

[54] **ORTHOGONALLY DEFLECTABLE
ENDOSCOPE**

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[52] **U.S. Cl.**..... **128/4, 74/501**

[51] **Int. Cl.**..... **A61b 1/00**

[58] **Field of Search**..... 128/4, 5, 6, 7, 8, 9, ;
138/120, 103; 74/501, 501.5; 356/241;
74/757, 378, 385, 401, 417, 423, 713, 625

[56] **References Cited**

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Primary Examiner—Richard A. Gaudet

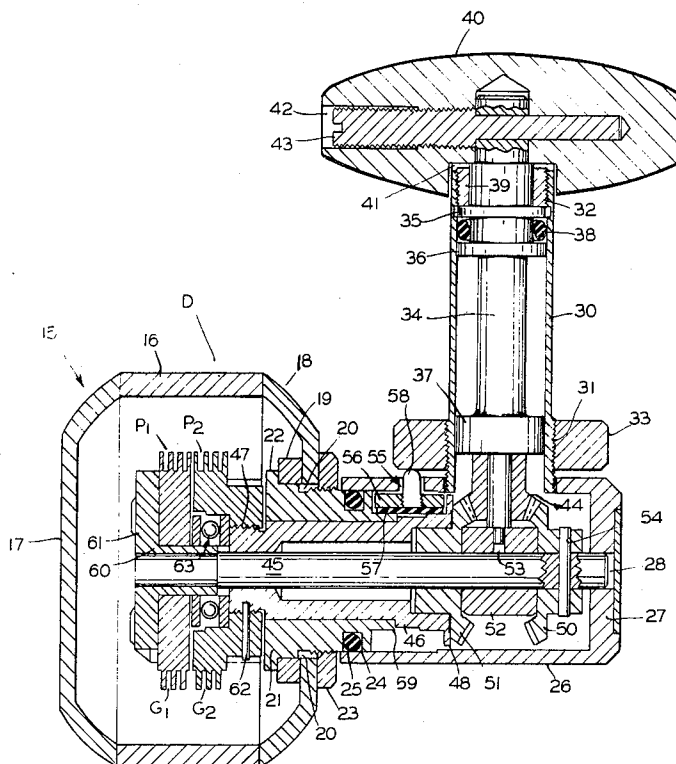
Assistant Examiner—Lee S. Cohen

Attorney, Agent, or Firm—Edgar N. Jay

[57] **ABSTRACT**

A device for controlling movement of a plurality of cables including support means, a rotary first shaft and shaft means which are carried by the support means, the shaft means consisting of telescopically arranged second and third shafts which are rotatable about a common axis that is normal to the axis of the first shaft. The device also includes a pair of coaxial pulleys, one of the pulleys being secured to and rotatable with the second shaft and the other being secured to and rotatable with the third shaft. Each pulley is equipped with a pair of cables that are secured thereto and partly and oppositely wound thereon. Coupling means connect the first shaft to the shaft means and effect rotation of the shaft means and the pulleys in response to rotary movement of the first shaft about its axis and/or bodily movement of the first shaft about the axis of the shaft means.

