July 19, 1966 F. J. WALLACE 3,261,349

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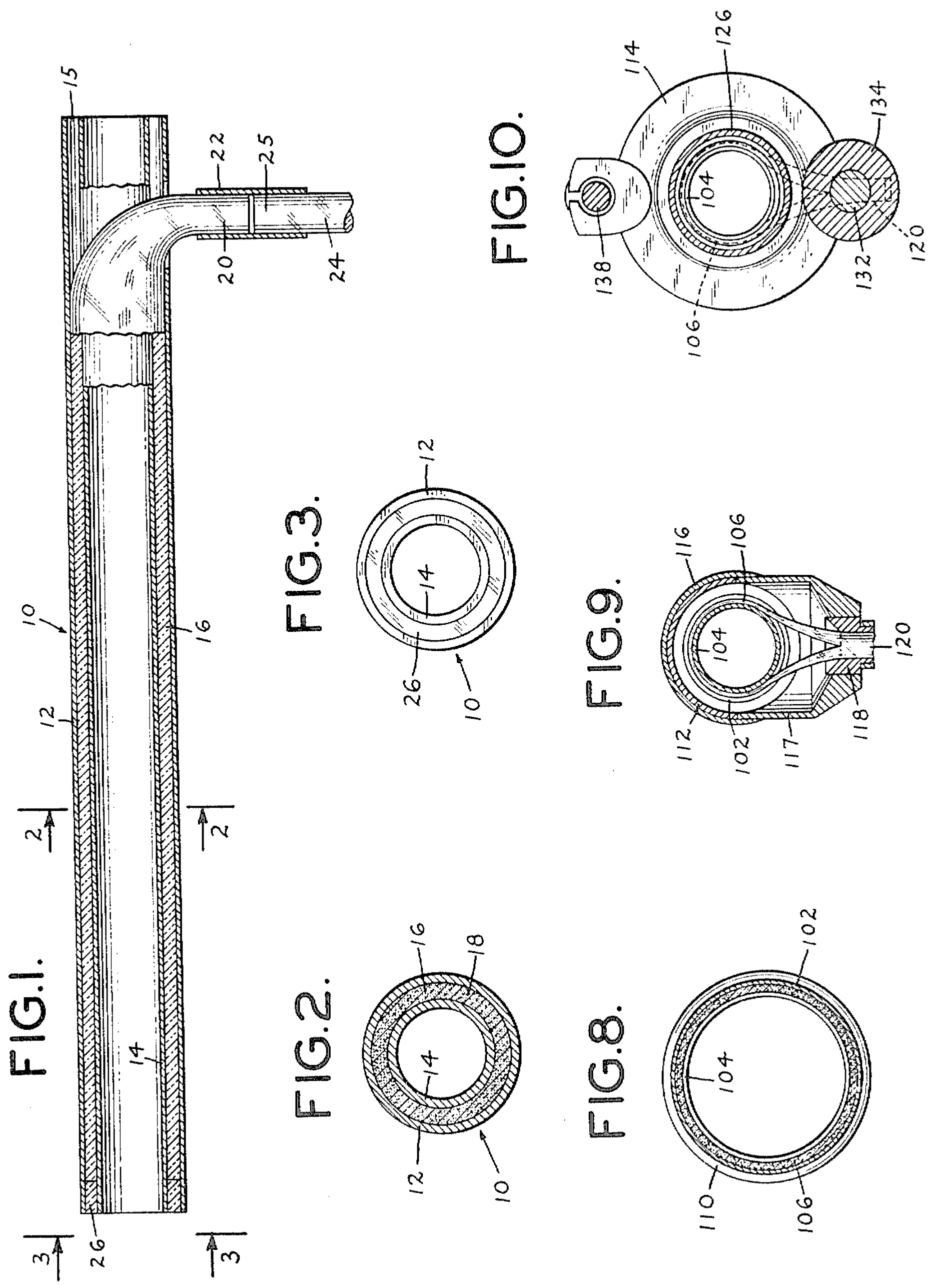
Filed Aug. 29, 1963 3 Sheets-Sheet 1



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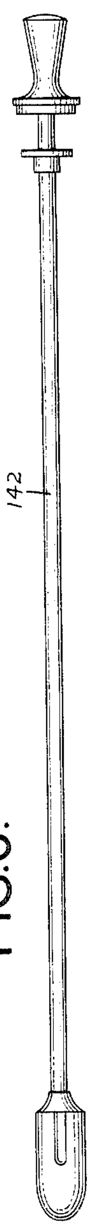

FIG.6.

