

[54] **LINEAR ACTUATOR SYSTEM WITH REVERSING MEANS**

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**Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 50,620, June 29, 1970.

[52] U.S. Cl. .... **74/25, 128/57**

[51] Int. Cl. .... **F16h 21/16**

[58] Field of Search ..... **74/25, 37, 89; 128/51, 52, 128/57**

[56] **References Cited**

**UNITED STATES PATENTS**

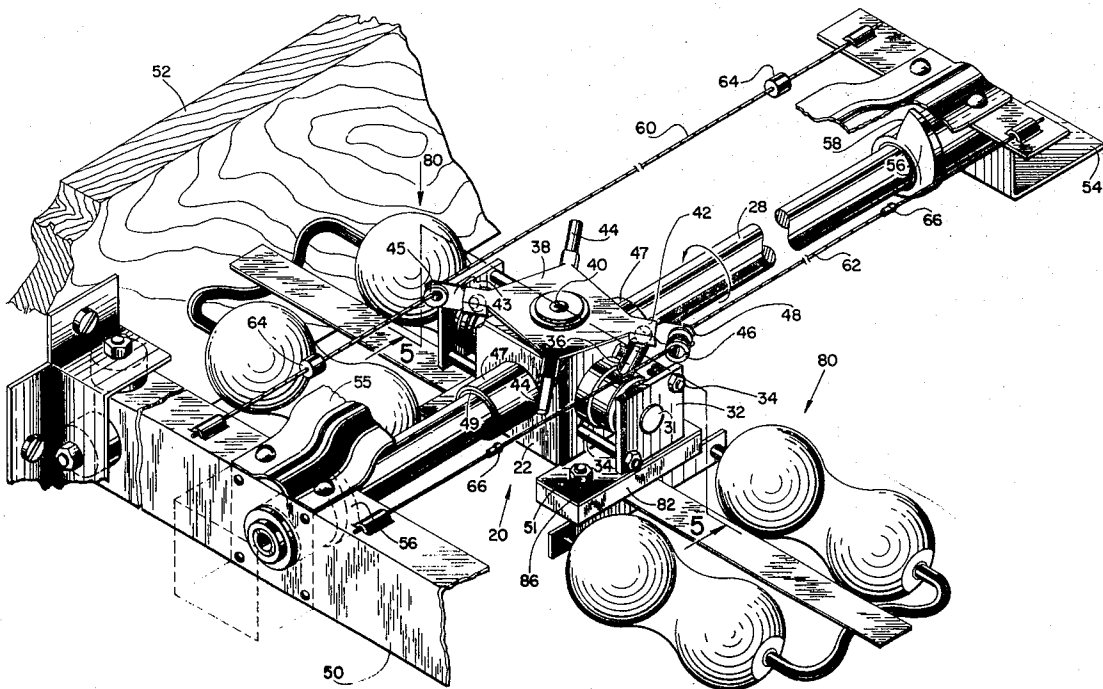
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| 402,674   | 5/1889 | Judson .....   | 74/25 |
| 2,204,638 | 6/1940 | Weathers ..... | 74/25 |
| 3,434,357 | 3/1969 | Roantree ..... | 74/25 |