7 Claims, 7 Drawing Figures



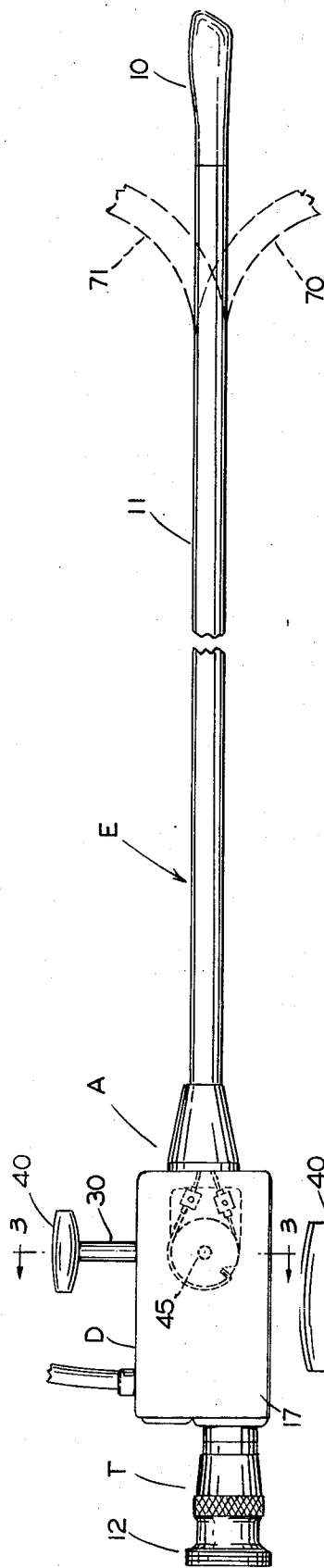


FIG. 1

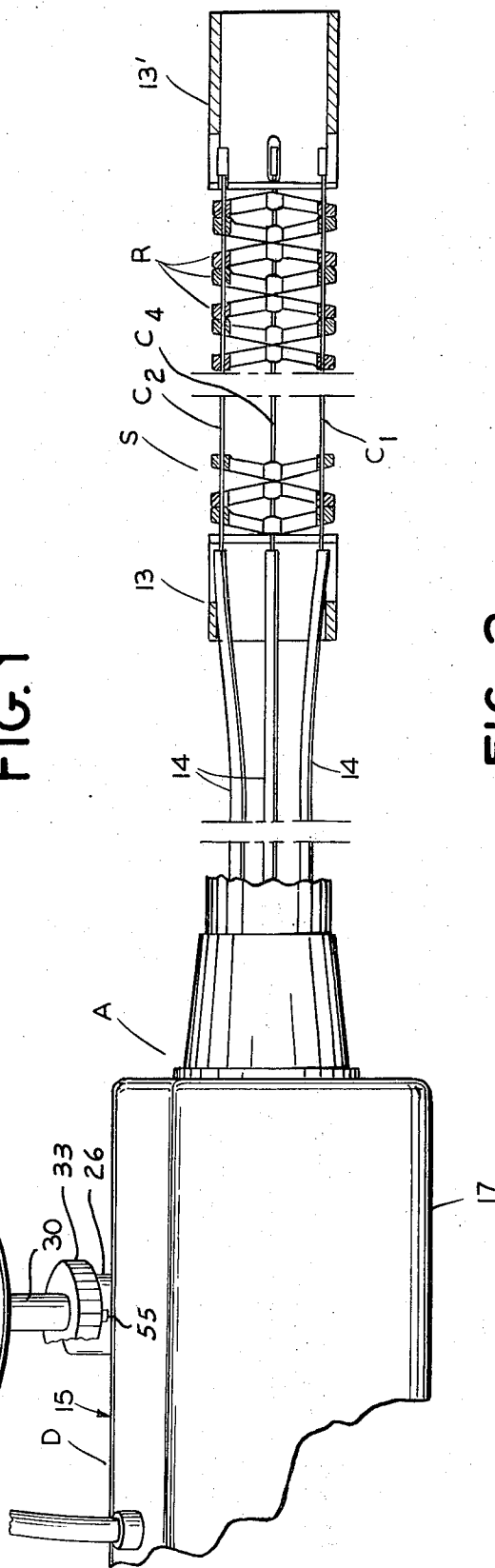
