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March 19, 1963

J. H. HETT

3,081,767

FLEXIBLE OPTICAL SURGICAL INSTRUMENT

Filed May 10, 1961

4 Sheets-Sheet 1

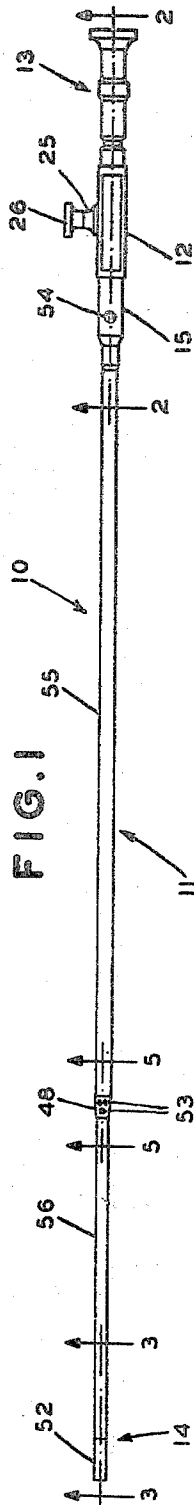


FIG. 2

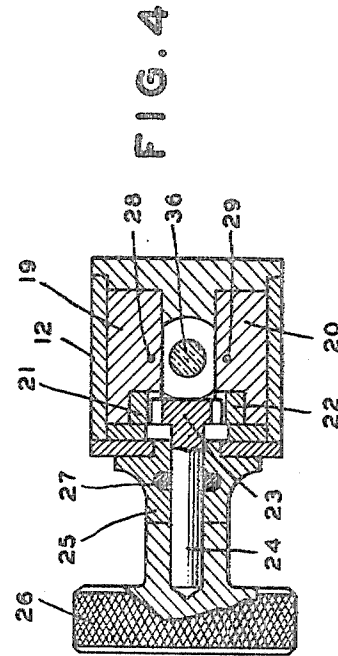
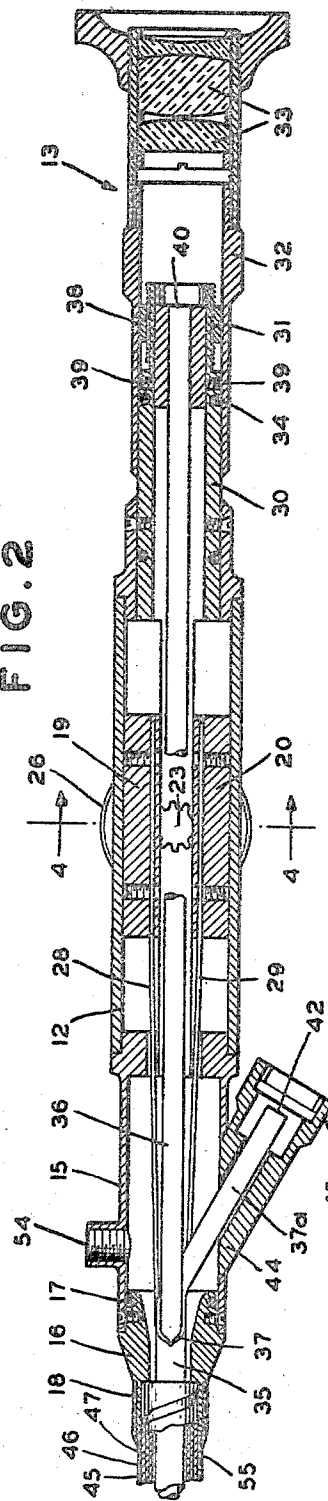