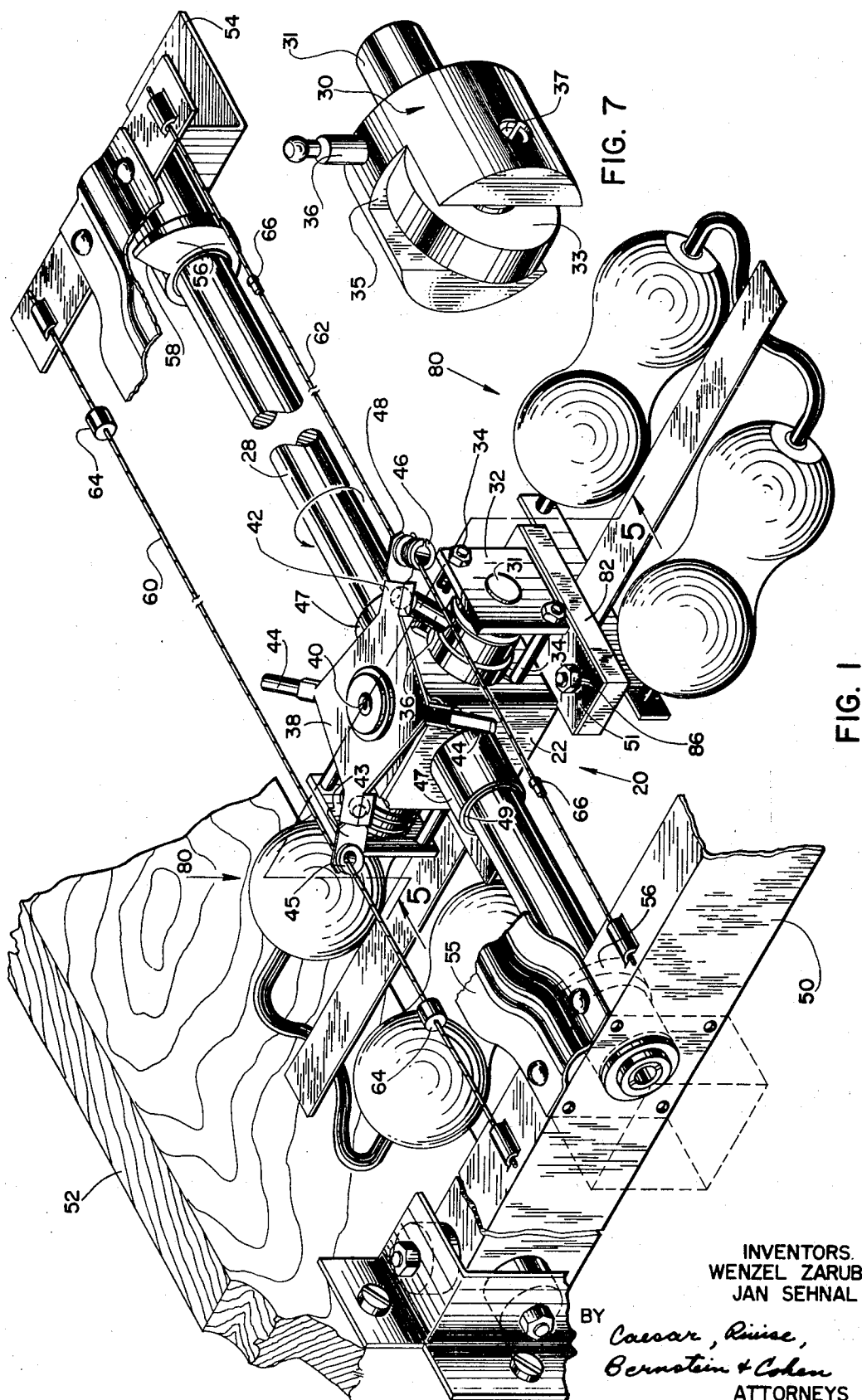
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[57] **ABSTRACT**

A linear actuator system with reversing means including a housing with a lateral opening to receive a rotating shaft that passes through the opening. A plurality of wheels are disposed against the shaft for initiating and controlling linear movement of the housing with respect to the rotating shaft, with the wheels being resiliently urged against the shaft. When the housing approaches either end of the shaft, it is caused to reverse and move in the opposite direction by means of contact with one or more studs located on wires that pass through the housing with stud contact causing a control member to be pivoted and thereby reverse the direction of the wheels. This in turn causes a reversal of movement of the housing. Friction balls are also provided on another wire that passes through the housing with the friction balls assuring a satisfactory reversal of the control member.

