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[11] 3,610,231

SUBSTITUTE FOR MISSING XR

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[33] Japan
[31] 42/62666 and 42/81013

[54] ENDOSCOPE

4 Claims, 12 Drawing Figs.

[52] U.S. Cl. ..... 128/6, 95/11 EM
[51] Int. Cl. A61b 1/06
[50] Field of Search 128/4, 5, 6, 7, 9, 2; 95/11, 11.5; 138/120

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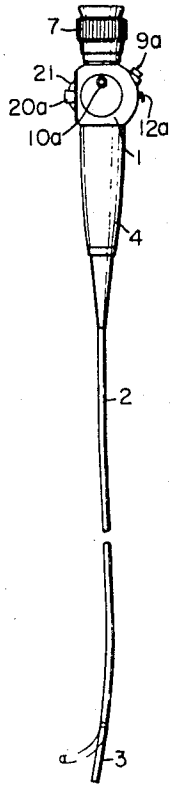
Assistant Examiner—G. F. Dunne
Attorney—Kurt Kelman

ABSTRACT: An endoscope especially adapted to inspect the bronchi of a human body or the like and having a forward end portion and a control housing connected to the forward end portion through an elongated flexible tube. The forward end portion can be flexed by the control from the control housing so that it can be smoothly inserted into the bronchi. The endoscope is provided with an observation optical system, an illuminating optical system and a control mechanism for flexing the forward end portion together with a pharmaceutical liquid injecting tube, a forceps conducting tube and a suction tube for sucking unwanted matter in the bronchi therefrom all in combination in compact form in the forward end portion without increasing the outer diameter of the forward end portion.

To ensure positive and exact flexing of the forward end portion, a stay means made of a resilient, relatively stiff wire is provided longitudinally adjacent to the inner wall of the flexible tube section of the forward end portion. The both ends of the stay means are fixedly secured to the inner wall of the flexible tube section at its forward and rearward ends so that the stay means serves as a backbone to prevent the flexible tube section from being unduly contracted as a whole while the flexibility of the flexible tube section is maintained. To effect the bending of the flexible tube section, string means extend from the control mechanism through the elongated tube, the forward ends of the string means are secured to the inner wall of the flexible tube section so that the flexible tube section can be flexed by pulling the string means by the operation of the control mechanism.