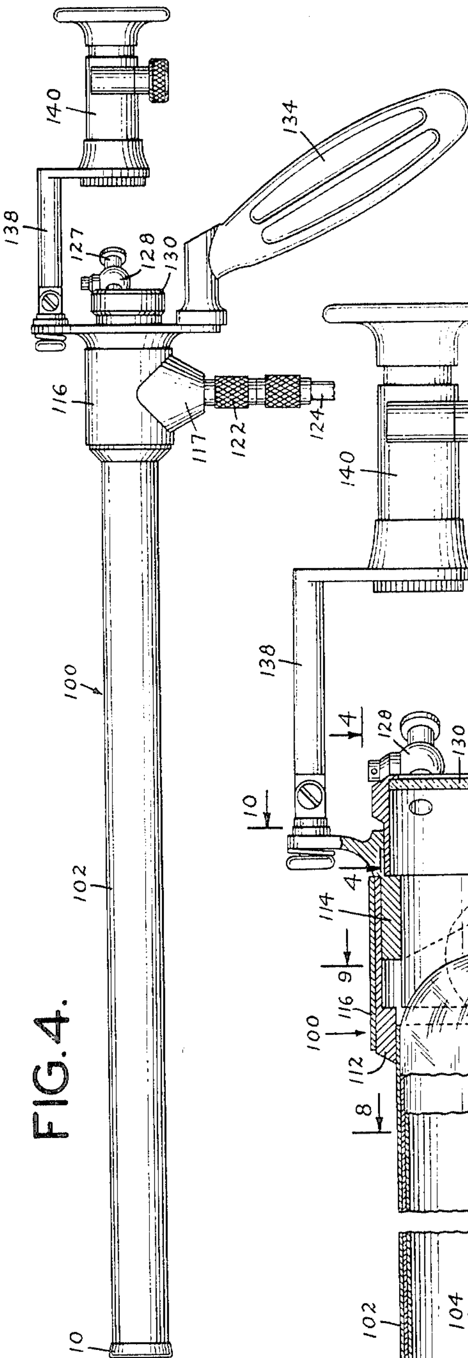

FIG.4.

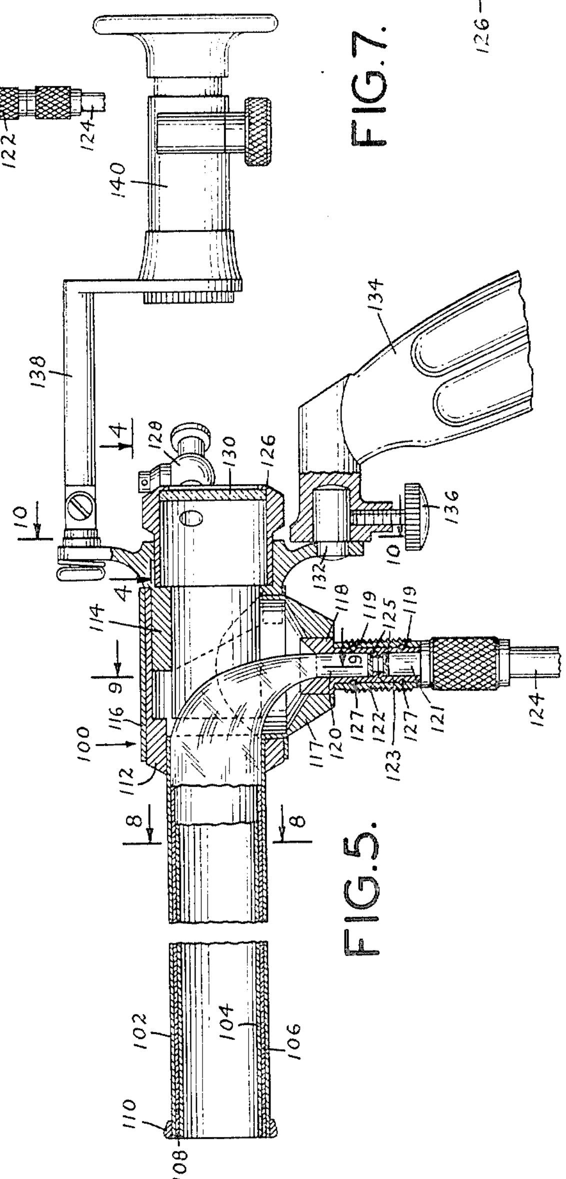

FIG.5.