**10 Claims, 12 Drawing Figures**





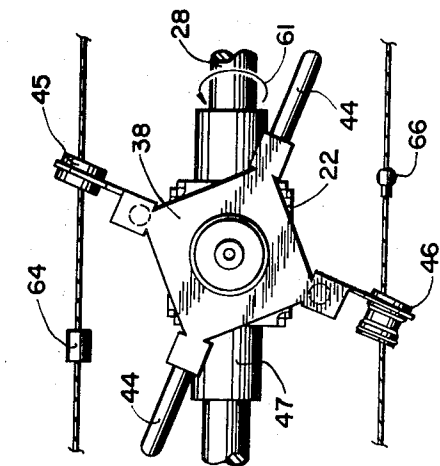


FIG. 4

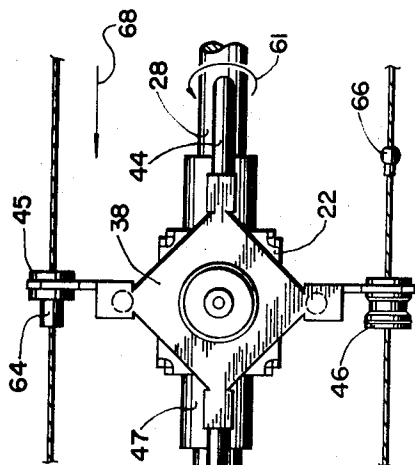


FIG. 3

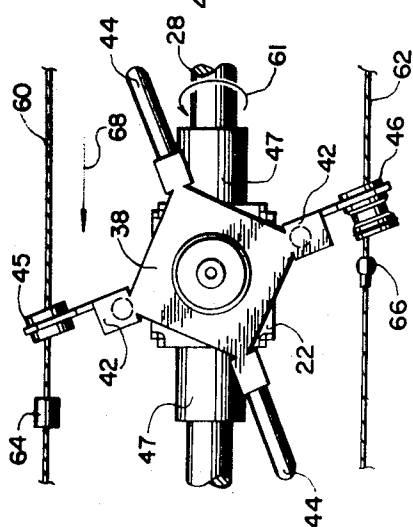


FIG. 2

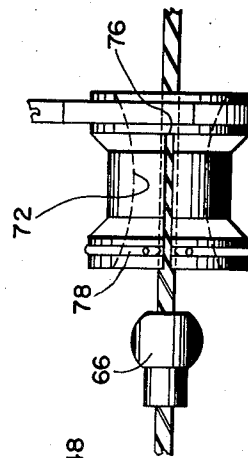


FIG. 6

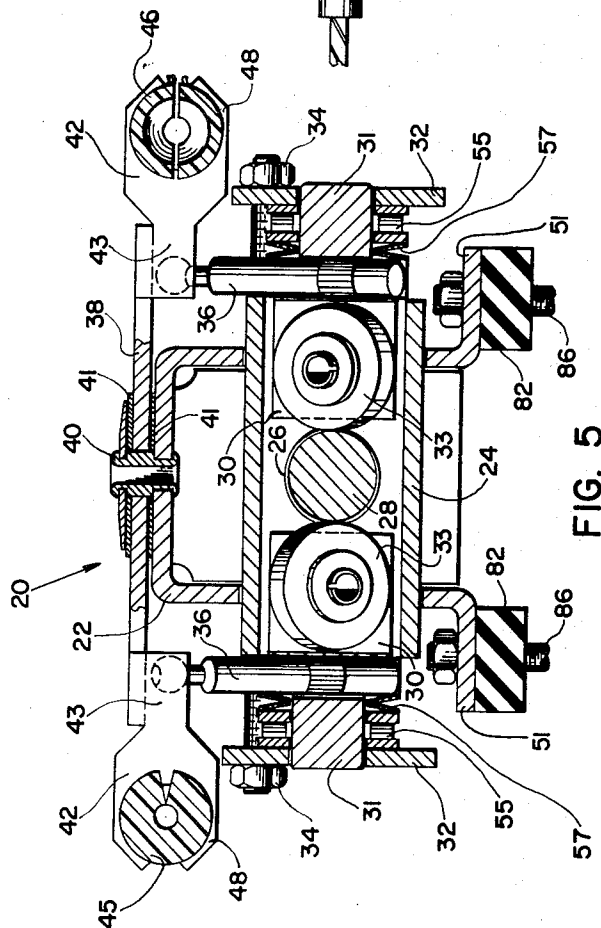


FIG. 5

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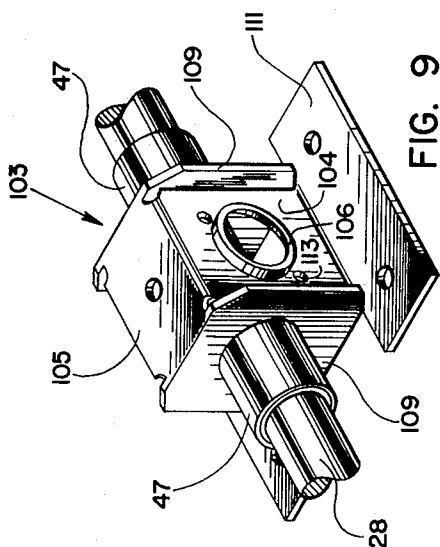


