

[54] **HOIST OR THE LIKE**

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Related U.S. Application Data

[62] Division of Ser. No. 191,371, Oct. 21, 1971, abandoned.

[52] U.S. Cl. **254/173 R**

[51] Int. Cl. **B66d 1/48**

[58] Field of Search 254/173 R, 174, 184

[56] **References Cited**

UNITED STATES PATENTS

2,228,072	1/1941	Borland	254/173 RX
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Primary Examiner—Richard A. Schacher
Attorney, Agent, or Firm—Carl E. Johnson

[57] **ABSTRACT**

A compact electro-mechanical actuator is disclosed wherein a pair of coaxial winding drums, enclosing mechanism for oppositely and reversely driving them at equal but variable speeds, control a load-moving means such as a chain or cable. A loadholding braking mechanism is provided by the gearing employed. Also, the line of force acting between the load and the actuator passes through its center and hence exerts no torque tending to twist the cable or deflect the actuator but maintains the unit in dynamic balance. Relatively simple, light weight construction facilitates one-man or one-hand control, the limits of drum rotation being determined by a counting mechanism.

3 Claims, 10 Drawing Figures

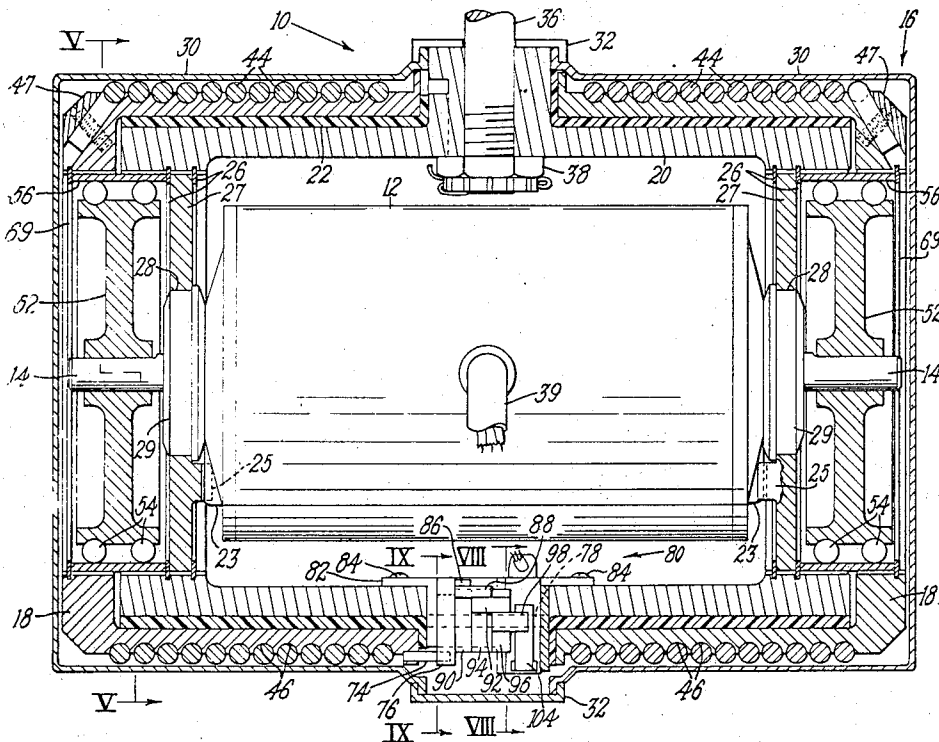


Fig. 1

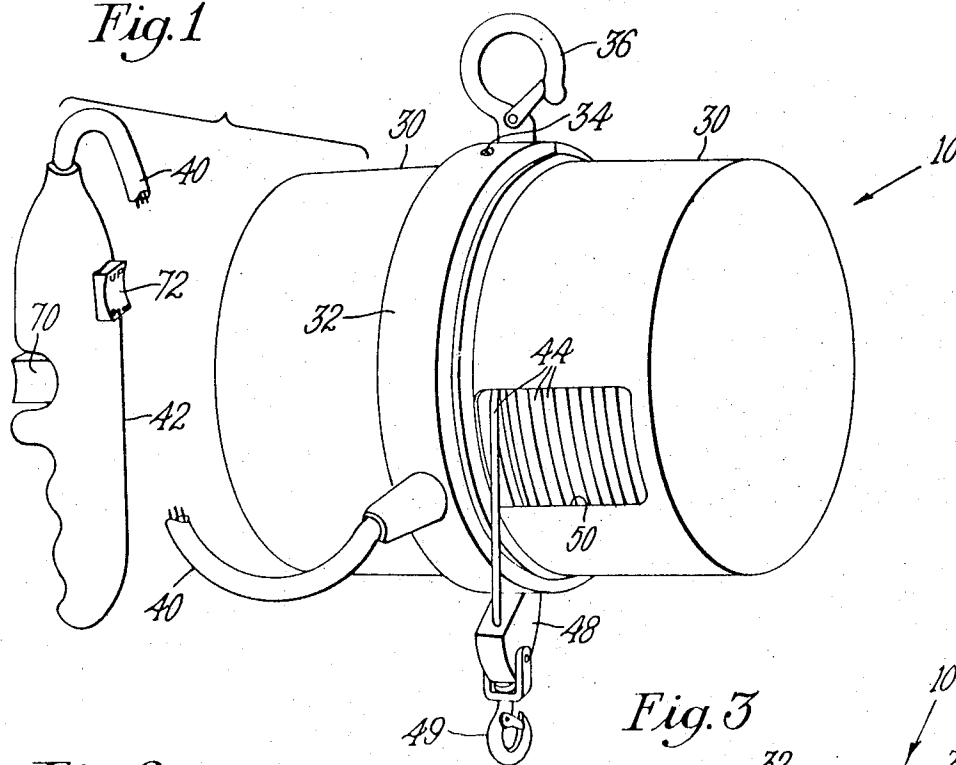


Fig. 2

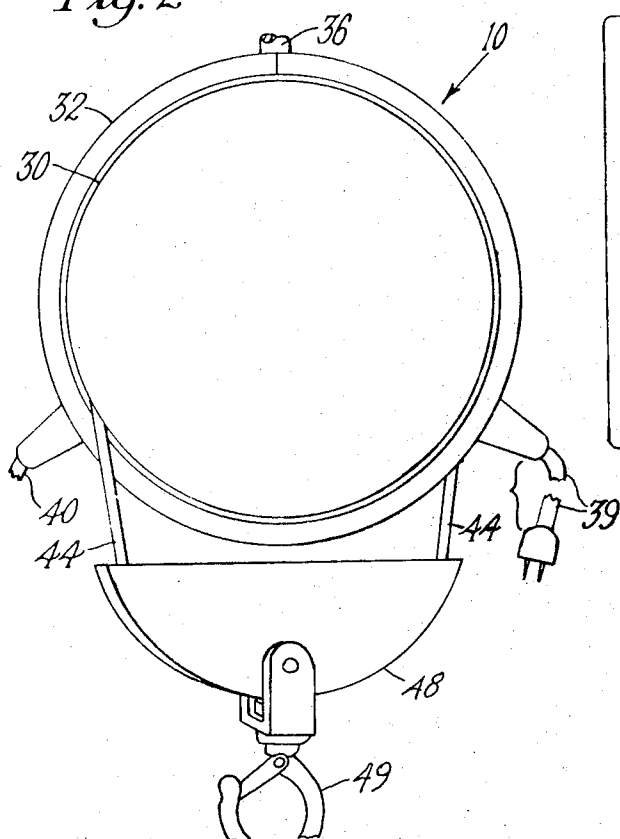
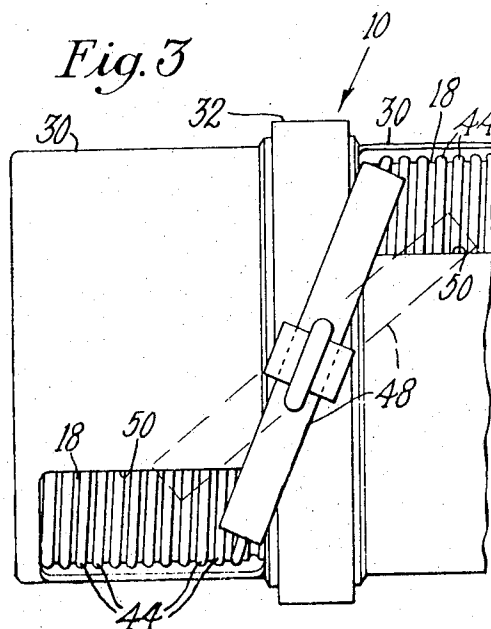