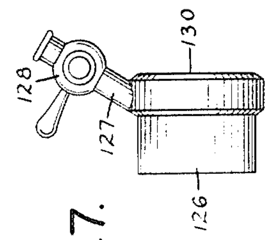

FIG.7.

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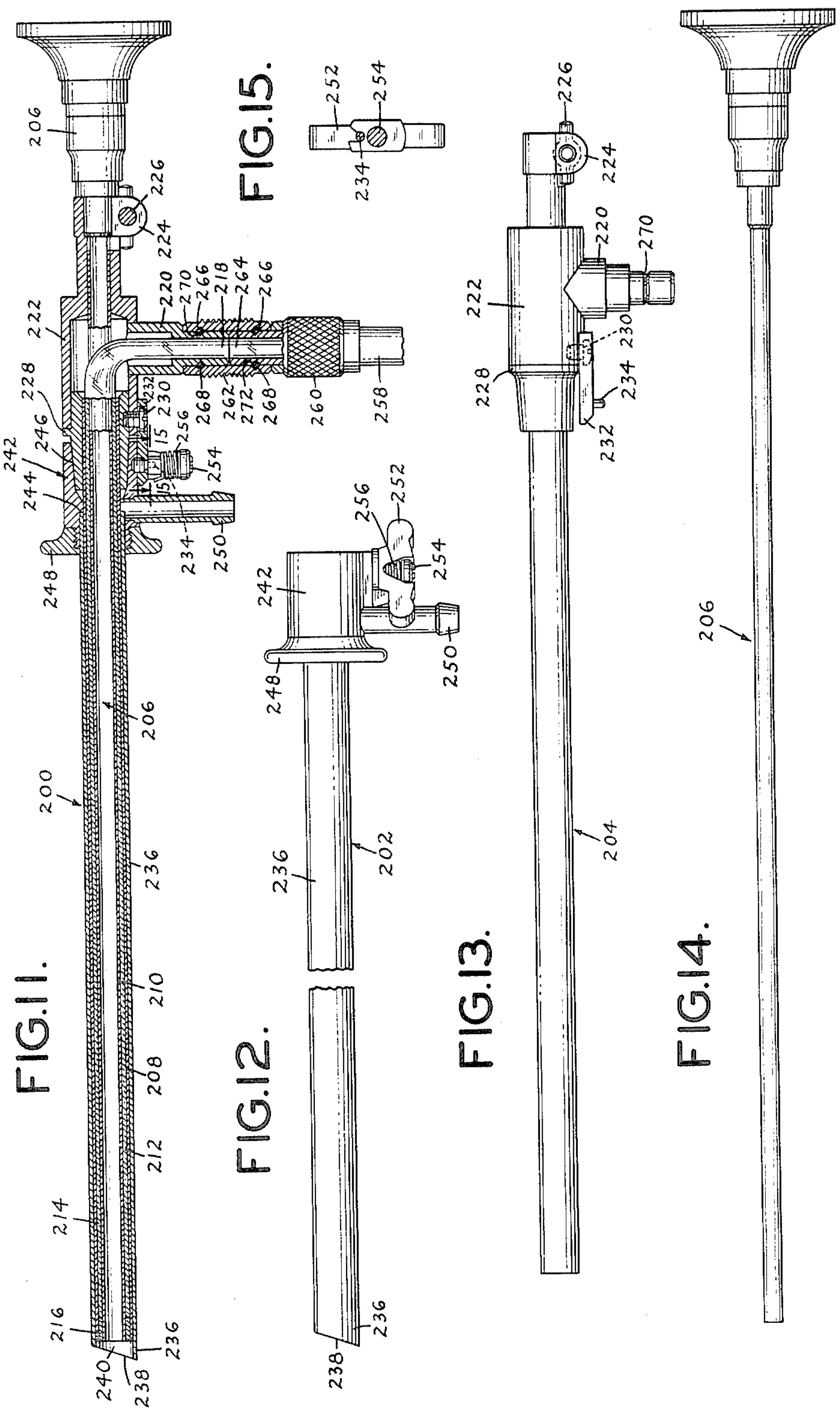

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3,261,349
ENDOSCOPE

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9 Claims. (Cl. 128—6)

This invention relates to endoscopic instruments for the examination of internal body orifices, and more particularly relates to such instruments which utilize optic fibers for illumination of the internal orifices.