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SHEET 1 OF 2

Fig. 1

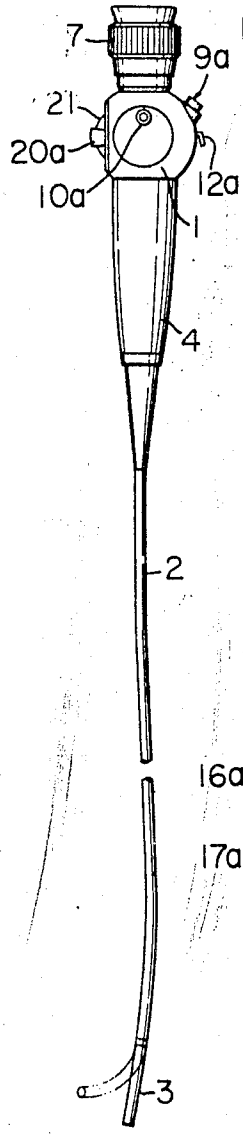

Fig. 2

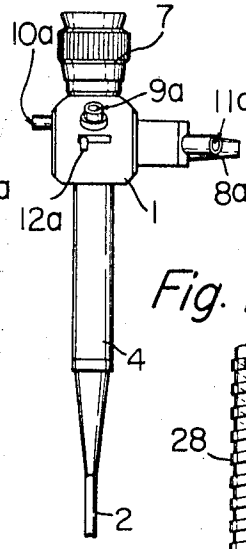

Fig. 3

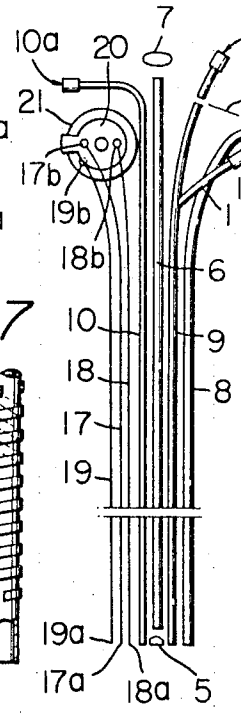

Fig. 4

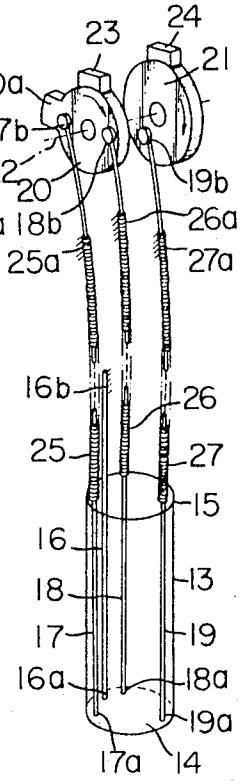

Fig. 7

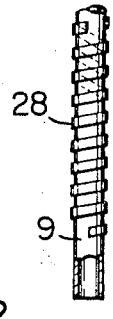

Fig. 8

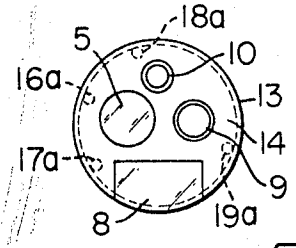

Fig. 5

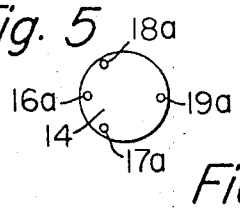

Fig. 6

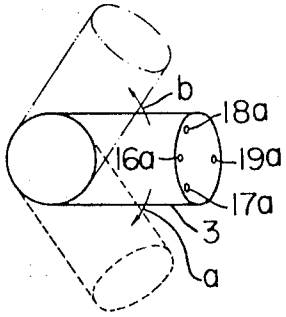

Fig. 9

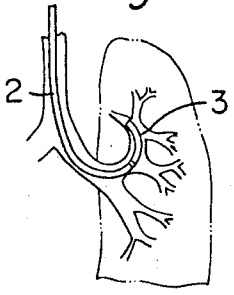

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Fig. 10

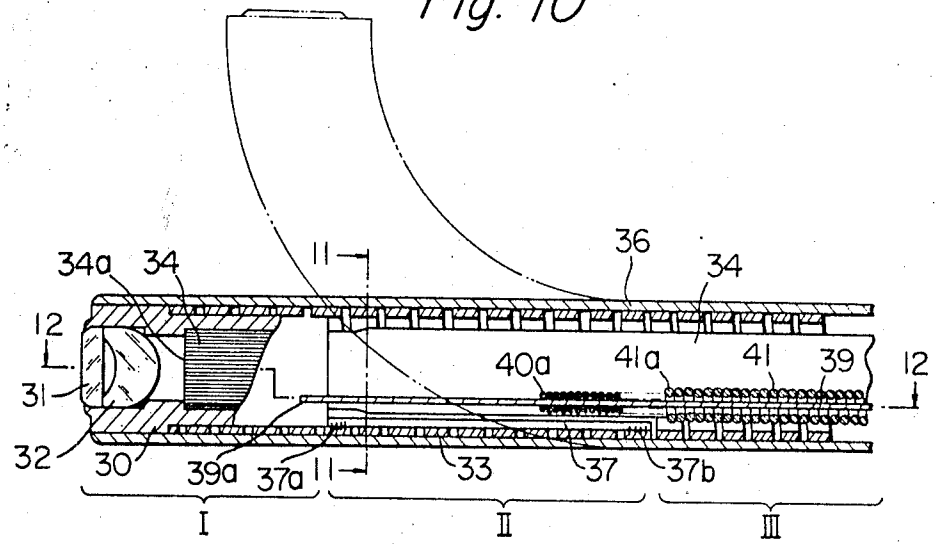


Fig. 11

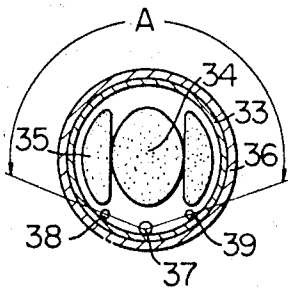
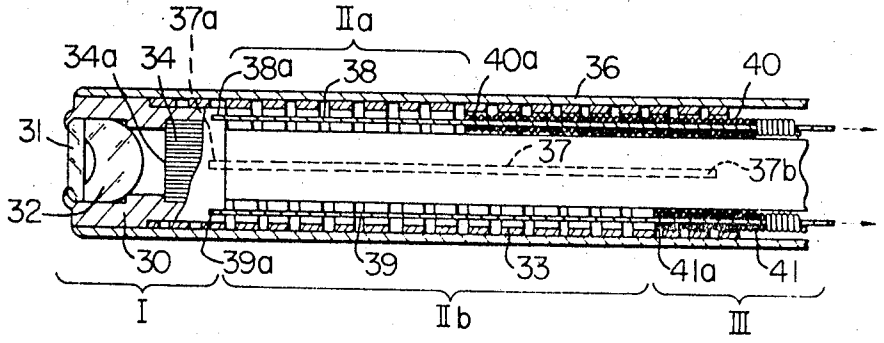


Fig. 12



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ENDOSCOPE

BACKGROUND OF THE INVENTION

The present invention relates to a novel and useful endoscope particularly adapted to be used for the inspection of the bronchi of a human body or the like having very narrow and tortuous paths having different radii of curvature.