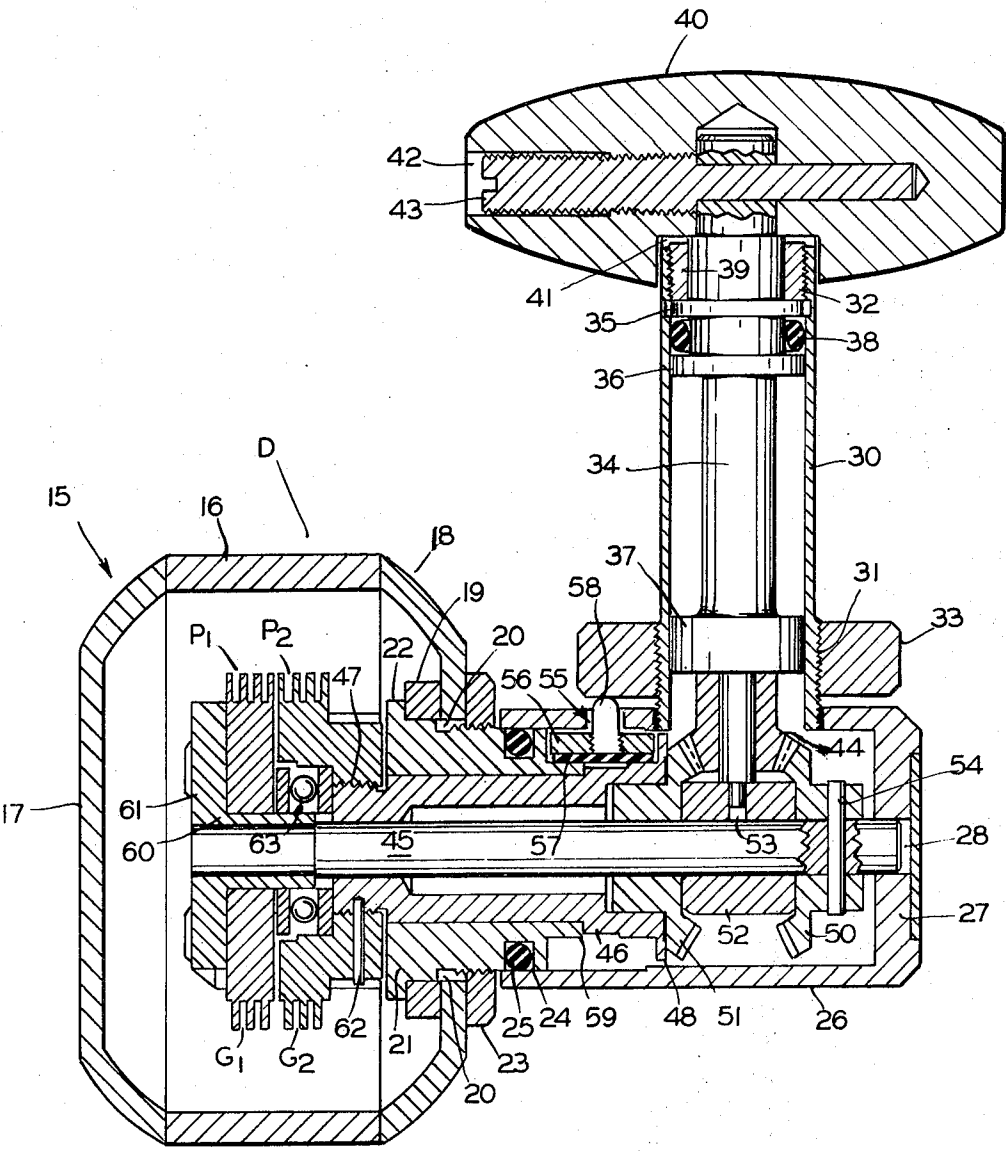
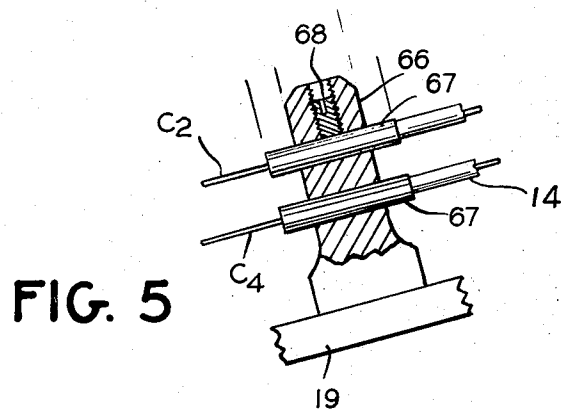
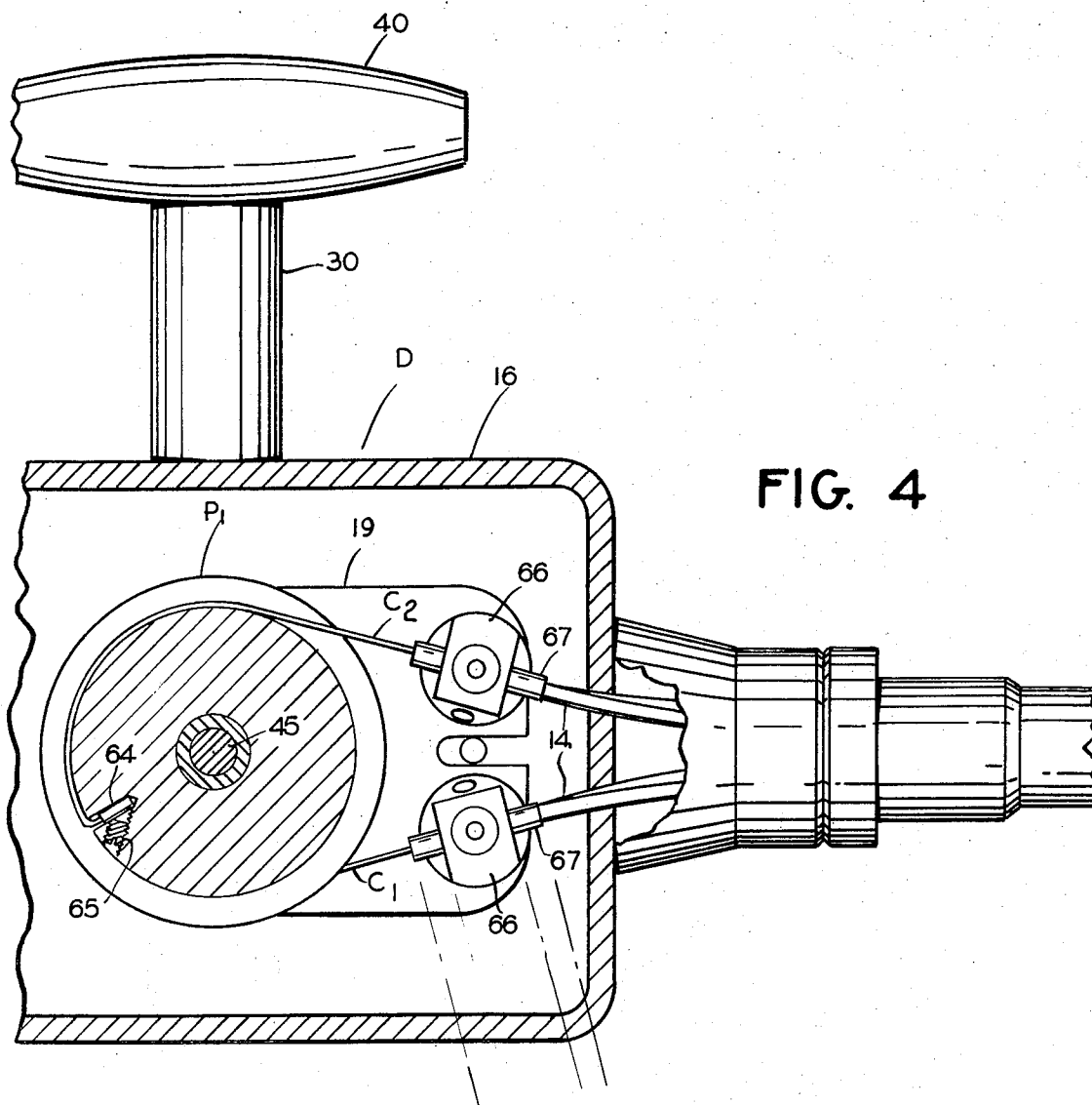


