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ROTARY ACTUATOR

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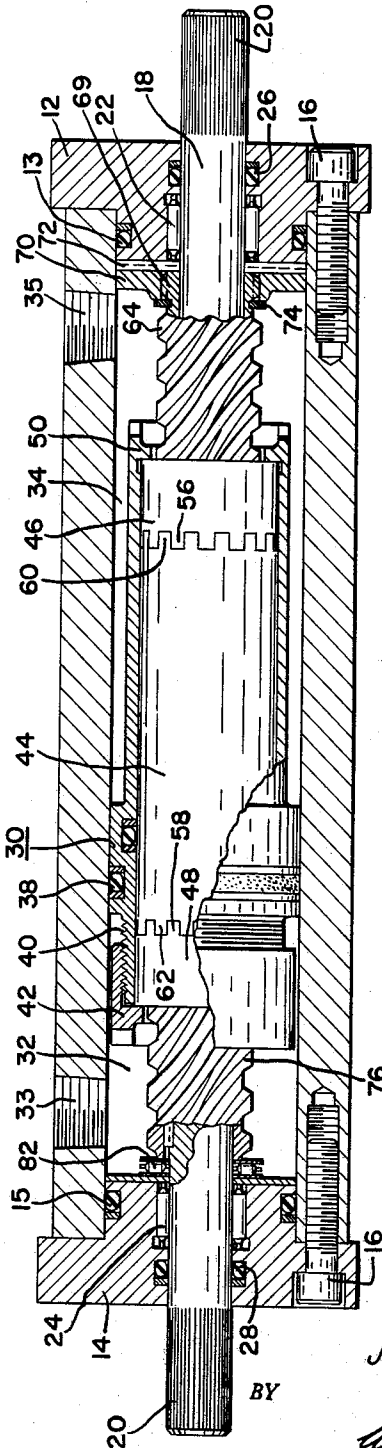
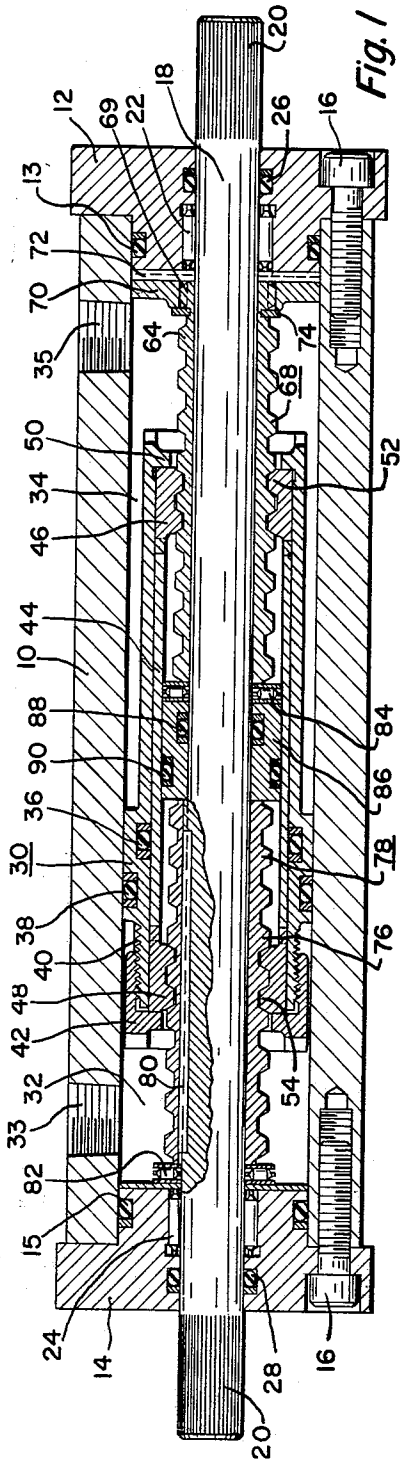


Fig. 2

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ROTARY ACTUATOR

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This invention relates to rotary actuators, and particularly to through shaft rotary actuators of the helical spline type.

Heretofore, it has been proposed to construct a through shaft rotary actuator utilizing a pair of externally helically splined sleeves and a piston having spaced internally helically splined interconnected sections mating respectively with the spaced externally helically splined sleeves. An actuator of this type is disclosed in copending application Serial No. 794,280, filed February 19, 1959, in the name of Howard M. Geyer and assigned to the assignee of this invention, now Patent No. 2,945,387. The present invention relates to an improved through shaft rotary actuator of the aforesaid type including a sleeve, or tube, separate from the piston for carrying the torsion load between the spaced internally helically splined elements of the actuator assembly. Accordingly, among my objects are the provision of an improved through shaft rotary actuator of the helically splined type; and the further provision of an actuator of the aforesaid type including means separate from the sleeve piston for supporting the torsion loads between the splined elements carried by the piston.

