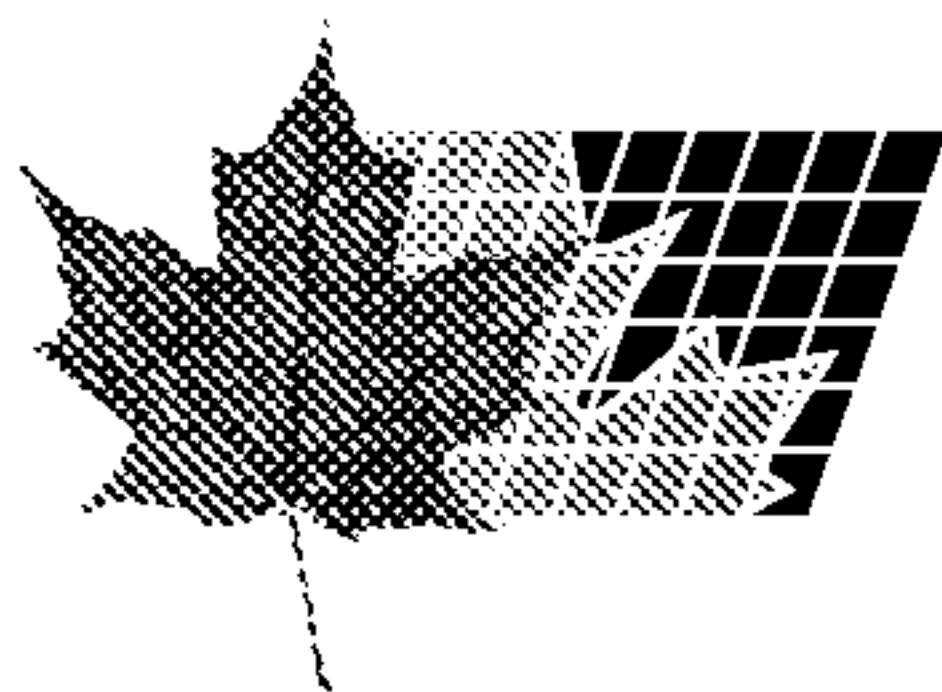




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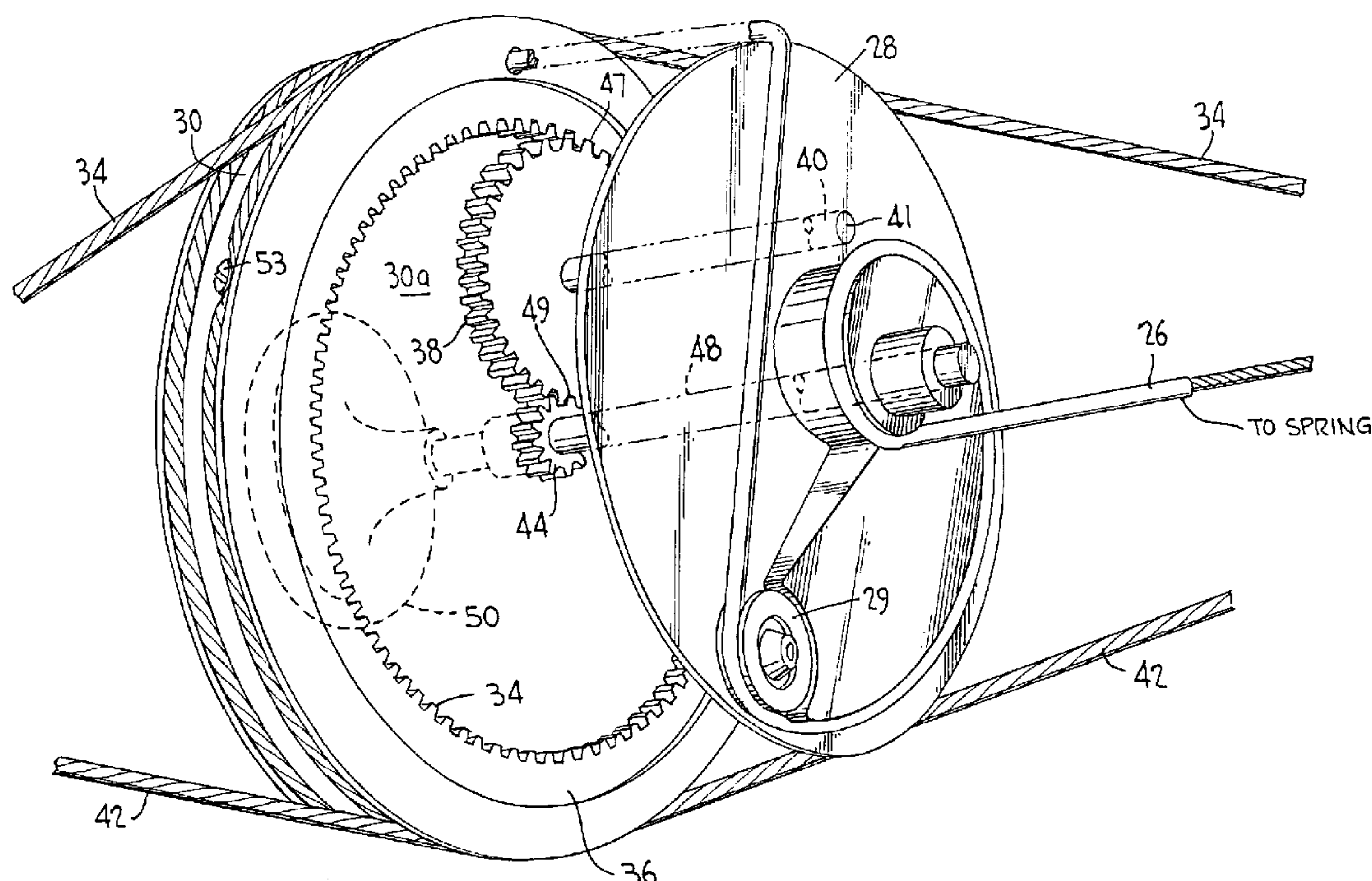
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(54) **COMPENSATEUR DE CHARGE POUR MECANISME DE  
CONTREPOIDS A RESSORT**

(54) **LOAD COMPENSATOR FOR SPRING COUNTER-WEIGHTING  
MECHANISM**



(57) An improved load compensator for a spring counter-weighting mechanism including a snail cam to provide a constant counter-weight force is described. The cam provides a constant torque to a drum on which are wound cables for exerting a constant counter-weighting force. A manually operable device for altering the relative radial positions of the cam and drum varies the amount of the constant counter-weighting force. The cam is rotated with respect to the drum by a spur gear fitting within a ring gear fixed to the drum and rotated by a knob connected to an axle carrying a pinion gear engaging the spur gear. The spiral surface can be effectively reconfigured with respect to a portion of the cable fitting therearound.





