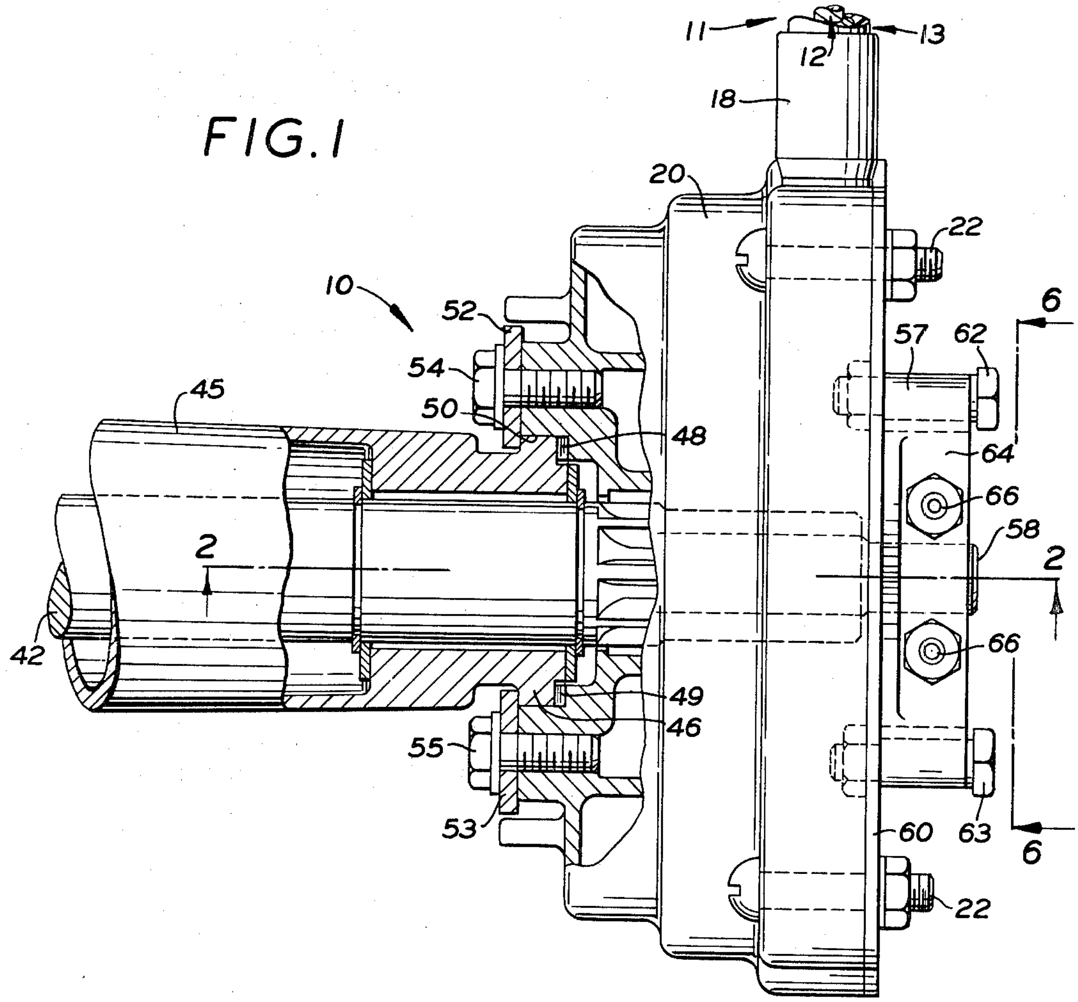
Dec. 29, 1970 J. F. MORSE 3,550,469

ROTARY ACTUATOR FOR PUSH-PULL CABLES

Filed Jan. 21, 1969 5 Sheets-Sheet 1

FIG. 1



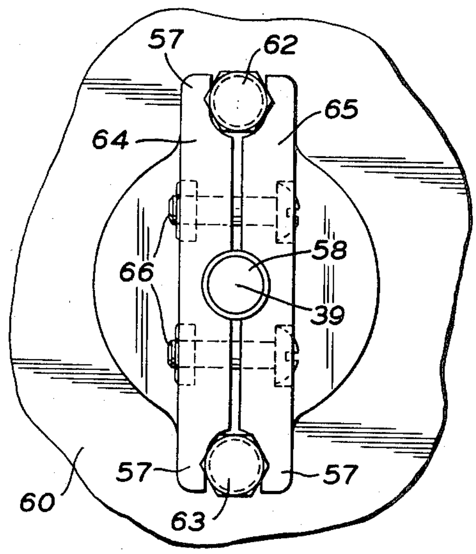


FIG. 6

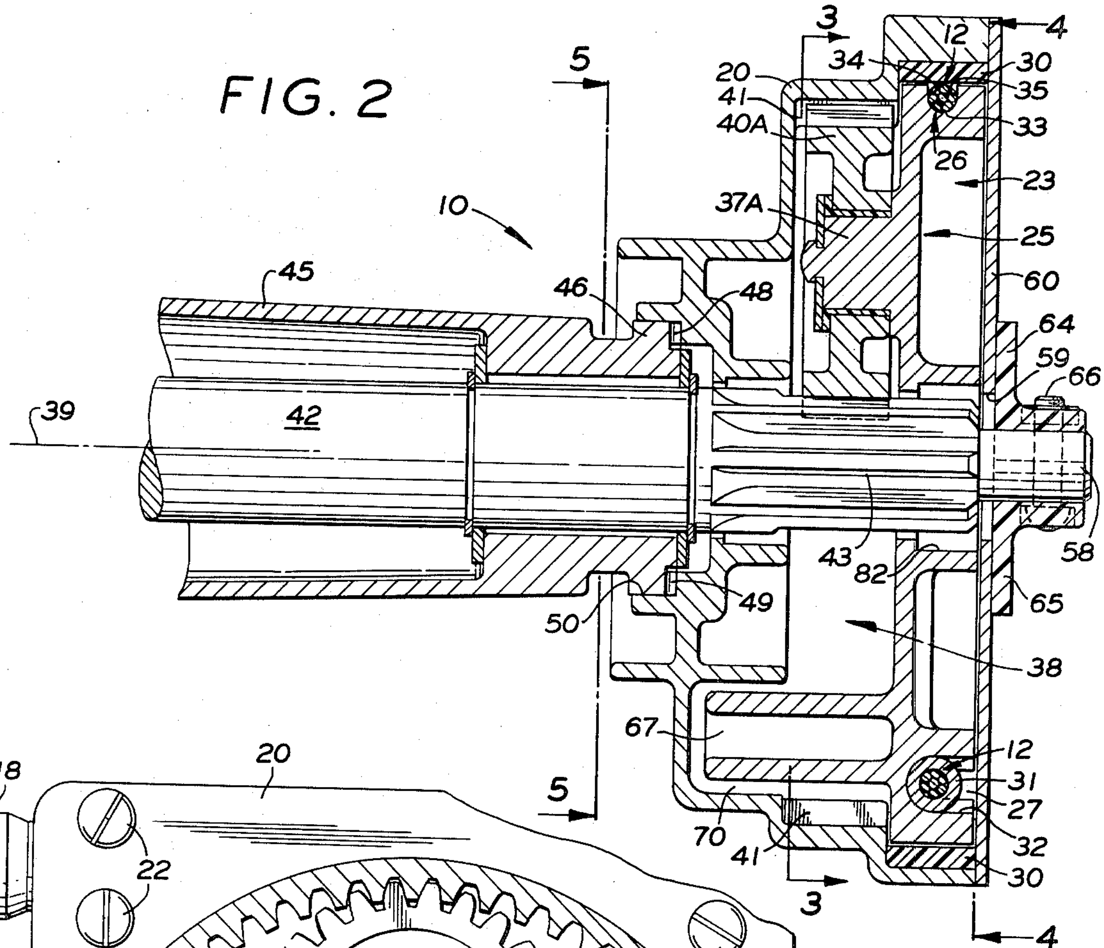
INVENTOR.
JOHN F. MORSE
BY Hamilton, Cook, Renner & Kenner
ATTORNEYS