The aforementioned and other objects are accomplished in the present invention by embodying a sleeve-type piston in the actuator assembly which carries a pair of spaced internally helically splined annuli interconnected by a tubular member coaxial with the sleeve piston. Specifically, the actuator comprises a stationary cylinder having an output shaft journaled therein and extending from both ends thereof. A pair of externally helically splined sleeves, coaxial with the shaft, are disposed within the cylinder and spaced apart by an annular bulkhead. One of the externally helically splined sleeves is keyed to the cylinder so as to be restrained against rotation, and thus constituting a reaction sleeve. The other externally helically splined sleeve is keyed to the shaft and journaled for rotation relative to the cylinder and constitutes an output shaft.

A sleeve piston is supported for reciprocable movement within the cylinder and divides the cylinder into opposed chambers which can be subjected to pressure differentials in alternate directions so as to reciprocate the piston. The sleeve piston carries a pair of spaced internally splined annuli engageable respectively with the reaction and output sleeves. The spaced piston carried annuli are interconnected with a tube coaxial with the sleeve piston, which tube supports the torsion loads between the spaced splined annuli during reciprocation of the piston assembly.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

FIGURE 1 is a longitudinal sectional view of a through shaft rotary actuator constructed according to the present invention.

FIGURE 2 is a view, partly in section and partly in elevation, with certain parts broken away depicting the improved actuator construction.

With particular reference to FIGURE 1, an actuator is shown including a cylinder 10, opposite ends of which are closed by cap assemblies 12 and 14 secured thereto by

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bolts 16. O-ring seals 13 and 15 are disposed between the end caps 12 and 14, respectively and the cylinder 10. The cylinder assembly is adapted for connection to a suitable fixed support, not shown, so as to preclude movement thereof. A through shaft 18 having splined ends 20 is journaled in the end caps 12 and 14 by needle bearing assemblies 22 and 24, with suitable O-ring seals 26 and 28 being mounted outboard of the needle bearing assemblies. A reciprocable sleeve piston 30 is disposed within the cylinder 10, and divides the cylinder into opposed chambers 32 and 34. The cylinder 10 has ports 33 and 35 communicating with chambers 32 and 34, respectively.

The sleeve piston 30 is coaxial with the through shaft 18 and carries internal and external O-ring seals 36 and 38, respectively. In addition, one end of the sleeve piston 30 is externally threaded at 40 and receives a nut 42. A tubular member 44 and a pair of annuli are retained in assembled relation between the inwardly flanged end 50 of the piston 30 and the nut 42. The annulus 46 has internal helical spline teeth 52 and the annulus 48 has internal helical spline teeth 54. In addition, as seen particularly in FIGURE 2, the annulus 48 is formed with axially extending circumferentially spaced dog teeth 58 and the annulus 46 is formed with axially extending circumferentially spaced dog teeth 56. The dog teeth 56 engage grooves between complementary dog teeth 60 on the right hand end of the tubular member 44 and the dog teeth 58 engage complementary grooves between dog teeth 62 of the left hand end on tubular member 44. Accordingly, the tubular member 44 interconnects annuli 46 and 48 so as to preclude relative rotation therebetween, and in addition supports the torsion load between the annuli 46 and 48. The internal O-ring seal 36 of the sleeve piston engages the outer periphery of the tubular member 44.

The internal helical spline teeth 52 on the annulus 46 mate with external helical spline teeth 64 formed on a reaction sleeve 68 which is keyed at 69 to the locking ring 70, the locking ring 70 in turn being keyed to the end cap 12 as indicated by numeral 72. A snap ring 74 maintains the locking ring 70 in fixed relation relative to the reaction sleeve 68.

The internal helical spline teeth 54 of the annulus 48 mate with external helical spline teeth 76 on an output sleeve 78 which is keyed at 80 to the through shaft 18. The output sleeve 78 is supported for rotation relative to the end cap 14 by a needle bearing assembly 82, and is likewise supported for rotation relative to the reaction sleeve 68 by a needle bearing assembly 84 located between the inner end of the reaction sleeve 68 and a bulkhead 86. The bulkhead 86 carries internal and external O-ring seals 88 and 90, which sealingly engage the shaft 18 and interior of tubular member 44, respectively.