An endoscope must meet limitations of size and shape dictated by the anatomical structure of the orifice in which it is to be used. Also, an endoscope must provide for light, vision and operating instruments or high frequency electrodes. For precision in diagnosis or other procedure, a fine, brilliant image that is accurate in regard to both color and definition is essential to the operator. Within the relatively small lumen or space inside the tubular portion of known rigid endoscopes, there is a complete electrical circuit of which a lamp is a part. The lamp circuit requires an insulated conductor or wire to carry current from a contact near the proximal end, to the lamp frequently located at the distal end. The circuit must function perfectly under water and must not be affected by other solutions during sterilization, a requirement most difficult to fulfill in any electrical structure. While the instruments are water-tight when they leave the factory, due to the fact that they must be opened for the replacement of lamps, their ability to exclude moisture is almost entirely dependent upon the care exercised by the user in again sealing the instruments.

In known endoscopic instruments most premature burning out of lamps results from attempts to obtain unusually brilliant illumination. The extent of illumination is limited by the filament of the lamp itself. It is the practice to make use of a current regulator and observe the lamp filament closely while gradually increasing the current. The limit of safe current is reached when the definite reddish tint of the lamp suddenly becomes white. Further increase in illumination by increasing the current beyond this point results in premature burning out of the lamp. Once the lamp burns out it is necessary to remove it, thus introducing the possibility of the prolems described above.

Problems also arise from the disinfection of parts of the endoscope containing lamps or lenses. It is not practicable to boil or autoclave any part of the endoscope which contains lamps. The usual chemical disinfectants may not be used or leaks and short circuits in the wiring may follow. As a result it is necessary to use special disinfectant methods and solutions in cleaning known endoscopes.

It is an object of the present invention to provide means for illuminating internal orifices which means provide significantly brighter illumination than was heretofore possible and may be sterilized by boiling, autoclaving or chemicals without deleterious results.

It is another object of the present invention to provide endoscopic instruments having illuminating means with an expected life equivalent to that of the rest of the instrument, which means do not require maintenance or replacement of parts in normal use.

It is still another object of the present invention to provide particular endoscopic instruments utilizing as an illuminating means a bundle of optic fibers which may be shaped at its distal end to configurations especially adapted to the particular use of the instrument.

It is another object of this invention to provide a fiber optic bundle for the illumination of internal orifices which is in a form rigid enough for insertion into such orifices.

Further objects as well as advantages in the present invention will be apparent from the following description and the accompanying drawings, in which:

FIGURE 1 is a side elevational view of a rigid light-carrying sheath for an endoscope constructed in accordance with the present invention, partially broken away for convenience;

FIGURE 2 is a transverse cross-sectional view taken generally along lines 2—2 of FIGURE 1;

FIGURE 3 is an end view taken generally along lines 3—3 of FIGURE 1;

FIGURE 4 is a side elevational view of a specific embodiment of an endoscope constructed in accordance with the present invention;

FIGURE 5 is a longitudinal cross-sectional view of the embodiment of FIGURE 4, partially broken away for convenience;

FIGURE 6 is a view of an obturator useful in conjunction with the embodiment of FIGURE 4;

FIGURE 7 is a top view of an insufflation cap useful with the embodiment of FIGURE 4;

FIGURE 8 is a transverse cross-sectional view taken generally along lines 8—8 of FIGURE 5;

FIGURE 9 is a transverse cross-sectional view taken generally along lines 9—9 of FIGURE 5;

FIGURE 10 is a transverse cross-sectional view taken generally along lines 10—10 of FIGURE 5;

FIGURE 11 is a longitudinal cross-sectional view, partially broken away for convenience, of another embodiment of an endoscope constructed in accordance with the present invention;

FIGURE 12 is a side elevational view of a sheath which is useful in connection with the embodiment of FIGURE 11;

FIGURE 13 is a side elevational view of a light-carrying bundle useful in the embodiment of FIGURE 11;

FIGURE 14 is a side elevational view of a surgical telescope useful in the embodiment of FIGURE 11; and

FIGURE 15 is a detail view, partly in section, of a connecting device useful in connection with the embodiment of FIGURE 11 taken generally along lines 15—15 of FIGURE 11.