ABSTRACT

1       An improved load compensator for a spring counter-weighting  
2 mechanism including a snail cam to provide a constant counter-  
3 weight force is described. The cam provides a constant torque to  
4 a drum on which are wound cables for exerting a constant counter-  
5 weighting force. A manually operable device for altering the  
6 relative radial positions of the cam and drum varies the amount of  
7 the constant counter-weighting force. The cam is rotated with  
8 respect to the drum by a spur gear fitting within a ring gear fixed  
9 to the drum and rotated by a knob connected to an axle carrying a  
10 pinion gear engaging the spur gear. The spiral surface can be  
11 effectively reconfigured with respect to a portion of the cable  
12 fitting therearound.



1     Field of the Invention

2             This invention relates to an improved load compensator  
3     for a spring counter-weighting mechanism useful in a wide  
4     variety of different applications. A particular use of the  
5     invention is in connection with counter-weighting a  
6     vertically movable desk or table top.

7     Background of the Invention

8             The prior art shows numerous mechanisms wherein springs  
9     are used to provide a counter-weighting force, to ease the  
10    labor of lifting a weight against the force of gravity. See  
11    U.S. Patent No. 3,820,478 issued 28 June, 1974 to Bergenthal  
12    directed to an article support stand for lifting a stack of  
13    trays, dishes or the like; U.S. Patent No. 2,168,209 issued  
14    1 August, 1939 to Haupt showing a spring counter-weight for  
15    lifting the weight of an x-ray apparatus or the like; U.S.  
16    Patent No. 4,760,622 issued 2 August, 1988 to Rohrman  
17    showing a spring counter-weighting system for a window sash  
18    or the like; and U.S. Patents No. 4,685,648 issued 11  
19    August, 1987 to Dobner et al and No. 4,684,225 issued 4  
20    August, 1987 to Clark et al relating to spring counter-  
21    weight mechanisms and related focusing mechanisms for  
22    optical microscopes. Also of interest are Rouverol U.S.  
23    Patent No. 2,924,411 issued 9 February, 1960 showing a  
24    spring support for piping, Leunig U.S. Patent No. 4,389,228  
25    issued 21 June, 1983 showing a spring-biased constant  
26    tensioning device for maintaining a filter bag assembly in  
27    a bag house, and U.S. Patent No. 4,351,245 issued 28  
28    September, 1982 to



1 Laporte showing a spring counter-weighting system for a vertically  
2 adjustable table top.

3 As is well known, the force exerted by the typical tension  
4 spring varies linearly with its extension. Thus, if the first inch  
5 of extension of the spring requires a force of  $x$ , the second inch  
6 of extension requires  $2x$ , the third inch of extension requires  $3x$   
7 and so on. If it is desired to employ the spring to provide a  
8 constant counter-weighting force, as is normally appropriate, some  
9 mechanism must be found to maintain the effective counter-weighting  
10 force constant despite the linearly increasing force exerted by the  
11 spring.

12 To this end, the art shows numerous mechanisms whereby a  
13 "snail cam" or similar device for continually decreasing the  
14 mechanical advantage of a lever is employed to convert the linearly  
15 increasing force exerted by a tension spring as it is extended to  
16 a constant force for counter-weighting moving assemblies. See,  
17 for example, the Haupt patent discussed above at Fig. 4, the Dobner  
18 patent at Figs. 1 and 5, and the Laporte patent at Fig. 2.

19 The snail cam devices shown in the prior art for converting  
20 the linearly-increasing force exerted by a tension spring to be  
21 constant over a substantial range of extension of the spring  
22 typically require means for adjusting the preload on the spring.  
23 The prior art fails to teach satisfactory means for adjusting the  
24 spring preload. More particularly, in most circumstances when a  
25 device using a spring for counter-weighting purposes is assembled,  
26 the spring must be given an initial tension or preload to provide



1 an initial force substantially equivalent to the load to be  
2 counter-weighted. Commonly a threaded member is provided to adjust  
3 the spring tension. As the threaded member is turned with respect  
4 to a tapped bore fixed to the structure of the device, the spring  
5 is gradually extended until the total force exerted by the spring  
6 is substantially equal to the load to be counter-weighted. See for  
7 example Bergenthal at 114; Haupt at column 2, lines 16 - 21;  
8 Rohrman at element 32, Fig. 5; Dobner at column 4, lines 35 - 38;  
9 and Laporte at column 3, lines 55 - 59.

10 Rouverol shows in Figs. 14 and 15 the use of a spiral spring  
11 for exerting a variable force through the intermediation of a snail  
12 cam surface 238. Preload in this system is provided by loosening  
13 a bolt 250 securing the fixed end of the spring, moving the end of  
14 the spiral spring, and retightening the bolt; see column 11, lines  
15 15 - 54.

16 It will thus be appreciated that the methods provided in the  
17 prior art for adjusting the preload or static force of springs used  
18 to provide counter-weighting force all require tools and are  
19 relatively complex. It would be preferable to provide a spring  
20 counter-weighting device including provision for simple  
21 compensation of variation in the load, not requiring tools for  
22 adjustment.

23 In addition to the devices shown in the patents discussed  
24 above, there are commercially available "tool balancers" comprising  
25 a housing supporting a sheave on which is wound a cable. The  
26 sheave is spring-loaded to exert a constant tension on the cable,



1 approximating the weight of a tool supported by the cable, so that  
2 its user need not heft the weight of the tool throughout the  
3 workday. A wide range of such devices are offered, each intended  
4 for use with tools of particular weight. It would be desirable to  
5 provide a tool balancer adjustable to support tools of widely  
6 varying weights, not requiring tools for adjustment, so that a  
7 single tool balancer would be suitable for use with a range of  
8 tools.

9 One application of the load compensator of the invention is in  
10 connection with tables or desks having spring counter-weighting  
11 mechanisms for lifting the desk top vertically. More specifically,  
12 the present invention is directed to a load compensator for  
13 adjusting the counter-weighting force provided by a tension spring,  
14 for example, as weight is added to the table. Such tables are  
15 particularly desired for supporting computer equipment. Thus, for  
16 example, the table may be supplied with a spring preloaded to  
17 effectively counter-weight the basic mass of the table top and  
18 supporting structure, so that the table top can conveniently be  
19 raised and lowered as desired. The user may want to add a basic  
20 computer system and will need to adjust the spring force to insure  
21 that the height of the table top continues to be readily  
22 adjustable. He may then desire to add a printer or another heavy  
23 device. He may then find himself in the habit of keeping heavy  
24 books, lamps, etc. on his table top. The counter-weighting force  
25 must be adjusted in each case in order that the table top may be  
26 readily raised or lowered. The prior art discussed above does not



1 provide a suitable manually operable mechanism for thus  
2 compensating for variation of the load in a spring counter-weighted  
3 mechanism, particularly one incorporating a snail cam for providing  
4 a constant counter-weighting force.

5 Objects and Summary of the Invention

6 It is therefore an object of the invention to provide a simple  
7 and efficient mechanism incorporating a manually operable load  
8 compensator for converting linearly increasing spring force to a  
9 constant counter-weighting force and permitting convenient  
10 adjustment of the counter-weighting force without requiring the use  
11 of tools.