FIG. 9

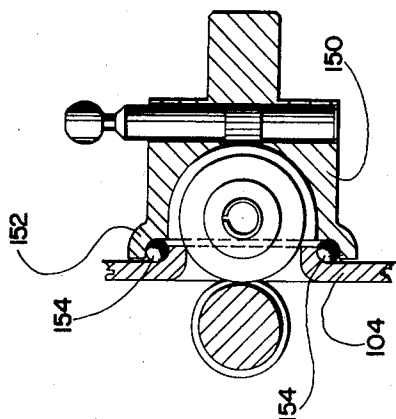


FIG. 12

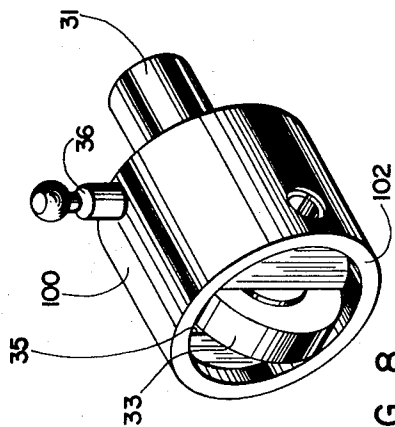


FIG. 8

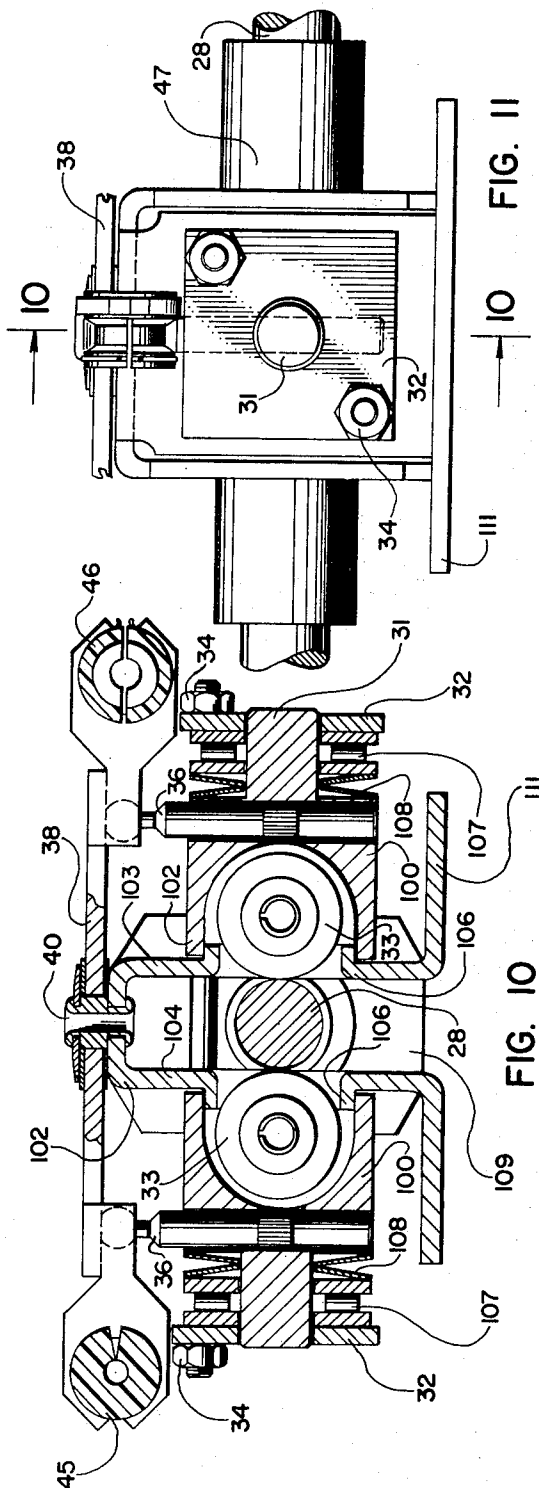


FIG. 10

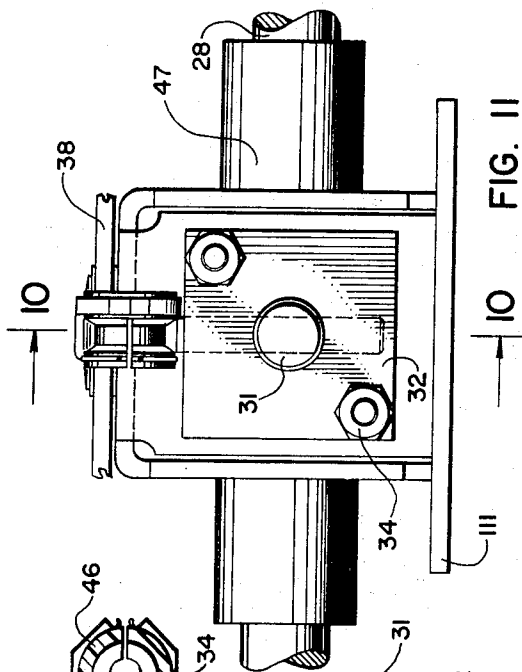


FIG. 11

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## LINEAR ACTUATOR SYSTEM WITH REVERSING MEANS

This application is a continuation-in-part application based on application Ser. No. 50,620, filed June 29, 1970, entitled "Reciprocating Linear Actuator."

This invention relates to a linear actuator system with reversing means and has as its objective the provision of a new and improved device of this general class.

Until recently, linear actuators were provided with a screw drive so that rotational movement would be used to initiate linear movement.

However, the shortcomings of a screw drive were long recognized. First, the ratio of linear displacement to angular displacement could be changed only by securing a screw drive having threads of a different pitch. Second, the thrust of the shaft will remain constant for the rate of rotation of the shaft. Also, the direction of linear movement can be changed only by changing the direction of shaft rotation.

The foregoing difficulties were overcome by devices shown in both Zaruba U.S. Pat. No. 3,473,393 and Steibel U.S. Pat. No. 3,475,972.