FIG. 4

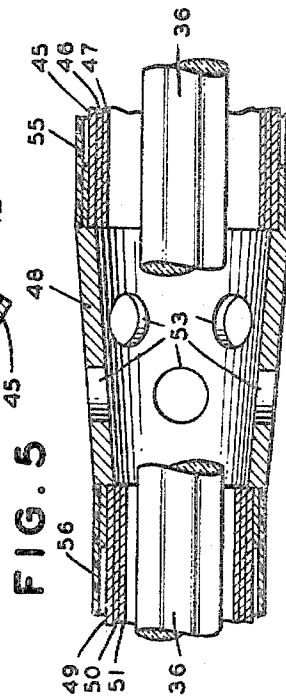


FIG. 5

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FIG. 3

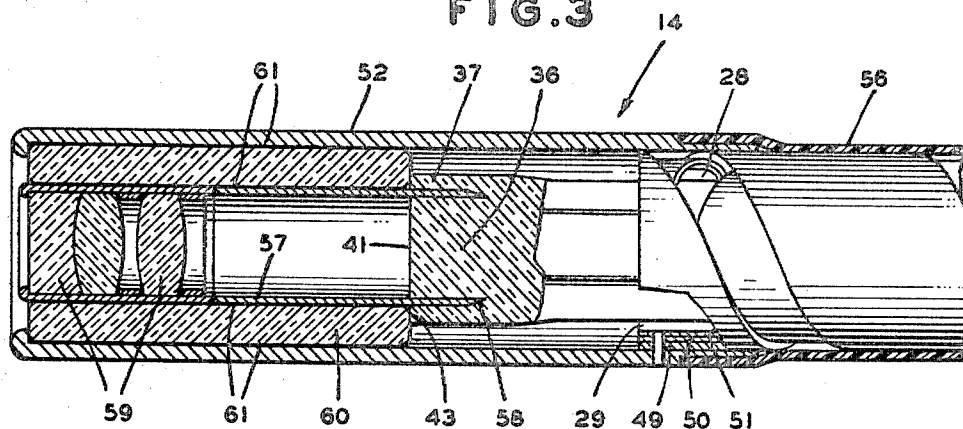
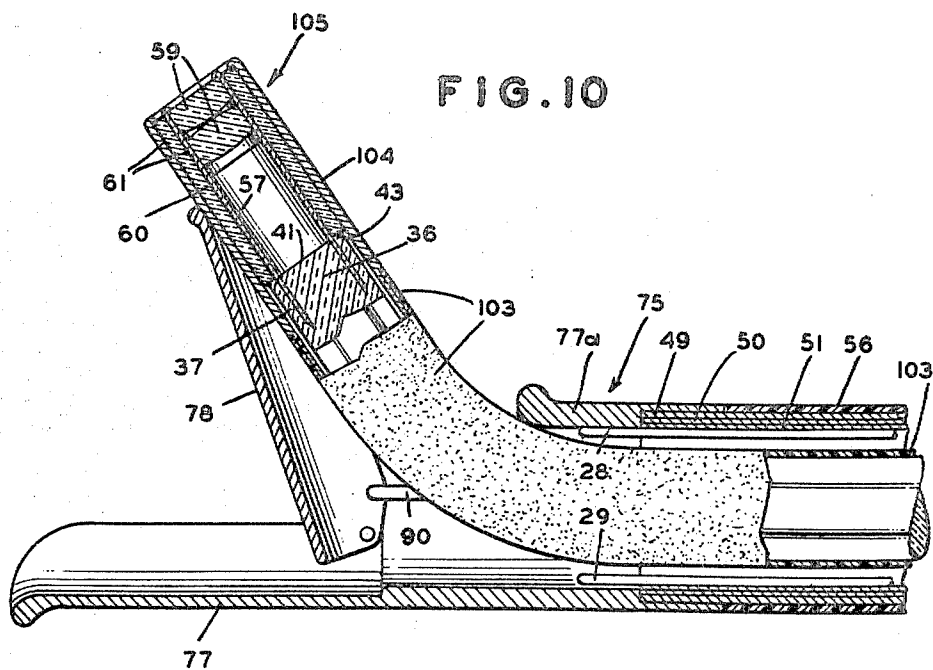


FIG. 10



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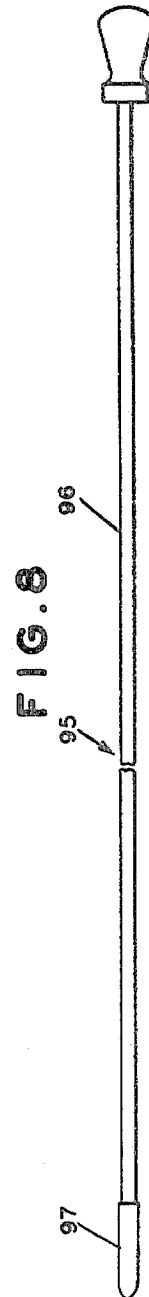
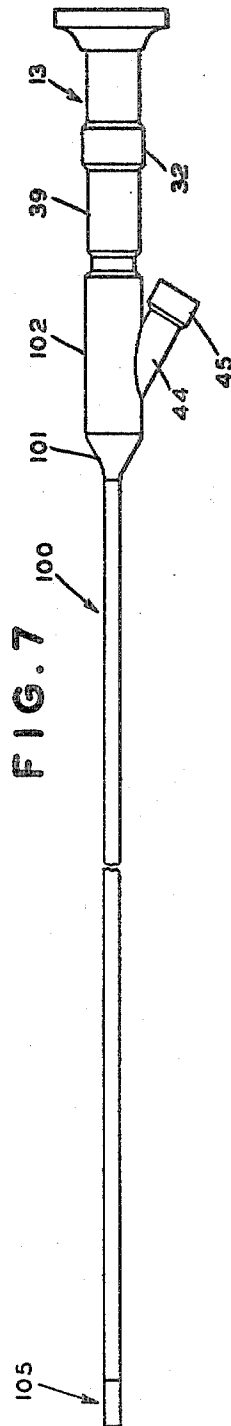
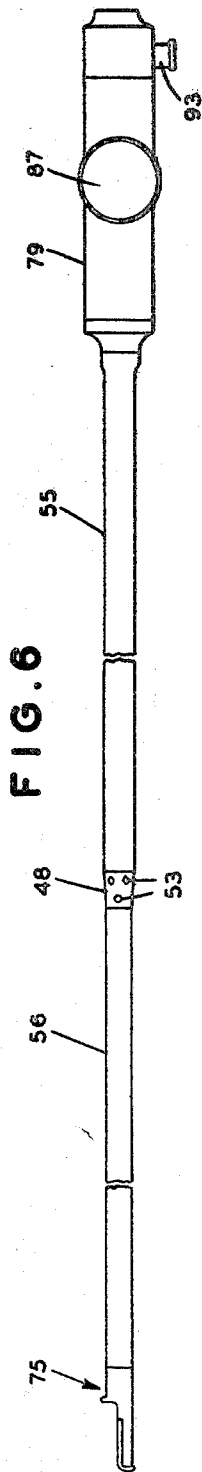
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FIG. 9