Dec. 29, 1970 J. F. MORSE 3,550,469

ROTARY ACTUATOR FOR PUSH-PULL CABLES

Filed Jan. 21, 1969 5 Sheets-Sheet 2

FIG. 2



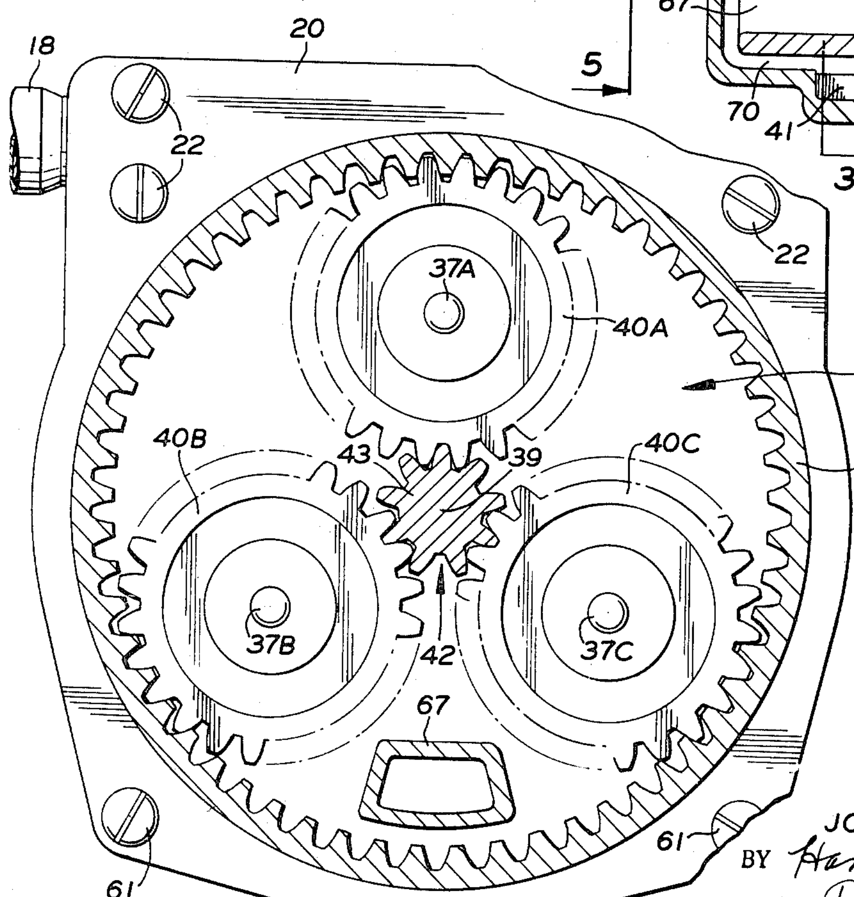


FIG. 3

INVENTOR.
JOHN F. MORSE
BY Hamilton, Cook, Renner & Kenner
ATTORNEYS

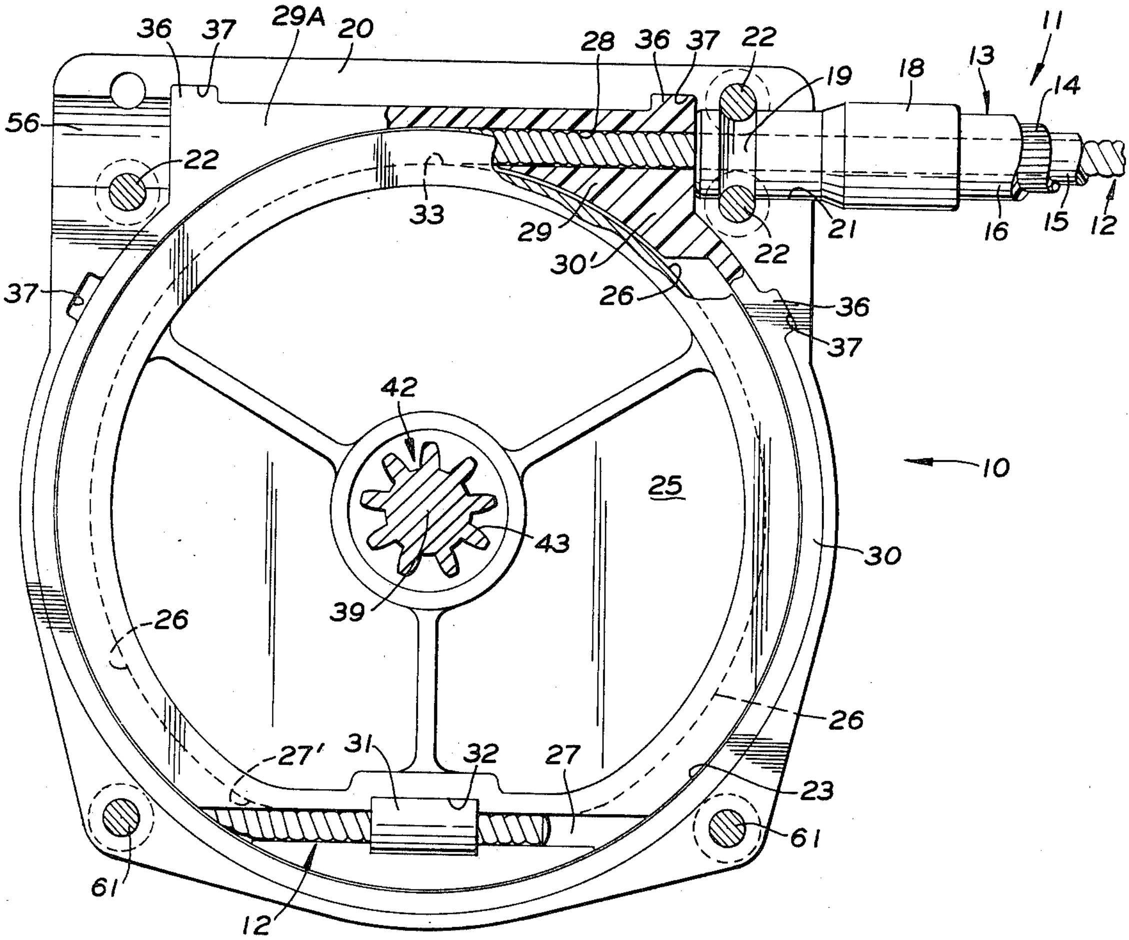


FIG. 4

INVENTOR.
JOHN F. MORSE
BY Hamilton, Cook,
Renner & Kenner
ATTORNEYS

Dec. 29, 1970 J. F. MORSE 3,550,469

ROTARY ACTUATOR FOR PUSH-PULL CABLES

Filed Jan. 21, 1969 5 Sheets-Sheet 4

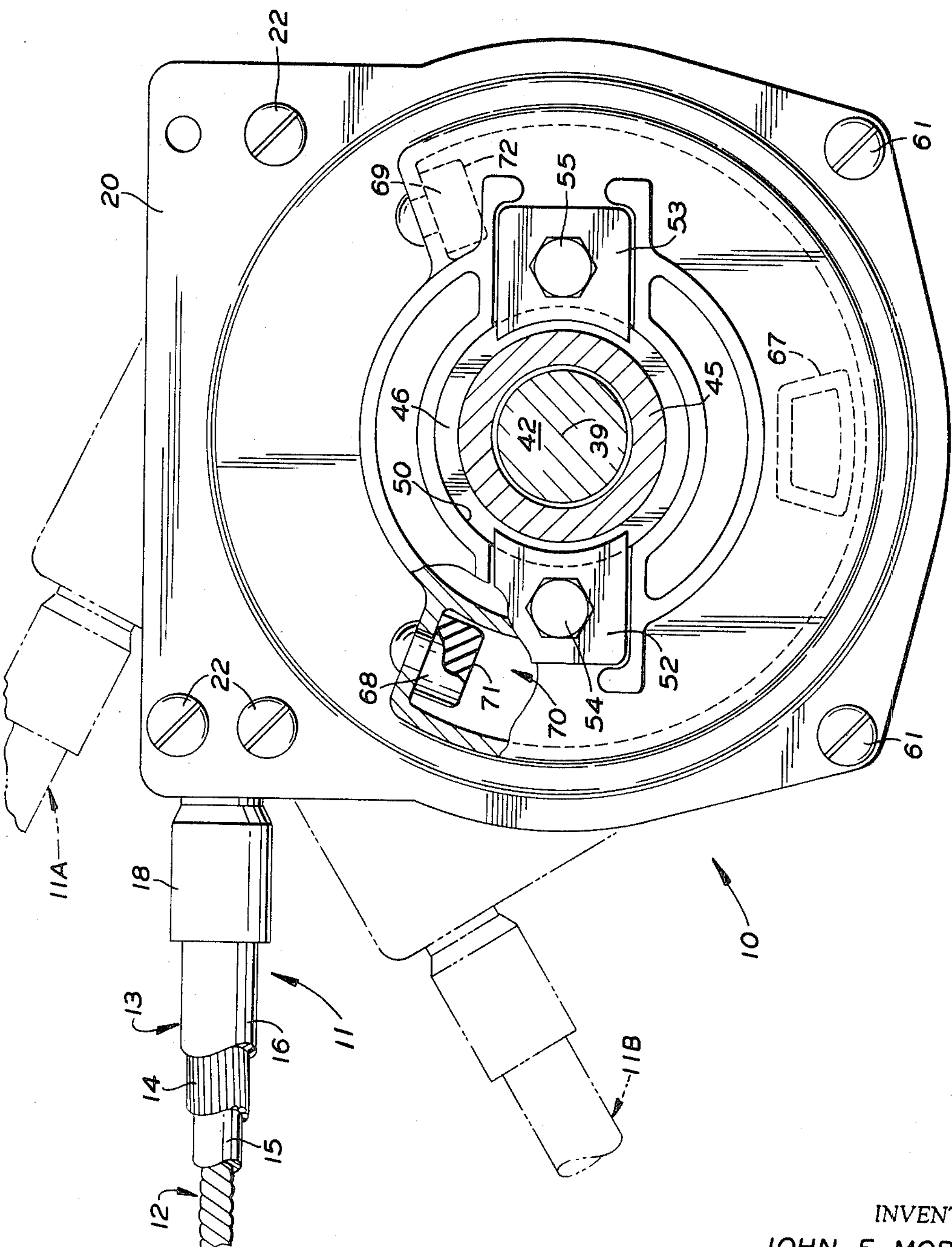


FIG. 5

INVENTOR.
JOHN F. MORSE
BY Hamilton, Cook,
Renner & Kenner
ATTORNEYS

Dec. 29, 1970 J. F. MORSE 3,550,469

ROTARY ACTUATOR FOR PUSH-PULL CABLES

Filed Jan. 21, 1969 5 Sheets-Sheet 5

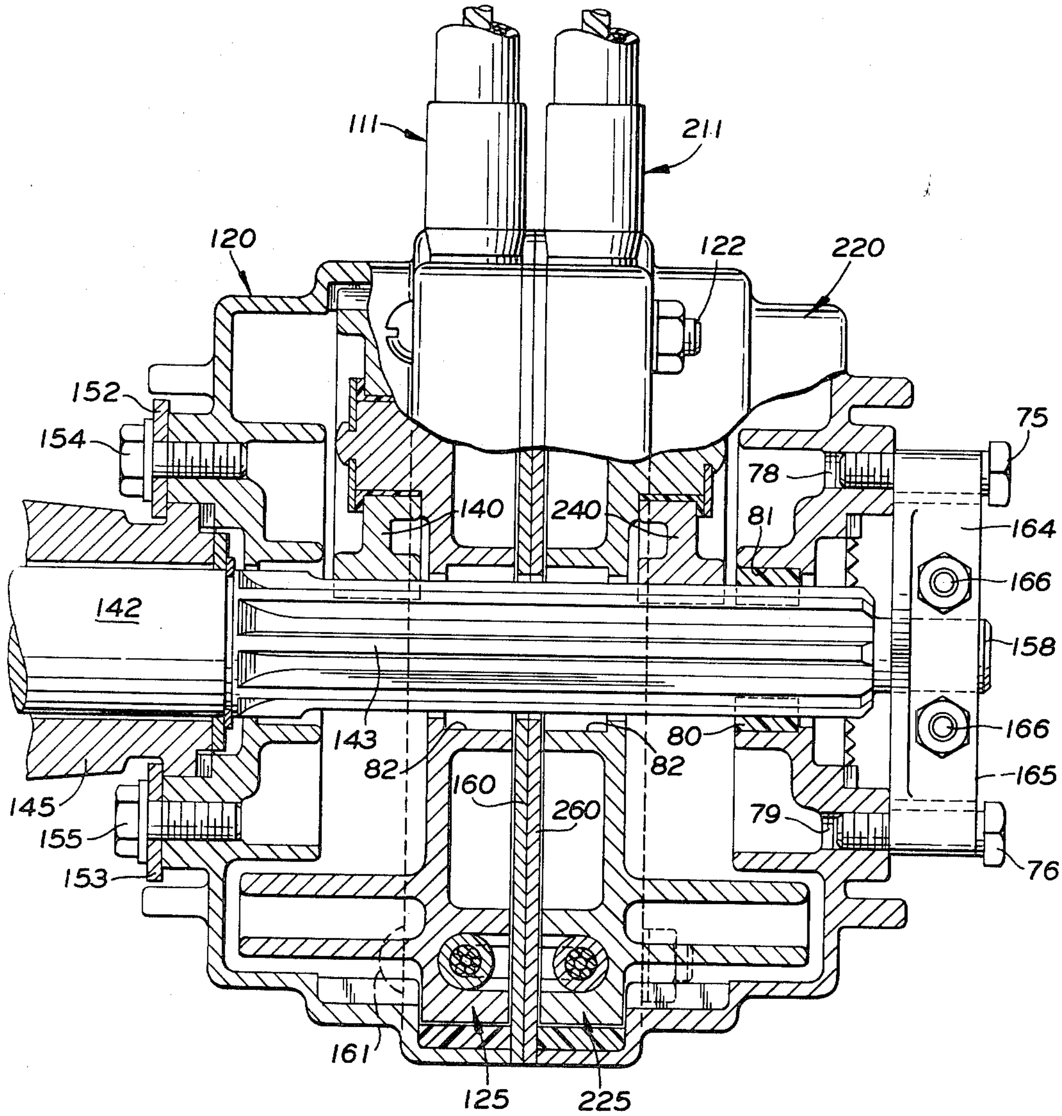


FIG. 7

INVENTOR.
JOHN F. MORSE
BY Hamilton, Cook, Renner + Kenner
ATTORNEYS

United States Patent Office

3,550,469

Patented Dec. 29, 1970

3,550,469

ROTARY ACTUATOR FOR PUSH-PULL CABLES

John F. Morse, Hudson, Ohio, assignor to Morse Controls Inc., Hudson, Ohio, a corporation of Ohio

Filed Jan. 21, 1969, Ser. No. 792,433
Int. Cl. F16c *1/10;* F16h *1/28*
U.S. Cl. 74—501 13 Claims

ABSTRACT OF THE DISCLOSURE

A rotary actuator for reciprocating the core of a push-pull cable. The actuator has a circular drive member received within a housing for rotation about a central axis. The cable casing is secured to the housing, but the cable core is attached to the drive member and is receivable in a peripheral groove therein. A cylindrical inner surface of an annular retaining means within the housing embraces the major portion of at least the peripheral groove. An annular gear is fixed within the housing axially of the retaining means and is intermeshed with a plurality of intermediate gears rotatably carried on the drive member. Each intermediate gear is rotatable about an individual axis located eccentrically of the central axis; the axes of the several intermediate gears being concentric to the central axis. A propelling gear means is simultaneously intermeshed with all the intermediate gears and is rotatable about the central axis selectively to rotate the drive member for winding the core into the groove or unwinding it therefrom.