FIG. 2





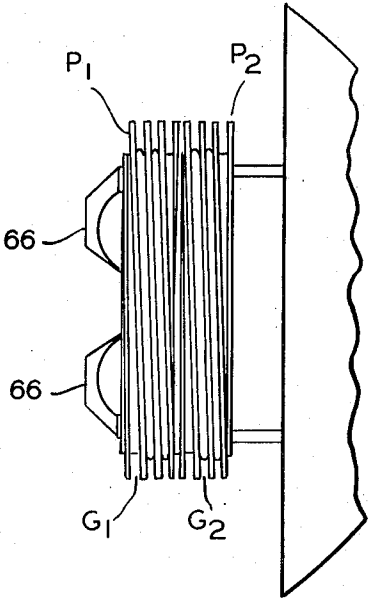


FIG. 6

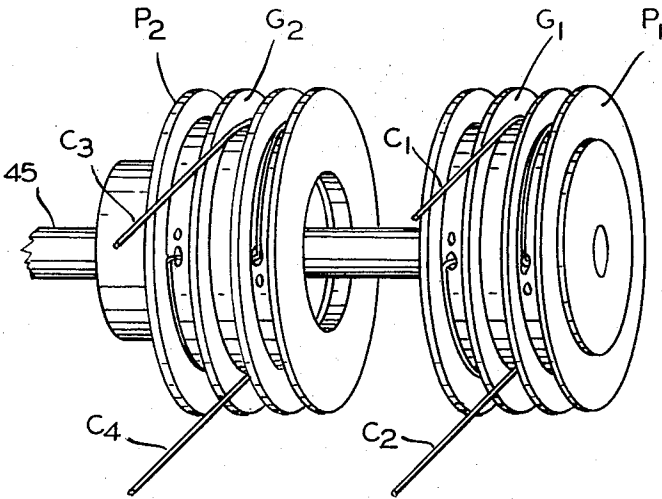


FIG. 7

ORTHOGONALLY DEFLECTABLE ENDOSCOPE

BACKGROUND OF THE INVENTION

This invention relates to the art of control devices and, more particularly, to a device for controlling the operation of a plurality of flexible connectors, such as cables, which, in turn, are adapted to correspondingly operate some other device or devices that are connected thereto.

The control device of this invention has varied applications. It is especially useful with a flexible endoscope having a deflection section. Accordingly, and for the purposes of this disclosure, the detailed description of the invention that follows and the accompanying drawings are directed to a flexible endoscope of the type indicated and embodying a preferred form of control device of this invention.

