

May 14, 1963

J. F. DE...
FLEXIBLE OPTICAL INSTRUMENT PARTICULARLY
FOR CARRYING OUT SURGICAL PROCEDURES

3,089,484

Filed Jan. 26, 1961

3 Sheets-Sheet 1

FIG. 1

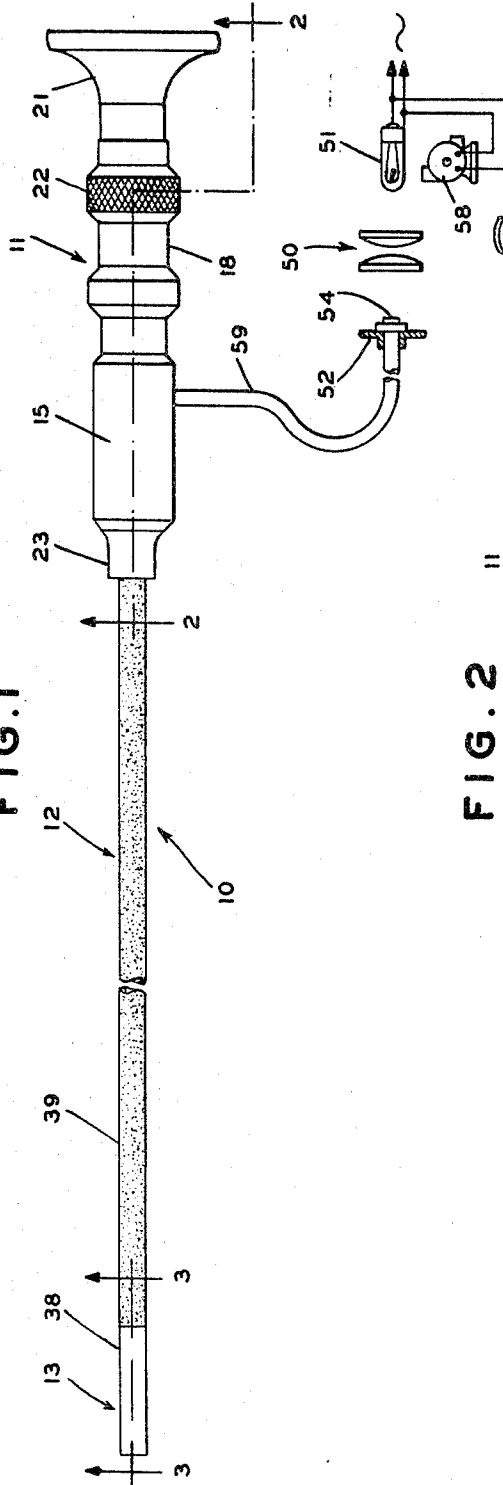
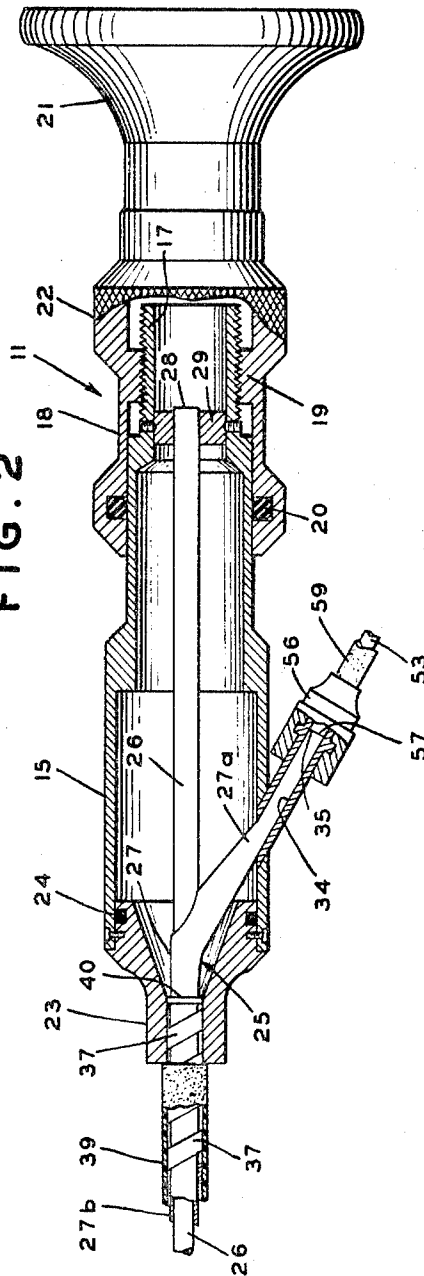


FIG. 2



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FIG. 3

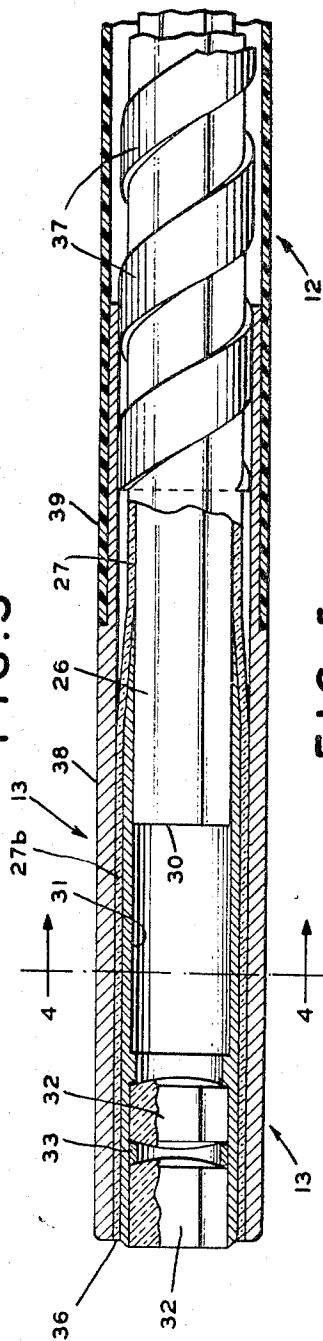


FIG. 5

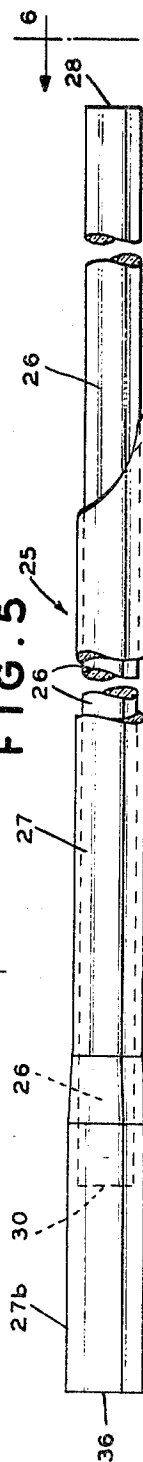


FIG. 4

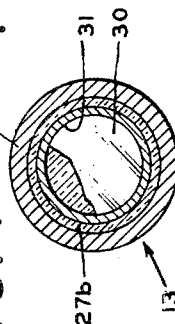
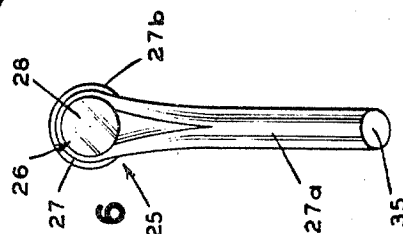


FIG. 6



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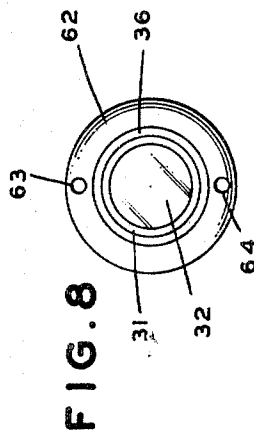
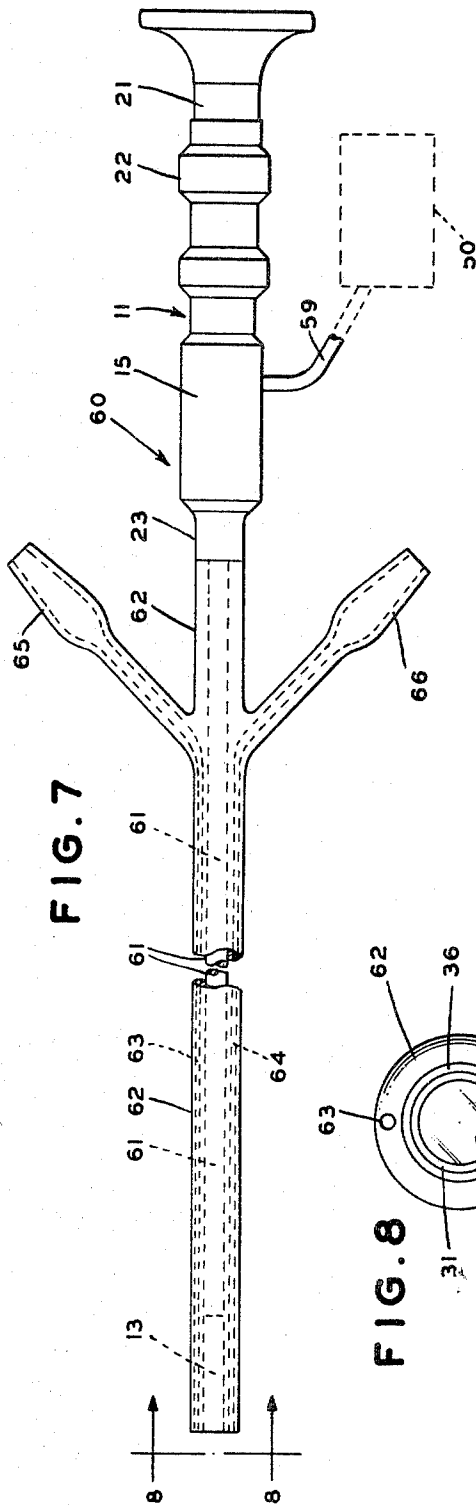
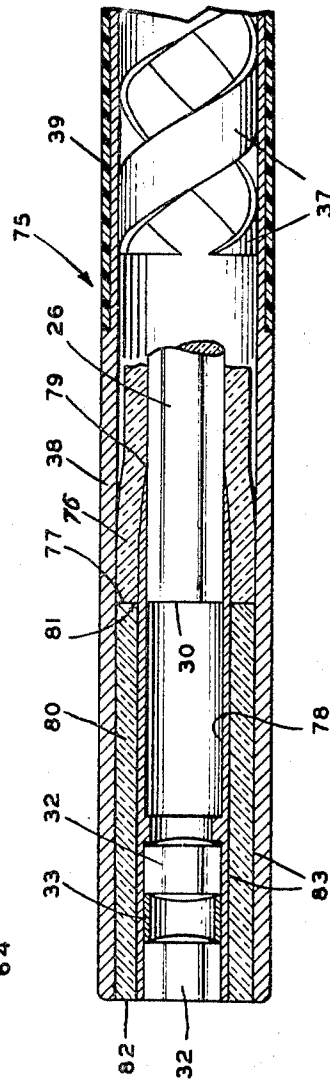


FIG. 9



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FLEXIBLE OPTICAL INSTRUMENT PARTICULARLY FOR CARRYING OUT SURGICAL PROCEDURES

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14 Claims. (Cl. 128—6)

This invention relates to flexible optical instruments and more particularly to a flexible surgical instrument which permits visualization and treatment of formerly inaccessible internal areas of the body of a patient, without the performance of surgical procedures involving the cutting of an opening into the body of the patient.

Instruments have long been desired which could be inserted into an opening in the body of a patient without need for the performance of any surgery and which would permit visualization and diagnosis of hitherto inaccessible areas and organs within the patient's body. For example, in the case of the ureter, a duct extending between the kidney and the bladder, only the end of which opens into the bladder has been visualized by means of cystoscopes adapted to be inserted through the urethra into the bladder. The angle formed between the ureter and the urethra has hitherto prevented access to all but the end of the ureter by means of the rigid instruments hitherto in use. Furthermore, because of the narrowness of the ureter an extremely small diameter or compact instrument is required if the ureter itself is to be traversed.

It is, therefore, a principal object of this invention to provide a highly flexible surgical instrument susceptible of being manufactured with such compactness as to be especially well suited for passing relative sharp angles and traversing extremely narrow passageways or ducts.

Another object is to provide such an instrument having an improved means for illuminating the field of view to the end that a high intensity lamp may be utilized to provide brilliant illumination of the field of view while at the same time maintaining the patient or the area viewed completely isolated from the electrical power supply and the heat generated by the lamp.

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 of an instrument constructed in accordance with the present invention, a high intensity light source being shown diagrammatically;

FIGURES 2 and 3 are cross-sectional views on an enlarged scale, taken respectively through the lines 2—2 and 3—3 of FIGURE 1;

FIGURE 4 is a sectional view taken through the line 4—4 of FIGURE 3;

FIGURE 5 is a side elevational view of the flexible optical fiber light and image conductor assembly;

FIGURE 6 is an end view of the light and image conducting assembly taken from the point of view of line 6—6 in FIGURE 5 in the direction indicated;

FIGURE 7 is a side elevational view of another embodiment of a surgical instrument constructed in accordance with the present invention;

FIGURE 8 is an elevational view on a further enlarged scale of the objective or distal end of the instrument shown in FIGURE 7; and

FIGURE 9 is a sectional view similar to FIGURE 3 showing a further modification of the instrument.

It is an important advantage of the present invention that an instrument may be provided having an extremely

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small diameter which is especially well suited for insertion into and traversing the smaller openings, passageways and ducts within the body of a patient. The flexible instruments of the present invention are eminently well suited for insertion into and for traversing narrow and tortuous passageways.

Instruments constructed in accordance with the present invention not only are successfully utilized to traverse and permit visualization of the entire ureter but also portions of the kidney itself may also be examined. For the purpose of exemplifying the present invention it will now be described in connection with an instrument constructed for the purpose of visualizing the ureter over its entire length in the body of a human patient, as well as portions of the pelvis of the kidney. However, it is to be noted that instruments constructed in accordance with the present invention are useful in examining other remote interior portions of the human body.

Referring now to the drawings in detail, flexible surgical instrument 10 comprises an eyepiece assembly 11 joined to one end, the proximal end, of an elongated flexible tubular assembly 12 which in turn terminates in an objective assembly indicated generally at 13.

While the instrument 10 is shown in the drawings on an exaggerated scale for clarity, it may be noted that in the case of the ureterscope now being described, the elongated flexible tubular assembly 12 may have an outer diameter of no more than about .09 to .13 inch.

As most clearly shown in FIGURE 2, eyepiece assembly 11 comprises a generally tubular body member 15 having an externally threaded portion 17 of reduced diameter at its proximal end. An eyepiece rotor 18 having an internally threaded portion 19 engaging the threaded portion 17, extends in telescoping relation over the body member 15. An O-ring 20 seated in an annular recess formed in the rotor 18 adjacent to its distal end provides a sliding seal with the outer surface of the body member 15. An eyepiece 21 is fitted to the end of the rotor 18 for axial movement therewith when the rotor is rotated relative to the body member 15 by means of the annular surface 22.

The end of the body member 15 remote from the eyepiece is connected to an adapter 23 having a central bore through which an optical light and image carrier indicated generally at 25 extends. An O-ring 24 seated in an annular recess formed in the adapter 23 serves to seal the connection between the body member 15 and the adapter 23.

The image conductor section 26 of the bundle 25 is made up of a large number of extremely small diameter light conducting fibers tightly packed together to form a generally cylindrical array having a diameter of less than about .065 inch. This image conductor section 26 may contain as many as 20,000 to 25,000 or more glass-coated glass fibers and together with the surrounding annular light carrier section 27 may be manufactured as described in the co-pending application of Lawrence E. Curtiss filed on December 19, 1960, serial No. 76,868. Each of the conducting fibers forming the image conductor section 26 extends continuously from end to end of the instrument, the eyepiece end face 28 of the image conductor section being optically polished so that an image formed thereon may be viewed directly or through a suitable lens system contained in the eyepiece 21. Preferably, the eyepiece 21 is provided with a lens system for magnifying the image received from the end of the image conductor section and focusing it on the eye of the viewer.

The portion of the image conductor section 26 extending between the adaptor 23 and the eyepiece 21 is preferably rigidified by means of a suitable cement and is supported within the body member 15 by means of an

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annular collar 29 fixed thereto and to the body member 15. The objective end portion of the image conductor section 26 is also rigidified by means of a suitable cement and the objective end face 30 is optically polished. This rigidified end portion of the image conductor section 26 extends into and is secured to one end of a tubular objective lens holder 31.

In the present instance, two conventional lenses 32 are mounted in the holder 31 spaced by spacer 33 and are adapted to form an image of the field of view on the optically polished end face 30 of the image conductor section 26. It is to be understood that each of the light conducting fibers which terminates at the end face 36 has a predetermined spacial relationship to the remaining fibers of this image conductor section and the opposite end of these light conducting fibers are fixed in the same mutual spacial relationship at the opposite end face 28. Thus, the light pattern forming an image on the objective end face 30 is conducted by the fibers of the section 26 to the end face 28 where the image is faithfully reproduced and is conveniently viewed through the eyepiece 21.

The light carrier section of the light and image carrier 25 surrounds the major portion of the image conductor section 26. As shown most clearly in FIGURE 2, the fibers of the light carrier section 27 are separated from the image conductor 26 within the body member 15 and are formed as a generally rigid rod-like extension 27a extending at an angle to the image conductor 26 and out through an opening formed in the wall of the body member 15. The outer end portion of the light carrier extension 27a is fitted with a female luer lock connector 34. The end face 35 of the light carrier extension 27a is optically polished to provide for the efficient entry of light into the fibers forming the light carrier.

Referring to FIGURES 3 and 5, it will be seen that the fibers forming the light carrier 27 extend continuously from the end face 35 of the extension 27a to the end of a hollow extension 27b of the light carrier which projects beyond the end face 30 of the image conductor 26. Light passes out through the annular end face 36 of the light carrier to illuminate the field of view of the front objective lens 32.

The elongated flexible tubular assembly 12 may be about 3 feet in length or more as desired and over the major portion of its length, the light and image carrier 25, may be so flexible as to require rigidification if the instrument is to pass an obstruction such as the valve located in the ureter. In the embodiment now being described flexible assembly 12 incorporates a pair of oppositely complementary flexible spiral members 37 formed of stainless steel or other suitable material, along the common axis of which the light and image carrier extends. At one end thereof, the spiral members 37 are connected to the adapter 23 while at their opposite ends, the spirals 37 extend partially within and are connected to a relatively short cover tube 38. While two spiral members have been described and shown in FIGURES 2 and 3, only one such member may be satisfactorily used in some instances, particularly in the smaller diameter instruments.

The interior diameter of the cover tube 38 is somewhat larger than the outer diameter of the objective lens holder 31. The light carrier extension 27b extends over the lens holder 31 and in the space between the latter and the cover tube 38. It will be noted that the light carrier extension 27b is spread sufficiently to accommodate the lens holder 31. At the objective or distal end of the instrument, the light carrier extension 27b and the cover tube 38 terminate substantially in alignment with each other and just short of the outer crowned face of the front objective lens 32.

As has been indicated hereinabove the parts have been shown in the drawings on an exaggerated scale. How-

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ever, it may be noted that in practice the cover tube 38 is less than about .7 inch in length and thus this rigid portion of the tubular assembly 12 is relatively short. Within the cover tube 38 the image conductor 26 and the light carrier 27 as well as its extension 27b may be rigid but the remainder of the light and image carrier 25 extending between the cover tube 38 and the adapter 23 is made up of mutually free fibers the diameter of which is so small that the carrier 25 is extremely flexible. To protect the fibers against wear and breakage resulting from abrasion, a liquid tight sheath 39 is preferably fitted over the entire length of the light and image carrier 25 and is secured in fluid-tight relation at one end to the cover tube 38 and at the other end to the adapter 23. The sheath 39 may be formed of rubber latex or other suitable material and is filled sufficiently with a suitable lubricating fluid such as an oil so that the fibers of the light and image carrier 25 are in effect "floating" in oil. An annular plug 40 may be fitted about the light and image carrier 25 in the adapter 23 when it is desired to prevent the lubricating fluid from seeping into the body member 15.

As thus far described the surgical instrument 10 may be assembled in any convenient manner. However, it may be noted that the light and image carrier 25 is left substantially rigid from end to end until it has been inserted within the spiral members 37. Then all but the end portions of the assembly is dipped in a suitable solvent, such as hot sulphuric acid, to leach out the resin or other cement which serves to hold the optical fibers in close packed substantially immovable relation. The end portions which were kept out of the solvent remain rigid and if not yet cured may be treated as by subjecting them to heat when the cement utilized is a thermosetting resin.

A high intensity light source is coupled with the light carrier extension 27a to provide illumination for the field of view when the instrument 10 is in use. For this purpose a lamp 51 is mounted within a container only a fragmentary portion of the wall of which is indicated at 52. A flexible optical fiber light conductor 53 having rigid end portions as was described in connection with the image and light conductor sections 26 and 27 is mounted in an aperture formed in the wall 52 so that its end face 54 receives the light from the lamp 51 through the condensor 50. The opposite rigid end portion of the light conductor 53 is fitted with a male Luer Lock connector 56 adapted to be engaged with the female connector 34 so as to hold the end face 57 of the light carrier 53 in close juxtaposition with the end face 35 of the light carrier extension 27a.

A blower 58 is conveniently mounted within the housing 52 to cool the lamp 51.

As in the case of the light and image carrier 25, the light conductor 53 may also be enclosed within a fluid tight sheath 59 which is filled with a suitable lubricant to protect the extremely fine glass-coated glass fibers of the light carrier.

In operation, with the Luer lock connectors 34 and 56 coupled together and with the lamp 51 connected to a source of electrical power, light passes along the fibers of the light carrier 53 and along the fibers of the light carrier 27 to emerge from the annular end face 36 and illuminate the field of view. Light reflected from the field incident on the face of the front objective lens 32 is formed as an image on the end face 30 of the image conductor 26 and this image is faithfully reproduced on the end face 28 where it is viewed through the eyepiece 21. When it is desired to examine the ureter the instrument may be passed through a standard catheterizing cystoscope positioned in the urethra. It is to be understood, however, that the instrument of the present invention is not limited to use in examining the ureter or portions of the kidney accessible from the ureter but may be used elsewhere to illuminate and examine otherwise inaccessible areas. For example, the instrument may be passed

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through the mouth of the patient into his lung or into his stomach.

In the instrument as described hereinabove, the outer face of the front objective lens 32 is self-cleaning in that fluids or other materials which would tend to obscure the image are usually removed from the lens face by the body tissues of the patient which pass over it.

Turning now to FIGURES 7 and 8, surgical instrument 60 comprises an eyepiece assembly 11 and an objective assembly 13 which may be identical to that described in connection with instrument 10. The elongated flexible tubular assembly 61 is similar to the assembly 12 except that the spiral members 37 are omitted and the elongated tubular assembly 61 including the objective assembly is enclosed within a flexible catheter 62 formed of a suitable plastic. Polyvinyl chloride is especially well suited for this purpose because the catheter may be formed with an extremely thin wall about .010 to .015 inch or less and will still have sufficient rigidity so that the extremely flexible light and image carrier 25 may be manipulated.

In the wall of catheter 62 there are formed two longitudinally extending passageways 63 and 64. Adjacent to the proximal end of the catheter 62, passageway 63 communicates through an opening formed in the wall of the catheter with the interior of an open-ended tube 65. Similarly, passageway 64 communicates with the interior of a hollow open-ended tube 66. The opposite or distal ends of the passageways 63 and 64 are open as clearly shown in FIGURE 8.

The sheath 39 utilized in the embodiments shown in FIGURES 1-6 may be omitted and the catheter 62 may be filled with the lubricating fluid and its opposite ends sealed to the rigid eyepiece and objective end portions of the light and image carrier 25.

The instrument 60 may be about 3 feet or more in length between the adapter 23 and its objective end. While extremely flexible, the catheter 62 imparts sufficient rigidity to the device so that it may be forced past obstructions and along passageways in which it has a relatively close fit. Depending upon the use of the instrument, a source of irrigating fluid such as water or an air supply may be connected to the tube 65, the fluid passing along the passageway 63 and then out through passageway 64 and tube 66. When necessary, the fluid may be utilized for clearing the areas under view or the exposed face of the objective lens.

As has been pointed out, the light and image carrier 25 may be manufactured in accordance with the method of said copending application of Lawrence E. Curtiss. Thus, a single bundle of oriented optical fibers may be formed and then the ends of the light conductor fibers may be separated from the image conductor fibers. Furthermore, the light carrier and the image carrier may be further isolated from each other by means of an opaque thin walled member extending about the interior of the annular light carrier and surrounding the image carrier. Such an arrangement may be constructed by forming the light carrier separately from the image carrier on a thin sheet, about .00025 inch thick as pointed out in said copending application with the sheet opaque and extending about the interior of the hollow portion of the light carrier. The image conductor section is inserted into the light carrier while both are substantially rigid and then the resin or other cement is leached out with a suitable agent. As before, the end portions of the light and image conductor sections are bonded together in rigid, substantially immovable relation.

The hollow extension 27b of the light carrier section provides highly efficient conduction of light beyond the end of the image carrier section 26 to the area under view. In polishing the end face 36 of the light carrier care must be exercised not to damage the ends of the fibers forming the extension 27b. The extension 27b may be omitted as when the distance between the end face 30 of the image conductor and the outer face of

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the front objective lens 32 is relatively short, as shown in FIGURE 9, and the light carrier section 27 may be terminated flush with the image conductor section 26. An instrument thus modified will now be described in connection with FIGURE 9 where only the distal or objective end portion of an instrument 75 is shown the remainder thereof being identical with instrument 10. In order to avoid unnecessary repetition those parts of instrument 75 which are identical with corresponding parts in instrument 10 are designated by the same reference characters.

Light carrier section 76 is similar to the light carrier section 27 except that it terminates in an annular end face 77 which extends in the same plane as that of image conductor end face 30. Objective lens holder 78 is formed with an annular feather edge as indicated at 79 at one end thereof. As indicated the feather edge or tapered end portion of the lens holder 78 is inserted between the adjacent end portions of the light carrier and image conductor sections, the end portion of the light carrier section being spread somewhat. As in the case of lens holder 31, the objective lens holder 78 supports a pair of spaced lenses 32, the outer face of the forward lens 32 being planar and flush with the end of the lens holder 78.

Mounted between cover tube 38 and the objective lens holder 78 is a glass cylinder 80 having an inwardly presented end face 81 in face-to-face contact with the light carrier end face 77. The outwardly presented end face 82 extends substantially in the same plane as the outer ends of the lens holder 78 and the cover tube 38. To minimize light loss through the glass cylinder 80, its inner and outer cylindrical surfaces are silvered as indicated at 83, the silver coating being shown with an exaggerated thickness in the drawing. It may be noted that glass cylinder 80 is relatively short and in the present instance is about .4 inch in length.

In operation light entering the end of light carrier 76 corresponding to the extension 27a of the light carrier 27, passes through and is emitted from the end face 82 of the glass cylinder 80 to illuminate the area viewed through the objective lens 32. The construction and operation of instrument 75 except as has been otherwise pointed out is the same as was described in connection with the instrument 10.

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 instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section forming at one end thereof a rod-like close packed array of fibers extending spaced from the other end of said image-conducting section, objective lens means supported adjacent to said image receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, means includ-

ing said light-conducting section for confining radiation for illuminating said field to a hollow beam along a path extending axially from said image-receiving end and having a hollow ring-shaped cross section transverse to its axis, said objective lens means extending entirely within the hollow portion of said beam path, and the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation.

2. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image-conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section forming at one end thereof a rod-like close packed array of fibers extending adjacent to and spaced from the other end of said image-conducting section, a tubular member connected to said image-receiving end, objective lens means supported in said tubular member adjacent to said image-receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, means including said light-conducting section for confining radiation for illuminating said field to a hollow beam extending coaxially with and outside of said tubular member, and the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation.

3. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite end of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image-conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section at one end thereof extending in said housing and forming a rod-like close packed array of fibers extending out of said housing spaced from said eyepiece means, a pair of coaxial tubular members connected to said image-receiving end and forming a longitudinally extending space therebetween, objective lens means supported in the inner one of said tubular members adjacent to said image receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, means including said light-conducting section for transmitting light through the space between said tubular members to the side of said objective lens means away

from said image-receiving end of said image-conducting section to illuminate said field, and the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation.

4. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image-conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section at one end thereof extending in said housing and forming a rod-like close packed array of fibers extending out of said housing spaced from said eyepiece means, a pair of coaxial tubular members connected to said image-receiving end and forming a longitudinally extending space therebetween, objective lens means supported in the inner one of said tubular members adjacent to said image receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, means including said light-conducting section for transmitting light through the space between said tubular members to the side of said objective lens means away from said image-receiving end of said image-conducting section to illuminate said field, the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation, a fluid-tight flexible member enclosing said light and image-conducting bundle intermediate said housing and said coaxial tubular members, and lubricating fluid in said flexible tubular member.

5. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section at one end thereof extending in said housing and forming a rod-like close packed array of fibers extending out of said housing spaced from said eyepiece means, a pair of coaxial tubular members connected to said image-receiving end and forming a longitudinally extending space therebetween, objective lens means supported in the inner one of said tubular members adjacent to said image-receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, means including said light-conducting section for trans-

mitting light through the space between said tubular members to the side of said objective lens means away from said image-receiving end of said image-conducting section to illuminate said field, the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation, a fluid-tight flexible tubular member enclosing said light and image-conducting bundle intermediate said housing and said coaxial tubular members, means for rigidifying said bundle while leaving the same free to flex and extending in said flexible tubular member, and lubricating fluid in said flexible tubular member.

6. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image-conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section at one end thereof extending in said housing and forming a rod-like close packed array of fibers extending out of said housing spaced from said eyepiece means, a pair of coaxial tubular members connected to said image-receiving end and forming a longitudinally extending space therebetween, objective lens means supported in the inner one of said tubular members adjacent to said image receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, means including said light-conducting section for transmitting light through the space between said tubular members to the side of said objective lens means away from said image-receiving end of said image-conducting section to illuminate said field, the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation, a fluid-tight flexible tubular member enclosing said light and image-conducting bundle intermediate said housing and said coaxial tubular members, said flexible tubular member having at least one fluid passageway formed along the wall thereof and opening at one end thereof adjacent to said objective lens means, means for connecting the other end of said passageway to a source of fluid, and lubricating fluid in said flexible tubular member.

7. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising an elongated light and image-conducting bundle having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, said fibers being arranged in first and second groups with the fibers of the first group at one end thereof forming a rod-like array extending spaced from the corresponding end of the fibers of the second group, the remaining portions of the fibers of said first group extending about said second group and forming a hollow extension projecting beyond the other end of said second group, and objective lens means positioned in said hollow extension for providing to said other end of said second group an image of a field of view adjacent to the end of said hollow extension, whereby light incident on the end of said rod-like array is conducted by

the fibers of said first group to illuminate said field and said image is conducted by the fibers of said second group to said one end thereof.

8. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally with the end portions of said fibers in fixed close packed predetermined relation, an eyepiece and means supporting the same for receiving and viewing an image from one end of said image-conducting section, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally with the fibers at one end of said light-conducting section fixed in close packed relation and forming a rod-like array spaced from said one end of said image-conducting section and with the fibers at the other end of said light-conducting section fixed in close packed relation and forming a hollow extension projecting beyond the other end of said image-conducting section, objective lens means supported adjacent to said other end of said image-conducting section and within said hollow extension, the fibers of said light-conducting section intermediate the portions thereof forming said hollow extension and said rod-like array being disposed about the fibers of said image-conducting section, and means for rigidifying said light and image-conducting bundle intermediate the end portions thereof and leaving the same free to flex.

9. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally with the end portions of said fibers in fixed close packed predetermined relation, an eyepiece and means supporting the same for receiving and viewing an image from one end of said image-conducting section, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally with the fibers at one end of said light-conducting section fixed in close packed relation and forming a rod-like array spaced from said one end of said image-conducting bundle and with the fibers at the other end of said light-conducting bundle fixed in close packed relation and forming a hollow extension extending about and projecting beyond the other end of said image-conducting section, objective lens means supported adjacent to said other end of said image-conducting section and within said hollow extension, the fibers of said light-conducting section intermediate the portions thereof forming said hollow extension and said rod-like array being disposed about the fibers of said image-conducting section, and at least one resilient spiral member surrounding said light and image-conducting bundle and leaving the same free to flex intermediate the end portions thereof.

10. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising an elongated light and image-conducting bundle having a light conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally with the end portions of said fibers in fixed close packed predetermined relation, an eyepiece and means supporting the same for receiving and viewing an image from one end of said image-conducting section, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers

extending longitudinally with the fibers at one end of said light-conducting section fixed in close packed relation and forming a rod-like array spaced from said one end of said image-conducting section and with the fibers at the other end of said light-conducting section fixed in close packed relation and forming a hollow extension projecting beyond the other end of said image-conducting section, objective lens means supported adjacent to said other end of said image-conducting section and within said hollow extension, the fibers of said light-conducting section intermediate the portions thereof forming said hollow extension and said rod-like array being disposed about the fibers of said image-conducting section, and an elongated flexible tubular member extending from adjacent to said one end of said light and image-conducting bundle to adjacent the other end thereof and enclosing the same, said tubular member having at least one longitudinally extending passageway formed in the wall thereof, one end of said passageway opening adjacent to said objective lens means, and means communicating with the other end of said passageway for connecting the same to a source of fluid.

11. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image-conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section forming at one end thereof a rod-like close packed array of fibers extending adjacent to and spaced from the other end of said image-conducting section, a tubular member connected to said image-receiving end, objective lens means supported in said tubular member adjacent to said image-receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, a cylinder having a light-conducting wall surrounding said objective lens means and having one end thereof juxtaposed to the other end of said light-conducting section for transmitting light through the wall thereof to the side of said objective lens means away from said image-receiving end of said image-conducting section to illuminate said field, the inner and outer surfaces of the wall of said light-conducting cylinder having a light-reflecting coating thereon, and the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation.

12. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image-conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin

flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section at one end thereof extending in said housing and forming a rod-like close packed array of fibers extending out of said housing spaced from said eyepiece means, a pair of coaxial tubular members connected to said image-receiving end and forming a longitudinally extending space therebetween, objective lens means supported in the inner one of said tubular members adjacent to said image-receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, a light-conducting glass tube in the space between said coaxial tubular members and having an end thereof in face-to-face engagement with the other end of said light-conducting section for transmitting light to the side of said objective lens means away from said image-receiving end of said image-conducting section to illuminate said field, the inner and outer surfaces of said glass tube having a light-reflecting coating thereon, the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation, a fluid-tight flexible tubular member enclosing said light and image-conducting bundle intermediate said housing and said coaxial tubular members, said flexible tubular member having at least one fluid passageway formed along the wall thereof and opening at one end thereof adjacent to said objective lens means, means for connecting the other end of said passageway to a source of fluid, and lubricating fluid in said flexible tubular member.

13. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section forming at one end thereof a rod-like close packed array of fibers extending spaced from the other end of said image-conducting section, objective lens means supported adjacent to said image receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light-conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, means including said light-conducting section for confining radiation for illuminating said field to a hollow beam along a path extending axially from said image-receiving end and having a hollow ring-shaped cross section transverse to its axis, said objective lens means extending entirely within the hollow portion of said beam path, the opposite end portions of the fibers of said light-conducting section being fixed in close packed relation, and means for connecting the end of said rod-like array to a light source including a flexible light conducting bundle having one end thereof presented to a source of intense light and having the other end thereof removably connected in face-to-face relation with the end of said rod-like array.

14. A flexible optical instrument particularly for insertion into restricted openings and passageways in the body of a patient in the carrying out of surgical procedures, comprising a housing, eyepiece means connected to said housing, an elongated light and image-conducting bundle having a light-conducting section and an image-conducting section, said image-conducting section having

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a multiplicity of very thin flexible light-conducting fibers extending longitudinally from an image-receiving end to the other end thereof with the fibers at the opposite ends of said image-conducting section being fixed in close packed predetermined relation, said other end portion of said image-conducting section extending in and supported in said housing with its end face presented to said eyepiece means, said light-conducting section having a multiplicity of very thin flexible light-conducting fibers extending longitudinally from end to end thereof, the fibers of said light-conducting section at one end thereof extending in said housing and forming a rod-like close packed array of fibers extending out of said housing spaced from said eyepiece means, a pair of coaxial tubular members connected to said image-receiving end and forming a longitudinally extending space therebetween, objective lens means supported in the inner one of said tubular members adjacent to said image receiving end of said image-conducting section for projecting an image of a field on said image-receiving end, the light conducting fibers of said light-conducting section extending substantially parallel with the fibers of said image-conducting section over a major portion of the length of the latter, a light-conducting glass tube in the space between said coaxial tubular members and having an end thereof in face-to-face engagement with the other end of said light-conducting section for transmitting light to the side of said objective lens means away from said image-receiving end of said image-conducting section to illuminate said field, the inner and outer surfaces of said glass tube having a light-reflecting coating thereon, the opposite end portions of the fibers of said light-conducting

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section being fixed in close packed relation, a fluid-tight flexible tubular member enclosing said light and image-conducting bundle intermediate said housing and said coaxial tubular members, said flexible tubular member having at least one fluid passageway formed along the wall thereof and opening at one end thereof adjacent to said objective lens means, means for connecting the other end of said passageway to a source of fluid, lubricating fluid in said flexible tubular member, and means for connecting the end of said rod-like array to a light source including a flexible light conducting bundle having one end thereof presented to a source of intense light and having the other end thereof removably connected in face-to-face relation with the end of said rod-like array.

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