The objects of this invention may be accomplished by forming an endoscope tubular member from two concentric, coaxial, rigid tubes. The concentric tubes may be circular in cross-section but for most applications are preferably slightly elliptical. For some applications it is desirable to taper the concentric tubes. A bundle containing a large number of optic fibers is placed in the annular space between the two tubes.

The proximal end of the optic fiber bundle is formed into a solid rod which is of a suitable configuration, preferably cylindrical, for coupling to a source of light.

Because endoscopes are shaped to conform to the orifice being examined, the distal end of the bundle may be formed into one of a variety of shapes. A preferred shape is that of an annulus substantially coextensive with the ends of the concentric tubes. Preferably the ends of the fiber bundle are optically polished to provide better light dissemination and a protective lens may be placed over the polished end of the bundle, if desired. Using an annular distal configuration, light is transmitted through the bundle to provide high intensity, cold illumination in an annular pattern at the distal end, permitting ready observation of internal areas. If desired, the distal end of the bundle may be adapted to illuminate an internal orifice by forming the fibers into a solid rod or other shape.

High intensity illumination is possible using the present invention. Intensities up to 2,000 foot candles or more at a working distance of one-half inch and up to 400 foot candles or more at four inches may be obtained by connecting the device to a fiber optic light source by means of a fiber optic light carrying bundle. Typically the illumination produced by the optic fiber bundle is fifteen times greater than that produced by an incandescent lamp commonly used in same size of endoscope.

Other features of the present invention are the elimination of wires and the elimination of rotating contacts on the instruments which were necessary in prior art instruments in order to provide electrical connections for the internal lamp circuit. The present invention may be made applicable to all types of endoscopic equipment, particularly examining, operating agnd catheterizing endoscopes. A particular advantage of the present invention is the adaptability of the instrument to small size, for instance, for use in an infant cystoscope.

Rigid endoscopes having annularly disposed fiber optics may be prepared by the following procedure. First, using the method described in the application of Lawrence E. Curtiss, Serial No. 76,868, filed December 19, 1960, continuous strands of fiber optics are wound on a Mylar (polyethylene terephthalate) sheet which is disposed around a drum. As each successive layer of fibers is laid on the drum, a layer of thermosetting resin is placed upon them. The resin is allowed to dry but is not cured; thus it remains tacky but does not become hard and stiff. The sheet is then cut parallel to the axis of the cylinder, and a flat sheet of Mylar having well oriented fibers is obtained.

Second, the inner tube of the endoscope is brought into contact with the flat sheet, and the flat sheet is rolled onto the inner tube in an even number of revolutions sufficient to produce the thickness of the annular bundle that is desired. Because the resin that was applied is tacky, the sheet sticks readily to the tube, and successive convolutions stick to each other.

Third, the inner tube and optic bundle are inserted in the outer tube which is shorter than the inner tube and the fibers used. The distal ends of the fibers are coextensive with the distal ends of both inner and outer tubes. The proximal end is formed into a rod by pulling the fibers together. If necessary a solvent is used to soften the resin. After forming, the rod is inserted through a terminal fitting which supports it, and epoxy resin is added to the rod end and also to the annular distal end. Finally the entire assembly is baked to cure the resin and produce a hard, rigid endoscopic tube.

Where a bend is to be produced in the tube, the fibers may be inserted as above and the bend made after the outer tube is applied, but before baking. The presence of the fibers between the two tubes aids in maintaining the tubes concentric. The resin is soft enough to permit the bundle to bend without breaking the fibers.

Turning now to FIGURES 1, 2 and 3, a generalized embodiment of the device of the present invention is shown. Rigid light carrying sheath **10** is comprised of outer tube **12** and concentric, coaxial, inner tube **14**. Disposed within the annular space **15** between tubes **12** and **14** is bundle **16** comprised of a plurailty of individual optic fibers **18**. The proximal end of bundle **16** is formed into a solid rod **20** for connection to a light source.

A high intensity light source may be coupled to the rigid bundle **16**. For this purpose a high intensity lamp (not shown) may be mounted within a container, and flexible optic fiber light conductor **24** having rigid end portions may be mounted adjacent to the lamp, so that it receives the light from the lamp. The opposite rigid end of the flexible light conductor **24** is fittted with a plug-in connector **25** adapted to be inserted into a receptacle or jack **22** so as to hold the end face of the light carrier **24** in close juxtaposition to the end face of bundle **20**. The proximal and distal ends of bundle **16** are optically ground to provide a maximum transmission of light in a controlled pattern to the internal orifice.