Fig. 3



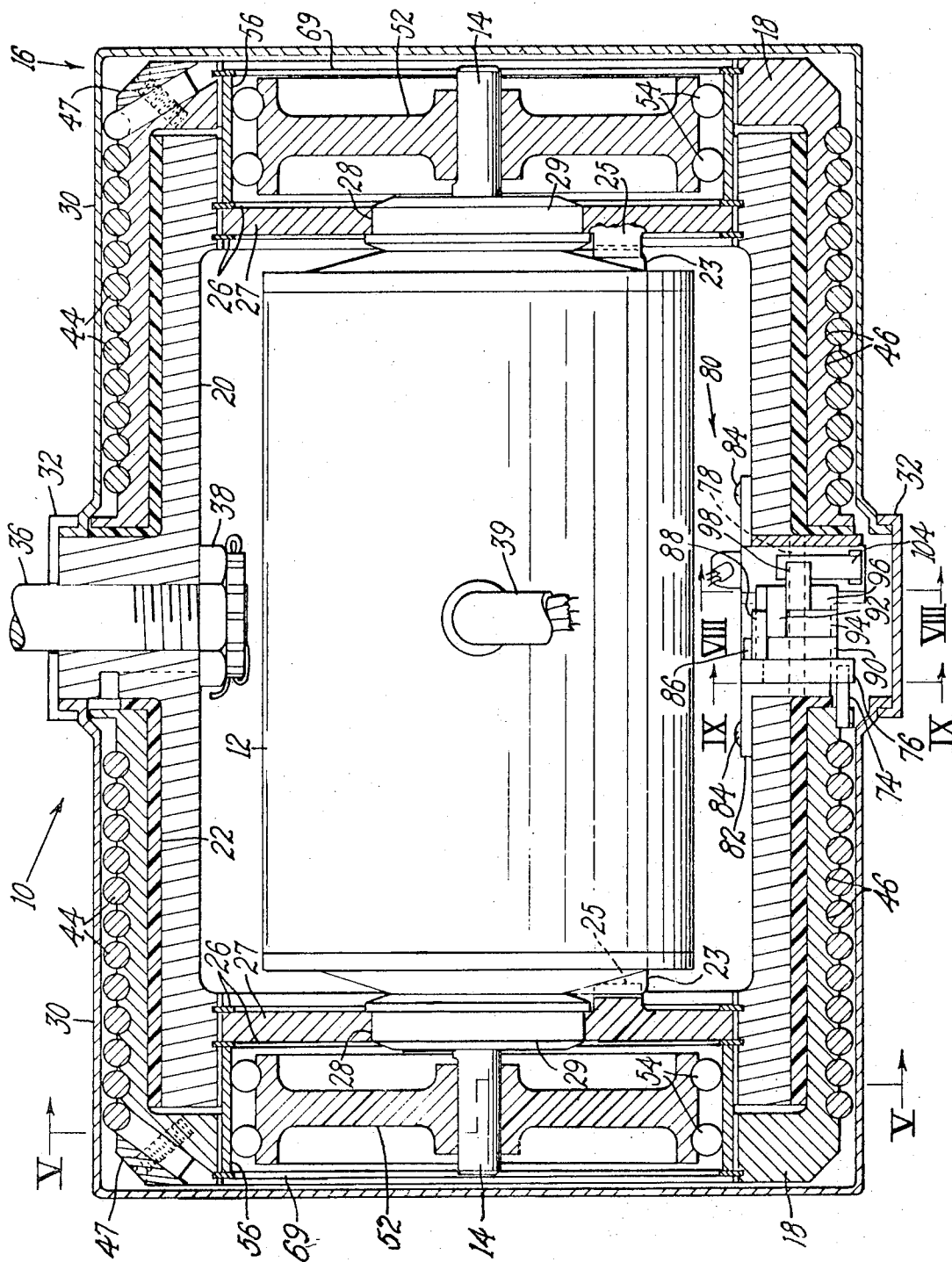


Fig. 4

Fig. 5

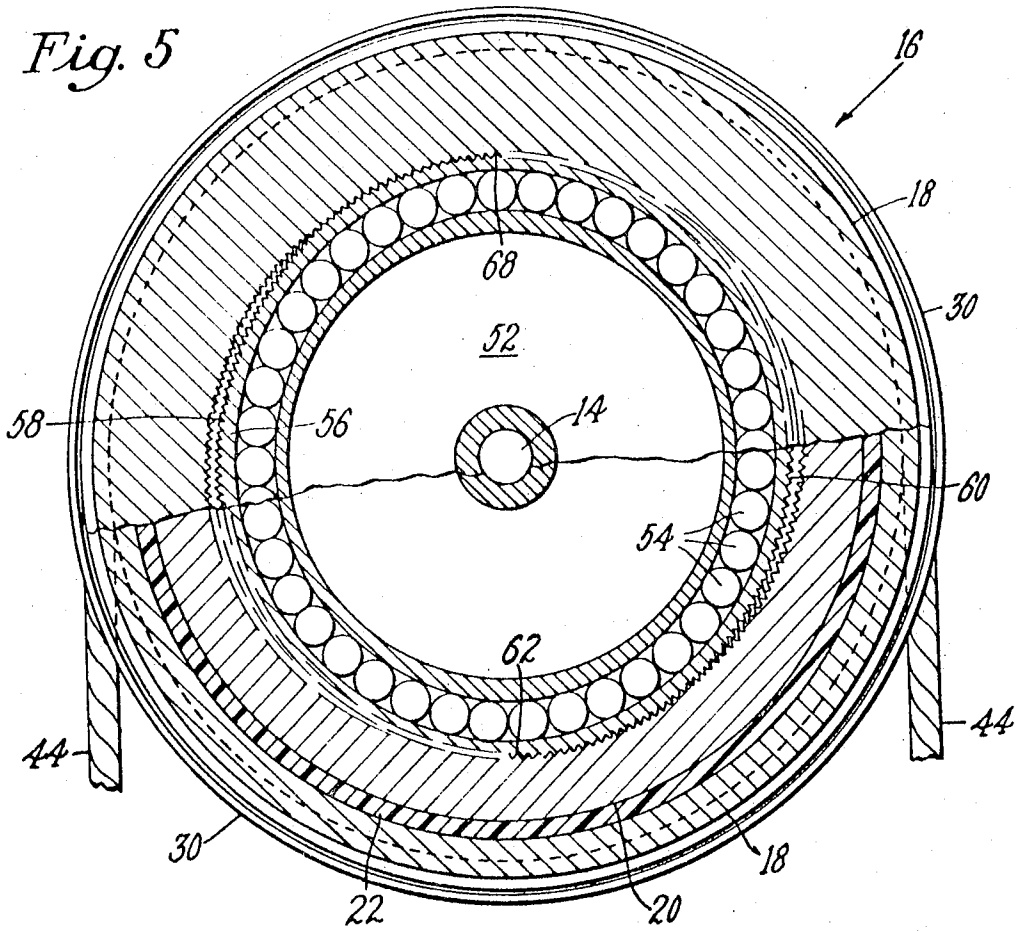


Fig. 6

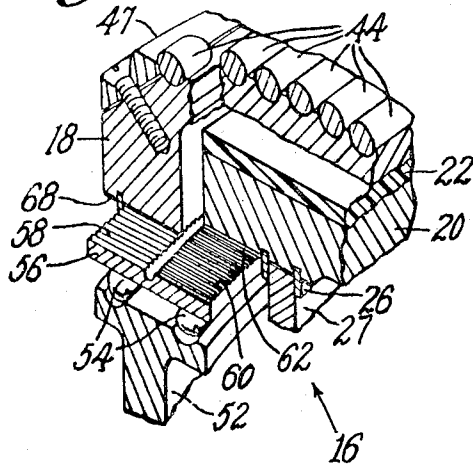


Fig. 7

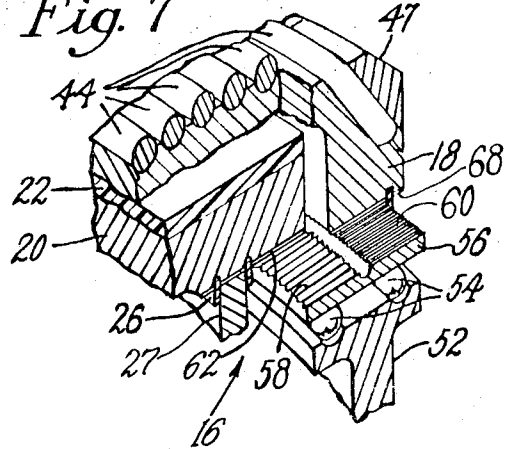


Fig. 8

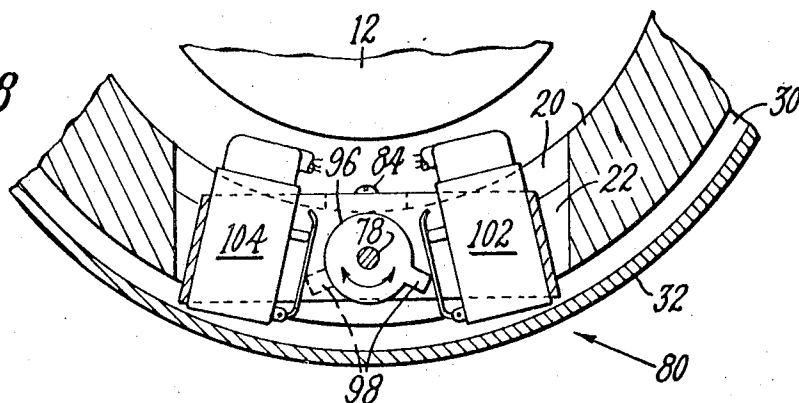


Fig. 9

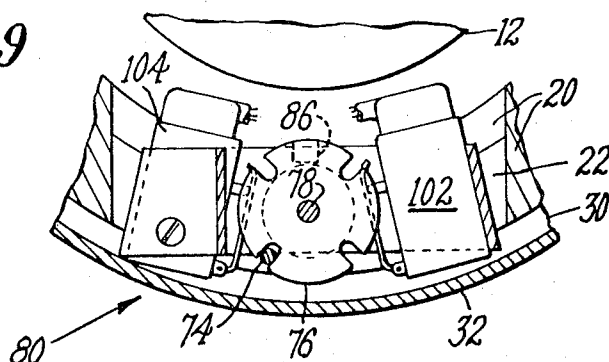
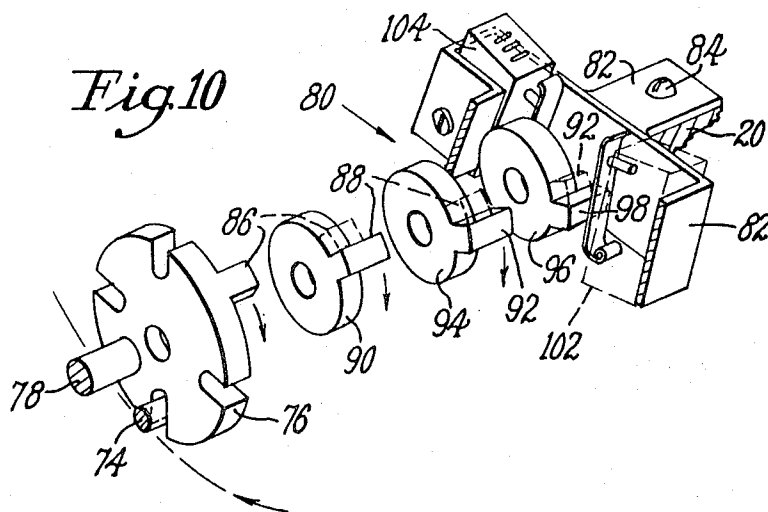


Fig. 10



HOIST OR THE LIKE

This is a division of application Ser. No. 191,371 filed Oct. 21, 1971 and now abandoned.

BACKGROUND OF THE INVENTION

Power hoists are widely employed in industry to enable one to control movement and positioning of different loads which otherwise would become exceedingly burdensome. In the overhead handling category these devices are most numerous in the less than two-ton capacity. They customarily employ a motor for driving through non-planetary reducer mechanism some wheel means for paying out or hauling in a cable, and additionally incorporate one or more usually complex braking mechanisms for insuring that, when motive power is intentionally or accidentally discontinued, the position of the load will be reliably maintained. While most hoists generally operate satisfactorily, they often are hefty and awkward in size: their excessive headroom and lack of maneuverability, and their complexity therefore leave much to be desired in these respects.

Since in the known hoists one end of the operating cable is secured to the motor housing while the other is coupled off-center to the torque applying mechanism, there is an unwanted tendency for the actuator and the cable to shift out of a balanced relation during operation.

SUMMARY OF THE INVENTION