In the Zaruba Patent there was provided a linear actuator which comprised a plurality of wheels in contact with a rotating shaft, with the pitch of the wheels being adjustable and changeable in order to change the rate of movement and direction of linear displacement of the rotating shaft.

In Zaruba co-pending application Ser. No. 851,421, filed Aug. 19, 1969 now U.S. Pat. No. 3,638,504, there were introduced several improvements including a pressure controlled diaphragm by which the pressure of the wheels against the shaft could be varied from a remote source, and thus the thrust of the linear actuator could be varied from a remote source.

With the principle of the modern linear actuator now established, it has become important to develop economies in the device in order to hasten its use in industry.

In view of the foregoing, co-pending application Ser. No. 50,620 disclosed and claimed a reciprocating linear actuator having a housing receiving a tubular member having a lateral opening with a shaft passing through the opening. A plurality of wheels were also mounted in the housing with the wheels being disposed against the shaft for initiating and controlling linear movement of the housing with respect to the shaft that is rotated by the source of power. The housing was made of a special sheet metal construction, and the wheels were urged against the shaft by a single spring in a special novel arrangement.

In use, the reciprocating linear actuator could be made a part of a carriage assembly of a therapeutic massaging chair, and could be fitted with shock absorbers so that reversal of movement for the chair can be achieved in a silent manner.

In said application Ser. No. 50,620, a spring was utilized to draw a control member to a reversed position utilizing an over-the-center action to reverse the pitch of the wheels in order to reverse the movement of the housing. While the device of said application Ser. No. 50,620 has proved to be quite satisfactory, nevertheless, it has become desirable to eliminate the spring associated with the control member since it is believed that over a period of time the spring will wear out.

Further attention is called to co-pending Zaruba application Ser. No. 50,621, filed June 29, 1970, entitled

"Linear Actuator with Yoke Actuated Pitch Control."

In this application there was disclosed a linear actuator with yoke actuated pitch control having a housing for receiving a plurality of yokes each including a wheel, the housing further having an opening to permit the passage of a rotatable power driven shaft with each of said wheels being resiliently urged against said shaft and means being provided to vary the pitch of the wheels with respect to said shaft. Each of the pitch varying means were interconnected to a control shaft that extends from the housing. The control shaft was turned by movement of a lever connected to the control shaft which afforded a relatively large mechanical advantage. The pressure of the wheels against the power shaft was changed by means of fluid pressure. The entire device was contained in an impervious housing.

In view of the foregoing, it is an object of the present invention to provide a linear actuated system with reversing means which can be manufactured at a cost that is competitive with similar devices that have already been proposed.

Yet another object of the present invention is to provide a linear actuator system with reversing means in which the pitch of the wheels can be varied or the direction of the linear actuator reversed while the device is in use.

Still another object of the present invention is to provide a linear actuator system with reversing means which eliminates the necessity to utilize a spring member in connection with the control member that gives rise to a reversing action.

Still another object of the present invention is to provide a linear actuator having pairs of opposing wheels to increase thrust and provide a more positive switching action.

The foregoing as well as other objects of the invention are achieved by providing a linear actuator system with reversing means including a housing that has a lateral opening to receive a rotating shaft and wherein a plurality of wheels are resiliently urged against the shaft. The wheels initiate and control linear movement of the housing with respect to the rotating shaft. As the housing approaches either end of the shaft, a control member causes the housing to reverse and move it in the opposite direction. This occurs by contact between the control member and a stud that is located on a wire that passes through the housing. Friction balls are provided on another wire that pass through the housing in order to assure a satisfactory reversal of the control member. The pitch of the wheels is changed in accordance with the movement of the control member.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of a linear actuator system with reversing means constituting an embodiment of the present invention;

FIGS. 2, 3 and 4 are plan views of various positions of the linear actuator along the rotating shaft in order to illustrate the reversing action;

FIG. 5 is a sectional view taken along the lines 5—5 of FIG. 1;

FIG. 6 is an enlarged elevational view showing the friction ring that extends from the control member when the friction ring is in close proximity with a friction ball;

FIG. 7 is a perspective view of a yoke which holds the shaft contacting wheel;

FIG. 8 is a view similar to FIG. 7 but showing another type of yoke that is used in the embodiment of FIG. 10;

FIG. 9 is a perspective view of an alternate housing with the yoke and certain other portions of the actuator assembly removed for the sake of clarity;

FIG. 10 is a sectional view taken along the lines 10—10 of FIG. 11;

FIG. 11 is a side elevational view of another embodiment of the present invention; and

FIG. 12 is a sectional view showing yet another type of yoke which uses ball bearings between the lowermost flange of the yoke and the flange extending from the inner housing of the linear actuator.