The present invention also relates to a novel and useful flexible tube assembly adapted to be incorporated in the forward end portion of the endoscope of the type described above which is to be inserted into he bronchi smoothly without injuring the inner wall of the bronchi.

It is well known that the diameters of the forward end portion and the elongated flexible tube of an endoscope for the inspection of the bronchi of a human body or the like must be very small such as the diameter of 5.0 mm. or 5.5 mm. for the inspection of the deeper portion in the bronchi in comparison with commonly used endoscopes provided with the forward end portion having the diameter of about12 mm. for the inspection of the gullet or the stomach or the like.

On the other hand, it is desirable for an endoscope for the inspection of the bronchi to incorporate therein not only an observation optical system such s an objective lens system and a fiber optical system but also an illuminating optical system for illuminating the object to be inspected, a pharmaceutical liquid injection tube for injecting a pharmaceutical liquid such as an anesthetic into the bronchi, a forceps conducting tube for inserting the forceps into the bronchi so as to collect the sample tissues to be inspected during the observation of the object, a suction tube for sucking unwanted matter such as phlegm out of the bronchi, and string means for adjustably flexing the forward end portion of the endoscope in desired direction.

However, because of the very limited diameter of the forward end portion of the endoscope for the inspection of the bronchi, it has been impossible to incorporate all or most of the above-described various elements compactly in the forward end portion of the endoscope while the operation of each of the elements is kept satisfactory.

The reasons for the above facts are as follows. The suction tube for sucking the unwanted matter such as phlegm form the bronchi cannot be made too small because the phlegm has a certain viscosity making it difficult to smoothly suck the phlegm through the tube. If the wall thickness of the suction tube is made too thin in order to increase the inner diameter of the tube, then the tube tends to be easily collapsed in the region of the forward end portion of the endoscope when it is bent for the smooth insertion thereof into the bronchi thereby causing the tube to be blocked.

Further, the mechanism for effecting the bending of the forward end portion of the endoscope requires relatively greater space thereby preventing the mechanism from being compactly incorporated in the forward end portion having a very limited diameter.

The present invention aims at avoiding the above disadvantages of the prior art and providing a novel and useful endoscope especially for inspecting the bronchi of a human body or the like and a novel and useful flexible tube assembly to be incorporated in the forward end portion of the endoscope.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a novel and useful endoscope for the inspection of the bronchi of a human body or the like which avoids the above-described disadvantages of the prior art endoscope.

Another object of the present invention is to provide a novel and useful endoscope of the type described above in which an observation optical system, an illuminating optical system and a mechanism including string means for effecting the bending of the forward end portion of the endoscope for facilitating the smooth insertion thereof into the bronchi are compactly incorporated in the forward end portion of the endoscope having a very limited diameter such as 5.0 mm. or 5.5 mm.

together with a pharmaceutical liquid injection tube, a forceps conducting tube and a suction tube for sucking unwanted matter such as phlegm form the bronchi into the which the forward end portion of the endoscope is inserted.

In order to smoothly insert the forward end portion of the endoscope into the bronchi, it is desired to permit the forward end portion of the endoscope to be bent not only in any desired direction but also to different radii of curvature so as to conform the flexure of the forward end portion with different curvatures of the bronchi.

This is accomplished by the significant feature of the present invention.

Therefore, further object of the present invention is to provide a novel and useful flexible tube assembly particularly adapted to be incorporated in the forward end portion of an endoscope which can be bent not only in any desired direction but also to different radii of curvature of the flexure of the forward end portion of the endoscope so as to facilitate the smooth insertion thereof into the bronchi having narrow and tortuous paths of different curvatures.

In principle, the forward end portion of the endoscope constructed in accordance with the present invention comprises a flexible tube section such as a coarsely helically coiled strip forming a tube and two or more string means with the forward ends thereof being secured to the forward end of the flexible tube section and with the rearward ends thereof extending through the flexible tube section and being secured to a control mechanism in a control housing of the endoscope connected to the forward end portion through an elongated flexible tube through which the string means extend so that the flexible tube section can be bent in any desired direction by pulling the selected one or more of the string means by the selective operation of the control mechanism.

According to an important feature of the present invention, a stay means is provided in the flexible tube section which is of a resilient, relatively stiff nature and extends longitudinally in the the flexible tube section adjacent to the inner wall thereof with the respective ends of the stay means being secured to the forward and rearward ends of the flexible tube section, respectively, so that the stay means serves as a backbone of the flexible tube section to prevent the flexible tube section from being unduly contracted as a whole by the actuation of the string means while the flexibility of the flexible tube section is maintained. Thus, the flexible tube section can be bent in any desired direction by selectively pulling one or more of the string means by different amounts by means of the control mechanism.