In view of the foregoing it is a main object of this invention to provide a compact power actuator of uncomplicated, substantially symmetrical design which overcomes the mentioned disadvantages and provides dynamic balance continuously while exerting control over a load.

Another object of the invention is to provide greater portability and convenience of operation in a power hoist or the like which exhibits smooth performance.

Yet another object of the invention is to provide an improved electrically powered hoist employing high ratio speed reducing mechanism of the planetary or non-planetary type which, by reason of its mechanical inefficiency, provides high resistance to back driving and hence functions automatically as a load holding brake.

These and other objects of the invention are attained in an actuator, illustrated herein as a hoist, comprising a driving motor having coaxial output shafts, a pair of oppositely rotatable cable winding drums disposed coaxially about the motor and shafts, a load-connectable cable anchored at its ends to the drums, respectively, and gearing (preferably of the general harmonic drive types disclosed in U.S. letters Pat. Nos. 2,959,065 or 2,943,513 issued Nov. 8, 1960 and July 5, 1960, respectively, and assigned to the present assignee,) functioning as an automatic load-holding brake and coupling each of the shafts to its adjacent drum.

Advantageously, a conventional electric driving motor may be employed, its shaft speed being directly reduced by a pair of planetary conventional high ratio harmonic drive units or of the dynamic spline or dual ratio types of strain wave non-planetary gearing units as a result of input rotation through their respective wave generator means. The latter may be of ellipsoidal wave generating shape as herein shown or employ more than two lobes, and be of various types of construction

