Jan. 1, 1963 G. A. ULRICH 3,071,161

BIDIRECTIONALLY FLEXIBLE SEGMENTED TUBE

Filed May 16, 1960

FIG. 1

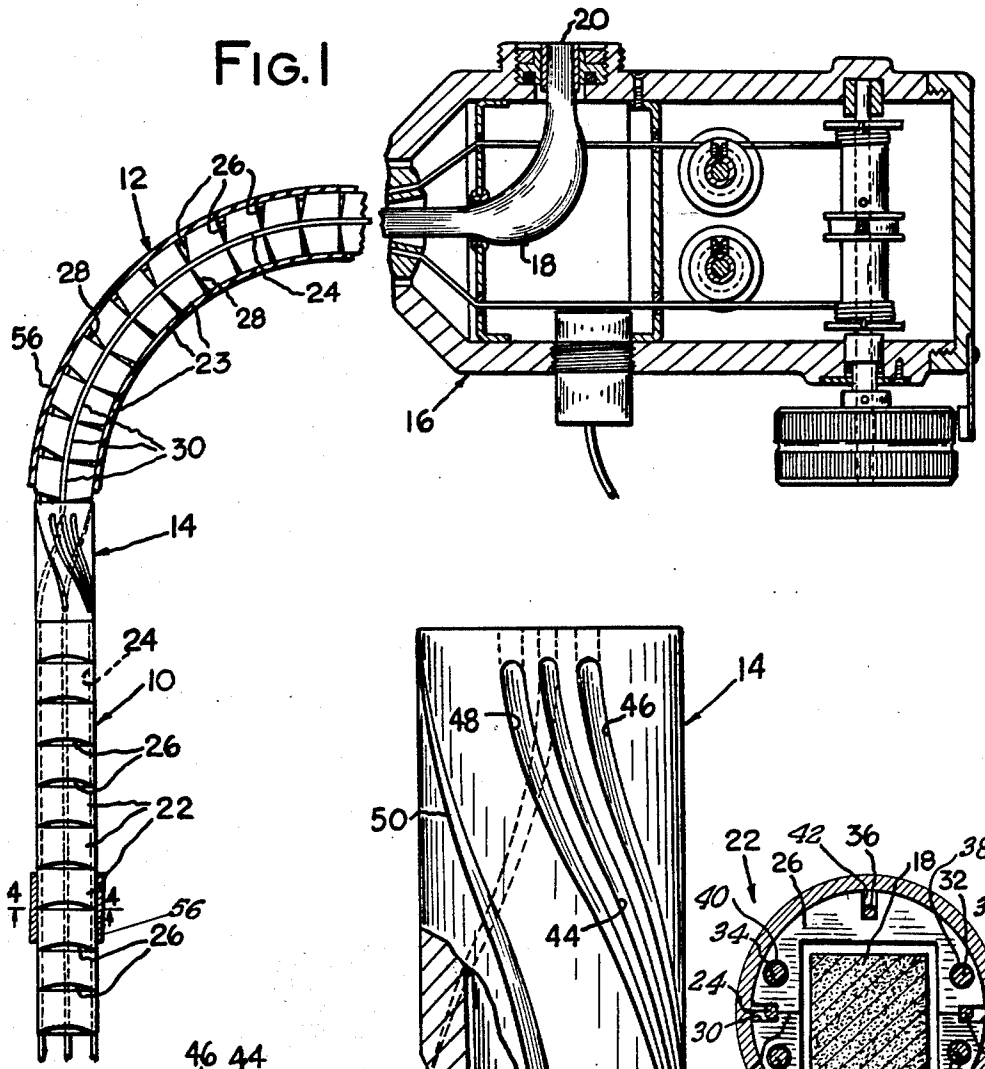

FIG. 2

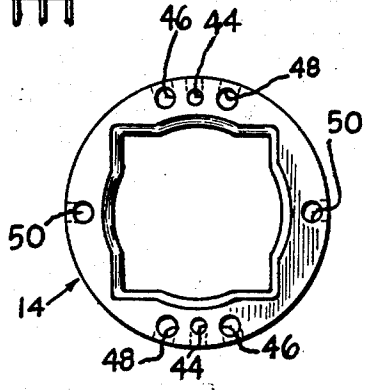

FIG. 3

FIG. 4

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BIDIRECTIONALLY FLEXIBLE SEGMENTED TUBE

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This invention relates to an improved flexible tube for use in endoscopic instruments or the like, and, more particularly, to a flexible tube of segmented construction including one portion free to flex in one plane and a second portion for flexing in a different plane.