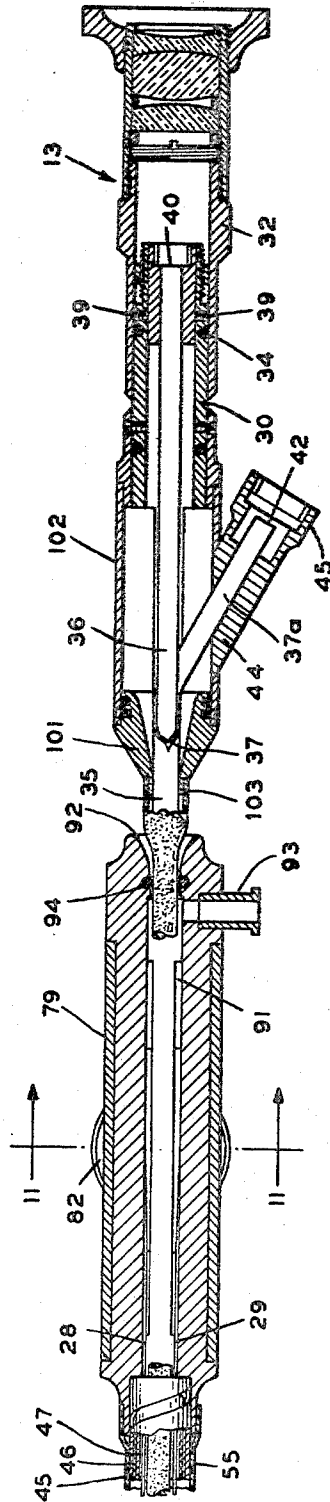
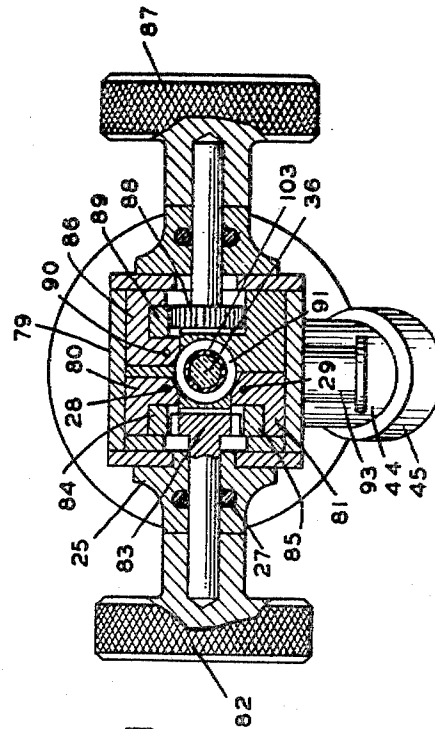


FIG. 11



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FLEXIBLE OPTICAL SURGICAL INSTRUMENT

John H. Hett, Cresskill, N.J., assignor to American Cystoscope Makers, Inc., Pelham Manor, N.Y., a corporation of New York

Filed May 10, 1961, Ser. No. 109,139

10 Claims. (Cl. 128-6)

This invention relates to a flexible surgical instrument and more particularly to one which permits visualization of formerly inaccessible portions of the bronchi of a patient.

Instruments have long been desired which could be inserted into an opening in the body of a patient without the need for performing any surgery, which would permit precise visualization and diagnosis of hitherto inaccessible areas and organs within the patient's body, and which result in a minimum of discomfort to the patient. In my co-pending patent application, Serial No. 85,040 filed January 26, 1961, assigned to the assignee of my present application and of which my present application is a continuation-in-part, there is set forth a flexible surgical instrument which is particularly adapted for use in visualizing the ureter and portions of the kidney. My present invention is concerned with the problem of permitting visualization of hitherto inaccessible bronchi in the lungs of a patient.

Hitherto, optical surgical instruments have been provided for visualizing through an optical instrument the upper lobe bronchi as well as certain other portions of the tracheal bronchial tree. Such instruments have left much to be desired particularly in that the areas susceptible of visualization were limited. In addition, it has long been desired to reduce the amount of discomfort suffered by a patient during the carrying out of such procedures.

It is, therefore, a principal object of the present invention to provide a highly flexible surgical instrument which permits visualization of hitherto inaccessible portions of the bronchi with a minimum degree of discomfort to the patient.

Another object is to provide such an instrument having a unique degree of flexibility which may be readily manipulated by the surgeon so that it may be inserted and directed into any of the bronchi to whatever depth may be required.

A further object is to provide such an instrument which is extremely compact and which is so constructed and arranged as to eliminate entirely the danger of a part of the instrument accidentally becoming detached in the body of a patient.

A further object is to provide such an instrument by means of which remote areas within the lungs of a patient may be illuminated by an electrical, high intensity light source without requiring the need for inserting any electrical components into the body of a patient.

An important feature of the present invention relates to the provision of a surgical instrument adapted for insertion through the mouth of a patient into the bronchus, having a relatively long tubular flexible assembly connected at one end to a viewing head assembly and at its opposite end to an eyepiece assembly. The interconnecting tubular assembly is flexible throughout its length but with the distal portion thereof having a greater degree of flexibility than the remainder. Means are provided operable at the proximal end of the instrument for deflecting the distal end of the instrument so that it may be directed into a desired bronchus, the greater degree of flexibility of the distal portion of the elongated tubular assembly serving to concentrate the bending of the instrument in the distal portion thereof.

In one embodiment of the present invention, a unitary,

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elongated flexible optical instrument is provided for insertion into the body of the patient. A composite flexible optical fiber bundle extends from end to end of an elongated flexible tubular assembly which is joined at its distal end to an objective or viewing head assembly. The proximal end of the elongated tubular assembly is joined to a housing through which the image-conducting section of the fiber bundle extends into an eyepiece assembly provided for magnifying and focusing on to the eye of a viewer an image presented on the proximal end of the image-conducting section. Means are provided in the housing for controlling and deflecting at will the distal end of the elongated tubular assembly which carries the viewing head. Provision is also made for introducing oxygen into the housing which passes along the tubular assembly to outlets located in relation to the length of the instrument so that in use, the oxygen outlet may always be located above the branch point between the right and left bronchi thereby insuring an oxygen supply to both lungs.

In accordance with a further feature of the present invention, the composite light and image-conducting optical fiber bundle together with the viewing head assembly connected to its distal end and the eyepiece assembly connected to its proximal end are formed as a unitary assembly adapted to be removably mounted in an elongated flexible tubular sheath constructed to provide the required supply of oxygen to the lungs of the patient and also to afford independent deflection of its own distal end and the viewing head assembly which projects therefrom in use.

The foregoing as well as additional objects and advantages of the present invention will be apparent from the following description of preferred embodiments of the present invention and the accompanying drawings in which

FIGURE 1 is an elevational view on an exaggerated scale of an instrument constructed in accordance with the present invention;

FIGURE 2 is a sectional view taken through the line 2-2 of FIGURE 1 and drawn on an enlarged scale;

FIGURE 3 is a sectional view taken through the line 3-3 of FIGURE 1 and drawn on a further enlarged scale;

FIGURE 4 is a sectional view taken along the line 4-4 of FIGURE 2;

FIGURE 5 is a sectional view on an enlarged scale taken through the line 5-5 of FIGURE 1;

FIGURES 6-8 are elevational views showing respectively the sheath, optical assembly and obturator of a further embodiment of the present invention;

FIGURES 9 and 10 are longitudinal sectional views respectively of the eyepiece and objective end portions of the sheath of FIGURE 6 with the optical assembly of FIGURE 7 mounted therein; and

FIGURE 11 is a sectional view taken through the lines 11-11 of FIGURE 9.

Referring now to FIGURES 1-5 of the drawing in detail, flexible surgical instrument 10 comprises an elongated flexible tubular assembly 11 connected at its proximal end to a housing 12 carrying an eyepiece assembly 13 and connected at its distal end to an objective or viewing head assembly 14.

The housing 12 is conveniently formed as an elongated rectangular enclosure one end of which is connected to a tubular member 15 which is in turn demountably connected to an adapter 16. The adapter 16 is provided with an annular groove in which an O-ring 17 is positioned to provide an airtight joint between the interior of the member 15 and the adapter. The adapter 16 termi-

nates in a sleeve 18 of reduced diameter for a purpose yet to be described.

As shown most clearly in FIGURE 4, a pair of blocks 19 and 20 are slideably supported in spaced relation in the housing 12. The slide blocks 19 and 20 along one side thereof each having elongated racks 21 and 22 respectively connected thereto and extending in opposed relation so as to mesh with the opposite sides of a pinion 23. The pinion 23 is carried on a shaft 24 which extends through an opening in the wall of the housing 12 and through an external collar 25 and has a control knob 26 fixed thereto. Collar 25 seals the opening in the housing and is formed with an annular recess in which an O-ring 27 is positioned to prevent the escape of oxygen from the housing along the shaft 24.

Each of the slide blocks 19 and 20 is formed with a longitudinally extending hole, a control wire 28 being anchored in the block 19 and a control wire 29 being anchored in the block 20. Rotation of knob 26 clockwise as viewed in FIGURE 2 causes a corresponding rotation of pinion 23 and slide block 19 together with the control wire 28 is shifted a corresponding distance to the right while at the same time, slide block 20 and control wire 29 are shifted a corresponding distance to the left. It will be noted, as most clearly shown in FIGURE 2, housing 12 is substantially longer than the slide blocks 19 and 20 which are there shown in their center or neutral position. As will be more fully pointed out hereinafter, the control wires 28 and 29 are connected to the distal end of the flexible tubular assembly 11 so that the distal end portion of the assembly 11 is flexed vertically to carry the viewing head assembly 14 upward or downward (as viewed in FIGURE 1) depending upon whether the control wire 28 or 29 is retracted to the right.

Eye-piece assembly 13 comprises an elongated tubular member 30 connected to the proximal end of housing 12 and having an externally threaded extension 31. An eye-piece rotor 32 carrying magnifying and focusing lenses 33 is in threaded engagement with the extension 31 and extends in telescoping relation over the tubular member 30, an O-ring 34 extending in a recess about the tubular member 30 providing an air-tight joint with the rotor 32.

A composite light and image-conducting bundle 35 extends through the adapter 16 into the tubular member 15. As shown, the composite light and image-conducting bundle 35 comprises a large number of extremely fine, optical, light-conducting fibers arranged in an image-conducting group 36 which is surrounded throughout the major portion of the bundle by a second group of light-conducting fibers 37. The image-conducting fibers 36 extend axially through the housing 12 into the tubular member 30 where its proximal end carrying a collar 38 is clamped by means of set screws 39.

The composite light- and image-conducting bundle 35 may be manufactured as described in the co-pending application of Lawrence E. Curtiss, filed December 19, 1960, Serial No. 76,868. As thus manufactured, although it is only about .2 inch in diameter, the bundle 35 may comprise an extremely large number, 75,000 to 100,000 or more extremely fine glass-coated optical glass fibers which extend continuously from end to end of the bundle 35. Thus, the optical fibers forming the image-conducting group 36 extend from the proximal end face 40 thereof to the distal end face 41 (FIGURE 3). Similarly, the optical fibers forming the light-conducting group 37, which are arranged about the group 36, extend continuously between the opposite end faces 42 and 43. It will be noted that, as shown in FIGURE 2, the optical fibers of the light-conducting group 37 are gathered together to form a rod-like extension 37a projecting through an opening formed in the tubular member 15 into arm 44 to which it is sealed as by a suitable cement to prevent leakage of oxygen. The arm 44 terminates in a female Luer lock connector 45 by means of

which a flexible light conductor (not shown) may be connected thereto.

It may be noted that the proximal end face 40 of the image-conducting group and the rotor 32 of the eyepiece assembly are positioned so that rotation of the latter serves to focus the image on the end face 40 to the eye of the viewer.

For the purposes of the present invention, the flexible composite light image-conducting bundle 35 may be approximately two and one half feet in length and is so highly flexible that rigidification is desirable to facilitate insertion and manipulation of the instrument. In the present instance such rigidification is advantageously achieved by means of two sets of flexible spiral members which together extend from end to end of the flexible tubular assembly 11. One set of spiral members comprises three spirally wound members 45, 46 and 47 extending one within the other, the outer-most spiral member 45 being of substantially greater thickness than the other two. These spiral members may be formed of stainless steel or other suitable resilient material and are wound so that the turns of each spiral member passes its neighbor at right angles. The proximal end of the spiral members 45-47 are anchored together and to the inner surface of the sleeve 18 as shown in FIGURE 2. The distal ends of the spiral members 45-47 are also anchored together and are connected to the inner surface of a tapered collar 48 which also functions as an oxygen outlet as will be more fully described hereinafter.

The second set of spiral members are similar in construction and arrangement to the first set. Thus, the three spiral members 49, 50 and 51 are wound so as to pass each other orthogonally and the outermost spiral member 49 is thicker than the inner spiral members 50 and 51. However, it is to be noted that each of the spiral members 49, 50 and 51 is thinner and substantially more flexible than the corresponding spiral members 45-47 of the first set. The proximal ends of the spiral members 49-51 are anchored to the inside of the distal end of the tapered collar 48 while the distal ends of these spiral members are anchored within the proximal end of a tubular cover member 52 of the viewing head assembly 14. It may be noted that the cover tube 52, in the present embodiment, has outer and inner diameters of about .280 inch and .260 inch respectively and is short, less than one inch in length.

The tapered collar 48 has a plurality of apertures 53 formed therethrough so that oxygen fed into a fitting 54 (FIGURE 1) mounted in the tubular member 15 may emerge through the collar 48 and pass into the lungs of the patient undergoing treatment.

A flexible thin-walled tube 55 encloses the spiral members 45-47 and is sealed at its proximal end to the exterior of the sleeve 18 while at its distal end it is sealed to the exterior of the proximal end of the collar 48. The tube 55 may be formed of polyvinyl chloride or other suitable material. A second tube 56 also formed of thin-walled polyvinyl chloride encloses the spirals 49-51 and has its opposite ends cemented to the tapered collar 48 and the cover tube 52. The tubes 55 and 56 serve to enclose and seal the two sets of spiral members and thus provide a sheath for the flexible tubular assembly 11 except for the central apertured portion of the tapered collar 48.

At the distal end of the composite image and light-conducting bundle 35, the fibers forming the image-conducting section 36 are separated from the fibers forming the light-conducting section 37 by the end of a tubular lens holder 57. The proximal end of the lens holder 57 is preferably tapered as indicated to form a feather edge 58. Lenses 59 mounted in the holder 57 serve to focus an image of the field under view onto the end face 41 of the image-conducting section 36. The optical fibers in the image-conducting section are mutually oriented in the opposite end faces 40 and 41 so that an image formed on

the end face 41 is faithfully reproduced on the end face 40 where it is viewed through the eyepiece assembly 13.

A tubular member 60 formed of glass or other suitable material is mounted within the cover tube 52 concentrically about the lens holder 57. The end walls of the tubular member 60 are optically polished and one of its ends is juxtaposed in butting relation against the end face 43 of the light-conducting section 37. Thus, light conducted along the light-conducting section 37 enters one end of the tubular member 60 and leaves through the opposite end wall thereof to illuminate the field of view. In order to minimize light loss along the tubular member 60, its interior and exterior surfaces are coated with silver as indicated at 61.

As has been indicated, the control wires 28 and 29 extend throughout the length of the tubular assembly 11 and both are anchored at points 180° apart to the distal ends of the set of spiral members formed by the members 49-51. While the tubular assembly 11 is highly flexible throughout its entire length, the outer spiral member 45 and 49 in the two spiral sets have sufficient thickness so as to insure that the distal end of the flexible tubular assembly 11 is deflected when the control wires 28 and 29 are operated.

The tubes 55 and 56 which form the outer sheath of the instrument are connected in air-tight relation to the sleeve 18, collar 48 and cover tube 52. Thus, oxygen fed into the instrument can only escape through the apertures 53 in the collar 48.

For use in examining the bronchi of a patient, the instrument is connected to a high intensity light source by coupling to the end face 42 of the light conductor 37, a flexible light conductor which is exposed at its opposite end to a high intensity lamp. A source of oxygen is connected to the fitting 54. The instrument may be directly introduced through the mouth of the patient into the trachea by controlling its curvature through adjustment of the control knob 26. However, the instrument is preferably inserted through an open shelf laryngoscope, such as a Lloyds. The laryngoscope is first positioned in the usual way in the mouth of the patient and then the instrument 10 is fed along the ramp or open shelf of the laryngoscope down through the trachea of the patient, oxygen being fed through the instrument as has been described. Progress of the instrument may be observed through the eyepiece 13 while the distal end of the instrument that is forward of the tapered collar 48 is controlled by the surgeon through the knob 26. Because of the greater degree of flexibility of the portion of the tubular assembly on the distal side of the tapered collar 48, a high degree of manipulation and control is made possible. Thus, by turning the control knob 26 in one direction or the other to retract either control wire 28 or 29 the viewing head assembly 14 is tipped so as to pass into the right or left bronchus and then into the small bronchi which are to be examined. The tapered collar 48 is located along the left of the tubular assembly 11 in such a position that it always remains above the branch point of the right and left bronchi thereby insuring that oxygen is fed to both lungs during the course of the examination.

When an even greater degree of control of the distal end of the instrument is desired, it may be constructed as will now be described in connection with FIGURES 6-11 where, in order to avoid unnecessary repetition, parts similar to those already described in connection with FIGURES 1-5, are designated by the same reference characters.

An open-ended elongated flexible sheath 75 comprises two sets of spiral members as was described in connection with elongated flexible tubular assembly 11. As was described in connection with FIGURE 5, the adjacent ends of the two sets of spiral members 45-47 and 49-51 are fixed to the opposite inner end portions of tapered collar 48. At their distal ends, the spiral members 49-51

are anchored within the generally tubular proximal end portion 77a of a smoothly curved tongue 77 on which is hingedly mounted a deflector 78.

As shown most clearly in FIGURE 9, the proximal ends of the spiral members 45, 46 and 47 extend into and are secured in an opening formed in the distal end wall of a housing 79. Slide blocks 80 and 81 correspond to slide blocks 20 and 21 previously described in connection with FIGURE 2 and are similarly mounted for longitudinal displacement in the housing 79. Control wires 28 and 29 are anchored respectively to the slide blocks 80 and 81 which may be shifted in the housing 79 by rotating a control knob 82 linked to the slide blocks through pinion 83 and racks 84 and 85.

A third slide block 86 is also longitudinally displaceable in the housing 79 and is shiftable along the housing by means of a control knob 87 linked thereto through pinion 88 and rack 89. A third control wire 90 is fixed to the slide block 86.