hitherto used in harmonic drive actuators. The wave of radial deflection in each unit is desirably carried circumferentially by a non-rotating, or relatively slowly rotated dual splined member, referred to herein as a flexspline, formed externally with one set of axially extending, relatively coarse spline teeth and one set of finer splines, i.e. circumferential teeth of smaller circular pitch. One of these sets of flexspline teeth is cooperative with and reacts on a rigid circular spline secured against relative rotation to a frame member, and the other set of flexspline teeth meshes at circumferentially spaced localities with a rigid circular spline having a greater number of internal spline teeth (the differential being small and a multiple of the number of wave generator lobes) and secured to the adjacent cable winding drum. To obtain counter rotation of the other drum, a dual flexspline otherwise similar to the one just described is axially shifted, i.e. the coarse teeth which on one unit may be outboard are mounted relatively inboard of the reduction unit of the other drum. The arrangement thus is such that a fine and a relatively coarse set of flexspline teeth are held against relative rotation and the output of the motor through the gearing oppositely rotates the drums simultaneously in the same, or very nearly the same, reduced, variable speed to haul in or pay out the load carrying cable, the ends of which are secured to the drums. The cable length extends from diametrically opposite sides of the drums at equal axial distances from a midpoint between the two drums for projection through openings in a cylindrical housing. The midportion of the cable is looped, for load hoisting purposes, through a pulley block or the like.