There are a number of known flexible endoscopes having deflection sections which are operable by cables or the like that are actuated by control devices remote from the deflection sections. Such endoscopes are exemplified by the constructions disclosed in several U.S. patents, namely, Stokes Pat. No. 3,190,286, Mori Pat. No. 3,525,331 and Takahashi Pat. No. 3,583,393, and in British Pat. No. 1,231,015 and German Pat. No. 1,541,153.

The deflection sections and control devices of known prior art flexible endoscopes are limited and, therefore, objectionable in use as they permit deflection in only one plane or in different planes by the use of corresponding independent control devices. This necessitates repeated manipulation and rotation of the entire endoscope by the operator in endeavoring to negotiate sharp corners and to visually locate areas of interest in a body passage or organ of a living being.

As will be evident to persons trained in the art from the ensuing detailed description and the annexed drawings, the control device of this invention embodies improved features of design and construction. As will also be evident, a flexible endoscope that is equipped with the subject control device is free of limitations and objections inherent in related known endoscopes and is adapted to be readily deflected in an infinite number of planes and on corresponding arcs.

SUMMARY OF THE INVENTION

A control device constructed in accordance with this invention comprises support means and actuating means. The support means preferably includes a housing for protectively encasing and supporting parts of the actuating means. The actuating means is comprised of a first shaft which is rotatable about its longitudinal axis and shaft means which is rotatable about a common axis that is normal to the axis of rotation of the first shaft. The actuating means also comprises a pair of coaxial rotary cable drive means, each preferably consisting of a pulley, which are carried by and rotatable with the shaft means, and coupling means connecting the first shaft to the shaft means and effecting rotation of the shaft means and both rotary cable drive means in response to rotary movement of the first shaft about its axis and simultaneous bodily movement of the first shaft about the axis of the shaft means. Connected to each rotary cable drive means is a pair of cables, one cable of each pair being adapted to be respectively pulled and released from its rotary cable drive means

and the other cable of each pair being adapted to be respectively released from and pulled on its rotary cable drive means upon corresponding rotary movement of the rotary cable drive means.

The shaft means preferably comprises a second shaft and a third shaft which is tubular and telescopically arranged relative to the second shaft. One of the rotary cable drive means is secured to and rotatable with the second shaft and the other rotary cable drive means is secured to and rotatable with the third shaft. Each rotary cable drive means preferably consists of a pulley which has a helical peripheral groove for receiving successive portions of each indicated pair of cables. The coupling means preferably includes first, second and third bevel gears which are respectively connected to and rotatable with the first, second and third shafts. The second and third bevel gears are mounted in spaced relation on the second shaft and mesh with the first bevel gear.

The term "rotary cable drive," as used in this description and in the claims, includes, without limitation unless otherwise modified, any conventionally configured pulley, spool, reel, sprocket, pinion of a rack and pinion, or the like, having a peripheral surface by which an elongated flexible element may be respectively pulled or released. The term "cable," as used in this description and in the claims, includes, without limitation, any suitable flexible connector, such as a cable, belt, twisted wire, chain, metallic rod, or the like. In certain applications, such as when the subject control device is used with a flexible endoscope, the cables should be substantially inextensible.

This invention has for its primary object the provision of a control device of the character indicated having improved features of design and construction.

Another object of this invention is to provide, in a flexible endoscope, a control device having its parts so constructed and arranged as to permit of ready deflection of the endoscope in an infinite number of planes by means of a single handle control, and to direct the distal portion of the endoscope in the same relation as a handle directly attached to the distal portion.

A further object of this invention is to provide a control device of the stated type which is relatively simple and compact in design; which is sturdy and durable in construction; which is reasonable in manufacturing and maintenance costs; which is adapted to be conveniently actuated by an operator; and which is adapted to perform its intended functions in an efficient manner.

The foregoing objects and additional objects, as well as the advantages of this invention, will be manifest to persons trained in the art from the following detailed description and the accompanying drawings which respectively describe and illustrate a preferred and recommended control device of this invention in combination with a flexible endoscope.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings wherein like reference characters denote corresponding parts in the several views:

FIG. 1 is a view in side elevation of a flexible endoscope in which the control device of this invention is incorporated;

FIG. 2 is an enlarged view similar to a portion of FIG. 1, certain parts being omitted and certain internal parts being shown in cross section;

FIG. 3 is an enlarged view taken along line 3—3 of FIG. 1, the operating handle being turned 90° and the cables being omitted;

FIG. 4 is an enlarged view of a portion of FIG. 2, the housing outer cover plate being omitted and other parts being shown in cross section or broken away;

FIG. 5 is a projected view of a fragmentary portion of FIG. 4, partly in cross section;

FIG. 6 is a side elevation view of pulleys and associated parts appearing in other views; and

FIG. 7 is an exploded isometric view of an arrangement of pulleys, cables and shafts that are elements of the inventive control device.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference is first had to FIG. 1 of the drawings which illustrates a flexible endoscope E which is equipped with a control device of this invention. The endoscope includes an assembly of devices and parts A at its proximal end, a hollow tip element 10 at its distal end and a sheath 11 intermediate assembly A and tip element 10. The sheath is made of a suitable elastomeric composition, such as neoprene. The endoscope includes an optical telescope T having an eyepiece 12 and other devices (not shown), such as fiber optics bundles, a water inlet and outlet tube and a forceps or suction tube.