The control wires 28 and 29 extend through the length of the sheath 75 and are connected to the distal end of the spiral members 49-51. The control wire 90 also extends through the sheath 75 and is connected to the toe portion of the deflector 78. In use the control knob 82 serves to shift the control wires 28 and 29 and thereby deflect the distal end of the sheath 75 as was previously described in connection with the instrument 10. Rotation of the control knob 87 serves to shift the control wire 90 thereby swinging the deflector 78 toward or away from the tongue 77, the deflector 78 being shown in a deflected position in FIGURE 10. The deflector 78 is shiftable to any desired position between its two extreme positions depending upon the extent to which the control knob 87 is rotated.

The housing 79 has an axially extending passageway 91 formed therein which at one end communicates with the interior of the spiral members 45, 46 and 47. At its opposite end, the passageway 91 communicates with a flared opening 92 formed in the proximal end wall of the housing 79. An O-ring 94 is seated in an annular recess formed in the wall of the opening 92 to provide a seal when a flexible obturator 95 or a flexible light and image-conducting assembly 100 is inserted into the sheath 75. A fitting 93, conveniently in the form of a Luer lock connector is mounted in the wall of the housing 79 and also communicates with the passageway 91 for connecting the sheath to a source of oxygen.

The obturator 95 comprises an elongated flexible shaft 96 of sufficient diameter at least at its proximal end to engage the O-ring 94 and seal the opening 92 when the obturator is in position in the sheath 75. The length of the shaft 96 is such that a smoothly rounded nose portion 97 mounted on its distal end extends through the tubular portion 77a and along the tongue 77 at the distal tip of the sheath 75 to provide a smoothly rounded closure.

The composite light and image-conducting assembly 100 comprises an elongated flexible optical fiber bundle 35 constructed in the same manner as that described in connection with instrument 10 and having an image-conducting group of fibers 36 surrounded by the light-conducting group of fibers 37. As is most clearly shown in FIGURE 9, the bundle 35 extends through an adapter 101 into a tubular member 102. Within the tubular member 102 the optical fibers forming the light-conducting section 37 formed as a rod-like extension 37a extend through the side wall of the tubular member 102. The image-conducting optical fiber section 36 is anchored centrally within the tubular member 102 where an image on its end face 40 may be viewed through the eyepiece assembly 13.

The elongated flexible portion of the light and image-conducting assembly 100 is enclosed within a thin-walled flexible tube 103 which may be made of latex or the like. The proximal end of the tube 103 is cemented to the adapter 101 while the distal end of the tube 103 is ce-

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mented to a cover tube 104 which corresponds to the tube 52 of the instrument 10.

The distal end of the light and image-conducting bundle 36 extends into the tube 104. As shown and described in connection with FIGURE 3, the lens holder 57 is mounted on the end of the fiber bundle and serves to separate the end portions of the fibers of the image-conducting group 36 from the light-conducting group 37. Glass cylinder 60 provided with silver coatings 61 extends in the space between the lens holder 57 and the tube 104 with its annular proximal end face juxtaposed against the distal end face 43 of the light-conducting group 37.

The cover tube 104 together with the lenses 59 and the other members enclosed therein form an objective or viewing head 105 which extends along the tongue 77 and over the deflector 78 when the light and image-conducting assembly 100 is seated within the sheath 75. As shown in FIGURE 10, movement of the deflector 78 under the influence of control wire 90 serves to shift the viewing head 105 as desired through a relatively wide angle while the sheath itself is left undisturbed. When, by operation of the deflector, the head 105 is properly positioned to enter and pass along one of the smaller bronchi, the light and image-conducting assembly 100 is inserted farther into the sheath 75 so as to advance the viewing head assembly beyond the tongue 77 into the bronchus as deeply as may be required.

In carrying out a procedure with the instrument shown and described in connection with FIGURES 6-11, the flexible obturator 95 is seated in the flexible sheath 75. The sheath 75 carrying the obturator 95 and with its fitting 93 connected to a source of oxygen is then introduced through the mouth of the patient preferably through an open shelf laryngoscope, such as a Lloyds, previously positioned by the surgeon. Shortly after introduction of the sheath, the oxygen supply is turned on and is fed to the lungs of the patient through the openings in the collar 48. After introduction and while the distal ends of the sheath and obturator are still above the carina, the obturator may be removed and the light and image-conducting assembly 100 is inserted in its place within the sheath 75. Initially the assembly 100 is inserted only far enough so that the head assembly 105 rests on the retracted deflector 78.

The field exposed to the viewing head 105 is illuminated as was described in connection with FIGURE 10, light from a suitable source being conducted by means of a flexible light conductor not shown to the light-conducting group 37 from which it passes along the wall of the glass cylinder 60 and out of the distal end of the instrument.

With the distal ends of the sheath 75 and the light and image-conducting assembly 100 properly positioned, the instrument may be now readily guided into either the left or right bronchus by suitable adjustment of the control knob 82 which serves to deflect the distal end portion of the instrument through operation of the control wires 28 and 29. Now when it is desired, for example, to probe the right eparterial bronchus, the control knob 87 is operated to actuate the deflector 77. This serves to deflect the head 105 relative to the distal tip of the sheath 75 and the assembly 100 may now be advanced along the sheath and into the eparterial bronchus.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention, in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

I claim:

1. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath having at

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least one aperture through which oxygen is free to pass into the lungs of a patient, first resilient means extending longitudinally along said sheath from adjacent the proximal end of said sheath over a predetermined portion thereof, second resilient means extending longitudinally along said sheath from adjacent the distal end of said sheath to adjacent the distal end of said first resilient means, said first and second resilient means each being flexible with said second resilient means being substantially more flexible than said first resilient means, means for conducting an image of a field from the distal to the proximal end of said sheath including an elongated flexible bundle of a very large number of extremely fine light-conducting fibers extending longitudinally within said sheath and mutually oriented at the opposite end faces of said bundle so that an image presented to the distal end of said bundle is conducted to the proximal end face thereof, means including control means adjacent to the proximal end of said sheath for selectively deflecting the distal end of said image-conducting means, means at the proximal end of said image-conducting means for viewing an image formed on the proximal end face of said bundle, means including means extending longitudinally along said sheath for illuminating a field presented to the distal end of said image-conducting means, and means for feeding oxygen along said sheath to said aperture.

2. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath having at least one aperture through which oxygen is free to pass into the lungs of a patient, first resilient means extending longitudinally along with said sheath from adjacent the proximal end of said sheath over a predetermined portion thereof, second resilient means extending longitudinally along said sheath to adjacent the distal end of said first resilient means, said first and second resilient means each being flexible with said second resilient means being substantially more flexible than said first resilient means, means for conducting an image of a field from the distal to the proximal end of said sheath including an elongated flexible bundle of a very large number of extremely fine light-conducting fibers extending longitudinally within said sheath and mutually oriented at the opposite end faces of said bundle so that an image presented to the distal end of said bundle is conducted to the proximal end face thereof, means adjacent to the proximal end of said sheath and connected to the distal end thereof for selectively deflecting the distal ends of said sheath and said image-conducting means, means at the proximal end of said image-conducting means for viewing an image formed on the proximal end face of said bundle, means including means extending longitudinally along said sheath for illuminating a field presented to the distal end of said image-conducting means, said image-conducting means extending out of the distal end of said sheath, second deflecting means including control means adjacent to the proximal end of said sheath for deflecting the distal end portion of said illuminating and image-conducting means relative to the distal end of said sheath, and means for feeding oxygen through said sheath to said aperture.

3. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath having at least one aperture through which oxygen is free to pass into the lungs of a patient, first resilient means extending longitudinally along said sheath from adjacent the proximal end of said sheath over a predetermined portion thereof, second resilient means extending longitudinally along said sheath from adjacent the distal end of said sheath to adjacent the distal end of said first resilient means, said first and second resilient means each being flexible with said second resilient means being substantially more flexible than said first resilient means, light and image-conducting means extending longitudinally

through said sheath and comprising two groups of a very large number of extremely fine light-conducting fibers with one group of fibers being adapted to illuminate a field presented to the distal end of the other group of fibers and said other group of fibers being adapted to conduct an image of said field from the distal to the proximal end thereof, means for connecting the proximal end of said first group of fibers to a source of light, means adjacent to the proximal end of said sheath and connected to the distal end thereof for selectively deflecting the distal ends of said sheath and said light and image-conducting means, said image-conducting means extending out of the distal end of said sheath, means for viewing an image of said field on the proximal end of said second group of fibers, and means for feeding oxygen along said sheath to said aperture.

4. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath having at least one aperture through which oxygen is free to pass into the lungs of a patient, first resilient means extending longitudinally along said sheath from adjacent the proximal end of said sheath over a predetermined portion thereof, second resilient means extending longitudinally along said sheath from adjacent the distal end of said sheath to adjacent the distal end of said first resilient means, said first and second resilient means each being flexible with said second resilient means being substantially more flexible than said first resilient means, light and image-conducting means extending longitudinally through said sheath and comprising two groups of a very large number of extremely fine light-conducting fibers with one group of fibers being adapted to illuminate a field presented to the distal end of the other group of fibers and said other group of fibers being adapted to conduct an image of said field from the distal to the proximal end thereof, means for connecting the proximal end of said first group of fibers to a source of light, means adjacent to the proximal end of said sheath and connected to the distal end thereof for selectively deflecting the distal ends of said sheath and said light and image-conducting means, said image-conducting means extending out of the distal end of said sheath, second deflecting means including control means adjacent to the proximal end of said sheath for deflecting the distal end portion of said illuminating and image-conducting means relative to the distal end of said sheath, means for viewing an image of said field on the proximal end of said second group of fibers, and means for feeding oxygen along said sheath to said aperture.

5. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath forming a longitudinally extending passageway and having at least one aperture communicating with said passageway for passing oxygen into the lungs of a patient, a housing connected to the proximal end of said sheath and having its interior in communication with said passageway, first resilient means connected to the distal end of said housing and extending longitudinally along said passageway in said sheath over a major portion thereof, second resilient means extending longitudinally along said passageway and connected at its proximal end to the distal end of said first resilient means, the distal end of said second resilient means being connected to the distal end of said sheath, said first and second resilient means being flexible with said second resilient means being more flexible than said first resilient means, elongated flexible means connected to the distal end of said second resilient means and extending along said passageway into said housing, means in said housing for actuating said flexible means to selectively deflect the distal end of said sheath, light and image-conducting means extending through said sheath along said passageway and into said housing, said

light and image-conducting means including two groups of a very large number of extremely fine light-conducting fibers with one group of fibers being adapted to illuminate a field presented to the distal end of the other group of fibers and said other group of fibers being adapted to conduct an image of said field from the distal to the proximal end thereof, means on said housing for connecting a source of light to the proximal end of said first group of fibers, means connected to said housing for viewing an image on the proximal end of said second group of fibers, means connected to the distal end of said second resilient means for forming an image of said field on the distal end of said second group of fibers, and means for connecting said housing to a supply of oxygen.

6. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising first and second elongated flexible tubular members with said second tubular member having a smaller diameter than said first tubular member, a connector joining the distal and proximal ends of said first and second tubular members and having an aperture formed therethrough communicating with the passageways of said tubular members for passing oxygen into the lungs of a patient, a housing connected to the proximal end of said first tubular member and having its interior in communication with the passageway of said second tubular member through said first tubular member, first resilient means comprising a plurality of spiral members wound one within the other about a common axis, said first resilient means being connected to the distal end of said housing and extending longitudinally through said first tubular member and being connected at its distal end to one end of said connector, second resilient means comprising a plurality of spiral members wound one within the other along a common axis, said second resilient means being connected at its proximal end to the other end of said connector and its distal end being connected to the distal end of said second tubular member, said second resilient means having a smaller diameter and being more flexible than said first resilient means, a pair of wire members connected to opposite sides of the distal end of said second resilient means and extending along said first and second tubular members into said housing, a pair of blocks movably mounted in said housing with each of said blocks being connected to one of said wires, means on said housing connected to said blocks for actuating said wire members and thereby selectively deflect the distal end portions of said second resilient means and second tubular member, elongated flexible light and image-conducting means extending axially along said first and second resilient means from the distal end thereof into said housing, said light and image-conducting means including two groups of a very large number of extremely fine light-conducting fibers with one group of fibers being adapted to illuminate a field presented to the distal end of the other group of fibers and said other group of fibers being adapted to conduct an image of said field from the distal to the proximal end thereof, means on said housing for connecting a source of light to the proximal end of said first group of fibers, means connected to said housing for viewing an image on the proximal end of said second group of fibers, means connected to the distal end of said resilient means for forming an image of said field on the distal end of said group of fibers, and means for connecting said housing to a supply of oxygen.

7. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath having at least one aperture for passing oxygen into the lungs of a patient, elongated light and image-conducting means longer than said sheath and adapted to be removably inserted in and movable longitudinally along said sheath with the distal end thereof projecting from the distal end of said sheath, said light and image-conducting means being adapted for illuminating a field presented to the distal

end thereof and for conducting an image of said field to the proximal end thereof, means for connecting the proximal end of said sheath to a supply of oxygen, and means including control means adjacent the proximal end of said sheath for deflecting the distal end portion of said sheath and for deflecting the distal end portion of said light and image-conducting means relative to said sheath.

8. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath having at least one aperture for passing oxygen into the lungs of a patient, elongated light and image-conducting means longer than said sheath and adapted to be removably inserted in and movable longitudinally along said sheath with the distal end thereof projecting from the distal end of said sheath, said light and image-conducting means being adapted for illuminating a field represented to the distal end thereof and for conducting an image of said field to the proximal end thereof, means for connecting the proximal end of said sheath to a supply of oxygen, shiftable means mounted on the distal end of said sheath for limited displacement into engagement with the distal end portion of said light and image-conducting means for deflecting the same relative to said sheath, and means including control means adjacent the proximal end of said sheath for deflecting the distal end of said sheath and for actuating said shiftable means to deflect said distal end portion of said light and image-conducting means relative to said sheath.

9. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising an elongated flexible sheath having at least one aperture for passing oxygen into the lungs of a patient, first resilient means extending longitudinally along with said sheath from adjacent the proximal end of said sheath over a predetermined portion thereof, second resilient means extending longitudinally along said sheath from adjacent the distal end of said sheath to adjacent the distal end of said first resilient means, said first and second resilient means each being flexible with said second resilient means being substantially more flexible than said first resilient means, means removably mounted in and longitudinally movable relative to said sheath for illuminating a field at the distal end thereof and for conducting an image of said field to the proximal end thereof including an elongated flexible bundle of a very large number of longitudinally extending extremely fine light-conducting fibers, means adjacent to the proximal end of said sheath and connected to the distal end thereof for selectively deflecting the distal end of said sheath, means at the proximal end of said bundle for viewing an image formed on the proximal end face thereof, a deflector mounted on the distal end of said sheath for limited displacement into engagement with the distal end portion of said bundle, means adjacent to the proximal end of said sheath connected to said deflector for deflecting the distal end portion of said bundle relative to the distal end of said sheath, and means for connecting the proximal end of said sheath to a supply of oxygen.

10. A flexible optical surgical instrument for insertion into and for examining the bronchi in the lungs of a patient, comprising first and second elongated flexible tubular members with said second tubular member having a smaller diameter than said first tubular member, a connector joining the distal end of said first tubular member to the proximal end of said second tubular member to form a sheath, said connector having an aperture formed therethrough communicating with the passageways of said tubular members for passing oxygen into the lungs

of a patient, a housing connected to the proximal end of said first tubular member and having its interior in communication with the passageway of said sheath, first resilient means comprising a plurality of spiral members wound one within the other about a common axis, said first resilient means being connected to the distal end of said housing and extending longitudinally through said first tubular member and being connected at its distal end to one end of said connector, second resilient means comprising a plurality of spiral members wound one within the other along a common axis, said second resilient means being connected at its proximal end to the other end of said connector and its distal end being connected to the distal end of said second tubular member, said second resilient means having a smaller diameter and being more flexible than said first resilient means, a deflector hingedly connected to the distal end of said sheath, a pair of wire members connected to opposite sides of the distal end of said second resilient means and extending along said sheath into said housing, a pair of blocks movably mounted in said housing with each of said blocks being connected to one of said wires, means on said housing connected to said blocks for actuating said wire members and thereby selectively deflect the distal end portions of said second resilient means and second tubular member, a third wire member connected to said deflector and extending along said sheath into said housing a third block movably mounted in said housing and connected to said third wire, said housing having an opening formed therein, elongated flexible light and image-conducting means removably insertable through said housing opening into said sheath and longitudinally movable relative to said sheath with the distal end thereof projecting from the distal end of said sheath, means for sealing said opening while leaving said light and image-conducting means free to move therethrough, said light and image-conducting means including two groups of a very large number of extremely fine light-conducting fibers with one group of fibers being adapted to illuminate a field presented to the distal end of the other group of fibers and said other group of fibers being adapted to conduct an image of said field from the distal to the proximal end thereof, means for connecting a source of light to the proximal end of said first group of fibers, means connected to the proximal end of said light and image-conducting means for viewing an image on the proximal end of said second group of fibers, means adjacent to the distal end of said second group of fibers for forming an image of said field on the distal end of said second group of fibers, means on said housing connected to said third block for actuating said deflector and thereby shift the distal end portion of said light and image-conducting means relative to the distal end of said sheath, and means for connecting said housing to a supply of oxygen.

References Cited in the file of this patent

UNITED STATES PATENTS

2,641,977	Tatsuro	June 16, 1953
2,975,785	Sheldon	Mar. 21, 1961

FOREIGN PATENTS

548,462	Great Britain	Oct. 12, 1942
1,234,883	France	Oct. 19, 1960

OTHER REFERENCES

Kapany article in the Strong Book, "Concept of Classical Optics," 1958, pages 565-567, published by W. H. Freeman and Co. Inc. (Copy in Div. 7, 88-1 (LCR).)