12 This object of the invention and others which will appear  
13 below are satisfied by the load compensator for a spring counter-  
14 weighting mechanism according to the invention, which comprises a  
15 snail cam providing a varying leverage ratio to convert the force  
16 provided by a tension spring to a constant counter-weighting force.  
17 For example, the variable leverage ratio device may be a snail cam  
18 arranged for transmitting torque to a drum for winding a cable  
19 thereupon. The cable applies the counter-weighting force to the  
20 load to be counter-weighted. A spring applies tension to a second  
21 cable wrapped around the snail cam, arranged such that as the  
22 spring is extended the leverage ratio provided by the snail cam  
23 decreases; in this way, the net counter-weighting force provided to  
24 the drum is maintained substantially constant.



1 Adjustment of the total counter-weighting force provided by  
2 the tension member wrapped around the constant radius drum is  
3 effected by varying the initial position of the snail cam with  
4 respect to the drum. In the preferred embodiment, both the snail  
5 cam and the drum carrying the cable exerting the counter-weighting  
6 force are journaled for free rotation on a rotatable axle. An  
7 adjustment knob is mounted on one end of the axle. A pinion gear  
8 fixed to the axle engages a spur gear in a recess in one end of the  
9 drum. The spur gear engages an internal ring gear forming the  
10 inner circumference of the recess in the drum. The axle of the  
11 spur gear is fixed to the snail cam. Accordingly, when the  
12 adjustment knob is manually rotated, turning the pinion gear, the  
13 spur gear is also rotated, moving the static position of the snail  
14 cam with respect to the drum, and varying the initial lever arm  
15 ratio provided by the snail cam. Variation in the load can thus be  
16 compensated very simply and conveniently without the use of tools.

17 In a further improvement, the effective diameter of the cable  
18 wrapped around the snail cam can be locally varied by provision of  
19 a series of beads of differing diameters fitting over the cable  
20 where it engages the surface of the snail cam.

#### 21 Brief Description of the Drawings

22 The invention will be better understood if reference is made  
23 to the accompanying drawings, in which:

24 Fig. 1 is a simplified schematic perspective view of a desk or  
25 table including the load compensator according to the invention;



1        Fig. 2 is a detailed exploded perspective view of the assembly  
2 of the snail cam and the cable drum;

3        Fig. 3 is an elevational view of the assembly of the snail cam  
4 and the cable drum, showing the cam at two different positions with  
5 respect to the drum;

6        Fig. 4 is a cross-sectional view taken through the axle on  
7 which the drum and snail cam are mounted; and

8        Fig. 5 is a detailed elevational view showing the provision of  
9 a series of beads fitting over the cable.

#### 10    Description of the Preferred Embodiment

11        Fig. 1 is a schematic diagram of a table incorporating the  
12 improved load compensator of the invention. The table comprises a  
13 top 10 on which a variable load indicated at 12 may be placed. The  
14 table top 10 is supported at either lateral end by supports 14  
15 moving vertically within guide members 16 mounted to legs 18  
16 resting on the ground, allowing adjustment of the height of table  
17 top 10. A transverse beam 20 extends between and is fixed to the  
18 legs 18. In order to ease the labor of raising the table 10 with  
19 its load 12, a tension spring 22 extends between a fixed end  
20 secured to the beam 20 at 24 and a free end fixed to a flexible  
21 tension member 26, typically a vinyl coated steel cable. The steel  
22 cable 26 wraps around a snail cam 28 so as to meet a peripheral cam  
23 surface 28a at an effective distance L (Fig. 3) from the axis of  
24 the cam 28. The distance L, measured from the axis of the snail  
25 cam 28 to the point where cable 26 meets cam surface 28a, is thus



1 the effective "lever arm" by which the spring force is applied to  
2 the cam 28. Cam 28 is formed such that cam surface 28a is disposed  
3 at a smoothly varying distance from the axis of cam 28. Thus, if  
4 the cam 28 is rotated clockwise in Fig. 1, so that the tension  
5 member 26 is wrapped further about peripheral cam surface 28a and  
6 further extending the spring 22, the effective lever arm length  $L$   
7 decreases, such that the net torque (the product of the spring  
8 force multiplied by the effective lever arm length  $L$ ) remains  
9 constant. Thus, Fig. 3 shows the cam at two positions, and  
10 illustrates at  $L_1$  and  $L_2$  the variation in  $L$  with rotation of the  
11 cam.

12 Torque imparted to the cam 28 by the spring 22 is transferred  
13 to a drum 30. To this end, the end 26a of tension member 26  
14 wrapped around cam 28 may be fixed to drum 30. See Fig. 4. Drum  
15 30 may be two separate members joined to rotate as one, or may be  
16 formed as an integral member, as shown. A first flexible cable 34  
17 extends from a fixed point 35 at one end of the table top 10 around  
18 a pulley 36, makes a complete wrap around the drum 30, passes over  
19 a second pulley 38 at the opposite end of the beam 20, and is fixed  
20 at 40 to the lower end of vertical support 14. Pulleys 36 and 38  
21 rotate about axes fixed with respect to legs 18 and beam 20. A  
22 second cable 42 follows a generally opposite route, from a fixing  
23 point 44 at the lower end of the opposite vertical member 14, over  
24 a pulley 46 fixed to the beam 20, makes a complete wrap about drum  
25 30, in the same direction as cable 34, passes over a further pulley  
26 48 and is fixed to the table top 10 at 50. Provision of such dual



1 cooperative cables 34 and 42 ensures the table top moves evenly and  
2 smoothly.

3 It will thus be appreciated that if the table top 10 is  
4 raised, drum 30 is rotated counterclockwise in the view of Fig. 1.  
5 Tension imparted to tension member 26 by spring 22 tends to rotate  
6 drum 30, exerting tension on cables 34 and 42 so as to assist in  
7 raising the table top 10. Thus, spring 22 provides an effective  
8 counter-weighting force opposed to the weight of the table top 10,  
9 the load 12, and the vertical members 14, all of which must be  
10 lifted against the force of gravity to raise the table top.  
11 Accordingly, when the table top is raised, the spring 22 is  
12 shortened. Conversely, when the table top 10 is lowered, spring 22  
13 is extended, storing energy to be employed in subsequently lifting  
14 the top 10.