Referring now in greater detail to the various figures of the drawings wherein like reference characters refer to like parts, there is shown at 20 in FIG. 1 a linear actuator system with reversing means constituting a first embodiment of the present invention. The linear actuator 20 basically comprises a rectangular housing 22 having a transversely extending cylindrical tube 24 (FIG. 5).

Tube 24 is continuous with the exception of centrally disposed openings 26 on opposed sides of the tube 24, with the openings 26 accommodating rotating shaft 28.

As further seen in FIG. 5, yoke assemblies 30 (such as shown in FIG. 7) are maintained within tube 24 by means of plates 32. The plates 32 are drawn together by means of bolts 34 which extend through appropriate openings in housing 22.

As seen in FIG. 7, the yokes 30 include stems 31 that are received in the plates 32 (FIG. 1). Wheels 33 are revolvably mounted within slot 35 in yokes 30 by means of connectors 37. As further seen in FIG. 7, each of the yokes 30 also includes a control pin 36 that is used to control the pitch of the wheel 33 within the yoke 30.

With further reference to FIG. 1, it will be seen that a rectangular control member 38 is provided at the top of housing 22, with the control member 38 being pivotally connected to the housing 22 by rivet 40. It will be seen in FIG. 5 that the pivotal securement of the plates 38 to the top of housing 22 also includes a pair of bearing surfaces 41 in order to minimize the effects of wear so that the linear actuator will have a long life.

It will be seen from FIGS. 1 and 5 that the control member 40 possesses at two of its corners, U-shaped corner portions 42, each of which include a pair of arms 43 which rotatably embrace one of the control pins 36. Thus, rotation of control member 38 is automatically conveyed to the control pins 36 which in turn will change the path of the wheels 33.

As further seen in FIG. 1, the other two corners of the control member 38 possess projections 44, the purpose of which will be discussed hereinafter.

It is to be noted that the corner portions 42 of the control member 38 possess rings 45 and 46 that are held by brackets 48. The rings 45 and 46 receive guide wires 60 and 62 as will be discussed hereinafter.

A cylindrical collar 47 is integrally secured to each end wall of housing 22. Collars 47 extend longitudinally of the shaft 28 and include a cylindrical bearing 49 (FIG. 1) which is provided on the inner surface of the bore of the collar. The collars 47 slidably embrace the cylindrical shaft 28 and maintain the housing in a substantially fixed position radially with respect to the shaft.

The housing 22 also includes a pair of flanges 51 which are integral with and extend transversely to the side walls of the housing. The flanges 51, as will be seen hereinafter, act to enable securement of ball carriages or other loads to the linear actuator.

As best seen in FIG. 5, the plates 32 each have an opening to accommodate stem 31. The stem 31 of each of the yokes has telescoped thereover a needle bearing 44 and springs 57. The needle bearings 55 enable the yokes 30 to rotate with respect to the plates 32. Springs 57 act to enable a resilient urging of the wheels against the shaft 28 and further act to assure an equalization of the forces between both wheels 33 and shaft 28.

It will be seen from FIG. 1 that the rotating shaft 28 is mounted on an arm that includes an L-shaped rail 50 that is secured to the wooden frame portions 52 of a massaging chair. The other end of the shaft 28 is supported by another L-shaped rail 54. Rails 50 and 54 are connected by a longitudinally extending bracket 55. Each end of shaft 28 possesses a cam-like engaging member 56 that has an engaging edge 58 which extends radially from the shaft 28.

A pair of wires 60 and 62 extend between the rails 50 and 54, with the wires 60 and 62 passing through engaging ring 45 and friction ring 46, respectively. The wire 60 is fitted with fixed studs 64 adjacent each end thereof. The wire 62 is fitted with fixed friction balls 66 adjacent each end thereof.

The reversal of the control member 28 is best seen from an inspection of FIGS. 2, 3 and 4 wherein shaft 28 is rotating in a clockwise sense as indicated by arrow 61. With reference to FIG. 2, it will be seen that the housing 22 is moving from right to left in the direction of arrow 68 by virtue of the rotation of shaft 28 and the engagement of wheels 33 in accordance with Zaruba U.S. Pat. No. 3,473,393 and the co-pending applications hereinabove specified, the disclosures of which are expressly incorporated by reference herein.

Movement of housing 22 in the direction of arrow 68 continues until the engaging ring 45 abuts stud 64 as shown in FIG. 3. When this occurs, further right to left movement in the direction of arrow 68 has the effect of causing the control member 38 to pivot in a clockwise sense and this in turn changes the pitch of the wheels 33 with respect to the rotating shaft 28. When the control member 38 reaches the position of FIG. 3, the wheels 33 lie in a plane that is perpendicular to the axis of shaft 28 and the control member 38 is in the neutral position.