BACKGROUND OF THE INVENTION

The present invention relates to an actuating mechanism by which the application of selective rotary motion imparts desired reciprocation to the core of a push-pull cable for transmitting mechanical motion.

Motion transfer from the wheel to the rudder in the marine environment, in particular, has for years conventionally utilized rope and pulley, or other "balanced" remote control systems. Balanced remote control systems are almost as old as ships themselves and, when used as steering mechanisms, have traditionally comprised a wheel and shaft with a rope drum to provide the required movement of the rope necessary to operate the rudder or other controllably driven components. The appellation "balanced" appears quite appropriate when it is realized that the mechanical motion transmitting ropes, or cables, form a closed system because of their inability to relay mechanical motion by other than tensile stresses.

These balanced systems are still widely used. However, they are quite bulky and cumbersome. Moreover, misalignment between the guiding pulleys, rope drum, rudder tiller or any of the other components can cause excessive binding and wear to the system.

The advent of the push-pull control cable provided, in a single cable, the necessary structure for effecting remote control by the application of either tensile or compressive forces. The push-pull cable thus provides a transfer device which overcomes the difficulties incident to balanced systems and is particularly easy to install in the conventional boat, either during or after construction of the boat, without requiring specialized engineering or mechanical ability.

Actuation of the core of a push-pull cable, however, requires something more than the prior rope drum of the balanced system, and complex actuating heads have been developed to translate rotative motion into the linear motion of the push-pull control cable core.

Most prior art actuating heads are not satisfactorily adaptable to a wide variety of installation situations. One type of prior art rotary actuating head employs a pinion shaft of relatively small diameter directly to drive an in-