15 As discussed above, tension spring 22 provides tension  
16 increasing linearly as the spring is extended. However, the weight  
17 of the table top 10, load 12 and supporting structure 14 does not  
18 increase as the table is lifted. Therefore a constant force  
19 counter-weighting the mass of the moving elements is required.  
20 Accordingly, if the table top 10 is lowered, so that drum 30  
21 rotates clockwise together with cam 28, winding cable 26 onto cam  
22 surface 28a and extending spring 22, the distance  $L$  from the axis  
23 of cam 28 to the point at which cable 26 meets cam surface 28a  
24 decreases, so that the net torque imparted to the cam 28 remains  
25 constant. Thus as the table top is lowered, rotating the cam 28  
26 clockwise, spring 22 is stretched, and  $L$  decreases from  $L_1$  to  $L_2$  in



Fig. 3. The net torque imparted by cam 22 to drum 30 - the product of the spring force times  $L$  at any given point - remains constant. Conversely, when the table top is raised, such that the weight of the table top 10, load 12 and associated structure, including uprights 14 must be lifted against the force of gravity, spring 22 is shortened as its stored energy is released, assisting in lifting the table top. Accordingly, during raising of the table top 10, as cam 28 rotates clockwise and spring 22 is shortened,  $L$  increases from  $L_2$  to  $L_1$ , such that the net torque exerted remains constant.

More generally, the counter-weighting force provided by spring 22 varies linearly with extension of the spring, and is converted to a constant force through the use of a tension member 26 wrapping around the periphery of a cam having a working cam surface 28a defining a varying effective lever arm  $L$ ; the tension member and cam surface are arranged such that as the spring is extended, the effective lever arm  $L$  decreases (as the cam 28 is rotated clockwise in the view of Fig. 1), and vice versa. In this way a constant counter-weighting force is imparted to cables 34 and 42 to assist in raising the table 10 and associated load 12.

It will be appreciated that the table by its nature tends to have massive objects such as load 12 placed on its upper surface. To render the counter-weighting spring 22 fully useful, a load compensator must be provided to vary the amount of force imparted by the spring to tension member 26 and thence to cables 34 and 42. As discussed above, the prior art has normally altered the static force imparted by a spring to a tension member by adjusting its



1 preload, typically by turning a threaded member fixed to one end of  
2 the spring and threaded through a nut or equivalent member fixed to  
3 the framework of the device. For example, according to the  
4 conventional prior art teaching, preload adjustment for spring 22  
5 might be implemented by securing one end of spring 22 to a movable  
6 mount, the motion of the movable mount with respect to beam 20  
7 being controlled by a lead screw arrangement or the like. See, for  
8 example, Laporte U.S. Patent No. 4,351,245 wherein preload  
9 adjustment is provided by threaded member 44. Such adjustment of  
10 the spring preload using a threaded member requires the use of a  
11 wrench to exert the relatively substantial turning forces required.  
12 Some considerable time may be required to turn the screw  
13 sufficiently to counter-balance an additional load placed on the  
14 table.

15 The improved method for adjusting the amount of force applied  
16 by the spring to the tension member 26 provided according to the  
17 invention is shown in Figs. 2 and 4. Fig. 2 is an exploded view  
18 generally corresponding to the orientation of Fig. 1 and  
19 illustrating the mechanism used for adjusting the relative position  
20 of the snail cam 28 with respect to the drum 30. Fig. 4 is a  
21 cross-section through axle 48.

22 As shown in Figs. 2 and 4, a recess 30a is provided in outer  
23 face of drum 30. The inner peripheral surface of recess 30a is  
24 provided with gear teeth 34, e.g., by assembling a separate ring  
25 gear 36 to the interior of the drum 30; equivalently, the gear  
26 teeth 34 may be formed integrally with the drum 30 in a molding



1 operation. A spur gear 38 confined within recess 30a by snail cam  
2 28 meshes at 47 with the teeth 34. Spur gear 38 is journaled for  
3 free rotation about a stub axle 40 fixed in a bore 41 in the snail  
4 cam 28. A pinion gear 44 meshing with spur gear 38 at 49 is fixed  
5 as indicated by key 46 in Fig. 4 to the axle 48 on which are  
6 journaled the drum 30 and the cam 28. That is, the pinion gear 44  
7 is fixed to and rotates with the axle 48, while the drum 30 and the  
8 snail cam 28 each pivot freely with respect to the axle 48. A load  
9 compensating adjustment knob 50 is keyed to the axle 48 by key 51  
10 on the outer side of the transverse beam 20, and can be manually  
11 operated to turn the axle 48. The distal end of axle 48 may be  
12 supported by member 60 fixed to beam 20 (Fig. 4). Screws 53  
13 prevent slippage of cables 34 and 42 with respect to drum 30.  
14 Bearing 29 prevents kinking of cable 26.

15 When the knob 50 is turned, rotating axle 48, pinion gear 44  
16 accordingly rotates, turning spur gear 38. As spur gear 38 is  
17 journaled to rotate freely with respect to stub axle 40, spur gear  
18 38 is driven along the teeth of ring gear 34. As stub axle 40 is  
19 fixed within bore 41 of cam 28, rotation of axle 48 by knob 50  
20 causes snail cam 28 to be rotated with respect to drum 30. As  
21 snail cam 28 is thus rotated, tension member 26 is wound (or  
22 unwound) from cam surface 28a, varying the distance L between the  
23 point on surface 28a at which member 26 meets surface 28a and the  
24 axis of cam 28, and thus varying the effective length L of the  
25 lever arm, whereby the linearly varying tension provided by spring  
26 22 is converted to constant torque applied to snail cam 28.



Rotating knob 50 thus varies the respective radial positions of cam 28 and drum 30, varying the constant counter-weighting force provided by cables 34 and 42. More specifically, rotation of knob 50 moves the cam between the positions shown in Fig. 3, varying the initial effective lever arm length through a range extending from  $L_1$  to  $L_2$ , or vice-versa, depending on whether the counter-weighting force is to be increased or decreased. In order that cam 28 can be rotated with respect to the drum 30 to a considerable degree, as indicated by angle A in Fig. 3, without extending spring 22, the rear of cam 28 may be relieved radially at 28b.

Rotation of cam 28 with respect to drum 30 thus does not normally involve extension of spring 22 to vary the counterbalancing force exerted on the load, e.g., by varying the spring preload as commonly practiced in the prior art. Instead, the constant counterweighting force exerted on the load is varied, corresponding to variation in the load, by varying the initial effective lever arm  $L$ .

Under certain circumstances, it is helpful to provide subtle alteration of the effective shape of the cam. More particularly, if a spring 22 of a particular spring rate is to be used, the snail cam is designed to compensate for variation in the force exerted as the spring is stretched or compressed. That is, the cam surface provides a changing lever arm corresponding to the change in force exerted by the spring as the spring is stretched or contracted. However, the ideal rate of change of the effective lever arm provided by the spiral surface varies with the preferred initial



1 lever arm. Accordingly, as the effective initial lever arm is  
2 varied as weight is added to or removed from the table top, in  
3 accordance with the invention as discussed above, the optimal  
4 spiral shape varies somewhat. It is impractical to change the  
5 shape of the spiral as the load changes, of course. However,  
6 according to a further aspect of the invention, the diameter of the  
7 cable can be effectively varied, providing the same result.

8 Fig. 5 illustrates this further aspect of the invention. A  
9 number of beads 70 of gradually increasing outer diameter are  
10 placed over the cable 26, between the spiral cam surface 28a and  
11 the spring 22, as shown. If a nylon-coated cable is employed, the  
12 nylon coating is removed in the region at which the beads are to be  
13 located. The beads are relieved at their outer circumference, as  
14 shown at 70a, so that they do not interfere with one another when  
15 being wrapped around the spiral surface. The beads are fixed in  
16 position along the cable 26 at manufacture by a collar 72 secured  
17 to the cable 26 by a setscrew 74. A spring 76 ensures that the  
18 beads remain in contact with one another.

19 Providing the series of beads 70 of gradually increasing  
20 diameter effectively increases the thickness of the cable 26,  
21 increasing the lever arm of the spiral surface as needed, typically  
22 at one end of the cable travel. As noted in detail above,  
23 according to one aspect of the invention, the adjustment knob 50 is  
24 turned, rotating the drum 32 with respect to the spiral cam surface  
25 28a and thus varying the initial effective lever arm, in order to  
26 compensate for changes in the load. According to a further aspect



1 of the invention, the rate of change of the lever arm provided by  
2 the spiral cam surface is altered as beads of increasing diameter  
3 gradually engage the spiral cam surface. For example, as the table  
4 top is lowered, beads of increasing diameter engage the spiral cam  
5 surface, effectively reconfiguring the spiral cam surface. In this  
6 way, the rate of change of the lever arm occurring as the drum  
7 turns is appropriate, i.e., responsive to the initial lever arm  
8 selected corresponding to the load. The result of thus  
9 reconfiguring the spiral shape is to render the effort needed to  
10 lift or lower the table top more consistent throughout its travel.

11 In a successfully-tested embodiment of the invention the beads  
12 are located such that, with the initial level arm position  
13 corresponding to a minimum load, the smallest of the beads just  
14 engages the spiral cam surface when the table is fully lowered.  
15 When the initial lever arm setting corresponds to a heavy load,  
16 substantially the entire string of beads engages the cam surface  
17 when the table is fully lowered. However, the exact configuration  
18 and location of the beads is dependent on the precise shape of the  
19 cam surface.

20 As noted, load compensation may be accomplished according to  
21 the invention without extension or compression of spring 22.  
22 Accordingly, the mechanical advantage provided by spur gear 38 is  
23 sufficient that no great strength is required to turn knob 50, and  
24 so that no tools or the like are required. Use of the phrase  
25 "manually operable" in the appended claims thus indicates that no  
26 tools or the like are required in order to adjust the counter-



1 weighting force. If the table is subsequently raised or lowered  
2 the spring provides a corresponding constant counter-weighting  
3 force. The table may be raised or lowered simply by gripping its  
4 edges and lifting or lowering it, as desired, or by a small motor.  
5 Provision of load compensation according to the invention allows a  
6 much less powerful motor to be used than would otherwise be  
7 possible. Friction then retains the table top in the desired  
8 position; alternatively, gripping lock mechanisms may be provided,  
9 for example, locking the supports 14 to the legs 18, or locking the  
10 drum with respect to transverse member 20.

11 It will be appreciated that while the invention has been  
12 described in connection with counter-weighting a table top, it may  
13 have many other uses. For example, a spring counter-weighting  
14 mechanism including the load compensating adjustment feature of the  
15 invention may be employed as a "tool balancer" that is readily  
16 adjustable to provide varying tension on a cable, to support a wide  
17 variety of tools. A spring counter-weighting mechanism with the  
18 load compensating adjustment feature of the invention may be  
19 employed as a load in an exercise machine; in this case the load  
20 compensator would provide a convenient means for adjusting the  
21 resistance experienced by the athlete in exercising, while the  
22 snail cam would provide a constant resistance to be overcome in  
23 performance of the exercise. Alternatively, the cam could be  
24 reshaped to provide a load varying to suit particular biomechanical  
25 requirements. Many other uses of the invention may be made.



1 Further, it will be appreciated that numerous other  
2 embodiments of the invention are within its essential spirit and  
3 scope. For example, while a pair of cables wrapped about a drum is  
4 a convenient way to translate torque from snail cam 28 into a  
5 constant counter-weighting force, other methods are satisfactory  
6 for doing so. In essence, the drum acts simply as a fixed-radius  
7 lever arm for translating torque applied by the cam 28 about the  
8 axle 48 to tension on cables 34 and 42. Tension spring 22 could  
9 be replaced with a compression spring. Moreover, other manually  
10 operable devices for varying the respective radial positions of the  
11 snail cam 28 and drum 30 are considered to be within the invention,  
12 where not excluded by the following claims.

13 Therefore, inasmuch as the present invention is subject to  
14 many variations, modifications and changes in detail, it is  
15 intended that all subject matter discussed above or shown in the  
16 accompanying drawings be interpreted as illustrative only and not  
17 be taken in a limiting sense.



What is Claimed Is:

1           1.     A load compensator for a spring counter-weighting  
2 mechanism, said counter-weighting mechanism comprising:

3           a spring arranged to exert tension on a tension member, said  
4 tension varying linearly with extension of said spring;

5           a snail cam journaled for rotation about an axis and  
6 comprising a cam surface for receiving said tension member, said  
7 cam surface effectively spacing the point at which said tension  
8 member contacts said cam surface from said axis by a radial  
9 distance varying continuously radially about said snail cam, such  
10 that a net torque applied to said snail cam due to tension applied  
11 to said tension member by said spring varies with respect to the  
12 point at which said tension member contacts said cam surface; and

13          fixed-radius lever arm means pivotable about an axis and  
14 adapted to receive torque exerted on said snail cam by said tension  
15 member and to transfer said torque from said snail cam to means for  
16 exerting a constant counter-weighting force on a load to be  
17 counter-weighted;

18          said load compensator comprising means for controllably  
19 varying the relative radial positions of said snail cam with  
20 respect to said lever arm means.

1           2.     The load compensator of claim 1, wherein said lever arm  
2 means and said snail cam are coaxially mounted for free rotation on  
3 a single first axle, said first axle being journaled for rotation  
4 with respect to a fixed frame member, and said means for



5 controllably varying the relative positions of said snail cam and  
6 said lever arm means comprising a pinion gear fixed to said axle  
7 effectively engaging gear teeth fixed to said lever arm means, and  
8 a manually operable means for turning said axle with respect to  
9 said snail cam and lever arm means, whereby said snail cam may be  
10 controllably rotated with respect to said lever arm means.

1 3. The load compensator of claim 2, wherein said pinion gear  
2 engages a spur gear engaging gear teeth fixed to said lever arm  
3 means.

1 4. The load compensator of claim 3, wherein said spur gear is  
2 engaged by said pinion gear and by an internally-toothed ring gear,  
3 said ring gear comprising said gear teeth fixed to said lever arm  
4 means.

1 5. The load compensator of claim 4, wherein said spur gear is  
2 journaled to rotate freely about a stub axle, said stub axle being  
3 fixed to said snail cam at a point radially spaced from said first  
4 axle, whereby rotation of said pinion gear drives said spur gear  
5 around said internally toothed ring gear, rotating said snail cam  
6 with respect to said lever arm means.