In accordance with a further important feature of the present invention, a noncontractable pipe such as a tightly coiled wire forming a pipe is slidably fitted on each of the string means with the rearward end of each of the noncontractable pipes being fixed to stationary points in the control housing while the forward ends thereof terminate in the region of the flexible tube section and are secured to the inner wall thereof so that the movement of each of the string means relative to the noncontractable pipe slidably fitted thereon at the rearward end thereof as given by the operation of the control mechanism is exactly transmitted to the forward end portion of the string means relative to the forward end of the noncontractable pipes, thereby permitting the flexible tube section to be flexed exactly as determined by the operation of the control mechanism

In accordance with a still further important feature of the present invention, only a pair of string means each having a noncontractable pipe slidably fitted thereon are provided together with a stay means in like manner as described above, each of the string means being arranged at opposite sides of the stay means in substantially symmetrical relationship to each other in cross section of the flexible tube section with an angle being formed between two lines passing the center of the stay means and the respective string means in cross section of the flexible tube section, the forward end of one of the noncontractable pipes terminating at a position intermediate the

forward and rearward ends of the flexible tube section and being secured thereto while the forward end of the other of the noncontractable pipes terminates at a position adjacent to the rearward end of the flexible tube section and is secured thereto so that the distance between the forward end of the flexible tube section and the forward end of the one of the noncontractable pipes is made smaller than the distance between the forward end of the flexible tube section and the forward end of the one of the noncontractable pipes is made smaller than the distance between the forward end of the flexible tube section and the forward end of the other of the noncontractable pipes. Since the bending of the flexible tube section is effected in the portion of the flexible tube section which is contracted by the actuation of the string means with the stay means serving as a backbone of the flexible tube section, the above-described construction in which the forward ends of the noncontractable pipes are secured to the inner wall of the flexible tube section at positions longitudinally shifted relative to each other permits the flexible tube section to be bent to different radius of curvature by selectively actuating either one of the string means. Further, by actuating both the string means selectively at different degrees, the flexible tube section can be bent in any desired direction and to varying radius of curvature between the range as determined by pulling either one of the string means only.

Other objects and advantages of the present invention will be clear by reading the following description of the preferred embodiments of the present invention with reference to the accompanying drawings illustrating the preferred embodiments of the present invention,

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a general side view showing the endoscope constructed in accordance with one feature of the present invention;

FIG. 2 is a fragmentary side view of the endoscope shown in FIG. 1 as viewed from the right in FIG. 1;

FIG. 3 is a schematic view showing the various elements incorporated in the endoscope shown in FIG. 1;

FIG. 4 is a schematic view showing the mechanism for effecting the bending of the forward end portion of the endoscope shown in FIG. 1;

FIG. 5 is a plan view of the forward end plate provided at the forward end of the forward end portion of the endoscope shown in FIG. 1 as seen from the rear side thereof;

FIG. 6 is a view showing the manner in which the forward end portion of the endoscope is bent in different directions by the selective actuation of the string means incorporated in the mechanism for effecting the bending of the forward end portion of the endoscope;

FIG. 7 is a fragmentary view showing the forward end of the forceps conducting tube around which a helically coiled strip is secured so as to prevent the forward end of the tube from being collapsed when the tube is bent;

FIG. 8 is a front end view showing the forward end plate provided with various elements for the operation of the endoscope;

FIG. 9 is a view showing the manner in which the forward end portion of the endoscope is inserted into the bronchi of a human body;

FIG. 10 is a longitudinal sectional view of the forward end portion of an endoscope constructed in accordance with another feature of the present invention;

FIG. 11 is a cross-sectional view taken along the line 11—11 in FIG. 10; and

FIG. 12 is a longitudinal sectional view taken along line 12—12 in FIG. 10.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now the present invention will be described in detail with reference to the drawings.