As the control member 38 approaches the position of FIG. 3, the cam member 56 which rotates with shaft 28 at the end of the housing will be in a position to abut one of the pins 44 extending from the control member 38. The edge 58 of the cam member 56 contacts the pin 44 and carries the control member 38 past the dead center point in order to achieve a good switching action.

It should be noted that before the control member 38 was rotated from the position of FIG. 2 to the position of FIG. 3, that the friction ring 46 had cleared friction ball 66 in moving from right to left from the position of FIG. 2 to the position of FIG. 3. Thus, as the housing 22 starts to move from left to right in FIG. 4, it is necessary for the friction ring 46 again to clear the friction ball 66. However, there will be some drag or friction as the ring 46 moves about the ball 66 and this further insures that the control member 38 has been completely pivoted from the position of FIG. 2 to the position of FIG. 4.

The friction ring 46 and the friction ball 66 are best seen in FIG. 6. The internal surface of the friction ring 46 is lined with a bearing surface, such as a well known plastic material sold under the Trademark "DELRIN" or "TEFLON." The internal surface of the friction ring 46 is generally cylindrical, but somewhat convex with an inner bore 72 that is narrowest at the center of the friction ring and which flares outwardly at each direction from the center.

As further seen in FIG. 6, the friction ring 46 further includes a transversely extending slot that extends diametrically through the friction ring 46 until the point 76 is reached. It follows that the portion of the friction ring 46 to the right of point 76 (as viewed in FIG. 6) is a unitary ring whereas the portion of the friction ring 46 to the left of point 76 is actually presented in two halves or as a split ring. This enables the left side of the friction ring 46 to spread as it passes over the friction ball 66. A C-spring 78 is slipped about the left side of the friction ring 46 in order to provide a degree of resiliency in the split ring side of the friction ring 46 so that the two halves will return together after the friction ring 46 has passed over the friction ball 66.

With reference again to FIG. 1, it will be seen that ball carriages 80 are secured to blocks 82 which are suitably secured by fasteners 86 to flanges 51. The ball carriages 80 are utilized to provide a massaging action within the back of a therapeutic chair. The ball carriages 80 ride on the rear surface of the backrest of a chair in a well known manner, with the ball carriages 80 acting to maintain the housing 22 against rotation with respect to the shaft 28, and the ball carriages 80 also act to guide the housing 22 along the shaft 28.

Alternate embodiments of the invention are shown in FIGS. 8 to 12 inclusive. In FIG. 8, a yoke 100 is shown which is essentially cylindrical. Yoke 100 is substantially similar to yoke 30 with the exception of the cylindrical wall provided about the yoke 30 which results in a flange 102 which extends beyond the slot 35 of the yoke. That is, the yoke 100 includes stem 31 and wheel 33 and is otherwise similar to yoke 30.

Also, yoke 100 includes control pin 36 which extends through the cylindrical outer wall of yoke 100 to the inner yoke. A pair of yokes 100 are provided in the alternate housing 103.

As best seen in FIGS. 9 and 10, housing 103 includes a pair of walls 104 which extend parallel to shaft 28. Walls 104 are connected together by an integral top wall 105 which also extends parallel to the shaft and a pair of end walls 109 which extend transversely to the shaft and walls 104 and 105. Cylindrical collars 47 are secured to each of the walls 102 and extend longitudinally of shaft 28.

A pair of flanges 111 which extend transversely to walls 104 and are integral therewith are also provided for enabling mounting of the housing to a carriage assembly or other load. Each of the walls 104 includes an annular flange 106 that extends perpendicular to the walls 104 and radially from shaft 28.

As best seen in FIG. 10, when yokes 100 are secured to the housing, the flanges 106 of walls 104 extend inwardly of the flange 102 of each yoke 100 with the flanges 106 extending between the flanges 102 and wheels 33. The yoke 100 are thus journaled by flanges 102 about the flanges 106.

The construction of the housing 103 is otherwise similar to the construction of housing 102 with a pair of openings 113 being provided in walls 104 which are aligned with respect to each other and which accommodate the fasteners 34 which are utilized to draw plates 32 together to secure therein needle bearings 107 and spring members 108 which are mounted over stems 31 of the yokes 100.

The control pins 36 are operatively engaged by control plates 38 in the same manner as that in housing 22 of the preferred embodiment. Similarly, the control plate 38 is pivotably secured to the top wall of the housing via rivet 40 and also includes rings 45 and 46 which are utilized to accommodate the wires 60 and 62. The wires 60 and 62 include studs and friction balls as in the main embodiment and are utilized to reverse the direction of the linear actuator housing as the shaft 28 rotates.