One object of the present invention is to provide an improved construction for a flexible tube for endoscopes or the like, of the type including two portions for flexing in mutually different planes so that it may be guided into difficultly accessible body cavities such as the duodenum.

Other objects are: to provide an improved construction for a flexible tube of this character in which a flexing force may be transmitted through a first portion for flexing a second portion without applying undue flexing force to the first portion; to provide an improved device of this character in which mechanical control lines extend through integrally formed guideways in the walls of the individual segments, all of the segments being identical to each other, and selected ones of the lines being independent of flexing of the different portions of the tube; and in general, to provide an improved bi-directionally flexible, segmented tube which is of relatively simple and inexpensive construction, easy to manufacture and assemble, and rugged and long lasting in service.

These and other objects and advantages of the invention will become apparent in the following detailed description of a presently preferred embodiment thereof, taken in conjunction with the drawing wherein:

FIG. 1 is an elevational view, partly in section of an endoscope including a flexible tube according to the invention;

FIG. 2 is an elevational view, on an enlarged scale of a rigid guide segment, which is included in the flexible tube shown in FIG. 1, being disposed between the two differently flexing portions thereof;

FIG. 3 is a plan view of the rigid segment shown in FIG. 2; and

FIG. 4 is a cross sectional view taken along the line 4—4 of FIG. 1.

Briefly, the invention contemplates a segmented, articulated tube having at least two longitudinally extending portions arranged in series for flexing in mutually different planes. Tension lines for hingedly securing the segments together and for mechanically operating various different portions of the device, as well as for controllably flexing one of the portions of the tube extend longitudinally through the entire length of the tube in separate guideways formed integrally in the individual segments thereof. A special, spirally grooved segment is disposed between the two differently flexing portions of the tube for guiding the control lines along a spiral path so that the control lines may be oriented in a rotated relation in one portion with respect to the other portion of the tube.

In this way, certain ones of the control lines may be guided through the length of the tube in positions closely adjacent to the hinge axes between the segments so that flexing of the tube has substantially no effect on them.

The control lines for controllably flexing the one portion of the tube are 90° offset from the hinge connecting points in both portions, so that it might be expected that they would exert a flexing force on both of the portions of the tube. However, in this type of construction, it appears that the flexing force achieved by tensioning the flexing control lines is such that the portion of the tube immediately adjacent to the points of anchorage for the lines flexes first, and substantially one entire portion of the tube may be almost completely flexed without the application of undue flexing force on the other portion, even though the lines are tensioned through the other portion.

Referring now to the drawing, the endoscope illustrated therein includes front and rear elongated flexible portions **10** and **12**, respectively, an intermediate cylindrical connector **14** disposed between the flexible portions **10** and **12**, an objective assembly (not shown) at the front of the front flexible portion **10**, and a control housing **16** secured at the rear of the rear flexible portion **12**. The objective assembly is arranged for projecting a light image of the object, or field to be viewed upon the front face of a flexible image transmitting device such as the coherent bundle **18** of glass fibres, which is fitted within the flexible portions **10** and **12** and extends therein from the objective assembly to the control housing **16**. A light image transmitted through the fiber bundle **18** may be viewed upon the rear face **20** of the bundle by any convenient viewing device (not shown) such as a low power microscope or other eyepiece.

The flexible portions **10** and **12** are made up of a plurality of relatively short, articulated tubular segments **22** and **23**, all of which are of identical construction. The segments **22** and **23** are urged towards each other by flexible tension members, or hinge lines **24**, which extend along opposite sides of the flexible portions **10** and **12** and serve also to align the segments one with another. One face **26** of each segment is tapered to form a diametrically extending pivot ridge **27**, which bears against the opposite face **28** of the next segment to provide a fulcrum. The hinge lines **24** extend through guideways **30** in the segment walls, passing through the pivot ridges **27** of the segments, and thereby permitting flexure of the flexible portions **10** and **12** without loss of tension and retaining force.

The segments **22** in the front flexible portion **10** are displaced 90° from the segments **23** in the rear flexible portion **12** so that the front portion **10** flexes perpendicularly to the direction of flexure of the rear portion **12**. The hinge lines **24** in the front portion **10** are also 90° displaced from their position in the rear portion **12**.

In addition to the hinge lines **24**, other control lines **32**, **34**, and **36** extend through separate guideways **38**, **40**, and **42** in the segment walls and are retained in the guideways by the elastomeric sheath **56**. The lines **32** and **34** may be, for example, tension members for controlling the focus and angular position of the objective assembly at the front end of the front flexible portion **10**. The last set of control lines **36**, as shown, are flexible tension members for controllably flexing the front portion **10**.