FIGS. 1 and 2 show an embodiment of the endoscope constructed in accordance with one feature of the present invention. The endoscope comprises a control housing 1, an elongated flexible tube 2 and a forward end portion 3. The control housing 1 is connected to the rearward end of the elongated flexible tube 2 around which gripping means 4 is provided for easy handling of the endoscope while the forward end of the elongated flexible tube 2 is connected to the forward end portion 3. The forward end portion 3 together with the elongated flexible tube 2 is adapted to be inserted into the bronchi of a human body or the like so as to inspect the desired portion of the bronchi as described hereinbelow. As shown in FIG. 3, an objective lens system 5 is provided in a viewing window of the forward end portion 3 so that the light from an object to be inspected is received through the viewing window by the objective lens system 5 to thereby form an image of the object in the forward end portion 3. An image transmitting optical system 6 such as a fiber optical system extends from the forward end portion 3 through the elongated flexible tube 2 to the control housing 1. The forward end of the image-transmitting fiber optical system is located in the forward end portion 3 in opposing relation to the objective lens system 5 in alignment therewith so that the image of the object is focused on the forward end of the image-transmitting optical system 6 thereby permitting the image to be transmitted through the image transmitting optical system 6 to the rearward end thereof. An ocular means 7 is provided in the control housing 1 which is located in opposing relation to the rearward end of the image-transmitting optical system 6 in alignment therewith so that the image of the object thus transmitting to the rearward end of the image-transmitting optical system 6 is viewed through the ocular means 7. An illuminating fiber optical system 8 extends from the forward end portion 3 through the elongated flexible tube 2 to the control housing with the forward end thereof being in alignment with an illuminating window provided in the forward end portion 3 while the rearward end thereof being in alignment with an illuminating window provided in the forward end portion 3 while the rearward end thereof terminates in a mounting 8*a* provided in the control housing 1. A light source (not shown) may be connected to the mounting 8*a* preferably through a further fiber optical system provided with a mating connecting member (not shown) for the mounting 8*8* at the outer end thereof so that, when the light source is connected to the mounting 8*a* and energized, the light from the light source is received by the rearward end of the illuminating fiber optical system 8 and transmitted therethrough to the forward end thereof thereby permitting the thus transmitted light to be emitted from the forward end of the illuminating fiber optical system 8 through the illuminating window in the forward end portion 3 so as to illuminate the image to be inspected. A forceps conducting tube 9 and a pharmaceutical liquid injecting tube 10 also extend from the forward end of the forward end portion 3 through the elongated flexible tube 2 to the control housing 1 with the rearward end of the forceps conducting tube 9 terminating at an opening 9*a* provided in the control housing 1 while the rearward end of the pharmaceutical liquid injecting tube 10 terminates at an opening 10*a* also provided in the control housing 1. Thus, the forceps (not shown) are inserted from the opening 9*a* into the forceps conducting tube 9 therethrough so as to be projected from the forward end of the forward end portion 3 thereby permitting the forceps to be manipulated from the exterior of the control housing 1 during the observation of the object by means of the observation optical system in order to collect the sample tissues necessary for the inspection from the bronchi into which the forward end portion 3 is inserted while the pharmaceutical liquid such as the anesthetic which is required for the inspection or the surgical operation of the bronchi can be supplied from a pharmaceutical liquid supply source (not shown) connected to the opening 10*a* through the pharmaceutical liquid injecting tube 10 to the forward end thereof so that the pharmaceutical liquid is injected into the bronchi.

The forceps conducting tube 9 is provided with a suction tube 11 branched from the forceps conducting tube 9 in the control housing 1 and terminating at an opening 11*a* which is provided in control housing 1. Means for closing the forceps

conducting tube 9 such as a shutter blade 12 is provided in the tube 9 at a position intermediate the rearward end of the tube 9 and the position at which the suction tube 11 is branched from the tube 9. A knob 12*a* for manually actuating the shutter blade 12 is attached thereto and projects outwardly from the control housing 1 so that the shutter blade 12 is opened and closed by the manual operation of the knob 12*a*. A suction device (not shown) may be connected to the opening 11*a* when unwanted matter such as phlegm in the bronchi should be removed from the bronchi into which the forward end portion 3 of the endoscope is inserted. In this case, the forceps are withdrawn from the endoscope and the shutter blade 12 is moved to its closed position by the operation of the knob 12*a*. Thus, when the suction device is operated, the unwanted matter such as the phlegm in the bronchi can be taken out from the bronchi through the forceps conducting tube 9 and the suction tube 11 by the sucking action of the suction device connected to the opening 11*a*.

FIGS. 3 and 4 show one embodiment of the mechanism for controlling the bending of the forward end portion 3 of the endoscope. The forward end portion 3 comprises a forward end plate 14, a rearward end 15 such as an annular ring and a flexible tube section 13 such as a coarsely helically coiled steel strip forming a tubelike shape which flexible connected the forward end plate 14 and the rearward end 15. As shown in FIG. 8, the forward end plate 14 is provided with the viewing window with which the objective lens system 5 in the forward end portion 3 is located in alignment, the illuminating fiber optical system 6 is located in alignment, opening connected to the forward end of the forceps conducting tube 9 and an opening connected to the forward end of the pharmaceutical liquid injecting tube 10. As shown in FIG. 4, a stay means 16 such as a resilient, relatively stiff wire extends longitudinally along the inner wall of the flexible tube section 13 adjacent thereto. The forward end 16*a* of the stay means 16 is connected to the forward end plate 14 while the rearward end 16*b* of the stay means 16 is fixedly connected to the forward end of the elongated flexible tube 2 adjacent to the rearward end 15 of the forward end portion 3 so that the stay means 16 serves as a backbone of the flexible tube section 13 of the forward end portion 3 to prevent the flexible tube section 13 from being unduly contracted as a whole when it is subjected to an external force tending to contract the flexible tube section 13 while it is allowed to be bent thereby. A pair of strings 17, 18 extend from the forward end portion 3 through the elongated flexible tube 2 to the control housing 1. The forward ends 17*a* 18*a* of the strings 17, 18 are connected to the forward end plate 14 at positions opposite to each other with respect to the position at which the forward end 16*a* of the stay means 16 is connected to the forward end plate 14. Further string 19 extends from the forward end portion 3 through the elongated tube 2 to the control housing 1. The forward end 19*a* of the string 19 is connected to the forward end plate 14 at a position substantially diametrically opposite to the position at which the forward end 16*a* of the stay means 16 is connected to the forward end plate 14.

A control mechanism comprising two manually rotatable discs 20, 21 having the common axis of rotation 22 is provided in the control housing 1. Either of the discs 20, 21 may be provided with projections 20*a* and/or 21*a* (only the projection 20*a* is shown) respectively, which project from the control housing 1 so as to be manually actuated selectively so that either or both of the discs 20, 21 are rotated. Alternatively, the outer periphery of each of the discs 20, 21 is provided with a knurled surface a part of which projects from the control housing 1 thereby permitting either or both of the discs 20, 21 to be manually rotated selectively by means of the knurled surfaces of the discs 20, 21. The rearward ends 17*b* 18*b* of the pair of strings 17, 18 are connected to the disc 20 at positions diametrically opposite to each other so that the manual rotation of the disc 20 in one direction causes one of the strings 17, 18 to be pulled while the other of the strings 17, 18 is loosened and vice versa. The rearward end 19*b* of the further string 19 is connected to the disc 21 so that the string 19 is pulled by the manual rotation of the disc 21 in one direction.

Brake means 23, 24 such as friction pads may be provided for the discs 20, 21, respectively so that the discs 20, 21 are frictionally held at their adjusted positions. Noncontractable pipes 25, 26 and 27 such as tightly coiled wires forming pipes extend through the elongated flexible tube 2 and are slidably fitted on the strings 17, 18 and 19, respectively, with the rearward ends 25*a* 26*a* and 27*a* thereof being fixedly secured to stationary points in the control housing 1 while the forward ends of the pipes 25, 26 and 27 terminate at the rearward end 15 of the forward end portion 3 of the endoscope and secured thereto, so that the movement of the strings 17, 18 and 19 relative to the noncontractable pipes 25, 26 and 27, respectively, as given at the respective rearward ends of the strings 17, 18 and 29 by the operation of the control mechanism can be exactly transmitted to the forward ends of the strings 17, 18 and 19 relative to the respective forward ends of pipes 25, 26 and 17, respectively.

In operation, the forward end portion 3 can be bent toward the right as viewed in FIGS. 5 and 6 by pulling only the string 19 by the manual operation of the disc 21 in the direction of the arrow shown in FIG. 4. Under this condition, when the disc 20 is manually rotated in the direction shown by the arrow in FIG. 4, the string 17 is pulled while the string 18 is loosened so that the forward end portion 3 is bent in the direction shown by the arrow *a* in FIG. 6. When the disc 20 is rotated in the opposite direction, the forward end portion 3 is bent in the direction, the forward end portion 3 is bent in the direction shown by the arrow *b* in FIG. 6.

It is apparent that the pulling of only of the string 17 or 18 causes the forward end portion 3 to be bent further upwardly or downwardly as viewed in FIG. 6. Therefore, the forward end portion 3 can be bent in any direction within a predetermined solid angle determined by the flexure of the flexible tube section 13 by selectively actuating the strings 17, 18 and 19 by means of the control mechanism. The stay means 16 serves as a backbone to prevent the flexible section 13 from being unduly contracted as a whole by the actuation of the strings 17, 18 and 19 while the flexibility of the forward end portion 3 is maintained.

The brake means 23, 24 frictionally hold the discs 20, 21 in their adjusted positions, respectively, thereby facilitating the inspection of the bronchi by the endoscope.

The forceps can be inserted into he forceps conducting tube 9 before or after the forward end portion 3 is inserted in the bronchi for the manipulation of the forceps during the inspection of the object by means of the observation optical system comprising the objective lens system 5, the image-transmitting fiber optical system 6 and the ocular means 7. The pharmaceutical liquid such as anesthetic can also be injected into the bronchi through the pharmaceutical liquid injecting tube 10. Further, unwanted matter such as phlegm in the bronchi can be sucked therefrom through the forceps conducting tube 9 and the suction tube 11 by connecting the suction device to the opening 11*a* of the suction tube 11 after the forceps are withdrawn from the forceps conducting tube 9 and the shutter blade 12 is moved to its closed position.

In order to prevent the forward end of forceps conducting tube 9 from being collapsed by the bending of the forward end portion 3 so as to permit the unwanted matter to be sucked from the bronchi through the forceps conducting tube 9 without hindrance when it is used for removing the unwanted matter from the bronchi, a thin-walled coarsely coiled strip 28 such as helically wound steel strip may be provided around the portion adjacent to the forward end of the tube 9 in the region in the forward end portion 3 of the endoscope. The helically would strip 28 can be fixedly embedded in the outer surface of the tube 9 by appropriately heating the tube 9 after the strip 28 is wound around the tube 9.

FIG. 9 shows the manner how the forward end portion of the endoscope in accordance with the present invention is inserted in the bronchi of a human body by the operation of the control mechanism of the endoscope as described above.

The above-described construction of the endoscope in accordance with the present invention enables the various elements necessary for the inspection and surgical operation of the bronchi or the like to be compactly housed in the forward end portion of the endoscope having very small diameter such as 5.0 mm. or 5.5 mm. so that the forward end portion of the endoscope can be easily and smoothly inserted into the deep internal portion of the bronchi by virtue of the convenient manipulation afforded by the control mechanism of the present invention without injuring the inner wall of the bronchi through which the forward end portion of the endoscope in inserted and various operation necessary for the inspection and the surgical operation of the bronchi can be freely carried out.

FIGS. 10 to 12 show another embodiment of the flexible tube assembly adapted to be incorporated in the forward end portion of the endoscope constructed in accordance with the present invention.

By this construction of the forward end portion of the endoscope, the forward end portion can be bent not only in any desired direction but also to different radii of curvature by the selective actuation of the string means connecting the flexible tube section of the forward end portion of the endoscope to the control mechanism in the control housing through the elongated flexible tube by the operation of the control mechanism.

As shown in FIG. 10, the forward end portion of the endoscope comprises a forward end section I and a flexible tube section II. A lens barrel 30 mounting therein a cover glass 31 and an objective lens system 32 is secured in the forward end section I. A coarsely helically coiled strip 33 forming a flexible tube such as that made of thin steel strip or steel wire constitutes the flexible tube section II. The forward end of the helically coiled strip 33 is connected to he rearward end of the lens barrel 30 while the rearward end of the helically coiled strip 33 is connected to the elongated flexible tube designated by the reference numeral III. As shown in FIG. 10, the image-transmitting optical system 34 such as a fiber optical system extends from the forward end section I through the flexible tube section II and the elongated flexible tube III toward the control housing (not shown) as in the case of the embodiment shown in FIGS. 1 to 8. The forward end 34*a* of the fiber optical system 34 is located in the lens barrel 30 behind the objective lens system 32 spaced an appropriate distance therefrom in alignment therewith so that an image of the object to be inspected is focused on the forward end 34*a* by means of the objective lens system 32. The image of the object is transmitted through the fiber optical system 34 to the rearward end thereof (not shown) provided in the control housing as in the case of the embodiment shown in FIGS. 1 to 8. Illuminating fiber optical systems 35 (FIG. 11) also extend from the forward end section I through the flexible tube section II and the elongate flexible tube III to the control housing. The rearward ends of the illuminating fiber optical systems 35 are illuminated by a light source (not shown) so that the light is transmitted through the fiber optical systems 35 to the forward ends thereof thereby permitting the light to be emitted thereof thereby permitting the light to be emitted therefrom so as to illuminate the object as in the case of the embodiment shown in FIGS. 1 to 8. The illuminating optical systems 35 can be replaced by lamp means located in the forward end section I to which the electric power is supplied through lead wire means extending from the control housing.

Other elements such as a forceps conducting tube also serving as a suction tube, a pharmaceutical liquid injection tube can also be incorporated in the endoscope of FIG. 10 as in the case of the embodiment shown in FIGS. 1 to 8.

The outer peripheral surfaces of the forward end section I, the flexible tube section II and the elongated flexible tube III are covered by a pliant sheath 36 such that comprises of a plastic tube and a fine tubular metallic netting fitted in the plastic tube or embedded therein so as to watertightly keep the assembly.

Now the mechanism for flexing the forward end portion of the endoscope shown in FIGS. 10 to 12 will be described in detail.

In the similar way to that shown in FIGS. 1 to 8, a stay means 37 such as a resilient, relatively stiff steel wire is provided longitudinally in the flexible tube section II adjacent to the inner wall thereof. The forward end 37*a* of the stay means 37 is secured to the rearward end of the lens barrel 30 while the rearward end 37*b* of the stay means 37 is secured to the rearward end of the flexible tube section II so that the flexible tube section II is prevented from being unduly contracted as a whole by virtue of the provisions of the stay means 37 serving as a backbone of the flexible tube section II while the flexiblity of the flexible tube section II is maintained.

A pair of strings 38, 39 extend from the forward end section I through the flexible tube section II and the elongated flexible tube III toward the control housing with the forward ends 38*a*, 39*a* of the strings 38, 39 being secured to the lens barrel 30 as shown. The location of the strings 38, 39 is such that they are located opposite to each other with respect to the stay means 37 spaced therefrom in cross section of the flexible tube section II as shown in FIG. 11 in substantially symmetrical relationship to each other with an angle A being formed between two lines connecting the center of the stay means 37 and the centers of the respective strings 38, 39 in cross section of the flexible tube section II as shown in FIG. 11. The angle A may be either an obtuse angle or an acute angle, preferably an angle other than 180°. The rearward ends of the strings 38, 39 are connected to a control mechanism (not shown) provided in the control housing so that either one or both of the strings 38, 39 can be selectively pulled by the operation of the control mechanism.

As shown in FIG. 12, noncontractable pipes 40, 41 such as tightly helically coiled wires forming the pipes extend through the elongated flexible tube III and are slidably fitted on the strings 38, 39, respectively. The rearward ends of the noncontractable pipes 40, 41 are fixedly secured to stationary points in the control housing (not shown) so that the movement of the strings 38, 39 relative to their pipes 40, 41 at the rearward ends of the pipes 40, 41 as given by the operation of the control mechanism can be exactly transmitted to the forward end portions of the strings 38, 39 at the forward ends of the pipes 40, 41 relative thereto. As shown in FIG. 12, the forward end 40*a* of the pipe 40 terminates at a position intermediate forward and rearward ends of the flexible tube section II and secured to the inner wall of the flexible tube section II thereat while the forward end 41*a* of the pipe 41 terminates at a position adjacent to the rearward end of the flexible tube section II and secured to the inner wall of the flexible tube section II thereat. In other words, the string 38 extends freely without being covered by the pipe 40 the distance IIa between the rearward end of the lens barrel 30 and the forward end 40*a* of the pipe 40 while the string 39 extends freely without being covered by the pipe 41 the distance IIb which is greater than the distance IIa between the rearward end of the lens barrel 30 and the forward end 41*a* of the pipe 41. Thus, the actuation of the string 38 causes the length IIa of the flexible tube section II to be contracted while the actuation of the string 39 causes the length IIb of the flexible tube section II to be contracted.

In operation, when only the string 38 is pulled by the operation of the control mechanism the length IIa of the flexible tube section II is bent in the direction from the stay means 37 toward the string 38 in cross section of the flexible tube section II only in the range of the length IIa, while the stay means 37 serves as a backbone for the flexible tube section II to prevent it from being contracted as a whole so that the radius of curvature of the flexure of the flexible tube section II is made very small. In like manner, when only the string 39 is pulled by the operation of the control mechanism, the flexible tube section II is bent in the direction from the stay means toward the string 39 in cross section of the flexible tube section II in the range of the length IIb of the flexible tube section II so that the radius of curvature of the flexure of the flexible

tube section II is made relatively large. When both the strings 38, 39 are pulled simultaneously by different amounts, then the flexible tube section II can be bent in any desired direction within the angle A as viewed in the cross section of the flexible tube section II with the radius of curvature of the flexure of the flexible tube section II being made intermediate the radii of curvature obtained when the respective strings 38 and 39 are pulled separately.

These features are extremely important in order to smoothly insert the forward end portion of the endoscope into the bronchi having very narrow tortuous paths without hindrance.

We claim:

1. An improved control mechanism for use in an endoscope which includes a control housing, an elongated flexible tube extending from said housing, a flexible tubular probe provided at the front end of said tube an objective lens system in said probe, ocular means in said housing, means for transmitting an image from said objective lens system through said tube to said ocular means, a combined forceps conducting and suction tube extending from said housing through said tube to said probe, a medication injecting tube extending from the housing through said tube to the probe, and illuminating means provided at the probe, said improved control mechanism comprising a single resiliently bendable but noncontractable stay extending longitudinally along only one side of said tubular probe, said stay having a front end secured to the front end of the probe and a rear end secured to said tube at the rear end of the probe so that the stay permits lateral bending of the probe in all radial planes but prevents longitudinal contraction thereof as a whole, and control means provided in said housing and including at least two strings passing through said flexible tube into said probe, the front ends of said strings being secured to the front end of the probe at points which are spaced from the front end of said stay in such manner that the probe may be bent laterally in at least two different radial planes by pulling of the respective strings.

2 The device as defined in claim 1 which is further characterized in that said stay comprises a length of resiliently flexible wire.

3. The device as defined in claim 1 wherein said control means also includes a third string passing through said flexible tube into said probe and having its front end secured t the front end of the probe at a point spaced from the front ends of the first-mentioned strings and of said stay.

4. The device as defined in claim 1 together with at least two flexible but noncontractable pipes secured in said housing and passing through said flexible tube, said strings passing slidably through the respective pipes, the front end of one of the pipes being secured at the rear end of said probe and the front end of the other pipe being secured intermediate the ends of the probe, whereby the probe may be laterally bent to different radii selectively along its whole length or along the length of its front end portion by selective actuation of said strings.