Positioned within sheath 11, adjacent tip element 10, is a deflection section S (FIG. 2) which includes a pair of spaced tubular fittings 13 and 13', a plurality of deflection rings R that are located between the tubular fittings and a total of four cables C₁, C₂, C₃ and C₄. Each cable C₁, C₂, C₃ and C₄ is slidable in a corresponding guide tube 14 which extends from fitting 13 to the interior of assembly A.

A preferred control device according to this invention is denoted by the letter D in the drawings and, as indicated in FIGS. 1 and 2, is incorporated in assembly A. The control device includes a housing 15 that protectively encases certain parts and that serves as a support means for other parts, all of which will be described further along herein. The housing consists of a rectangular tubular side wall 16, a dished outer cover 17 and a dished inner cover 18 which is equipped with a cable support plate 19. An opening 20 extends through inner cover 18 and support plate 19. The housing side wall and the covers are joined by screws (not shown) or in any other suitable manner known to the art.

A tubular shaft housing 21 extends through housing opening 20 and is provided with an end flange 22 which bears against plate 19. The shaft housing is maintained in the illustrated assembly position by an internally threaded retainer ring 23 which engages corresponding threads on the housing. The shaft housing is formed with an annular recess 24 for receiving an O-type sealing ring 25. A tubular gear housing 26 is carried by and rotatable relative to shaft housing 21. The gear housing has a closed end 27 having an opening 28.

Mounted on gear housing 26 is a tubular member 30 which is externally threaded at its lower end, as indicated at 31, and internally threaded at its upper end, as indicated at 32. The lower extremity of tubular member 30 registers with an opening in the gear housing and is secured thereto, preferably by soldering. A ring nut 33 engages the externally threaded portion 31 of tubular member 30. A rotary first shaft 34 is positioned in

tubular member 30 and extends beyond both ends thereof. This shaft is machined on several diameters, as illustrated, and is formed with a plurality of axially spaced annular flanges 35, 36 and 37. An O-type sealing ring 38 is located in the space between flanges 35 and 36 and bears against the inner surface of tubular member 30. An externally threaded ring 39 is coaxial with shaft 34 and engages the internal threads 32 at the upper end of tubular member 30. As shown in FIG. 3, ring 39 bears against the upper face of flange 35 and restrains shaft 34 against upward axial movement relative to tubular member 30 but permits rotary movement of this shaft relative to the tubular member. A hand grip or handle 40, having a stepped, blind, bottom bore 41 and a stepped, blind, side tap 42, is positioned at the upper ends of tubular member 30 and shaft 34. As illustrated, the upper end portions of the tubular member and the shaft project into corresponding portions of bore 41. The handle is detachably secured to shaft 34 by a screw 43 which engages threads in tap 42 and projects through a transverse opening (unnumbered) in the shaft. By virtue of this arrangement, increments of turning movement of handle 40 in either direction about the axis of shaft 34 causes corresponding increments of rotation of this shaft relative to tubular member 30. Also bodily movement of handle 40 and tubular member 30 causes corresponding increments of rotation of gear housing 26 about the axis of shaft housing 21.

A driving bevel gear 44 is carried by and affixed to the lower portion of shaft 34 directly below flange 37.

Control device D also includes shaft means consisting of a second or inner rotary shaft 45 and a third or outer rotary shaft 46 which is tubular and which is intermediate and coaxial with shaft 45 and tubular housing 21 and is rotatable relative thereto. One end of shaft 45 is journaled for rotation in opening 28. As is best shown in FIG. 3, shaft 46 is provided at its left end with external threads 47 and at its right end with an annular flange 48.

Shaft 45 is provided with a pair of coaxial, oppositely facing, driven bevel gears 50 and 51 which mesh with driving bevel gear 44. Interposed between bevel gears 50 and 51 is a bushing 52 which is also coaxial with shaft 45. Bushing 52 has an opening 53 for the free reception of the extreme lower end of shaft 34. Bevel gear 50 and shaft 45 are keyed together by a pin 54 for rotation in unison about the axis of this shaft. Bevel gear 51 is freely rotatable about shaft 45. This bevel gear and hollow shaft 46 are joined, preferably by soldering, for rotation in unison about the axis of shaft 45.