1        6. The load compensator of claim 4, comprising a grippable  
2 handle fixed to said first axle to facilitate rotation of said  
3 pinion gear and consequent rotation of said snail cam with respect  
4 to said lever arm means.

1        7. The load compensator of claim 4, wherein said lever arm  
2 means is a drum supported for free rotation on said first axle, and  
3 said internally-toothed ring gear is mounted to said drum.

1        8. The load compensator of claim 7, wherein said means for  
2 exerting a constant counter-weighting force comprises at least one  
3 flexible tension member extending at least partially around said  
4 drum.

1        9. The load compensator of claim 1, wherein said tension  
2 member is a flexible cable wrapped around said snail cam along said  
3 cam surface, one end of said cable being fixed to said spring.

1        10. The load compensator of claim 9, wherein the other end of  
2 said cable is anchored to said lever arm means to transfer torque  
3 from said snail cam to said lever arm means.

1        11. The load compensator of claim 9, further comprising means  
2 for effectively reconfiguring the cam surface of said snail cam  
3 during a portion of the rotation of said snail cam.



1        12. The load compensator of claim 11, wherein said means for  
2 effectively reconfiguring the cam surface of said snail cam  
3 comprises a series of beads of gradually increasing outer diameter  
4 fitting over a portion of said cable.

1        13. Counter-weighting mechanism for counter-weighting a load  
2 movable vertically with respect to a fixed member, comprising:

3        a spring secured at one end with respect to said fixed member;

4        a snail cam freely pivoting about a first pivot axis fixed to  
5 said fixed member, said snail cam comprising a spiral cam surface  
6 disposed at a smoothly varying radial distance from said axle;

7        a drum freely pivoting about a second pivot axis fixed to said  
8 fixed member;

9        means for transmitting torque from said snail cam to said  
10 drum;

11       means for transmitting a constant counter-weighting force from  
12 said drum to said load;

13       flexible tension means fixed at one end with respect to a  
14 second end of said spring, and adapted to be wrapped about said  
15 snail cam so as to rest on said spiral cam surface to exert torque  
16 on said snail cam; and

17       manually operable means for altering the relative radial  
18 positions of said snail cam with respect to said drum, whereby said  
19 constant counter-weighting force may be altered without the use of  
20 tools.



1        14. The mechanism of claim 13, wherein said drum and said  
2 snail cam are coaxially supported for free rotation about a single  
3 axle, whereby said first and second pivot axes coincide.

1        15. The mechanism of claim 14, wherein a pinion gear is fixed  
2 to said axle, said pinion gear effectively engaging gear teeth  
3 fixed to at least one of said drum and said snail cam, whereby  
4 rotation of said axle alters the relative radial positions of said  
5 snail cam and said drum.

1        16. The mechanism of claim 15, wherein said manually operable  
2 means comprises a manually grippable handle fixed to said axle for  
3 rotating said axle with respect to said fixed member.

1        17. The mechanism of claim 15, wherein said pinion gear  
2 engages a spur gear, and said spur gear engages internal teeth  
3 fixed to said drum, whereby rotation of said pinion gear is  
4 effective to cause said spur gear to pivot about said axle and to  
5 alter the relative radial positions of said drum and said snail  
6 cam.

1        18. The mechanism of claim 17, wherein said spur gear is  
2 received in a recess formed in one end of said drum, said internal  
3 teeth fixed to said drum forming the circumferential inner surface  
4 of said recess.



1        19. The mechanism of claim 17, wherein a stub axle is fixed  
2 to the center of said spur gear, said stub axle extending through  
3 a bore in said snail cam spaced radially from said first axle.

1        20. The mechanism of claim 13, wherein said load comprises a  
2 table top and supporting structure, and said fixed member comprises  
3 a stationary transverse frame member of said table extending  
4 horizontally between laterally spaced legs of said table.

1        21. The mechanism of claim 20, wherein said drum and said  
2 snail cam rotate freely about an axle extending horizontally from  
3 and rotating with respect to said transverse frame member.

1        22. The mechanism of claim 20, wherein said means for  
2 transmitting a constant counter-weighting force from said drum to  
3 said load comprises at least one flexible cable wrapped around and  
4 secured to said drum and fixed at one end to said table top and at  
5 the other to a vertically extending table top support member, said  
6 cable passing over pulleys fixed to said frame of said table, such  
7 that torque exerted on said drum responsive to force exerted on  
8 said snail cam by said spring and transmitted from said snail cam  
9 to said drum tends to urge said table top upwardly.

1        23. The mechanism of claim 22, wherein two such flexible  
2 cables are provided, one end of each being fixed to said table top  
3 at opposite lateral sides thereof and the other end of each being



4 fixed to vertically extending structure supporting said table top  
5 at opposite lateral ends thereof, said cables being wrapped upon  
6 said drum so as to move cooperatively upon rotation of said drum to  
7 raise said table top equally at both lateral ends.

1 24. The mechanism of claim 13, wherein said spring is a  
2 tension spring.

1 25. The load compensator of claim 13, further comprising  
2 means for effectively reconfiguring the cam surface of said snail  
3 cam during a portion of the wrapping of said flexible tension means  
4 over said cam surface.

1 26. The load compensator of claim 25, wherein said means for  
2 effectively reconfiguring the cam surface of said snail cam  
3 comprises a series of beads of gradually increasing outer diameter  
4 fitting over a portion of said flexible tension means.



FIG. 1

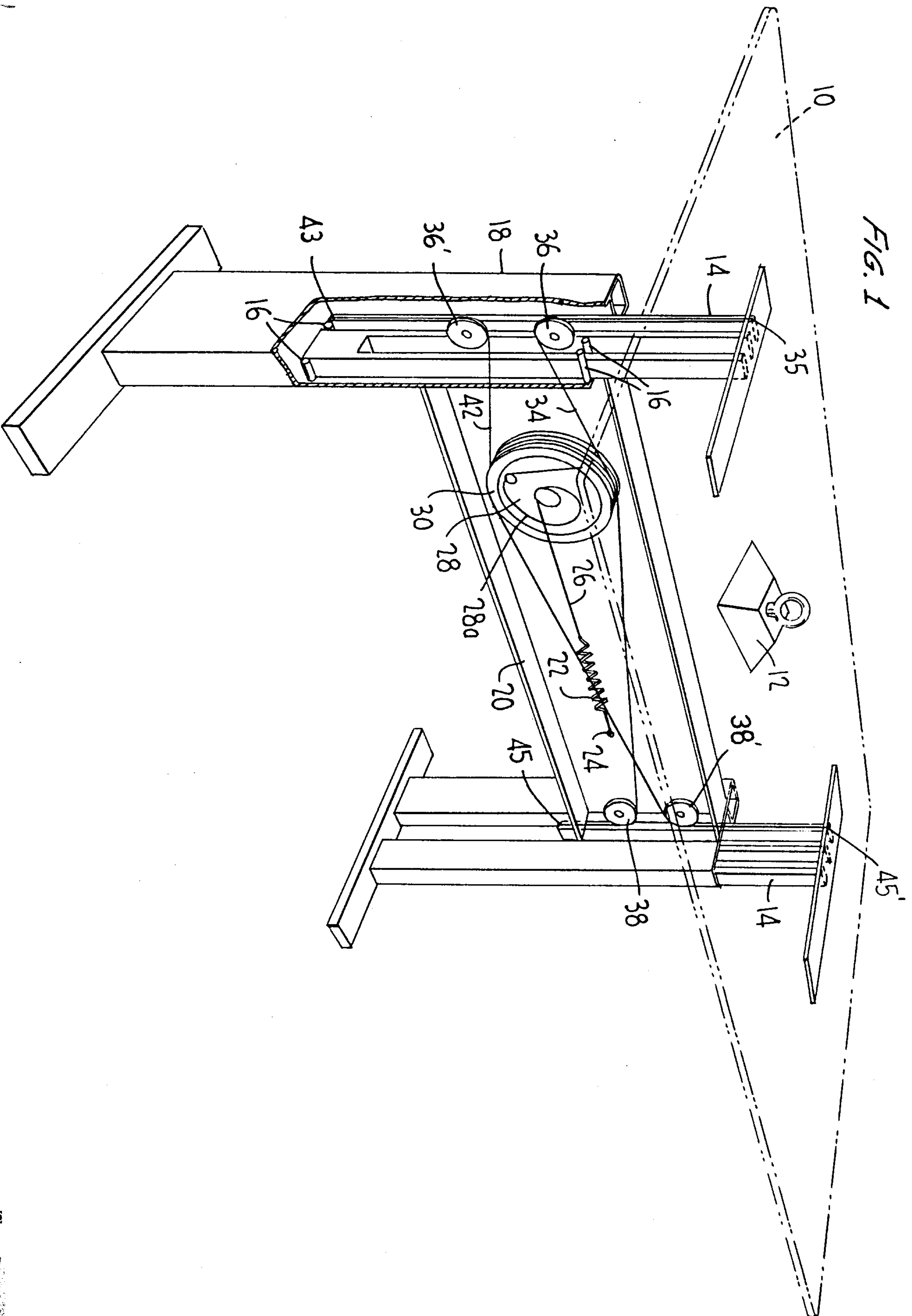
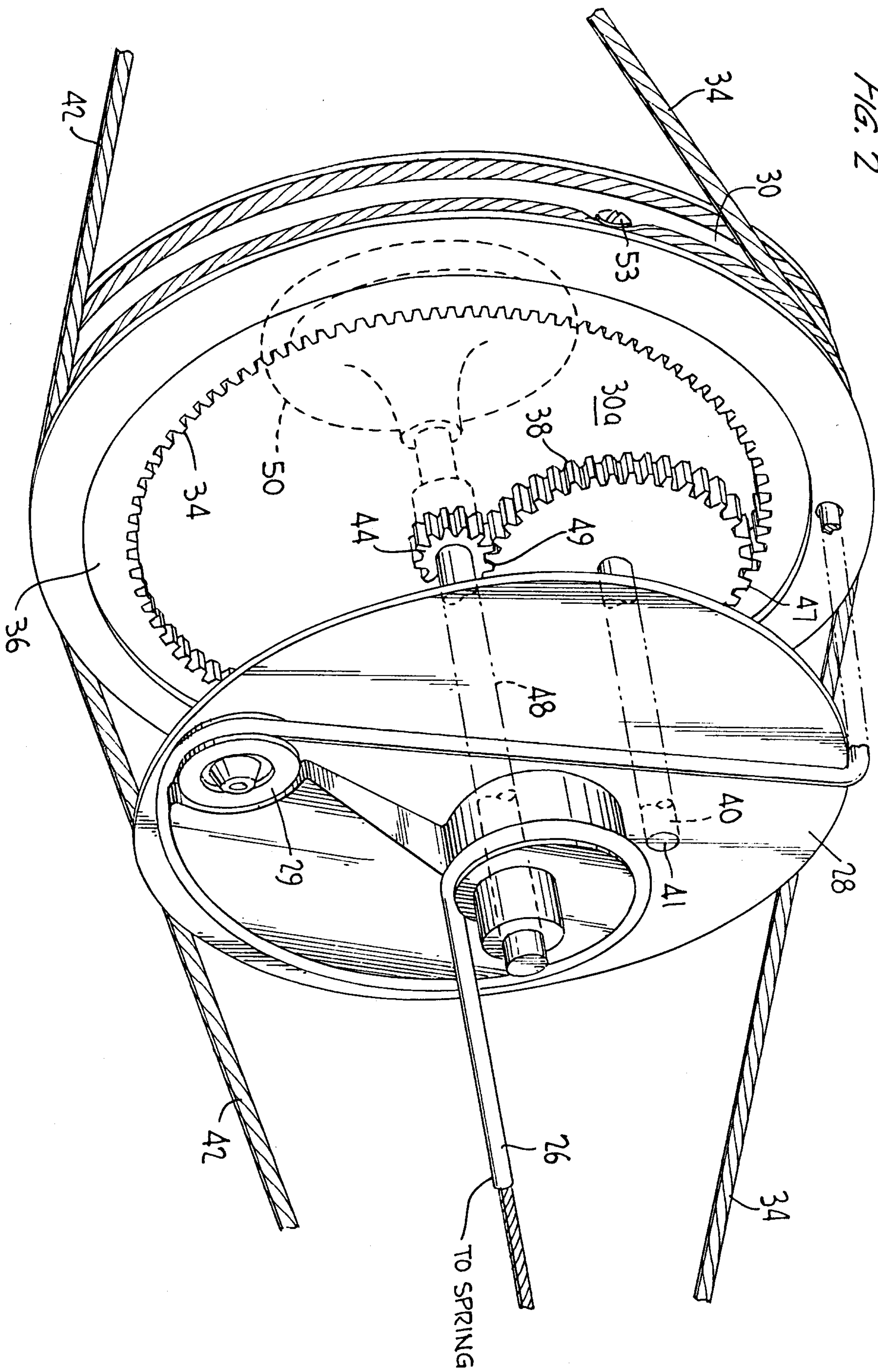




FIG. 2





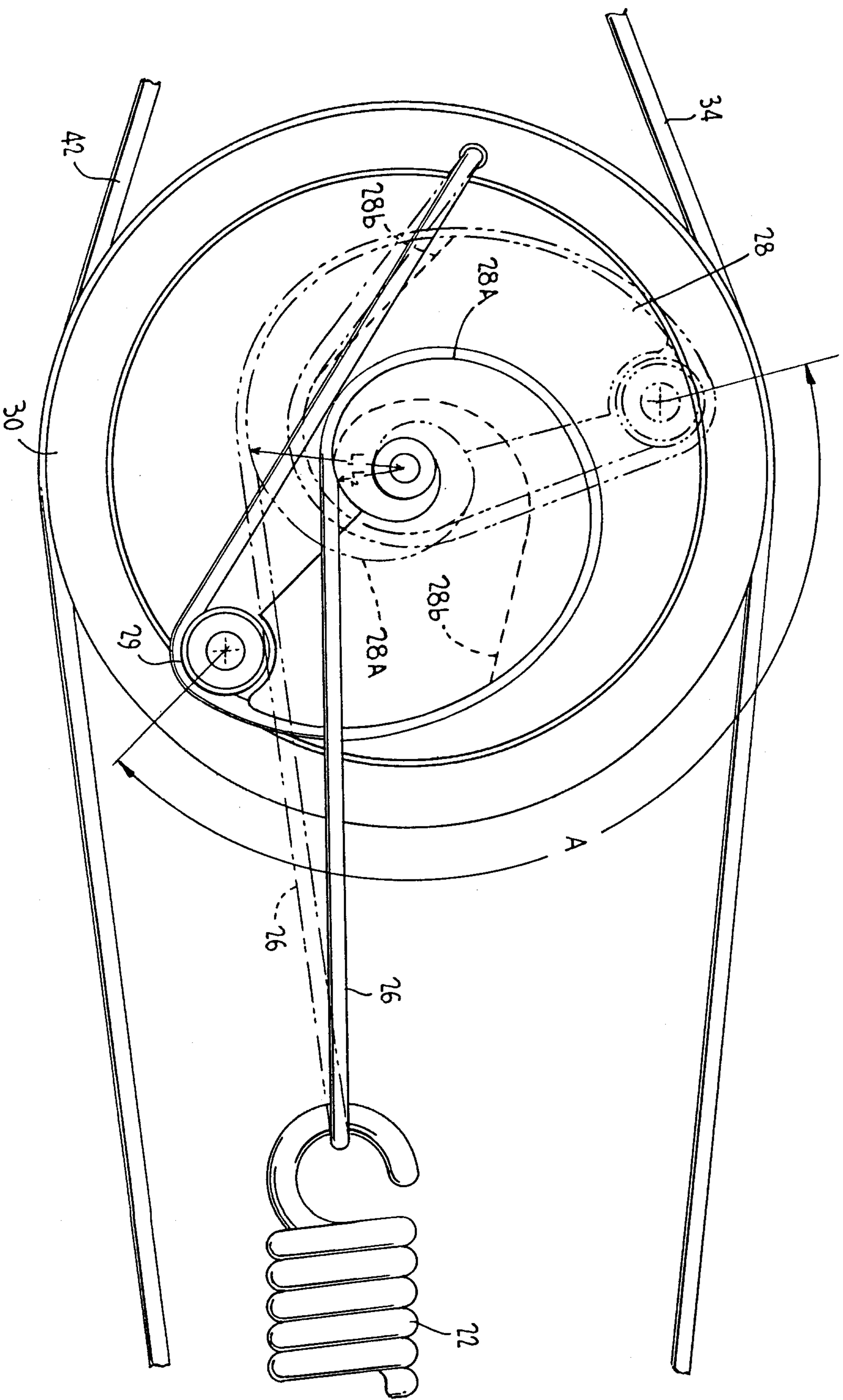


FIG. 3



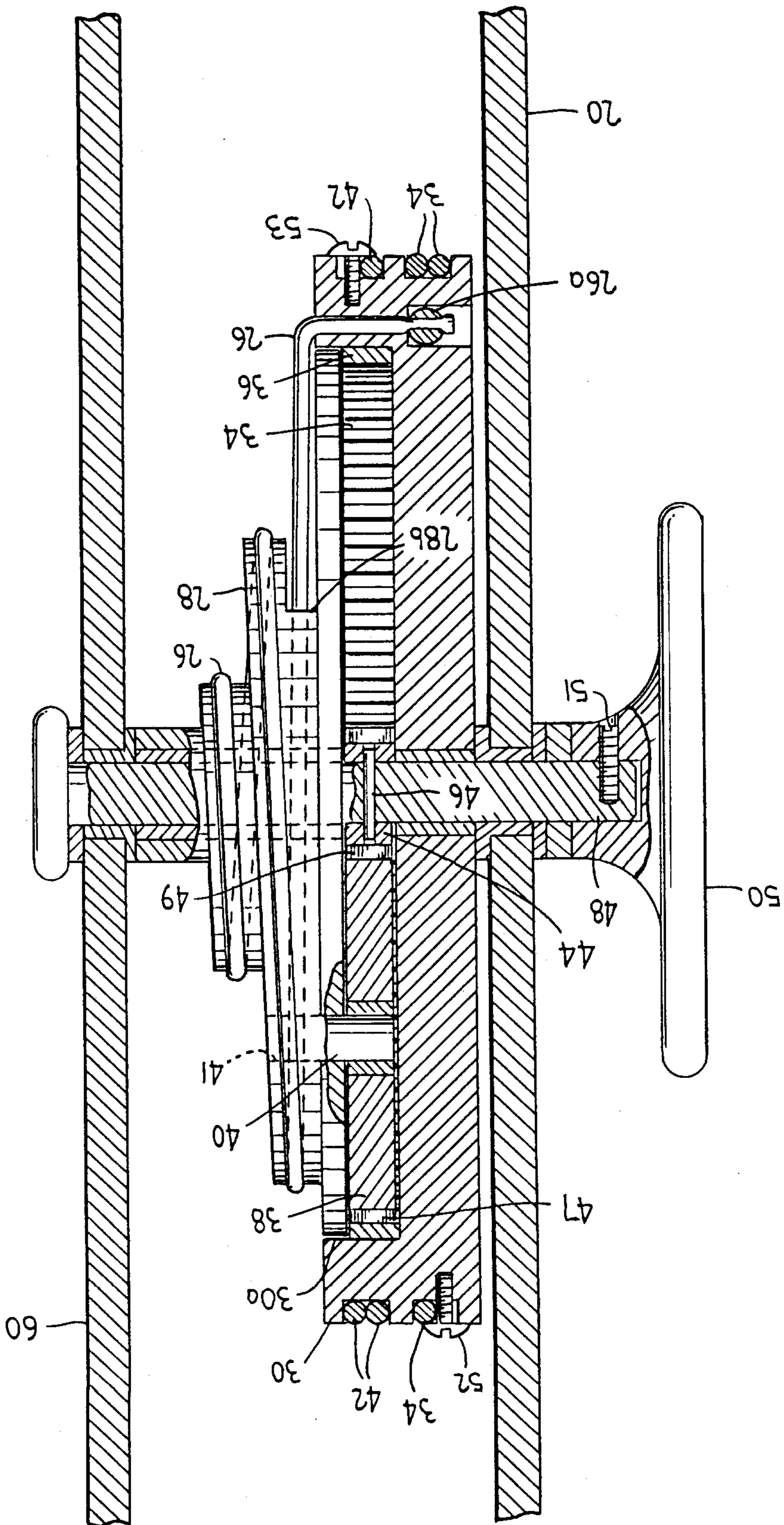


FIG. 4



FIG. 5

