between the stub shaft and the output member; and the second end of the stub shaft is disposed within the cavity of the output member.

9. A detent mechanism within a steering-gear according to claim 8, in which the annular piston has a

chamfered side contacting the spheroids.

10. A detent mechanism within a steering-gear, substantially as hereinbefore particularly described with reference to Figures 1 to 3 of the accompanying drawings.

Dated: 24 November 1992

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POWER STEERING-GEAR PERMITTING SEPARATE MECHANICAL AND HYDRAULIC BALANCING

Abstract

A power steering-gear (10) with a hydraulic valve (32) and a detent mechanism (34) allows simultaneous hydraulic and mechanical balancing. The hydraulic valve (32) is rotatively separate from the detent mechanism (34) to allow separate balancing. The hydraulic valve (32) is integral with an input member (22). The detent mechanism (34) is integral with a tubular stub shaft (36) which is concentric with, but rotatively independent of, the input member (22). The tubular stub shaft (36) and the input member (22) are rotatively fixed to each other when both the hydraulic valve (32) and the detent mechanism (34) are balanced.

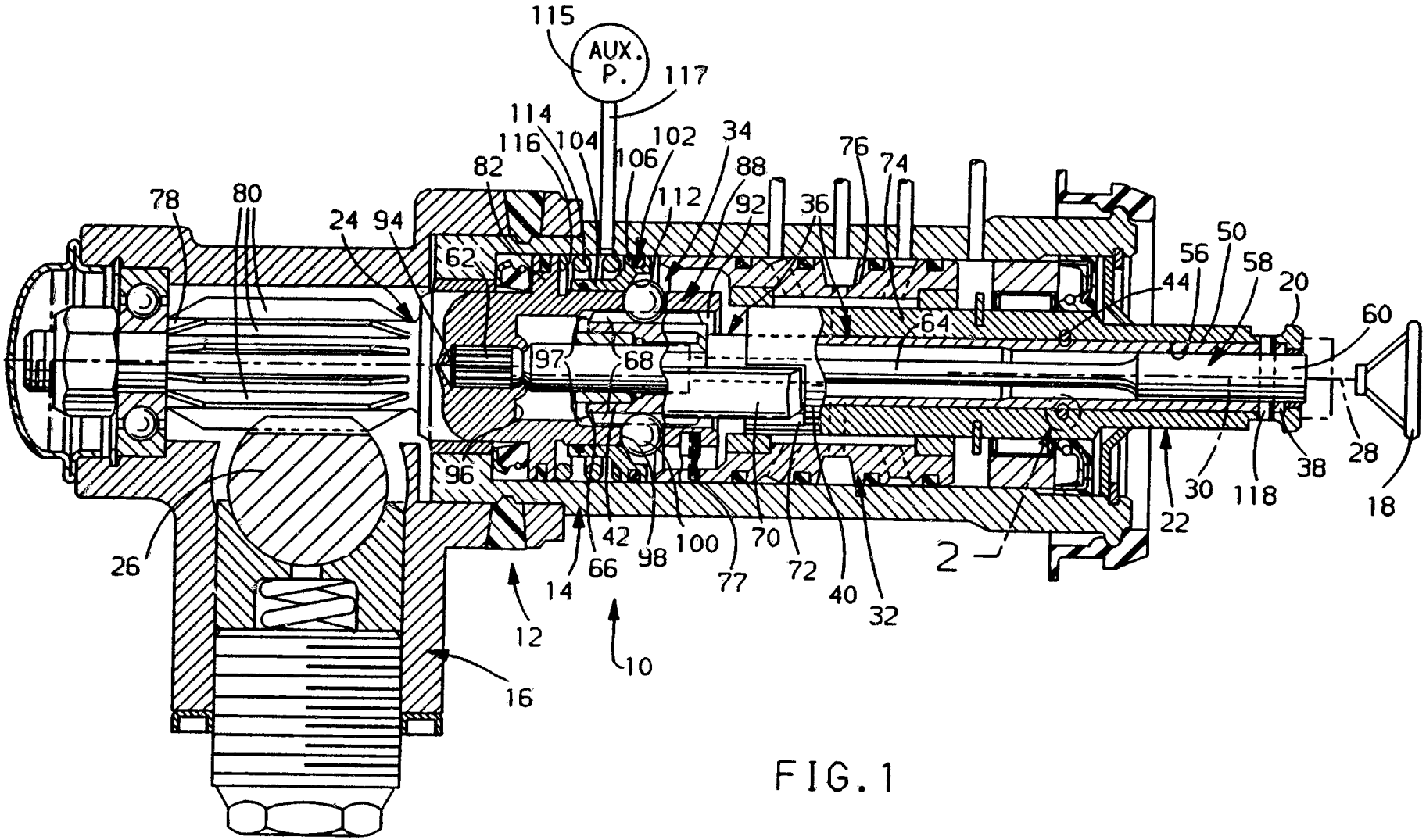

FIG. 1

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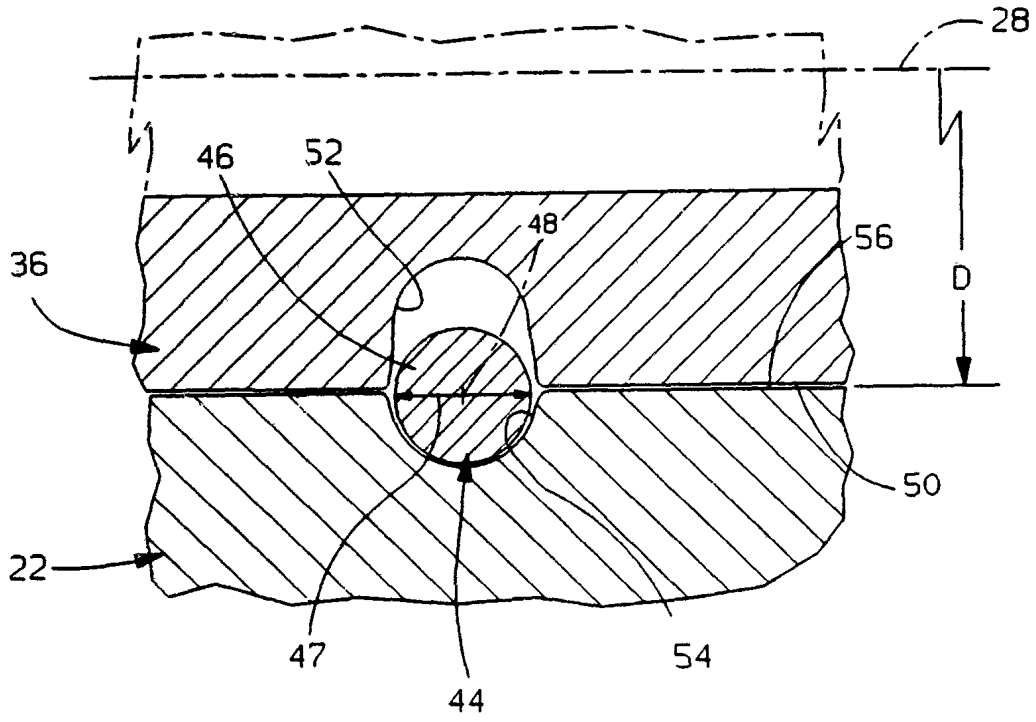

FIG.2

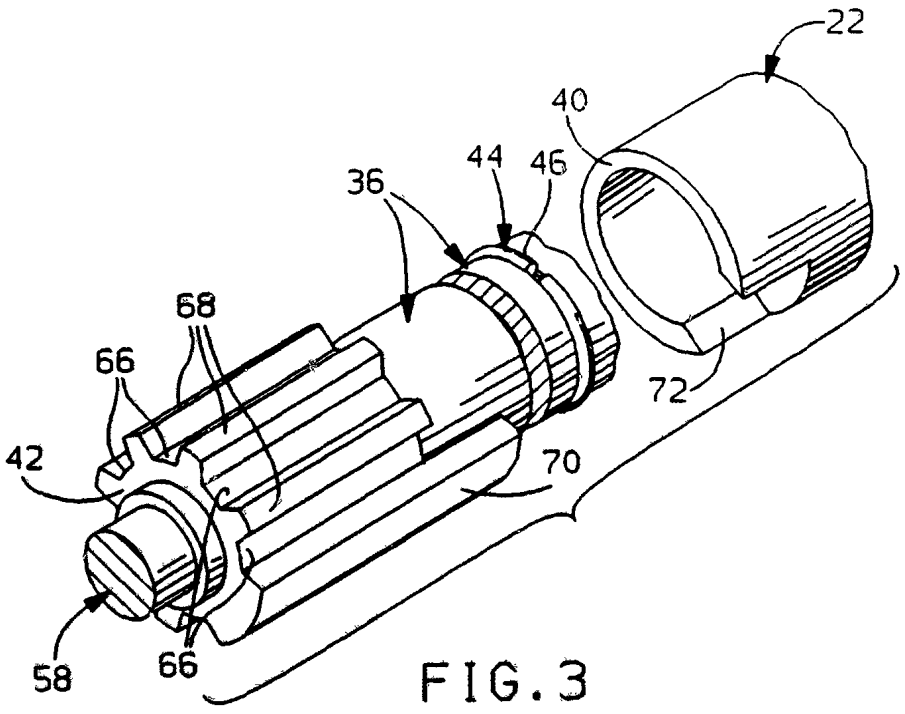

FIG.3