ternally toothed ring gear. One of the major disadvantages of this type rotary actuator is the required eccentric location of the drive shaft. This eccentricity tends to locate the bulk of the actuator housing to one side of the drive shaft. When space is at a premium such an eccentric locations of the housing can severely limit the installation adaptability.

Another type of prior known actuating head employs a rack and pinion, but the extreme lateral expanse required to accommodate the rack and its housing assembly is, similarly, a disadvantage inherent to this type of actuator. Further disadvantages, to varying degrees, of both style prior art actuators is that they cannot be efficiently employed as driven assemblies, primarily because excessively high frictional forces generally develop in the bearing supporting the pinion shaft when such heads are used as the driven units rather than the drivers.

Still further disadvantages reside with the core support afforded by most prior art actuators and the attendant wear and/or frictional resistance.

In marine steering units using a push-pull cable for motion transfer, a maximum core travel of 8 to 9 inches is usually employed. This travel length is long enough to minimize the loading on, and backlash ratio of, the cable and yet is short enough to keep the terminal fittings of the cable within practical lengths.

Small craft steering generally requires from 3 to 4 wheel turns for stop-to-stop rudder travel. This has been found to be the most useful steering ratio to combine: good leverage for heavy steering loads; good "feel" and stability at high speeds; and, minimum wheel turning for slow speed maneuvering around docks. As an example, in a steering unit using twelve pitch tooth size and a pinion of nine teeth, three and one-half wheel turns will move the cable core approximately eight inches.

The conventional employment, for economic reasons, of die cast and/or molded plastic parts in steering units makes the use of gear tooth sizes smaller than twelve pitch impractical due to a general lack of precision tooth mesh in such structures.