Novel mechanism controlled by the drum rotation is provided for limiting the operating movement of the cable and thus protecting the hoist.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features of the invention, together with various novel details in construction and combinations of parts, will now be more particularly described in connection with an illustrative embodiment and with reference to the accompanying drawings thereof, in which:

FIG. 1 is a perspective view of an actuator with its controls as adapted for hoisting;

FIG. 2 is a view in end elevation of the hoist shown in FIG. 1;

FIG. 3 is a bottom view of a portion of the device shown in FIGS. 1 and 2;

FIG. 4 is a longitudinal section of the hoist;

FIG. 5 is a section taken on the broken line V—V in FIG. 4;

FIG. 6 is a perspective view illustrating an arrangement of the spline gearing associated with one hoisting drum;

FIG. 7 is a view similar to FIG. 6 but showing the spline gearing associated with the other hoisting drum;

FIG. 8 is a sectional view taken on the line VIII—VIII in FIG. 4 showing control mechanism for limiting cable movement;

FIG. 9 is a section taken on the line IX—IX in FIG. 4, and

FIG. 10 is an exploded perspective view of certain parts shown in FIGS. 4, 8, and 9.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring mainly to FIGS. 1 and 4, an actuator for controlled moving and/or positioning of loads is shown in the form of an overhead hoist generally designated 10. It comprises an electric motor 12 (FIG. 4) having coaxial drive shafts 14, 14 for respectively operating in either direction a pair of combination load-holding and speed reducing mechanisms 16, 16 coupled as will be described to coaxial cable-winding drums 18, 18 surrounding the motor, its shafts, and the reducers 16. For maintaining the centered and insulated coaxial relation of the motor 12 with respect to the drums 18, a hollow frame member 20 (FIGS. 4 and 5) has a cylindrical sleeve bearing 22, preferably of an insulating copolymer such as polytetrafluoroethylene or the like, thereon upon which the drums rotate, and pairs of peripherally toothed snap rings 26, 26 seated in grooves within the frame member 20 axially retain plates 27, 27. The latter are respectively coaxially bored to mate with circumferential band portions 28, 28 of bearings 29, 29 mounted on the shafts 14, respectively. The plates 27 each have axial projections 25 (FIG. 4) for abutting axial lugs 23 on the motor 12 to hold it against rotation relative to the frame 20.

Largely enclosing the hoist mechanism to protectively seal out dirt and unwanted elements is a composite housing comprising cylindrical cups 30, 30 the adjacent portions of which are overlapped by a central circular band or belt 32 (FIGS. 1-3). Means such as a pair of retaining screws 34 (one shown in FIG. 1) extends through the belt 32 and into the cups 30 to hold them detachably assembled. For conveniently supporting the hoist in operating position a safety hook 36 is inserted radially into a center portion of the frame member 20 and threadedly receives a castellated nut 38 and its cotter pin. The belt 32 may be formed on one side with an aperture for receiving a power cable 39 (FIG. 2) connecting the motor 12 to a suitable source of energy, and be formed with another aperture for receiving an electric control cable 40 (FIGS. 1 and 2) leading to a push button control generally designated 42 (FIG. 1).

As used herein the term "winding cable" will be understood in its broadest sense to comprehend any windable, elongated force-exerting means including, but not limited to, rope, wire, chain, or the like and whether of metal or otherwise. In the event chain is employed it will be understood that the cooperating lifting medium will be a sprocket means corresponding to the drums.

The turns of a continuous length of winding cable 44 are disposed on the spiral flute or groove 46 (FIG. 4) externally formed on the drums 18 with same hand. Axially outer ends of the cable 44 are each suitably secured as by a clamp piece 47 (FIG. 4) to the adjacent drum 18. When the drums 18 are simultaneously rotated in opposite directions by the reducer mechanisms 16 to be explained, axially inner or unwound portions of the cable 44 extend freely from the drums and are looped through a suitable load-connecting member, for instance a pulley block or other tackle such as an arcuately grooved block 48 (FIGS. 1, 2 and 3) which may carry a safety hook 49 for coupling to a load to be hoisted. Each of the cover cups 30, 30 is formed with an axially elongated opening 50 (FIGS. 1 and 3) to ac-

comodate the winding cable during operation of the hoist.