It is desirable to maintain the relative positions of the various lines **24**, **32**, **34**, and **36** constant throughout the length of the endoscope so that all of the segments **22** and **23** may be of identical construction, thus minimizing the cost of manufacturing the instrument. Toward this end, in order to maintain the relative positions of the various lines uniform throughout the length of the endoscope, while at the same time providing for differently polarized flexure of the front and rear portions **10** and **12** respectively, an intermediate connector **14** having spiral guideways **44**, **46**, **48**, and **50** is disposed between the two portions **10** and **12** for positively guiding the lines **24**, **32**, **34**, and **36** through the required 90° displacement.

The guideways **44**, **46**, **48** and **50** are preferably formed along the natural lines of tension between their angularly displaced entrant and exit ends, so that the lines **24**, **32**, **34**, and **36** will have a natural tendency to remain in the guideways when they are tensioned.

Preferably, the entrance and exit portions of each guideway are holes formed by drilling, as best shown in FIG. 2, to provide positive retention of the lines at both ends of the guideways. Intermediate portions of the guideways may be formed by milling spiral grooves between the end portions.

The lines are retained within the spiral grooves by an elastomeric sheath **56** which extends over the entire flexible portion of the endoscope.

The intermediate connector **14** thus maintains the desired angular relationship between the two flexible portions **10** and **12** despite tension applied to the various lines **24**, **32**, **34**, and **36**, which extend through both of the portions **10** and **12**, and which would tend to draw the two portions **10** and **12** into angular alignment with each other. The connector also minimizes friction against the lines **24**, **32**, **34**, and **36**, and permits overall simplification of the construction.

Various features of the illustrated endoscope, which are not described in detail herein, are described and claimed in the following co-pending applications of the same assignee:

Gilbert J. Sheldon, Ser. No. 679,566, filed August 22, 1957, entitled "Flexible Tube Structures";

Gilbert J. Sheldon, Ser. No. 686,320, filed September 26,1957, entitled "Optical Viewing Instrument," now Patent Number 2,975,785;

Gilbert J. Sheldon, Ser. No. 715,820, filed February 17, 1958, entitled "Optical System for Endoscopes and the Like," now Patent Number 2,987,960;

Gilbert J. Sheldon, et al., Ser. No. 29,416, filed concurrently herewith, entitled "Focusing Endoscope";

Gustav A. Ulrich, Ser. No. 29,255, filed concurrently herewith, entitled "Holder for Camera and Viewing Device."

What is claimed is:

1. A flexible tube for an endoscope or the like comprising two elongated flexible portions arranged in series for flexure in mutually different planes, a tension line extending through both of said portions along the side walls thereof, and a guide member between said two portions, an elastomeric sheath encasing said portions and said guide member, said guide member having a spiral guideway for guiding said tension line through an angular displacement between said two portions so that when the respective portions of said line coextensive with said two flexible tube portions are oriented in a rotated relation between said flexible tube portions and said line is tensioned the twisting force exerted by said line upon the tube is resisted by said guide member and the angular displacement between said flexible tube portions remains undisturbed.

2. A flexible tube for an endoscope or the like comprising two flexible portions arranged in series for flexure in mutually different planes, said portions being composed of a plurality of articulated tubular segments, all of said segments being of substantially identical construction and including longitudinally extending guideways in their walls, tension lines extending through said guideways from one of said portions to the other one thereof and lying in corresponding guideways in said two portions, and a guide member disposed between said portions, an elastomeric case receiving said member and said portions of the tube, said guide member having spiral guideways for guiding said lines through an angular displacement between said two portions, the opposite ends of said spiral guideways being aligned respectively with the corresponding longitudinal guideways of said segments of said two portions, whereby the twisting force exerted by said lines when they are tensioned is taken by said guide member without imposing substantial torsional forces between said two flexible portions.

3. A flexible tube for an endoscope or the like comprising two elongated flexible portions arranged in series for flexure in mutually different planes, a tension line extending through both of said portions along the side walls thereof, and a guide member between said two portions, an elastomeric sheath enclosing said member and said portions of said tube, said guide member having a spiral guideway for guiding said tension line through an angular displacement between said two portions so that when the respective portions of said line coextensive with said two flexible tube portions are oriented in a rotated relation between said flexible tube portions and said line is tensioned the twisting force exerted by said line upon the tube is resisted by said guide member and the angular displacement between said flexible tube portions remains undisturbed, said spiral guideway including tubular end portions and an outwardly opening groove portion intermediate said end portions, said groove portion extending along the natural line of tension between said end portions.

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