On the other hand, gears with less than sixteen to twenty teeth, show poor load life due to compromised tooth form and the increasing tendency toward single tooth contact as the number of teeth is reduced. However, the designers of steering devices of this type are constrained to use a drive pinion having considerably fewer teeth than are considered good engineering practice, as exemplified by the aforementioned nine tooth, twelve pitch pinion.

The load carrying capacity of a gear train employing such a nine tooth pinion is seriously impaired by single tooth contact, high tooth loading and poor meshing characteristics. As a result, many, if not most, of the failures with such units in service or on wearout test result from the drive pinion (usually steel) cutting the teeth out of the rack or ring gear (usually plastic or a die casting of zinc or aluminum).

SUMMARY OF THE INVENTION

It is, therefore, a primary object of the present invention to provide a rotary actuator for push-pull cables, the actuator affording full support to the core with minimal frictional contact.

It is another object of the present invention to provide a rotary actuator, as above, in which the housing is substantially centered about the drive shaft to permit installation in the most advantageous location.

It is still another object of the present invention to provide a rotary actuator, as above, which, even while employing a nine tooth, twelve pitch propelling gear means, effects load transfer to and from such a gear means through multiple teeth and thereby promotes exceptional service life to the steering unit.

It is a further object of the present invention to provide a rotary actuator, as above, that is readily adapted to operate multiple push-pull cables.

It is a still further object of the present invention to provide a rotary actuator, as above, which is readily adaptable for use as the driven, as well as the driving, head.

It is an even further object of the present invention to provide a rotary actuator, as above, which have a variable drag.

These and other objects, together with the advantages thereof over existing and prior art forms, which will become apparent from the following specification are accomplished by means hereinafter described and claimed.

In general, a rotary actuator embodying the concept of the present invention has a housing to which the casing of a push-pull control cable is attached. A circular drive member is received within the housing and is rotatable about a central axis. The core of the push-pull cable is secured to the drive member and is receivable within a groove provided around the periphery of the drive member.

Presented within the housing is a retaining means that embraces the drive member to confine the core radially of the groove. Fixed to the housing axially of the retaining means is an annular gear means that is intermeshingly engaged with a plurality of intermediate gear mounted on the drive member, each intermediate gear being mounted for rotation about an axis located eccentrically of the central axis about which the drive member is rotatable. Compositely, the axes about which all the intermediate gears are located are concentric with respect to the central axis.

A propelling gear means, incorporated on a drive shaft, is supported within the housing by the intermediate gears with which it meshes for rotation about the central axis. Rotation of the drive shaft, and the propelling gear means, rotates the intermediate gears against the fixed annular gear. The rotation of the intermediate gears against the fixed annular gear results in rotion of the drive member selectively to wind the core into the groove or unwind it therefrom.

One preferred embodiment of the subject invention and an alternative mounting arrangement therefor are shown by way of example in the accompanying drawings and are described in detail without attempting to show all of the various forms and modifications in which the invention might be embodied; the invention being measured by the appended claims and not by the details of the specification.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation, partly broken away and partly in section, of a rotary actuator embodying the concept of the present invention;

FIG. 2 is a longitudinal section taken substantially on line 2—2 of FIG. 1;

FIG. 3 is a cross sectional view taken substantially on line 3—3 of FIG. 2 and depicting the relationship of the propelling, intermediate and fixed annular gear means;

FIG. 4 is a further cross sectional view taken substantially on line 4—4 of FIG. 2 and depicting the relationship of, and the connection between, the push-pull cable core and the drive member;

FIG. 5 is a still further cross sectional view taken substantially on line 5—5 of FIG. 2 to show the actuator housing in elevation, the housing being partly broken away to depict the bumper stops on the housing;

FIG. 6 is a partial end elevation taken substantially on line 6—6 of FIG. 1; and,

FIG. 7 is a view similar to FIG. 2 but depicting a tandem arrangement of rotary actuators embodying the concept of the present invention being actuated by a common propelling gear means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to the drawings, the preferred form of a rotary actuator embodying the concept of the present invention is designated generally by the numeral **10** in FIGS. 1–6 and is depicted operatively connected to the end of a push-pull cable **11**.

The push-pull cable **11**, as best shown in FIG. 4, may be of any conventional construction in which a core **12** slidably reciprocates within a casing, indicated generally by the numeral **13**, to transmit mechanical motion by the application of tensile or compressive forces to the core **12** while at least the ends of the casing **13** are clamped in a relatively fixed position with respect to the core **12**. In the exemplary construction depicted, the casing **13** is formed of a plurality of casing wires **14** laid contiguously, in the form of a long pitched helical coil, about the radially outer surface of an inner, flexible, plastic tube **15** which extends the full length of the casing **13**. An outer cover **16** encases the coil of wires **14** up to within a short distance from the ends thereof. A fitting **18** is positioned over the end of the cable casing **13** and is cold swaged, or otherwise suitably connected, onto the exposed portion of the cylindrical grouping of wires **14**. A plurality of ribs, not shown, may be provided within the end fitting **18** which, when crimped onto the outer cover **16**, effects a seal between the end fitting **18** and the cover **16**.

A retaining notch **19** extends annularly about the end fitting **18** for attaching the casing **13** to the housing **20** of the actuator **10**. Specifically, the fitting **18** is inserted into a cylindrical recess **21** within the housing, and one or more securing bolts **22** are mounted in the housing **20** transversely of the fitting **18** so as to lie within a portion of the notch **19** and fixedly position the end of the casing **13** to the actuator **10**.

The interior of the housing **20** has a generally cylindrical cavity **23** (FIG. 2) in which a circular drive member **25** is rotatably received. A groove **26** provided in the periphery of the drive member **25** intercepts a chordal groove **27** therein (FIG. 4). The grooves **26** and **27** are adapted fully to receive the core **12** that extends from the fitting **18**, through an access passage **28** that lies along the entrance head **29** of the retaining ring **30** and into the cavity **23** substantially tangentially of the peripheral groove **26**. Although the ring **30** is substantially annular, the entrance head **29** bulges radially outwardly thereof to accommodate the access passage **28**. The access passage **28**, like the interior of the tube **15**, embraces the core **12** so as to give it full circumferential support against buckling under compressive loading and yet permit it freely to reciprocate therein. The ring **30** even contributes radial support after the core enters the groove **26**. Radially outer support is achieved by a smooth transition between the access passage **28** and the inner circumference of the ring **30**, and radially inner support is achieved by a spur **30'** that extends radially inwardly of the ring **30** and circumferentially within the groove **26** beneath the core **12**.

A sleeve **31** is cold swaged, or otherwise suitably connected, onto the end portion of the core **12**. The sleeve **31** is received within an anchor niche **32** located along the medial portion of the chordal groove **27** to affix the core **12** against axial translation with respect to the chordal groove **27** and thereby anchor it to the drive member **25**. Accordingly, when the drive member **25** is rotated counterclockwise, as viewed in FIG. 4, this anchoring of the core **12** to the drive member will apply a tension loading to the core and thereby tend to extract it from the casing **13**. Under this tension loading the core will lay tightly against the base **33** of the peripheral groove **26**, the base **33** being preferably of semicircular cross section as best seen in FIG. 2.

In response to clockwise rotation of the drive member **25** (again as viewed in FIG. 4) the core **12**, unless fully supported, will tend to follow the line of least resistance whether that be a lateral buckling or a mere radial displacement. With the core fully received within the peripheral groove **26** the substantially simultaneous engagement of the core **12** with the opposed radial side walls **34** and **35** (FIG. 2) of that groove preclude lateral buckling. Radial displacement is precluded by the annular retaining ring **30** that lines the circumference of the cavity **23** in radial proximity to the drive member **25** and, thereby, the peripheral groove **26**. Inasmuch as the radial depth of the groove **26** is preferably equal to—i.e., approximates—the diameter of the core **12**, only a lineal contact exists between the core **12** and the retaining ring **30**, so that as the drive member **25** is rotated clockwise the core **12** has moving contact only along the line at which it engages the retaining ring **30**. In this regard it must be noted that even though the drive member **25** presents a transitional curve **27'** to join the base of groove **26** with the base of groove **27**, the transition is still sufficiently sharp that the core should be "kinked," or otherwise preset, so that it will naturally follow from the transitional curve **27'** immediately against the base **33** of groove **26** without arching radially outwardly against the retaining ring **30**.

Movement of the core **12** with respect to the peripheral groove **26** occurs only as the core passes from the groove **26** into the access passage **28**. This itself greatly reduces the frictional resistance as the application of a compressive load to the core **12** resulting from clockwise rotation of drive member **25** effects an insertion of the core **12** into the casing **13**, and, if desired, the retaining ring **30** may be made of a plastic material further to reduce the frictional resistance. Although any number of plastic materials will perform quite satisfactorily, an acetyl copolymer such as Celcon, by Celanese Plastics Company, provides an excellent material for the retaining ring **30**, particularly in view of the fact that it possesses almost identical static and dynamic coefficients of friction.

Rotation of the retaining ring **30** with respect to the housing **20** is precluded by the interengagement of one or more lugs **36** on ring **30** with corresponding notches **37** in the peripheral wall of cavity **23**. The radially outward bulge of the entrance head **29** and the false entrance head **29A** also tend to preclude rotation of retaining ring **30** by their interengagement with the conforming periphery of the cavity **23**.

Certain other prior art rotary actuators have also employed friction reducing plastic material against which to slide the core, but the concept of these constructions required that the plastic member include a groove within which the core is at least partially received. Such a groove provides a surface, as distinguished for a linear, contact between the core and the plastic material and that configuration inherently includes at least two major drawbacks that are nonexistent to the present concept. First, the very fact that the plastic member partially embraces the core positions the boundry between the drive member and the plastic member laterally of the core so that full support of the core against lateral buckling cannot be assured. Second, the provision of a substantial area of contact with the core in two members that are relatively movable—the drive member and the plastic member—induces a very effective snubbing action by the mutuality of their contact with substantial areas of the core, particularly in the situation where any lateral misalignment occurs between the drive member and the plastic member. When the retaining ring has a purely cylindrical inner surface, as in the present invention, misalignment between the ring and drive member **25**, whether occasioned by manufacturing tolerances or eccentric loading to the drive member, will not result in such a snubbing action. The mutuality of contact inherent to the prior art construction also increases the exposure of the plastic member to wear occasioned as the core slides along the groove. In this situation even modest, acceptable "snaking" (limited lateral buckling) of the core will have an eroding action on the groove of the plastic member.

Rotation of the drive member **25** in actuator embodying the full concept of the present invention is accomplished by a mechanism which requires no friction imparting bearing assembly for the propelling gear means. The present concept also employs a much more favorable tooth loading between the propelling gear means and the toothed members with which it meshes. As best seen from FIGS. 2 and 3, a plurality, preferably three, stub axles **37A**, **37B** and **37C** extend from the drive member **25** into a gear chamber **38** adjacent the substantially cylindrical cavity **23** in which the drive member **25** is rotatably received. Each of the stub axles **37A**, **37B** and **37C** is located eccentrically of, and parallel with, the central axis **39** about which the drive member **25** rotates, and the three are, compositely, concentric therewith. Intermediate gears **40A**, **40B** and **40C** are rotatably mounted on the respective axles **37A**, **37B** and **37C** intermeshingly to engage with an annular gear **41** fixed to the housing **20** and defining the circumference of gear chamber **38**.

A drive shaft **42**, having a rotational axis concurrent with the control axis **39**, is provided with a propelling gear portion **43** that mutually intermeshes with the three intermediate gears **40A**, **40B** and **40C**. Because the propelling gear portion **43** is cradled medially of the three, circumferentially spaced, intermediate gears **40A**, **40B** and **40C**, the interaction therebetween does not induce lateral thrust and no bearing is required between the propelling gear portion and either the housing or the drive member. However, for some installations, and particularly when operating multiple actuators from a common propelling gear, a bearing may be desirable.

Most prior art constructions that utilize a pinion gear meshing directly against the drive member to rotate the latter require a large bearing in close association with the pinion to support it against the lateral thrust that is inherent thereto. With the diameter of the journal surface of such a bearing being generally larger than the pitch circle of the pinion teeth, the bearing tends to act, because of the lateral thrust, as a brake when the core applies back pressure into the actuator. This situation most frequently obtains when the actuator is employed as the driven member. By having the intermediate gears **40A**, **40B** and **40C** provide equally spaced circuferential support for the propelling gear portion **43** of the shaft **42**, any tendency toward lateral displacement of the propelling gear means **43** is eliminated. This tendency toward lateral displacement in prior art actuators contributes greatly to the existence of the undesirable braking action, and it is also the absence of this induced braking that permits the present actuator to be efficiently employed as a driven, as well as a driving, unit.

The use of the three intermediate gears to contact the propelling gear also drastically reduces the tooth loading as compared with that inherent to prior known devices in which the relatively small diameter pinion directly engages the drive member. In such a device the contact ratio is only about 1 and the tooth loading can become quite high. This is a major disadvantage, because, while the small pinion gear is often steel, the larger member with which it meshes is, for economical considerations, generally fabricated from a weaker material, often a die casting. As such, failure in prior known actuators most often occurs by tooth failure on the member made of the weaker material. However, it must be appreciated that the environmental requirements of a rotary actuator, particularly when employed in a steering system, do not permit the adoption of a pinion having sufficient size to afford a more favorable contact ratio. Similarly also, the diametral pitch is limited by the nature of the steering environment. In brief, it is desirable that the shaft connected to the actuator turn through three or four revolutions to effect full travel to the push-pull cable core. It is also highly desirable that the travel of the push-pull cable core be on the order of eight to nine inches. Moreover, experience has shown that when economically feasible manufacturing tolerances are employed, the diametral pitch of the pinion-type gear member must be as low as ten to twelve in order to provide sufficiently large teeth to transfer the typical loads encountered.