Control device D is equipped with a brake unit 55, consisting of a plate 56, a brake shoe 57 and a pin 58 which is connected to plate 56 and projects through and beyond an opening in tubular housing 26. The brake unit registers with an annular recess 59, that is formed in shaft housing 21 and tubular shaft 46, and serves as a friction coupling between these parts to prevent undesirable rotation of tubular shaft 46 and gear housing 26 relative to shaft housing 21. The frictional force exerted by the brake unit may be readily varied, as desired, by adjusting the position of ring nut 33.

A pair of spaced, coaxial pulleys P₁ and P₂ are disposed in housing 15. Extending through pulley P₁ is a sleeve 60 that is mounted on the left end of shaft 45 (FIG. 3) and this is secured to this shaft for rotation therewith, preferably by soldering. Sleeve 60 has an

end flange 61, which bears against an end of pulley P₁, and is secured to this pulley, also preferably by soldering. It will be noted that, by virtue of this arrangement, pulley P₁ is carried by and rotatable with shaft 45.

Pulley P₂ is tapped for engagement with the external threads 47 of tubular shaft 46, as shown in FIG. 3. Pulley P₂ is keyed to tubular shaft 46 by a pin 62 and, as a consequence, is rotatable with the tubular shaft. A ball bearing 63 is positioned between facing ends of pulley P₁ and tubular shaft 46.

Pulleys P₁ and P₂ are formed with respective, identical, peripheral, helical grooves G₁ and G₂. Each of cables C₁ and C₂ is anchored at one end to pulley P₁ and is oppositely and partly wound in a corresponding portion of groove G₁ (FIG. 7). Each of cables C₃ and C₄ is anchored at one end to pulley P₂ and is oppositely and partly wound in a corresponding portion of groove G₂. As is illustrated in FIG. 4, the indicated end of cable C₁ is provided with a fitting 64 that is located in an unnumbered radial opening in pulley P₁ and is releasably maintained therein by a set screw 65 in a tap (also unnumbered) which intersects the radial opening.

Referring further to FIG. 4, cable support plate 19 is provided with a pair of spaced posts 66 which are parallel to shaft 45. Extending through each post is a pair of guide sleeves 67 which are retained in the illustrated position by corresponding set screws 68 (FIG. 5). The proximal end of each cable guide tube 14 terminates in and is anchored to a corresponding sleeve 67.

For the purpose of describing the operation of the illustrated embodiment of control device D, it is assumed that endoscope E is assembled and that its parts are in the relative position shown in FIGS. 1 and 2, tubular member 30 projecting vertically upwardly and handle 40 being normal to the axis of shaft 45 and parallel to sheath 11. When these parts are in the indicated position, sheath 11 and tip element 10 are in a substantially straight line or rectilinear condition. Tubular member 30 is adapted, through the medium of handle 40, to be swung in a clockwise or counterclockwise direction, from the position shown in FIG. 1, about the axis of shaft 45 to impart corresponding pivotal or rotary movement to housing 26 and, at the same time, impart corresponding rotary movement to pulleys P₁ and P₂ about the axis of shaft 45 by virtue of the interconnection of shaft 34, the several bevel gears, shaft 45 and tubular shaft 46 with these pulleys. Rotation of the pulleys causes corresponding winding or unwinding of the respective cables and like deflection of rings R and deflection section S.

When tubular member 30 is swung in a clockwise direction from the position shown in FIG. 1, it causes deflection of the portion of sheath 11 containing the deflection section to the broken line position indicated by the numeral 70. When tubular member 30 is swung in a counterclockwise direction from the position shown in FIG. 1, it causes deflection of the portion of sheath 11 containing the deflection section to the broken line position indicated by the numeral 71. When handle 40 is rotated in either direction relative to tubular member 30, it causes like rotation of shaft 34 which in turn causes corresponding rotation of pulleys P₁ and P₂ through the interconnection of this shaft and the pulleys with the several bevel gears, shaft 45 and tubular shaft 46. It will be observed that the pulleys are operable by bodily movement of tubular member 30 and handle 40 about the axis of shaft 45 and/or by turning

handle 40 and shaft 34 relative to tubular member 30. Thus the control device is adapted to impart universal or orthogonal movement to deflection section S, i.e., cause the deflection section to be bent in an infinite number of planes and on corresponding arcs.

The relative positions of tubular member 30 and handle 40 indicate to an operator the condition of deflection section S. Thus, when tubular member 30 and handle 40 are in the relative position shown in FIG. 1, they indicate that the deflection section is in its rectilinear condition. When the tubular member is swung in a clockwise or counterclockwise direction from the position shown in FIG. 1, it indicates to the operator that the portion of the sheath containing the deflection section is bent downwardly or upwardly, respectively, as indicated by numerals 70 and 71. Also, when handle 40 is turned in either direction, it indicates that the deflection section has been correspondingly bent in another plane. When the control device is operated both by swinging tubular member 30 and turning handle 40, the deflection section is correspondingly bent in other planes and corresponding arcs.

Based on the foregoing, it is believed that the construction, operation, objects and advantages of my present invention will be readily comprehended by persons skilled in the art, without further description. It is to be clearly understood, however, that various changes in the construction described above and illustrated in the drawings may be made without departing from the scope of the invention, it being intended that all matter contained in the description or shown in the drawings shall be interpreted as illustrative only and not in a limiting sense.

I claim:

1. An endoscope, comprising, in combination, a proximal portion, a distal portion and a hollow portion connected to the proximal and distal portions, said hollow portion comprising a flexible sheath and a deflection section within the sheath and adjacent the distal portion, support means and actuating means carried by the support means being mounted on the proximal portion, said actuating and support means including a first shaft rotatable about its longitudinal axis, shaft means rotatable about a common axis which is normal to the axis of rotation of the first shaft, a pair of rotary cable drive means carried by and rotatable with the shaft means, coupling means connecting the first shaft to the shaft means and effecting rotation of the shaft means and both rotary cable drive means in response to rotary movement of the first shaft about its axis and to bodily movement of the first shaft about the axis of the shaft means, one of said rotary cable drive means being rotated in response to and in a direction depending upon the direction of rotation of the first shaft about its axis and the other of said rotary cable drive means being rotated in response to and in a direction depending upon the direction of bodily movement of the first shaft about the axis of said shaft means, a first pair of cables secured to said one of the rotary cable drive means and to points on opposite sides of said deflection section disposed substantially in one plane, and a second pair of cables secured to said other rotary cable drive means and to points on opposite sides of said deflection section disposed substantially in another plane normal to said given plane, whereby rotation of said first shaft about its axis caused deflection of said deflection section in said one plane and bodily movement of said first

shaft about the axis of said shaft means causes deflection of said deflection section in said other plane.

2. The combination according to claim 1 wherein each rotary cable drive means comprises pulley means.

3. A control device according to claim 2 wherein the shaft means comprises a second shaft and a third shaft which is tubular and is telescopically arranged relative to the second shaft and wherein one of the pulley means is secured to and rotatable with the second shaft and the other pulley means is secured to and rotatable with the third shaft.

4. A control device according to claim 3 wherein each pulley means comprises a pulley having a helical peripheral groove, one of the pulleys being rotatable with the second shaft and the other pulley being rotatable with the third shaft.

5. A control device according to claim 3 wherein the coupling means includes intermeshing gears comprised of first, second and third gears that are respectively connected to and rotatable with the first, second and third shafts.

6. A control device according to claim 4 wherein the coupling means includes intermeshing first, second and third bevel gears that are respectively connected to and rotatable with the first, second and third shafts, the second and third bevel gears being spaced apart and mounted on the second shaft and meshing with the first bevel gear.

7. An endoscope, comprising, in combination, a proximal portion, a distal portion and a hollow portion connected to the proximal and distal portions, said hollow portion comprising a flexible sheath and a deflection section within the sheath and adjacent the distal portion, support means and actuating means carried by the support means being mounted on the proximal portion, said actuating and support means including a first shaft rotatable about its longitudinal axis, shaft means rotatable about a common axis which is normal to the axis of rotation of the first shaft, first and second deflection means connected to said deflection section for orthogonally deflecting the latter in response to said shaft means, coupling means between said first shaft and said shaft means responsive to rotation of said first shaft about its said axis for actuating said first deflection means to deflect said deflection section in a first plane and in a direction and extent corresponding to the direction and extent of rotation of said first shaft, said coupling means also being responsive to bodily movement of said first shaft about said common axis of said shaft means for actuating said second deflection means to deflect said deflection section in a second plane normal to said first plane in a direction and to an extent corresponding to said direction and extent of the bodily movement of said first shaft about said common axis.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,788,303 Dated January 29, 1974

Inventor(s) Richard W. Hall

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

Front page, Item 73, assignee's address, for "Manor, N.Y."
read -- Pelham Manor, N.Y. --.

Column 4, line 24, for "Also" read -- direction --.
line 48, for "BEvel" read -- Bevel --.

Signed and sealed this 16th day of July 1974.

(SEAL)
Attest:

McCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents