

[54] **HYDRAULIC ACTUATOR**

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60/593, 533; 74/89.14, 89.15

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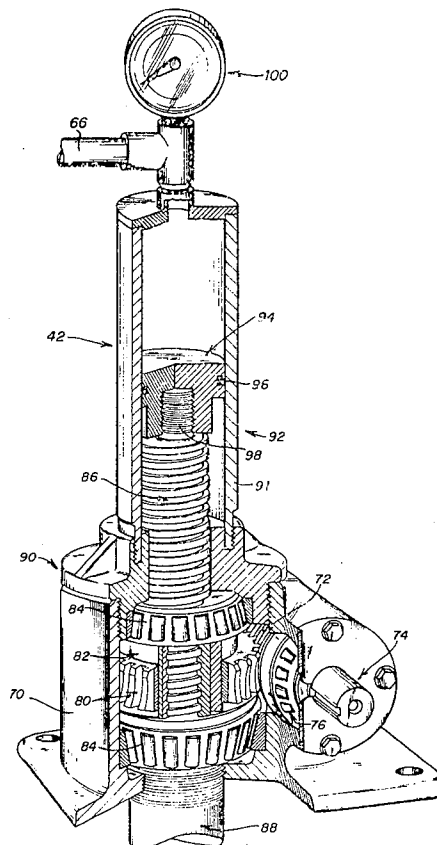
[57] **ABSTRACT**

A hydraulic actuator comprises a worm gear including

a worm supported for rotation by means of a handle and a worm wheel driven by the worm. The worm wheel surrounds and drives a sleeve which is threadedly engaged with the lead screw. A piston is supported on one end of the lead screw for reciprocation thereby in response to rotation of the worm. The piston is enclosed by the barrel of a hydraulic cylinder, and upon reciprocation functions to cause hydraulic fluid flow into and out of the cylinder. The worm gear and the lead screw provide an overall mechanical advantage of about 40:1, so that substantial actuation of the handle is required in order to provide even a relatively small output from the hydraulic cylinder.

The hydraulic cylinder is utilized in a line tensioning machine of the type in which line from a supply reel is directed around a bull wheel. A caliper-type disk brake is utilized to control the rotation of the bull wheel and thereby regulates the tension of the line as it is paid out from the machine. The disk brake of the line tensioning machine is actuated by means of hydraulic pressure supplied by the hydraulic actuator. The high mechanical advantage afforded by the worm gear and the lead screw of the hydraulic actuator facilitates precise control over the braking force which is applied by the disk brake, which in turn provides precise control over the tension of the line.

6 Claims, 3 Drawing Figures



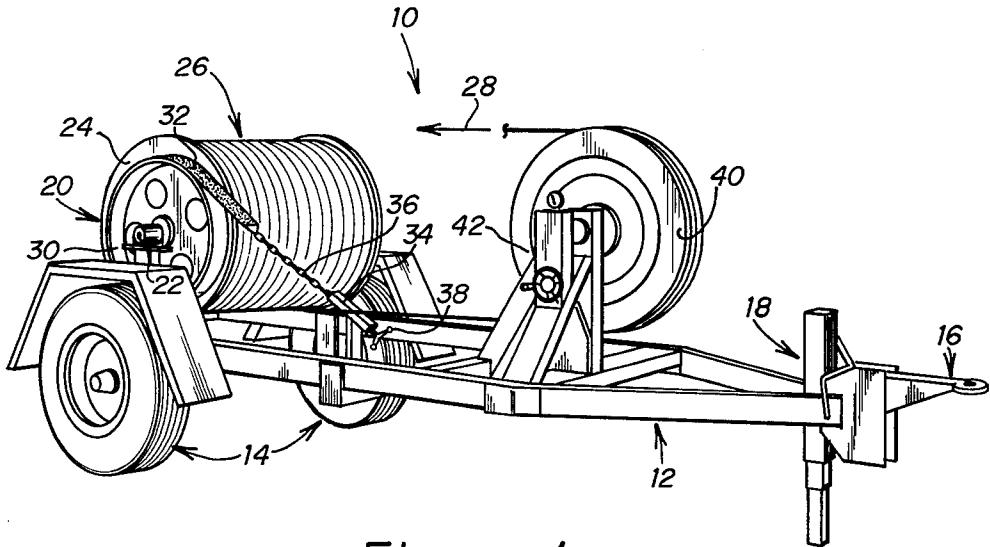


Figure 1

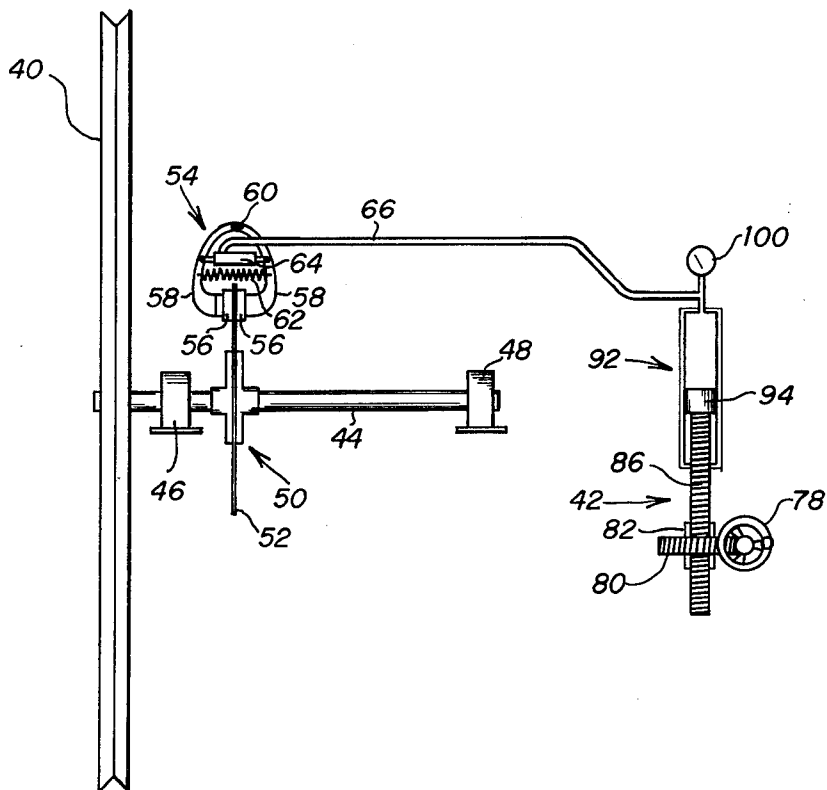


Figure 2

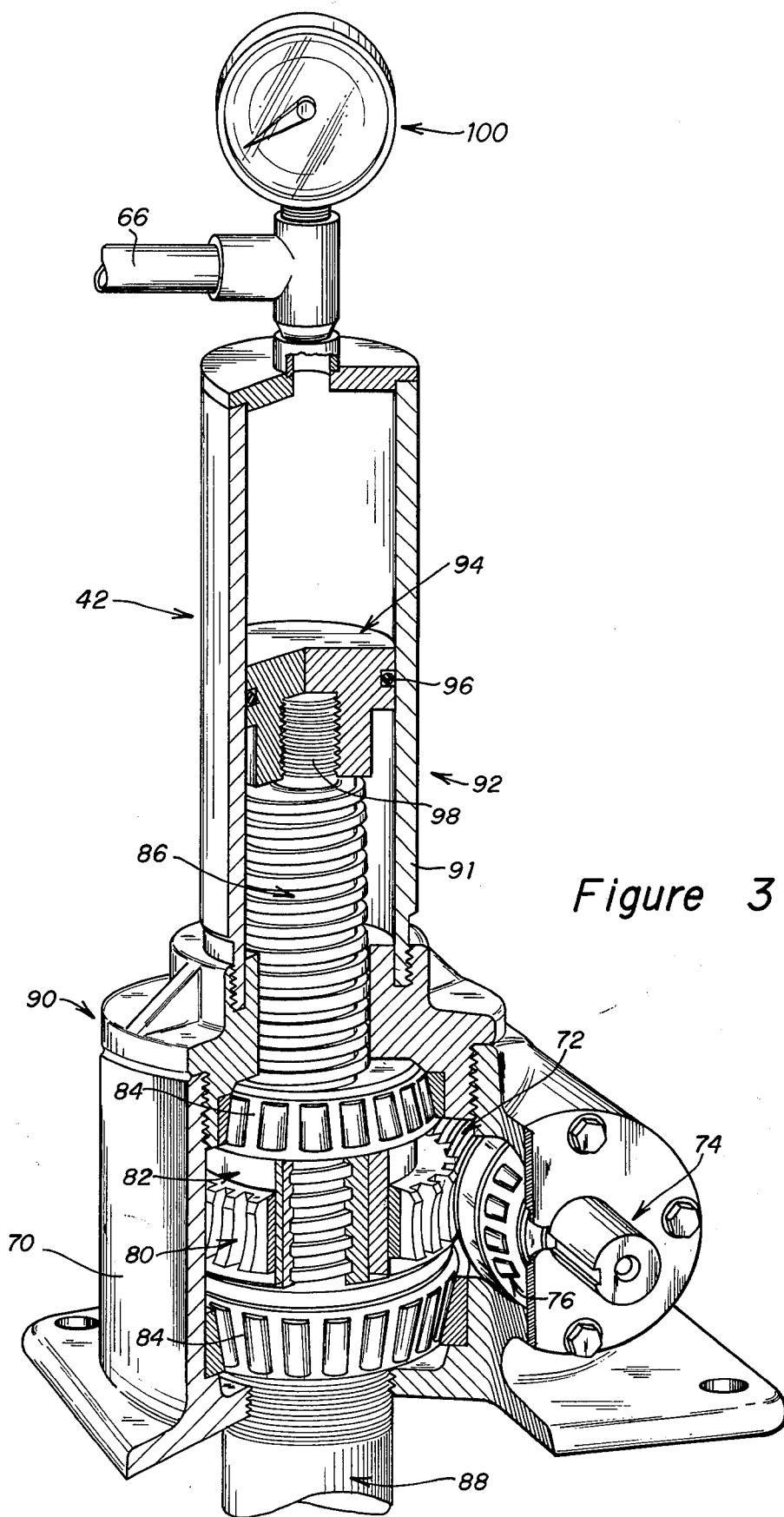


Figure 3

HYDRAULIC ACTUATOR

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to a hydraulic actuator, and more particularly to a hydraulic actuator which facilitates extremely precise regulation of hydraulically driven apparatus.

In certain line tensioning machines, line is paid out from a supply reel and is directed around a bull wheel. Caliper-type disk brakes may be utilized to control the rotation of the bull wheel and thereby regulate the tension that is applied to the line. Both mechanical and hydraulic caliper actuation systems have been used in line tensioning machines, however, none of the caliper actuation systems provided heretofore has proven wholly satisfactory. For example, most of the prior art hydraulic-type caliper actuating systems have utilized hand pumps to provide the necessary hydraulic pressure. This is unsatisfactory because hand pumps are incapable of raising or lowering hydraulic pressure in fine increments, and therefore do not afford precise control over the actuation of the disk brake of a line tensioning machine. This has often necessitated numerous readjustments of the caliper actuation system of such a device in order to provide the exact tension that may be required for a particular line tensioning operation.

The present invention relates to a hydraulic actuator which facilitates extremely precise regulation of hydraulically driven apparatus, and is therefore especially adapted for use in the actuation of the caliper-type disk brakes of line tensioning machines and in similar applications. In accordance with the broader aspects of the invention, a hydraulic actuator includes a hydraulic cylinder which is actuated by means of a mechanism having a high mechanical advantage. This necessitates substantial actuation of the mechanism in order to produce even a relatively small output, and thereby facilitates very precise regulation of a hydraulically driven apparatus which is operated by the actuator.

In accordance with more specific aspects of the invention, the hydraulic cylinder is actuated by a mechanism including a worm gear and a lead screw. The overall mechanical advantage of the mechanism is about 40:1, whereby extremely precise control over the output of the cylinder is provided. Moreover, the worm gear is self-locking which eliminates the necessity of providing auxiliary locking mechanisms, check valves, etc. in order to maintain a desired setting.

In accordance with still more specific aspects of the invention, the worm gear includes a worm adapted for rotation by a handle or similar actuator. The worm rotates a worm wheel which surrounds and drives an internally threaded sleeve. The sleeve is threadedly engaged with the lead screw, so that the lead screw is actuated linearly in response to rotation of the worm. A piston is secured to the lead screw for reciprocation thereby with respect to a barrel comprising part of the hydraulic cylinder. By this means very precise control over the positioning of the piston within the barrel is provided, which in turn provides precise control over the flow of hydraulic fluid into and out of the cylinder.

DESCRIPTION OF THE DRAWINGS

A more complete understanding of the invention may be had by referring to the following Detailed Descrip-

tion when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a perspective view of a line tensioning machine utilizing the invention;

FIG. 2 is a schematic illustration of various component parts incorporated in the line tensioning machine shown in FIG. 1; and,

FIG. 3 is an illustration of a hydraulic actuator incorporating the invention in which certain parts have been broken away more clearly to illustrate certain features of the invention.

DETAILED DESCRIPTION

Referring now to the Drawings, and particularly to FIG. 1 thereof, there is shown a line tensioning machine 10 utilizing the present invention. The line tensioning machine 10 includes a frame 12 including a rear end supported by a pair of wheels 14. The front end of the frame 12 is provided with a hitch 16, whereby the line tensioning machine may be towed by a truck or other towing vehicle. The front end of the frame 12 is supported by a conventional landing gear 18 whenever it is not connected to the towing vehicle.

The rear end of the line tensioning machine 10 further comprises a reel spindle mechanism 20. The reel spindle mechanism 20 comprises an axle 22 which supports a reel 24. The reel 24 carries a quantity of line 26 which is paid out from the line tensioning machine 10 in the direction indicated by the arrow 28.

The reel spindle mechanism 20 further includes a drum 30 supported for rotation with the reel 24. A brake band 32 is connected to a lead screw mechanism 34 by a chain 36. The lead screw mechanism 34 includes an operating handle 38 whereby the mechanism 34 may be actuated to control the tension of the brake band 32. By this means the brake band 32 and the drum 30 function to prevent over-running of the reel 24.

The line 26 extends from the reel 24 around a bull wheel 40. The function of the bull wheel 40 is to regulate the tension in the line in accordance with the requirements of the particular operation wherein the line is utilized. In the line tensioning machine 10, this is accomplished by means of a hydraulically actuated, caliper-type disk brake which regulates the rotation of the bull wheel 40. The operation of the disk brake is in turn controlled by a hydraulic actuator 42 incorporating the present invention.

Referring now to FIG. 2, the bull wheel 40 is mounted on a shaft 44 which is rotatably supported on the frame 12 of the line tensioning machine 10 by means of a pair of spaced apart bearings 46 and 48. A caliper-type disk brake mechanism 50 includes a disk 52 mounted on the shaft 44 for rotation with the bull wheel 40. A caliper mechanism 54 includes a pair of brake pads 56 supported for engagement with the disk 52 to regulate rotation of the shaft 44 and the bull wheel 40. The pads 56 are mounted on a pair of arms 58 which are pivotally interconnected by a shaft 60. The arms 58 biased outwardly by a spring 62 and are selectively drawn inwardly against the action of the spring 62 by a hydraulic cylinder 64. By this means the brake pads 56 are engaged with the disk 52 of the caliper-type disk brake mechanism 50. It will be understood that the disk brake mechanism shown in FIG. 2 is illustrative only, and that any of the conventional disk brake mechanisms commonly employed in line tension-

ing machines may be utilized in the practice of the invention.

The hydraulic cylinder 64 of the caliper mechanism 54 is actuated by means of hydraulic fluid supplied from the actuator 42 through a conduit 66. As is best shown in FIG. 3, the hydraulic actuator 42 comprises a housing 70 which encloses a worm 72. The worm 72 is mounted on a shaft 74 which is rotatably supported in the housing 70 by means of a pair of tapered roller bearings 76. As is best shown in FIGS. 1 and 2, a handle 78 is secured to one end of the shaft 74 for selective actuation to rotate the shaft and the worm 72.

The worm 72 is mounted in mesh with a worm wheel 80 and cooperates therewith to form a worm gear having a mechanical advantage of about 10:1. The worm wheel 80 is secured to a sleeve 82 which is rotatably supported in the housing 70 by means of a pair of tapered roller bearings 84. The sleeve 82 is internally threaded, and a lead screw 86 is threadedly engaged with the sleeve 82. The lead screw 86 is secured against rotation relative to the housing 70, and has a pitch of about 0.25. Therefore, upon rotation of the handle 78, the lead screw 86 is either advanced or retracted relative to the housing 70 under an overall mechanical advantage of about 40:1.

A sleeve 88 is threadedly secured to the bottom of the housing 70 of the hydraulic actuator 42, and extends downwardly therefrom. The sleeve 88 merely serves to enclose and protect the lead screw 86 during retraction thereof relative to the housing 70. A cap 90 is threadedly secured to the upper end of the housing 70 and serves to support the upper tapered roller bearing 84. The cap 90 also supports a barrel 91 which is threadedly received in the upper portion of the cap.

The barrel 91 comprises part of a hydraulic cylinder 92 which further includes a piston 94. The piston 94 is mounted for reciprocation within the barrel 91 and includes an O-ring 96 or other conventional packing means. The piston 94 is secured to the lead screw 86 by means of a threaded extension 98 thereon. It will therefore be understood that upon rotation of the handle 78, the actuator 42 functions by means of the worm 72, the worm wheel 80, the sleeve 82 and the lead screw 86 to reciprocate the piston 94 of the hydraulic cylinder 92.

The blind end of the cylinder 92, the conduit 66 and the rod end of the hydraulic cylinder 64 are all filled with hydraulic fluid. Therefore, upon upward (FIG. 3) reciprocation of the piston 94, hydraulic pressure within the cylinder 64 is increased, and the pads 56 are drawn inwardly against the action of the spring 62 by the cylinder 64. On the other hand, upon downward (FIG. 3) reciprocation of the piston 94, the hydraulic pressure within the rod end of the cylinder 64 is reduced, whereby the pads 56 are permitted to move outwardly under the action of the spring 62. The actuator 42 may be provided with a hydraulic pressure gauge 100 which is useful in regulating the operation of the actuator 42 and hence the operation of the caliper-type disk brake 50.

Those skilled in the art will appreciate the fact that the use of the present invention incorporates numerous advantages over the prior art. Thus, by means of the invention, a hydraulic actuator is adapted to facilitate extremely precise regulation of hydraulically driven apparatus. This is highly advantageous in any apparatus wherein very precise operational control is necessary

or desirable. For example, in a line tensioning mechanism, the hydraulic actuator of the present invention may be utilized to afford precise control over the braking force that is applied by a caliper-type disk brake to a bull wheel. This in turn provides precise control over the tension that is applied to a line being paid out from the line tensioning machine.

A related advantage stemming from the use of the invention involves the fact that in accordance with the embodiment thereof shown in the drawings, the hydraulic actuator incorporates a hydraulic cylinder which is actuated by means of a worm gear. As will be appreciated by those skilled in the art, such a device is substantially self-locking. Therefore, by means of the present invention a hydraulically driven apparatus is not only regulated with extreme precision, but is thereafter maintained in the regulated condition without the necessity of additional locking apparatus, check valves, or the like.

Although particular embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing Description, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of numerous rearrangements, modifications, and substitutions of parts and elements without departing from the spirit of the invention.

What is claimed is:

1. A hydraulic actuator for facilitating precise control over an apparatus to perform a function by means of the action of pressurized hydraulic fluid outside said actuator which comprises:

a housing with a hydraulic cylinder rigidly attached thereto, said hydraulic cylinder including a piston mounted for relative reciprocation to selectively cause hydraulic fluid flow to and from the apparatus;

operator means; and

a mechanism having a relatively high mechanical advantage for effecting relative reciprocation of the piston in response to actuation of the operator means so that a relatively substantial actuation of the operator means is required in order to effect a relatively small change in the performance in the function by the apparatus.

2. The hydraulic actuator according to claim 1 wherein the mechanism for effecting reciprocation of the piston includes:

a lead screw operatively connected to the piston;

a member threadedly engaging the lead screw and supported for rotation to extend and retract the lead screw and thereby effect relative reciprocation of the piston; and

means responsive to actuation of the operator means for rotating the member and thereby effecting a change in the performance of the function by means of the lead screw, the hydraulic cylinder, and the hydraulically actuated apparatus.

3. A hydraulic actuator actuating an apparatus outside said actuator by means of pressurized hydraulic fluid comprising:

hydraulic cylinder means including piston means mounted for relative reciprocation to cause hydraulic fluid flow into and out of the cylinder means;

a lead screw operatively connected to the piston means to effect actuation thereof;

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a sleeve threadedly engaging the lead screw for rotation to cause selective extension and retraction of the lead screw and thereby effecting relative reciprocation of the piston means of the hydraulic cylinder means;

a worm gear including a worm and a worm wheel mounted in mesh and operatively connected to the sleeve to effect rotation thereof; and

means for selectively rotating the worm of the worm gear and thereby actuating the worm wheel, the sleeve, and the lead screw to effect relative reciprocation of the piston means of the hydraulic cylinder means.

4. The hydraulic actuator according to claim 3 further including housing means enclosing the worm gear, the sleeve, and the lead screw, wherein the hydraulic cylinder means further includes a barrel enclosing the piston means which is mounted on and extends from the housing, and wherein the piston of the hydraulic cylinder means is mounted on the end of the lead screw.

5. A hydraulic actuator comprising:

a housing;

a shaft rotatably supported in the housing;

a handle secured to one end of the shaft for manual actuation to rotate the shaft;

a worm mounted on the shaft for rotation by means of the handle;

a sleeve rotatably supported in the housing;

a worm wheel supported by the sleeve and mounted in mesh with the worm for rotation thereby;

said sleeve having an internally threaded portion concentric with the worm wheel;

a lead screw threadedly engaged with the internally

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threaded portion of the sleeve and mounted for reciprocation relative to the housing in response to rotation of the worm by means of the handle;

a hydraulic cylinder including a barrel secured to and extending from the housing; and

a piston mounted on the lead screw and enclosed by the barrel for reciprocation therein to cause hydraulic fluid flow into and out of the cylinder hydraulically actuating an apparatus outside said actuator.

6. A hydraulic actuator for facilitating precise control over an apparatus to perform a function by means of the action of pressurized hydraulic fluid outside said actuator which comprises:

a hydraulic cylinder including a piston mounted for relative reciprocation to selectively cause hydraulic fluid flow to and from the apparatus;

a lead screw operatively connected to the piston;

a member threadedly engaging the lead screw and supported for rotation to extend and retract the lead screw and thereby effect relative reciprocation of the piston;

an operator means; and

means responsive to actuation of the operator means including a worm wheel operatively connected to said member and a worm mounted in mesh with said worm wheel, wherein the operator means is effective upon actuation to rotate the worm and thereby cause a change in the performance in the function of said apparatus by means of the worm wheel, the member rotatable thereby, the lead screw, the hydraulic cylinder and the hydraulically actuated apparatus.

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