The construction of one of the reducers 16, assumed for the illustration to be of the dual ratio type according to the U.S. Pat. No. 2,943,913 above cited will next be described with reference to FIGS. 4-6, it being understood that the other reducer is preferably and usually of the same structure and, as shown in FIG. 7, axially shifted but not reversed end for end. The frame grounding of one coarse and one relatively finer set of the dual flexspline teeth sets provides counter rotation of the drums and thus produces the same predetermined ratio of speed reduction between the motor 12 and the drums 18. An illustrative wave generator of the reducer comprises an ellipsoidal cam 52 (FIGS. 4-7) mounted for rotation with the shaft 14, and in this case a double row of anti-friction rollers in the form of balls 54 arranged in races disposed peripherally on the cam 52. The balls 54 are in external engagement with, and impart corresponding ellipsoidal shape to, an annular flexspline 56 which is provided externally with two sets of spline teeth. One set 58 (FIG. 6), is of relatively coarse circular pitch and the other 60 is greater in number and of finer circular pitch. As shown in FIGS. 5 and 6, the flexspline teeth 60 at the major axis localities at one end of the hoist are in meshing engagement with spline teeth 62 formed integrally with an outboard portion of the stationary frame member 20. Axial extensions of the teeth 62 are conveniently used for anchoring the plates 27 against relative rotation. At the opposite end of the hoist, as shown in FIG. 7, the coarser teeth 58 of the other reducer 16 are in meshing engagement at major axis localities with the teeth 62 there formed outboard on the frame.

The coarser flexspline teeth 58 at the major axis localities are thus in one reducer 16 (FIG. 6) in meshing engagement with a greater number of circular spline teeth 68 (the differential in this case being a multiple of two) integral with the adjacent drum 18, while in the other reducer 16 (FIG. 7) the coarser teeth 58 similarly mesh with and react on the frame spline teeth 62. One drum 18 (FIG. 6) is rotated in one direction by relatively coarser flexspline teeth 58, and the other drum 18 is counter rotated by relatively finer flexspline teeth 60.

It will accordingly be understood that, as a consequence of carrying the circumferential wave of radial deflection and the differential between the teeth 60 and 62, the flexspline 56 will rotate at a much reduced speed from that of the drive shaft 14, and by reason of the further differential between the flexspline teeth 58 and the drum spline teeth 68, the latter will be driven at a further greatly reduced output speed. An outboard snap ring 69 (FIG. 4) seated in a groove in the drum axially retains the flexspline 56.

Merely by way of a specific illustration of one dual ratio reducer unit arrangement which in this instance provides a reduction ratio of 1,000:1, and not to be construed as a limitation on tooth differentials or spline numbers and combinations employable, a 200 tooth flexspline set is meshed with a 202 tooth set on the frame 20, and a 220 tooth set of the same flexspline is meshed with a 222 tooth set formed on the drum 18. At the other end of the actuator the 220 set of flexspline teeth mesh with the 202 tooth set on the frame, with the 200 tooth flexspline set meshing with the 222 tooth set of the adjacent drum.

As has been indicated above, inboard portions of the cable 44 extend freely from the drums 18, respectively, at opposite sides thereof as shown in FIGS. 2 and 3. For simultaneously controlling their retractive or paying out movement, the push button control 42 preferably includes a rheostat control 70 for regulating speed of the motor 12, and a two-way polarity switch 72 for determining its direction of rotation. An operator with the fingers of one hand may accordingly precisely control the load to which the block 48 is connected and the block may progressively turn about its center during operation as indicated in FIG. 3.

Mechanism for drum revolution counting or monitoring next to be described is provided for automatically determining the upper and lower, i.e., in and out limits of operating movement of the cable 44. Referring to FIGS. 4, 8, 9, and 10 one of the drums 18 is fitted in its inboard end with an axial pin 74. The pin 74 is arranged for each drum revolution to transfer 90° rotation to a Geneva wheel 76 (FIGS. 4, 9 and 10) rotatably mounted on a pin 78 journaled in a limit switch assembly generally designated 80. This assembly includes a support 82 secured by screws 84 to the inside of the frame 20. The Geneva wheel 76 excentrically carries an axial lug 86 for abutting and rotatively advancing a lug 88 for circumferential engagement with a lug 92 on a wheel 94 on the pin 78. A fourth wheel 96 on the pin 78 has a lug 98 to be engaged circumferentially by the lug 92. The lug 98 is a switch operating arm. The arrangement accordingly is such that at the desired limit of drum rotation in one direction the lug 98 will actuate a spring-return micro switch 102 to deenergize the motor 12, and at the limit of desired rotation in the other direction the lug 98 will actuate a similar switch 104 to stop the motor 12. Thus the cable 44 is never completely wound or unwound on the drums 18.

It will be apparent that other suitably equivalent drum rotation limiting means may alternatively be provided. It is also contemplated, though not so illustrated, that a second switch-controlled limit means may be operatively connected to the other drum as a precautionary safety mechanism for insuring that, in the event of overload or failure of either reducer unit 16, the motor drive of the drums would be stopped without the hoist incurring a shock load.

Operation of the hoist will now be briefly reviewed. With a load connected to the hook 49, the speed of the motor 12 and hence of the drums 18 is controlled by the degree of depression of the rheostat control 70, and the hauling in or paying out of the load is determined by the direction of movement of the switch 72. Upward shifting of this switch is generally used to effect upward motion of the load. The counter rotation of the drums 18 causes the unwound or free portions of the cable 44 synchronously to move in lifting or lowering the load. If the suspended load is hoisted, the block 48 will be swung from its phantom line position shown in FIG. 3 to the solid line position, and the resultant line of force from the load continues to extend substantially through the center of the hoist 10; thus no imbalanced condition develops. An operator is enabled easily to control the hoist to inch the load precisely as desired.

While two dual or dynamic spline types of reducers 16 are preferred for attaining high ratio speed reduction in a compact yet powerful hoist, it will be observed that a planetary type of gear train reduction may be

employed within the scope of this invention when desired. An idler gear would be introduced in one of the epicyclic gear trains to attain counter rotation. An outstanding advantage in either case is the fact that, upon deenergizing the motor 12 intentionally or through accident in some way, a high resistance to back-driving is inherent; hence load pull on the cable 44 is unable without driving assistance of the motor to lower the load through influence of the drum tending to back-drive the wave generators. Another way of expressing this is to say that the mechanical inefficiency of the reducers 16 provides high brake or load-holding power whereby any position of the load is automatically maintained despite possible power failure. Supplemental braking means (not shown) may be associated with the motor 12 to overcome momentum of a moving load.

It is to be noted that the harmonic dual ratio drives described advantageously effect counter rotation of the drums without requiring an added element such as the idler gear in one of the trains and hence are interchangeable.

Counter-rotating drums for hoisting are normally preferred, as above explained, because of the dynamic balance and compactness afforded by the design. It is to be noted, though, that for some actuator applications a single drum, single reducer arrangement may be advantageous with a single shaft motor and come within the scope of this invention; thus, in the general manner of a capstan drive, the motor speed is reduced through gearing providing high resistance to back-driving and coupled to the drum, and the frame circumferentially disposed between the drum and the motor secures the latter against relative rotation while providing bearing support for the drum as it acts on the cable thereon. Either a dual ratio harmonic drive reducer unit or a dynamic spline type reducer is effective for this purpose.

Having thus described our invention what we claim as new and desire to secure by Letters Patent of the United States is:

1. In a hoist having a cable-winding drum rotatable about its axis by a stationary driving motor mounted within the drum, the cable having one end secured to the drum, an intermediate portion of the cable including turns wound on the drum, and another portion of the cable being coupled to a load, reducer mechanism coupling the motor to the drum and having high resistance to back-driving, and automatic mechanism for limiting the extent of rotation of the drum, said mechanism including between the motor and the drum a device operatively connected to the latter for predeterminedly stopping the drive of said motor.

2. In a hoist having a pair of coaxial, counter-rotatable cable-winding drums respectively driven from the coaxial shafts of a stationary electric motor mounted within the drums, the cable being secured at its ends to the drums and having a midportion freely extending therefrom for coupling to a load, a frame for holding the motor against relative rotation, control means for limiting the range of operating movement of said cable midportion, the control means including a limit switch for interrupting electrical connection of the motor to a source of energy, and a mechanism supported on the frame and operatively connected to one of the drums for actuating the limit switch when the cable midportion is a predetermined distance from the one drum.

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3. A hoist comprising a hollow, stationary frame, an electric motor non-rotatably mounted in the frame and having a pair of drive shafts extending coaxially therein, a pair of winding drums coaxially mounted for counter rotation about the axis of said shafts, said drums being supported by bearing means carried by the frame, a length of load connectable cable in wound relation on the two drums, speed reducer gearing units driven by said shafts, respectively, one gear of each reducer unit being in driving relation with the adjacent

drum, and another gear of each reducer unit meshing with and reacting on teeth formed outboard of the frame, one of the drums being operatively connected to a revolution counting mechanism, and a limit switch secured to the frame is actuatable by said mechanism for deenergizing the motor when the number of turns of cable on either of the drums approaches zero or they become nearly fully wound.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,807,697

Dated April 30, 1974

Inventor(s) Alex P. Cotreau; Robert A. Sayce

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the title page:

After inventors, insert: --Assignee: USM Corporation
Boston, Massachusetts

Signed and sealed this 22nd day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents