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[33] **Japan**
[31] **42/109292**

[54] **BENDABLE TUBE ASSEMBLY**
7 Claims, 4 Drawing Figs.

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[51] Int. Cl. **A61b 1/00,**
F16l 11/18
[50] Field of Search 16/150;
128/4, 5, 6, 7, 8, 9; 138/103, 120; 95/11 H.C.;
73/151; 285/253, 283; 220/31

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ABSTRACT: Bendable tube assembly for an endoscope comprised of a plurality of thin-walled cylindrical segments arranged in series endwise to each other. The end edge of the segment is bevelled starting from the diametrically opposed two points in the end edge so that two diametrically opposed raised portions are formed in the end edge thereby permitting the series of the segments connected endwise to each other to be bent. A bifurcation having two leg portions is provided at each of the two diametrically opposite raised portions, one of the two leg portions being offset radially inwardly so that it engages with the inner surface of the adjacent segment while the other of the two leg portions is offset radially outwardly so that it engages with the outer surface of the adjacent segment. Thus, each of the two bifurcations in one end edge of a segment is engaged with the corresponding bifurcation in the adjacent end edge of the neighboring segment thereby permitting the pivotal movement of the segment with respect to the neighboring segment about the axis passing through the points of engagement of the mating bifurcations located at the two diametrically opposed points in the end edge of the segment. Means is provided to prevent the disengagement of the bifurcations engaged with each other while permitting the pivotal movement therebetween.

A pair of control strings is provided extending along the bendable tube assembly at diametrically opposed positions thereof disposed normal to the diameter passing through each of the diametrically opposed bifurcations. One end of each of the control strings is secured to one endmost segment in the series while the other end extends beyond the other of the endmost segments so as to be operated from the exterior of the bendable tube assembly for controlling the bending thereof.

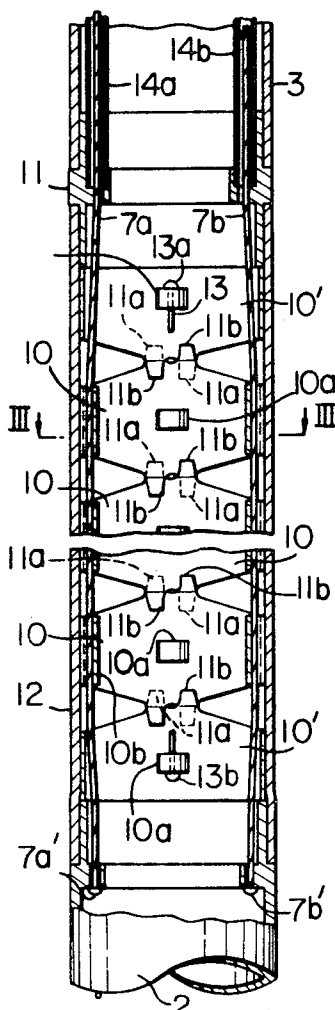


Fig. 1

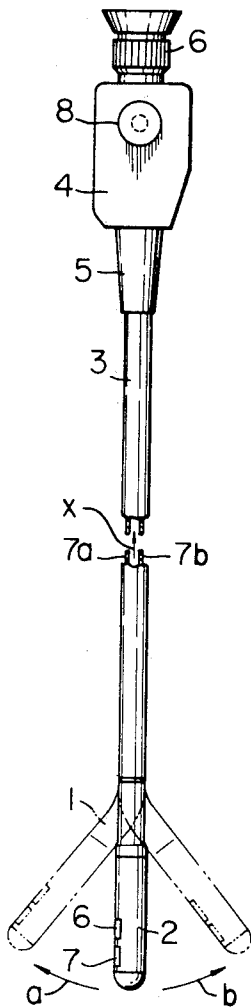


Fig. 2

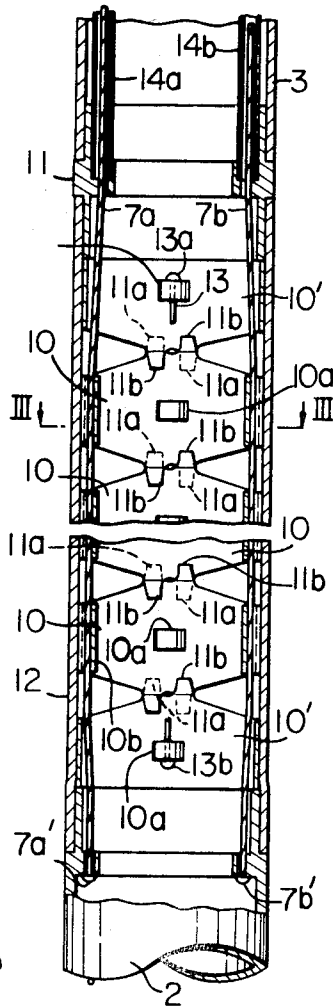


Fig. 3

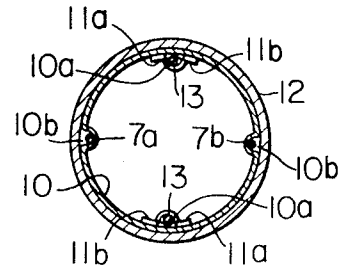
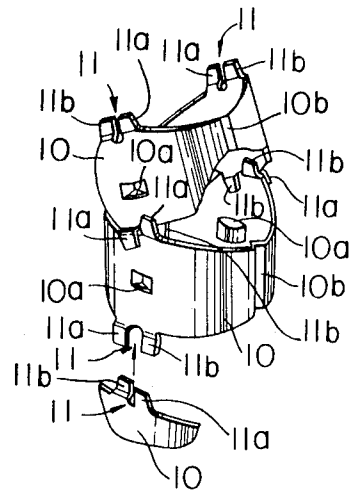


Fig. 4



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BENDABLE TUBE ASSEMBLY

BACKGROUND OF THE INVENTION

The present invention relates to a novel and useful bendable tube assembly and, more particularly, to a bendable tube assembly particularly useful for an endoscope which can be operated to control the bending thereof.

It is well known in an endoscope to provide an elongated flexible tube connecting the forward end portion adapted to be inserted in a cavity of a living body or the like for the inspection thereof to the control housing for operating the forward end portion. The forward end portion is provided therein with an objective for focusing the image of an object to be inspected onto the forward end of an image transmitting optical system such as a fiber optical system extending through the elongated flexible tube from the forward end portion to the control housing. The image transmitted through the image transmitting optical system to the rearward end thereof is viewed through an ocular provided in the control housing. An illuminating optical system is also provided extending through the elongated flexible tube so as to illuminate the object from the forward end portion.

In such a well-known endoscope, a bendable tube section is provided between the forward end portion and the forward end of the elongated flexible tube, and a pair of control strings extend through the bendable tube section and the elongated flexible tube in diametrically opposite positions therein with their forward ends secured to the forward end portion while the rearward ends thereof are connected to a control mechanism in the control housing so that the control strings are manually operated so as to control the bending of the bendable tube section for facilitating the inspection of the object.

In order to effectively inspect the object, the length of the bendable tube section must be made as short as possible and the inner diameter of the bendable tube section must be made as large as possible to provide a sufficient space for arranging therein the image transmitting optical system, the illuminating optical system and pipe means for inserting forceps and the like therethrough for assisting the inspection of the object.

The outer diameters of the forward end portion of the endoscope, the bendable tube section and the elongated flexible tube are extremely limited in order to permit these elements to be easily inserted into the cavity of a living body or the like without harming the passageway leading to the cavity through which the forward end portion is inserted or without giving any pain to the living body. Therefore, the wall thickness of the bendable tube section must be as thin as possible.

To this end, it has been known to construct the bendable tube section in such a manner that one of the two cylindrical segments forming the bendable tube section is provided at its end edge with two diametrically opposed leg portions extending endwise outwardly therefrom which are engaged with the opposing end edge of the other of the two cylindrical segments and the leg portions are pivotally connected to the opposing end edge of the other of the segments by pivot pins or the like secured thereto. Since the pins must be of substantial length in the radial direction of the segment in order to properly pivot the leg portions, the inner diameter of the segments must necessarily be reduced in comparison with the outer diameter thereof which is limited to permit the segments to be inserted into the cavity of the living body thereby extremely reducing the space within the segments available to arrange the various elements therein as stated above. The present invention aims at avoiding the above-described disadvantages of the prior art bendable tube section and providing a novel and useful bendable tube assembly.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a novel and useful bendable tube assembly particularly useful for an en-

doscope which is simple in construction and reliable in operation.

The other object of the present invention is to provide a novel and useful bendable tube assembly of the type described above which does not require the provision of any hinge means or pivot pin means for the pivoting movement of the tube assembly thereby providing large space therein available for arranging the various elements therein.

The above objects of the present invention are achieved in accordance with the present invention by arranging a plurality of thin-walled cylindrical segments in series endwise to each other, at least one of the end edges of each of the segments facing to the adjacent end edges of the neighboring segment being bevelled off starting from the diametrically opposite points in the end edge so as to provide two diametrically opposed raised portions in the end edge thereby permitting the swinging movement of the segment with respect to the neighboring segment, a bifurcation having two leg portions being provided at each of the diametrically opposite raised portions in the end edge of one segment as well as in the opposite end edge thereof facing to the adjacent end edge of the neighboring segment at positions axially aligned with those of the diametrically opposite raised portions, one of the two leg portions of each of the bifurcations being radially inwardly offset so as to fit in the inner surface of the adjacent segment while the other of the two leg portions is offset radially outwardly so as to engage with the outer surface of the adjacent segment, thereby permitting each of the bifurcations at the diametrically opposite raised portions to be pivotably engaged with the respective bifurcation in the opposing end edge of the neighboring segment, holding means being provided for preventing the bifurcations engaged with each other from being disengaged from each other while maintaining the pivotal engagement therebetween.

Thus, the bendable tube assembly of the present invention can be bent as desired by virtue of the pivotal movement between the adjacent two segments in the series afforded by the engagement of the mating bifurcations in the opposite two end edges of the adjacent two segments in the series, while the wall thickness is kept at the minimum because of no provision of any additional hinge means or pivot pin means thereby providing maximum space in the segments available to arrange various elements therein.

In accordance with one feature of the present invention, the holding means is constructed by a pliant flexible tube closely surrounding the bendable tube assembly so as to prevent each of the segments located therein in coupled relationship to each other from moving endwise relative to the inner wall of the pliant flexible tube while permitting the bendable tube assembly to be bent together with the pliant flexible tube.

A pair of flexible but nonextensible strings may be provided along the bendable tube assembly at diametrically opposite sides thereof in alignment with the lines passing the bifurcations arranged axially of the bendable tube assembly, respectively, with both ends of each of the strings fixedly secured to the respective endmost segments to thereby prevent the disengagement of the bifurcations coupled with each other.

In accordance with further features of the present invention, a pair of control strings are provided each extending axially of the bendable tube assembly at diametrically opposite positions thereof disposed normal to the diameters passing through the diametrically opposed bifurcations in each of the end edges of the segments, one end of each of the control strings being fixedly secured to a position adjacent to one of the endmost segments while the other end of each of the control strings extends beyond the other of the endmost segments so as to be operated from the exterior of the bendable tube assembly for controlling the bending thereof.

Thus, the bendable tube assembly of the present invention can be controlled its bending by alternately operating the control strings from the exterior of the bendable tube assembly. Therefore, the bendable tube assembly of the present invention can be advantageously incorporated in an endoscope.

BRIEF DESCRIPTION OF THE INVENTION

FIG. 1 is a side view showing an endoscope in which the bendable tube assembly of the present invention is incorporated;

FIG. 2 is a longitudinal sectional view along the axis of a preferred embodiment of the bendable tube assembly constructed in accordance with the present invention;

FIG. 3 is a cross-sectional view along line III-III in FIG. 2; and

FIG. 4 is a fragmentary perspective view showing the details of the bifurcations of the thin-walled cylindrical segments of the bendable tube assembly of the present invention and the manner how they are engaged with each other for the pivotal movement therebetween.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

As shown in FIG. 1, the bendable tube assembly 1 of the present invention is located between the rear end of the forward end portion 2 of an endoscope and the forward end of the elongated tube 3 preferably of the flexible nature, the rearward end of which is connected to the control housing 4 through a grip portion 5. The forward end portion 2 is provided with an observation window 6 and an illuminating window. The light conducted through the elongated tube 3 to the forward end portion 2 from a light source (not shown) by means of a light conducting optical system such as a fiber optical system extending through the elongated tube 3 or generated in the forward end portion 2 by a lamp located therein and energized by an electric source (not shown) through lead wires extending through the elongated tube 3 passes through the illuminating window 7 and illuminates an object to be inspected. The light from the object passes through the observation window 6 and is incident to an objective lens in the forward end portion 2 through a reflecting optical system such as a prism also provided in the forward end portion 2 so that an image of the object is focused on the forward end of an image transmitting optical system such as a fiber optical system extending through the elongated tube 3 into the control housing 4. The image of the object transmitted to the rearward end of the image transmitting optical system is viewed through an ocular 6 provided in the control housing 4.

As described in detail hereinbelow, the bendable tube assembly 1 of the present invention is controlled its bending by means of a pair of control strings 7a, 7b extending through the elongated tube 3 at diametrically opposite sides thereof. The forward end of each of the control strings 7a, 7b is fixedly secured to the rearward end of the forward end portion 2 while the rearward end of each of the control strings 7a, 7b is connected to a control mechanism in the control housing 4 which is manually operated by means of a knob 8 provided in the control housing 4. When the control string 7a is pulled in the direction of the arrow x by operating the knob 8, the bendable tube assembly 1 is bent in the direction shown by the arrow a, whereas the bendable tube assembly 1 is bent in the direction shown by arrow b when the control string 7b is pulled in the direction indicated by the arrow x.

Now referring to FIGS. 2 to 4 illustrating the detailed construction of the preferred embodiment of the bendable tube assembly 1 of the present invention, the bendable tube assembly 1 comprises a plurality of thin-walled cylindrical segments 10, 10' of substantially the same configuration and size with each other which are arranged endwise in series. As shown, each of the opposite two end edges of each of the segments 10 is bevelled starting from the two diametrically opposite two points in the end edge so as to form two diametrically opposite raised portions. As shown, the diametrically opposite raised portions in one end edge of each of the segments 10 are axially aligned with those formed in the opposite end edge of the segment 10. The outermost end edge of each of the outermost two segments 10', however, is cut flatly normal to the axis of the segment 10' so as to facilitate the connection

to the rearward end of the forward end portion 2 or the connecting member 11 provided at the forward end of the elongated tube 3. Each of the diametrically opposite raised portions of the segments 10 as well as the diametrically opposite raised portions of the segments 10' are provided with a bifurcation 11 comprised of two leg portions 11a, 11b. As seen from FIG. 4, the leg portion 11a is radially outwardly offset from the wall of the segment so as to engage with the outer surface of the neighboring segment while the leg portion 11b is offset radially inwardly from the wall of the segment so as to fit with the inner surface of the neighboring segment. Thus, the adjacent two segments 10 or 10' can be pivotably coupled by engaging the bifurcations 11 in the end edge of one segment with the corresponding bifurcations 11 in the opposing end edge of the neighboring segment. Therefore, the thus assembled tube assembly can be bent as desired by virtue of the pivotable engagement of the mating bifurcations 11.

The inner diameter of the assembled tube assembly can be made at the maximum, because it is not necessary to provide any hinge means or pivot pin means for pivotably connecting the segments. respect

In order to prevent the disengagement, of the engaged bifurcations 11, it suffices to cover the assembled tube assembly with a pliant flexible tube 12 in close contact with the assembled tube assembly so as to prevent the relative endwise movement of the segments with bending to the pliant flexible tube 12 while the bending movement of the assembled tube assembly together with the pliant flexible tube 12 is permitted. As shown, one of the endmost segment 10' of the assembled tube is connected to the rearward end of the forward end portion 2 of the endoscope while the other of the segments 10' is connected to the connecting member 11 and the forward end of the pliant flexible tube 12 is watertightly joined to the rearward end of the forward end portion 2 while the rearward end of the tube 12 is watertightly joined to the connecting member 11 so that the entire assembly is watertightly incorporated in the endoscope.

In order to positively prevent the engaged bifurcations 11 from being disengaged, a pair of flexible but nonextensible strings may be provided at diametrically opposite sides in the assembled tube assembly along the lines passing through the axially arranged series of the bifurcations 11.

Press-cut depressions 10a having openings at the the press-cut edges thereof are provided in each of the segments 10, 10' at positions where the string 13 passes. The string 13 terminates at a short distance after it passes through the depression 13 in each of the endmost segments 10' where the string 13 is fixedly secured as shown by 13a and 13b to the segment 10' by means such as soldering so that the tube assembly is positively prevented from being disassembled, while the bending of the tube assembly is permitted.

In order to control the bending of the tube assembly, a pair of control string 7a, 7b extend along the tube assembly with the forward ends 7a, 7b' being secured to the rearward end of the forward end portion 2. The pair of control strings 7a, 7b are positioned at diametrically opposite sides of the tube assembly intersecting the diameter thereof normal to the diameter passing through the diametrically opposite bifurcations 11 in any of the end edges s of the segments 10 forming the pair. In order to prevent the control strings 7a, 7b from being circumferentially displaced with respect to the segments 10, 10', axially extending grooves 10b are formed in the segments 10, 10' by means such as pressing at diametrically opposite positions intersecting the diameter of the segment normal to that passing through the diametrically opposite depressions 10a.

The rearward end of each of the control strings 7a, 7b extends through the elongated tube 3 to the control housing 4 and is connected to the control mechanism therein. As described previously, the control strings 7a, 7b can be manually operated by means of the knob 8 so that one of the strings is tensioned while the other is loosened.

In order to insure the operation of the control strings 7a, 7b, closely wound noncontractable coiled tubes 14a, 14b are pro-

vided extending through the elongated tube 3 from the control housing 4 to the rearward end of the tube assembly 1 and the control strings 7a, 7b are passed through the respective coiled tubes 14a, 14b, respectively. This insures that the movement of the control strings 7a, 7b given by the control mechanism at the rearward ends of the coiled tubes 14a, 14b exactly transmitted to the forward ends of the control strings 7a, 7b regardless of the flexure of the elongated tube 3, if it is flexed during the operation of the endoscope.

Thus, by alternately operating the control strings 14a, 14b, the tube assembly 1 is bent in the direction in which the tensioned control string exists.

The present invention has been thus far described in connection with a preferred embodiment thereof. However, it is evident that one end edge of the segment 10 can be shaped in a flat plane normal to the axis thereof instead of forming two diametrically opposite raised portions therein insofar as the opposing end edge of the neighboring segment is formed with the diametrically opposite raised portions.

Also, the depressions 10a as well as the grooves 10b may be formed in the reversed directions to those as shown insofar as they properly guide the strings 13 or 7a, 7b.

I claim:

1. In an endoscope including a control housing having a proximal end and a distal end, an observation window connected to the proximal end and a bendable tube assembly connected to the distal end, an improvement in the bendable tube assembly including a plurality of thin-walled cylindrical segments each having substantially the same diameter arranged in endwise series with each other, at least one end edge of each segment being sloped axially from diametrically opposite points to diametrically opposite points displaced circumferentially 90° in each direction from the first diametrically opposite points to form opposed extensions on the tube, an ear projecting axially beyond each extension and split axially to provide two spaced bifurcations, one being offset radially inwardly and the other displaced radially outwardly and engaging, respectively, the inner and outer surfaces of the adjacent

segment, and holding means for preventing the separation of the assembled sections.

2. Bendable tube assembly according to claim 1, wherein the holding means includes a pair of flexible but nonextensible strings extending axially along the inner surfaces of the series of segments in alignment with the split between the bifurcations and means securing each end of the strings to the inner surface of the endmost segment in the series of segments.

3. Bendable tube assembly according to claim 1, wherein a pair of control strings are provided each extending axially of the bendable tube assembly at diametrically opposite positions thereof disposed normal to the diameters passing through the diametrically opposed bifurcations, in each of the end edges, one end of each of said control strings being fixedly secured to a position adjacent to one of the endmost segments while the other end of each of said control string extends beyond the other endmost segment so as to be operated from the exterior of the bendable tube assembly for controlling the bending thereof.

4. Bendable tube assembly according to claim 2, wherein means are provided in each of said segments for preventing said flexible but nonextensible strings from being circumferentially displaced with respect to each of the segments.

5. Bendable tube assembly according to claim, 4 wherein said means for preventing the circumferential displacement of said strings are depressions in the wall of each of said segments having openings at the edges thereof through which said string passes.

6. Bendable tube assembly according to claim 3, wherein means are provided in the circumferential of said segments for preventing said control strings from being circumferentially displaced with respect to each of said segments.

7. Bendable tube assembly according to claim 6, wherein said means for preventing the circumferential displacement of said control strings are axially elongated depressed portions in the wall of each of said segments in which said control string is extended.

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