When the opposed chambers 32 and 34 of the cylinder are subjected to a pressure differential, the sleeve piston 30 will move in one direction or the other depending upon whether chamber 32 or chamber 34 is pressurized. As the sleeve piston 30 moves relative to the cylinder, the annulus 46 will move relative to the reaction sleeve 68 thereby imparting a slight angular movement to the annulus 46 and the piston 30 as determined by the leads of the helical splines 64 and 52. The torsion loads between the spaced annuli 46 and 48 will be supported and transmitted therebetween by the tubular member 44. Due to the action of the helical spline teeth 54 and 76, the output sleeve 78 and the through shaft 18 will move angularly throughout a distance equal to the sum of the rotation caused by the spline teeth 52 and 64, and 54 and 76. Moreover, during movement of the piston 30 to the right, as viewed in FIGURE 1, the shaft 18 will be rotated in one direction, whereas during movement of the piston 30

to the left, as viewed in FIGURE 1, the shaft 18 will be rotated in the opposite direction.

The extent of angular movement of the shaft 18 is determined by the type of the helical spline teeth 64 and 76, respectively, on the sleeves 68 and 78, respectively. In order to obtain maximum angular movement of the shaft 18 with a minimum torque, the spline teeth 64 and 76 are of different hands and of the same lead. On the other hand, minimum angular movement of the output shaft 18 with maximum torque is obtained when the spline teeth 64 and 76 are of the same hand and of different leads.

By embodying the tubular member 44 which mechanically interconnects the helically splined annuli 46 and 48, an integral sleeve piston can be used thus simplifying the actuator assembly and improving the operating characteristics thereof by rigidly interconnecting the internally helically splined annuli independently of the sleeve piston.

While the embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted.

What is claimed is as follows:

1. A rotary actuator including, a cylinder, a sleeve piston disposed in said cylinder capable of fluid pressure actuation in both directions, a reaction member disposed within said cylinder and restrained against rotation relative thereto, a rotary member disposed within said cylinder and supported for rotation relative thereto, said members having external helical means of different hands or leads, a pair of spaced elements carried by said sleeve piston having internal helical means mating with the external helical means of said members whereby reciprocation of the sleeve piston imparts rotation to said rotary member, and a tubular member interlocked with said elements and carried by said sleeve piston for supporting the torsion loads between the two elements during reciprocation of said sleeve piston.

2. A rotary actuator including, a cylinder, a sleeve piston disposed in said cylinder capable of fluid pressure actuation in both directions, a reaction member disposed within said cylinder and restrained against rotation relative thereto, a rotary member disposed within said cylinder and supported for rotation relative thereto, said members having external helical spline teeth of different hands or leads, a pair of spaced elements carried by said sleeve piston having internal helical spline teeth mating with the external helical spline teeth of said members whereby reciprocation of said sleeve piston imparts rotation to said rotary member, and a tubular member interlocked with said elements and carried by said sleeve piston for

supporting the torsion loads between said two elements during reciprocation of said sleeve piston.

3. A rotary actuator including, a stationary cylinder, a through shaft supported for rotation relative to said cylinder, a reciprocable sleeve piston coaxial with said through shaft and disposed within said cylinder, a reaction sleeve coaxial with said shaft and interconnected with said cylinder so as to prevent rotation therebetween, a rotary output sleeve spaced from said reaction sleeve and keyed to said shaft, said sleeves having external helical spline teeth of different hands or leads, a pair of spaced elements carried by said sleeve piston having internal helical spline teeth mating with the external helical spline teeth of said sleeves whereby reciprocation of the sleeve piston imparts rotation to said shaft, and a tubular member interlocked with said elements and carried by said sleeve piston for supporting the torsion loads between said two elements during reciprocation of said sleeve piston.

4. A rotary actuator including, a stationary cylinder, a reciprocable sleeve piston disposed in said cylinder, a pair of annuli carried by said sleeve piston adjacent opposite ends thereof, a tubular member coaxial with said sleeve piston and mechanically interlocked with said annuli for supporting the torsion loads therebetween, said annuli having internal helical spline teeth, a reaction sleeve restrained against rotation relative to said cylinder having external helical spline teeth mating with the internal helical spline teeth of one of said annuli, and a rotary output member having external helical spline teeth mating with the internal helical spline teeth of the other annuli whereby reciprocation of said sleeve piston will impart rotation to said rotary member, the helical spline teeth on said reaction sleeve and said rotary output member being of different hands or leads.

5. The rotary actuator assembly set forth in claim 4 wherein said tubular member has a plurality of circumferentially spaced dog teeth at each end, and wherein said annuli have complementary dog teeth engaging the dog teeth on opposite ends of said tubular member.

6. The actuator assembly set forth in claim 5 wherein said sleeve piston includes an inwardly extending shoulder at one end and an externally threaded portion at the other end, and wherein said externally threaded portion of said sleeve piston is engaged by a nut so as to maintain said annuli and said tubular member in assembled relation with said sleeve piston for movement in unison therewith.

References Cited in the file of this patent

UNITED STATES PATENTS

2,944,431	Dexter	July 12, 1960
2,945,387	Geyer	July 19, 1960