A still further embodiment of a yoke is shown in FIG. 12 wherein the yoke 150 includes a flared flange 152 that is flared so that it can accommodate balls 154 to provide a frictionless engagement between the flange of the housing and the yoke. In both the embodiment of FIGS. 10 and 12, a flange acts to abut the walls 104 of the housing after the wheels 33 have become somewhat worn. Thus, the presence of flanges 106 and 152 serve to prevent undue wear on the shaft which would occur as a result of the wearing down of the wheels 33 which would start to scratch the surface of shaft 28.

From all of the foregoing, it can be seen that the embodiments of the invention as set forth hereinabove greatly minimize manufacturing cost. Furthermore, the structures of the present invention permit relatively easy replacement of the wheels and the yoke without having to remove the shaft 28 from its mounting on the frame of L-shaped rails 50. Instead, it is a relatively simple matter to remove the screws 34, and after this is done, the plate 32 can be removed. The yoke is then removed from either tube 24 or away from the flanges of the walls 104 of housing 103 in the embodiment of FIG. 10.

Furthermore, with the present invention, the tube 24 can be easily removed and the yoke is so constructed in FIGS. 10 and 12 as to prevent scratching of the shaft 28 by unduly worn wheels.

The friction ball and studs as well as the housing and other components of the invention are made of metal, plastic or other materials that will occur to those skilled in the art.

From the foregoing, it can be seen that reversal of the housing 22 starts when the engaging ring 45 abuts stud 64 as shown in FIG. 3. This has the effect of initiating a change in the pitch of the wheels 33 with respect

to shaft 28. As the pitch of the wheels nears the neutral position, the engaging member 56 at the end of the housing will be in a position to abut one of the pins 44 extending from control member 38. In particular, the edge 58 of engaging member 56 contacts a pin 44 and this carries the control member 38 past the dead center or neutral point in order to achieve switching action. As the housing now moves in the opposite direction, the friction ring 46 must clear a friction ball 66. The drag or friction that is created as the ring 46 rides about the friction ball 66 insures a complete switching action of control member 38 and insures that the pitch of the wheels 33 is now in the diametrically opposite sense.

Without further elaboration, the foregoing will so fully illustrate our invention that others may, by applying current or future knowledge, readily adapt the same for use under various conditions of service.

What is claimed as the invention is:

1. A linear actuator system with reversing means including a housing having a lateral opening to receive a rotating shaft that passes through said opening, the opposite ends of said shaft being secured for rotation, a plurality of wheels associated with said housing and disposed against said shaft for initiating and controlling linear movement of the housing along said shaft, at least one stud located near the end of said shaft, a control member secured to said housing for controlling the pitch of said wheels with respect to said shaft for movement of said housing along said shaft, said control member having means to contact said stud as said housing approaches one of the ends of said shaft, said contacting means serving to automatically start reversal of the pitch of said wheels with respect to said shaft, and means adjacent to said shaft for engaging said control member to continue reversal of said pitch of said wheels to cause said housing to move in the opposite direction.

2. The linear actuator system of claim 1 including friction balls assuring the complete reversal of said control member.

3. The linear actuator system of claim 2 wherein said studs and friction balls are mounted on support wires, said control member including rings through which said wires pass, one of said rings being adapted to abut said stud and the other ring member being adapted to pass

about one of said friction balls in a friction action.

4. The linear actuator system of claim 3 wherein the internal surface of said friction rings is somewhat convex with a plastic bearing material.

5. The linear actuator system of claim 1 including pin members extending from said control member, and said means adjacent said shaft comprising a cam secured adjacent at least one end of said shaft, said cam being adapted to contact at least one of said pin members to assist in the movement of said control member in order to reverse the direction of said wheels.

6. A linear actuator including a housing having a lateral opening to receive a rotating shaft that passes through said opening, said housing closely surrounding said shaft and having a plurality of annular projections extending radially with respect to said shaft from said housing and each projection having a cylindrical bore, a plurality of holders each having a wheel mounted therein, said holders each having a cylindrical flange which is journaled over one of said projections with said wheel extending into the bore of said projection and means for resiliently urging each of said holders toward said shaft to cause said wheels to bear against the outer periphery of said shaft, the pitch of said wheels being rotatable with respect to said shaft by rotation of said holders about said projections.

7. The linear actuator of claim 6 wherein said housing includes a pair of planar walls which extend parallel to said shaft on diametrically opposed sides thereof, each of said walls including one of said radially extending annular projections.

8. The linear actuator of claim 6 wherein said walls further include at least one opening, a pair of plates, said plates being secured together by a fastening means extending through said openings in said walls for maintaining said holders with said wheels urged against said shaft.

9. The linear actuator of claim 6 wherein said plates are connected to said holders by needle bearings which act to reduce the frictional engagement between said plate and said holder.

10. The linear actuator of claim 6 wherein said cylindrical flange of said holders is flared so that ball bearings can be utilized between said cylindrical flange and said annular projection.

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