Within the above parameters the pinion-type gear member will have only about nine teeth, and that is well below the number of teeth considered generally acceptable in accordance with standard engineering practice. Nevertheless, the art has persisted in the employment of such pinions with the resulting excessive loading and wear, particularly to the teeth on the member with which the pinion meshes.

An actuator embodying the concept of the present invention benefits in this regard because the number of intermediate gears reduces the tooth load—and, concomitantly, the wear—proportionately to the number of intermediate gears employed.

The drive shaft **42** is journaled within a shaft support column **45** that may be mounted to the dashboard, or the like, in a well-known manner (not shown). To facilitate mounting of the actuator **10** and permit the housing **20** to be most suitably aligned with the push-pull cable **11**, the housing **20** may be variably mounted with respect to the shaft support column **45**.

To accomplish this adjustability that end of the support column **45** adjacent housing **20** is necked to provide an annular mounting flange **46**. The axially outermost side of the mounting flange **46** presents radial serrations **48** to engage with mating, radial serrations **49** in the base of a coupling recess **50** in the housing **20**. The cylindrical side wall of recess **50** embraces the outer perimeter of the mounting flange **46** and a pair of clamps **52** and **53** are secured to the housing **20**, as by cap screws **54** and **55**, respectively, so as to engage the mounting flange **46** and selectively maintain serrations **48** and **49** engaged. This arrangement permits adjustment of the radial orientation of the housing **20** with respect to the support column **45** in order to assure accommodation of the run of cable **11**, as, for example, from positions **11A** through **11B** depicted, in phantom, in FIG. 5.

The housing **20** is also provided with a second cylindrical recess **56** (FIG. 4), opposed to recess **21**, so that the push-pull cable may, with equal facility, be admitted into the opposite side of housing **20**. This permts selective adoption of either a push or a pull to the cable core in response to either clockwise or counterclockwise rotation of the drive member. The only internal change required is that the substantially annular retaining ring **30** be repositioned. It should be noted that the lug, or lugs, **36** and the recesses **37**, the entrance head **29** and the false entrance head **29A** are all symmetrical with respect to the housing **20** in order that the ring **30** may be selectively positioned within the cavity **23** to accept a core irrespective of whether the cable is secured to recess **21** or **56**.

In addition, the housing **20** may be secured to the support column **45** through a similar variable range with the housing oriented at generally 180° with respect to the orientation depicted. This permits selective rotation of the drive member to effect a push or a pull to core **12** without limiting that selection on the basis of the side to which the cable **11** is attached to the actuator housing **20**.

Because of the extremely low frictional resistance possessed by a control embodying the concept of the present invention, it has been found desirable to incorporate a braking mechanism that imparts a resistance, or drag, preselected for the particular installation. However, in order to maintain the desired "feel" for the operator of the subject actuator, it is mandatory that no backlash be inherent to the braking mechanism employed. This result has been effectively accomplished by applying a unique frictional brake to the drive shaft **42**. As best shown in FIGS. 1, 2 and 6, the drive shaft **42** may be provided with a cylindrical drum portion **58** beyond the propelling gear portion **43**. The drum portion **58** preferably extends through an opening **59** in the cover plate **60**, the cover plate **60** being removably secured to the housing **20** as by cover plate bolts **61** in addition to the securing bolts **22** that also fasten the end fitting of the control cable **11** to the housing **20**. A pair of stabilizing pins in the form of shoulder bolts **62** and **63** are secured to the cover plate **60** and extend outwardly thereof in spaced, parallel relation with respect to the axis of the drum portion **58**—an axis concurrent with the central axis **39**. A pair of shoes **64** and **65** simultaneously embrace the pins **62** and **63** as well as the drum portion **58**, and adjusting means, such as the nuts and bolts **66** which extend through the shoes **64** and **65** on opposite sides of drum portions **58**, are provided to vary the embracing pressure. The pressure applied against the drum portion **58** selectively effects a drag against the rotation thereof and the corresponding pressure against the stabilizing pins **61** and **62** assures that no backlash exists in the braking mechanism.

It should be noted that the braking mechanism disclosed should be somewhat flexible and should also be positionable somewhat laterally within the plane of stabilizing bolts **62** and **63** to accommodate the drum portion **58** and not restrict the shaft against assuming its natural axis. The flexibility of the shoes may well be accomplished by the use of a plastic material, and the variable location of the shoes may be accomplished by having the embracing ear **57** on each end of each shoe **64** and **65** extend sufficiently beyond the body portion of the shoe to effect this result.

It has been found that the acetyl copolymer, Celcon, also provides an excellent material for the shoes **64** and **65**, again particularly in view of its substantially identical static and dynamic coefficients of friction.

In operation, the drive shaft **42** may be rotated, as by a wheel or other mechanism (not shown), in either a clockwise or a counterclockwise direction to effect the desired movement of the core **12** within the casing **13**. Should the drive shaft **42** be rotated clockwise, as viewed in FIG. 3, the propelling gear portion **43** thereof would similarly rotate in a clockwise fashion and thereby rotate all three intermediaee gears **40A**, **40B** and **40C** in a counterclockwise fashion against the fixed annular gear **41**. With the annular gear **41** fixed the intermediate gears will therefore accomplish a motion compounded of rotation about their axles **37A**, **37B** and **37C**, respectively, and a rotation of those axles about the central axis **39**. The drive member **25** will, therefore, rotate clockwise in response to clockwise rotation of the propelling gear portion **43**. By the same token, the drive member **25** will rotate counterclockwise in response to counterclockwise rotation of the propelling gear portion **43**. And, rotation of the drive member **25** will effect a push or a pull to the core **12**, as hereinbefore set forth.

To limit the range through which the drive member **25** can rotate, and thus assure that the actuator will not bind as a result of attemping to wind a second wrap of cable core in the same peripheral groove **26**, an engaging arm **67** carried on the drive member **25** is permitted to move only between two, opposed, circumferentially spaced stops **68** and **69** (FIG. 5) secured to the housing **20**. As best seen from FIG. 2, the engaging arm **67** extends from the drive member **25**, through gear chamber **38** and into a cavity **70** arcuate about central axis **39**. The stops **68** and **69** are located, one at each of the circumferentially spaced ends of the cavity **70**. In order to provide a shock-absorbing cushion, it is desirable that the stops be made of a resilient material, such as rubber.

When the faces **71** and **72** of the stops **68** and **69**, respectively, are oriented radially of the drive member it is convenient to utilize a trapezoidal cross section for the engaging arm **67** in order to provide a full surface contact between the arm **67** and either stop **68** or **69** while assuring a rigid, but light weight, arm **67**.

Although the construction hereinbefore described is suitable primarily for the actuation of a single push-pull control cable, it should be appreciated that multiple cables as well can be actuated. Because the actuator operates primarily about a central axis **39**, it is quite convenient to stack multiple housings for operation from a single drive shaft.

As shown in FIG. 7, two housings **120** and **220** are mounted back to back on the common propelling gear portion **143** of a drive shaft **142** simultaneously to actuate two control cables **111** and **211**. The intermediate gears **140** in housing **120** and the intermediate gears **240** in housing **220** are both engaged by the single propelling gear portion **143**.

The housing **120** is secured to the drive shaft support **145** by clamps **152** and **153** and cap screws **154** and **155** in the same manner as the housing **20** is secured to support column **45**, and the two housings **120** and **220** are secured together by the use of cover plate bolts **161** and securing bolts **122** having sufficient length to extend through both housings **120** and **220**.

The brake mechanism, however, can not readily be mounted on the cover plates **160** and **260** but can be mounted on the housing **220** remote from the support column **145**. A pair of shoulder bolts **75** and **76**, identical to bolts **62** and **63**, are received in the bores **78** and **79** which normally accept the cap screws by which the mounting clamps are tightened, and the shoulder bolts **75** and **76** function as stabilizing pins against which the shoes **164** and **165** are tightened by adjusting means **166**. The drum portion **158** of drive shaft **142** extends axially beyond the housing **220** for embracing engagement by the brake shoes **164** and **165** in the same manner as shoes **64** and **65** embrace drum portion **58**.

It must be appreciated that when the housings are stacked in this manner, and thus carried from only one end on support column **145**, cumulative dimensional variations, even within permissible manufacturing tolerances, could well tend to impose a misalignment of the axis of the drag shaft **142**, and propeller gear portion **143**, with respect to the central axis **139** of the housings. This tendency can be easily precluded by the use of a bearing between the propelling gear portion **143** and that housing located most remotely from the support column **154**. As shown in FIG. 7, an internally toothed sleeve bearing **80** may be fitted over a section of the propelling gear portion **143** to turn in a raceway **81** provided in housing **220**. Similar bearings, while not generally required, may, in the unusual situation, also be interposed between the propelling gear portions **43** or **143** and a raceway 82 formed as the hub of the drive member **25**, **125** or **225**. A typical unusual situation might occur when the core is being subjected to such heavy loading that even the nominal eccentricity of the drive member with respect to the intermediate gears requires additional support.

It should now be apparent that a rotary actuator constructed in accordance with the concept of the present invention fulfills all the objects thereof.

I claim:

1. A rotary actuator for at least one push-pull cable having a core that slidably reciprocates within a casing, said actuator comprising, at least a first housing, means for attaching the casing to said housing, a circular drive member received within said housing to rotate about the central axis thereof, a peripheral groove in said drive member, means for attaching the cable core to said drive member so that the core is received in said peripheral groove, retaining means within said housing radially embracing at least that portion of said peripheral groove in which the core is received, annular gear means located axially of said retaining means and fixed within said housing, a plurality of intermediate gears carried on said drive member and each rotatable about an axis eccentrically of the axis about which said drive member rotates, said intermediate gears intermeshed with said annular gear means, a propelling gear means intermeshed with said intermediate gears, and means to rotate said propelling gear means selectively to wind said core into said groove and to unwind said core therefrom.

2. A rotary actuator, as set forth in claim **1**, in which the depth of said peripheral groove approximates the diameter of the core received therein and in which said retaining means makes only lineal contact with that portion of the core received in said peripheral groove.

3. A rotary actuator, as set forth in claim **2**, in which the retaining means comprises a ring, said ring having an entrance head, an access passage lying along said head and fully supporting the core from substantially said casing into said peripheral groove.

4. A rotary actuator, as set forth in claim **3**, in which an engaging means is carried on said drive member and opposed circumferentially spaced stops are carried on said housing, rotation of said drive member being restricted to the range defined by the travel of said engaging means arcuately between said stops.

5. A rotary actuator, as set forth in claim **4**, in which the means for attaching the cable core to said drive member comprises a chordal groove in said drive member that intercepts said peripheral groove, a niche medially of said chordal groove, an anchor sleeve secured to the core, said anchor sleeve received in said niche to attach the core to said drive member.

6. A rotary actuator, as set forth in claim **5**, in which there are at least three, circumferentially spaced, intermediate gears, the circumferentially spaced location of said intermediate gears supporting said propelling gear means.

7. A rotary actuator, as set forth in claim **6**, in which a brake means applies a preselected drag to resist rotation of said propelling gear means.

8. A rotary actuator, as set forth in claim **1**, for operating at least two push-pull cables, said rotary actuating means comprising at least a second housing conjoined with the first housing about a common central axis, means for attaching the casing of a second push-pull cable to said second housing, a second drive member rotatably received within said second housing, a peripheral groove in said second drive member, retaining means within said second housing radially embracing the peripheral groove in said second drive member, a second annular gear means located axially of said retaining means and fixed within said second housing, a plurality of intermediate gears carried on said second drive member and each rotatable about an axis eccentrically of the common central axis, the intermediate gears carried on said second drive member intermeshed with said second annular gear means, said propelling gear means intermeshed with the intermediate gears carried on both said drive members, and common means to rotate said propelling gear means selectively to push or pull said cores.

9. A rotary actuator, as set forth in claim **8**, in which there are at least three, circumferentially spaced, intermediate gears carried on each said drive member, the circumferentially spaced location of said intermediate gears supporting said propelling gear means within said housings.

10. A rotary actuator, as set forth in claim **9**, in which the depths of said peripheral grooves approximates the diameter of the cores received therein and in which said retaining means make only lineal contact with that portion of the cores received in the corresponding peripheral grooves.

11. A rotary actuator, as set forth in claim **10**, in which the retaining means comprises a ring in each said housing, said rings each having an entrance head, an access passage piercing each said head and fully supporting the corresponding core from substantially said corresponding casing into said corresponding peripheral groove.

12. A rotary actuator, as set forth in claim **11**, in which an engaging means is carried on at least one of said drive members, and opposed, circumferentially spaced stops are carried in the corresponding housing means, rotation of said drive members being restricted to the range defined by the travel of said engaging means arcuately between said stops.

13. A rotary actuator, as set forth in claim **12**, in which at least one brake means applies preselected drag to resist rotation of said propelling gear means.

References Cited

UNITED STATES PATENTS

2,452,178	10/1948	Brownlee	74—801
2,579,368	12/1951	Curtis et al.	74—789
3,060,767	10/1962	Parrett	74—798
2,890,595	6/1959	Loeffler	74—501

FOREIGN PATENTS

853,933	12/1959	Great Britain	74—501

FRED C. MATTERN, Jr., Primary Examiner

W. S. RATLIFF, Jr., Assistant Examiner

U.S. Cl. X.R.

74—801