An embodiment of the present invention is shown in the proctoscope of FIGURES 4 to 10. The proctoscope is comprised of two rigid concentric tubes and a layer of optic fibers which are positioned in the annular space between the tubes. The distal end of the bundle is formed into an annulus, and the proximal end is formed into a circular rod for connection to a flexible optic fiber light-carrying bundle.

Referring now to the drawings in detail, proctoscope **100** is comprised of an elongated outer tube **102** containing within it concentric coaxial inner tube **104**. Substantially filling the annular space between outer tube **102** and inner tube **104** is optic fiber bundle **106**. Distal end **108** of optic fiber bundle **106** is a solid annulus, optically ground. Rim **110** surrounds outer tube **102** at the distal end. At its proximal end outer tube **102** is joined in liquid-tight relation to an annular mounting member **112** which is connected to mounting ring **114**. Yoke **116** surrounds annular mounting member **112** and engages terminal support **117** containing collar **118** which supports proximal end **120** of fiber bundle **106**. Proximal end **120** of bundle **106** is optically ground and is joined by receptacle or jack **122** to flexible light-carrying bundle **124**, as more fully described below. Planar glass plates **125** protect the ends of bundles **106** and **124**. Insufflation cap **126** forms a liquid-tight seal with mounting ring **114**. As best shown in FIGURE 7, insufflation cap **126** is equipped with conduit **127** and valve **128** for connection to an external insufflation medium and also contains transparent planar lens **130** to permit visual inspection during insufflation.

Stud **132** connected to mounting ring **114** supports handle **134** which is held in place by thumb screw **136** engaging stud **132**. By means of mounting rod **138**, connected to mounting ring **114**, proximal telescope **140** is maintained in spaced relation to planar lens **130** and is arranged for clear vision down the interior length of inner tube **104**. Obturator **142** may be utilized with the proctoscope in well known manner.

For removably connecting the endoscope to a high intensity light source (not shown), flexible light-carrier **124** is fitted with plug-in connector **123** for insertion into a receptacle or jack **122** removably mounted on collar **118**. The end portion **121** of flexible light-carrier **124** carrying planar lens **125** is positioned in jack **122** and is anchored in place by means of its engagement with plug-in connector **123**, which in turn is in frictional engagement with jack **122**. The interior surface of jack **122** makes good surface-to-surface contact with the exterior surface of terminal support **118** and has annular recess **119** for clamping engagement with annular spring **127** carried by the jack.

In use, proctoscope **100** is inserted into the internal cavity of a patient with obturator **142** in place to provide a smooth rounded end as an aid to insertion. The optic fiber bundle is connected at its proximal end to light-carrying bundle **124**, the opposite end of which is presented to a source of light. The light transmitted by bundle **106** exits at its distal end **108** and illuminates the internal cavity under view through telescope **140**. If desired, insufflation may be carried out through insufflation cap **126** by manipulation of valve **128** in conduit **127** which is connected to a source of suitable insufflation fluid.

FIGURES 11–15 detail the embodiment of a urethroscope utilizing the present invention. Urethroscope **200** is made up of sheath **202**, rigid light-carrier **204** and surgical telescope **206**. As best shown in FIGURE 11, rigid light-carrier **204** is further comprised of outer tube **208** and concentric inner tube **210**, coaxial with outer tube **208**. Optic fiber bundle **212** is disposed in annular space **214** between outer tube **208** and inner tube **210**. Distal end portion **216** of bundle **212** is formed into an annulus and optically ground. Proximal end portion **218** is formed into a generally cylindrical rod, the end face of which is optically ground. Proximal end portion **218** is positioned within and supported by annular terminal support **220** which is brazed to housing **222**. To facilitate the manipulation and arrangement of the fiber bundle around inner tube **210**, outer tube **208** terminates near the distal end of housing **222**, while inner tube **210** terminates near the proximal end of housing **222**. At its proximal end, housing **222** is formed into clamp **224** which may be tightened or loosened by screw **226**. The clamp holds telescope **206** in water-tight connection to the rigid light-carrier when the urethroscope is assembled.

At its distal end housing **222** is held in position on annular mounting member **228** by screw **230** which serves further to support fork **232** containing pin **234**, as is best shown in FIGURE 13.

Sheath **202** comprises an elongated tubular member **236** formed of Bakelite or other suitable material and terminating at its distal end in a smoothly rounded end wall **238** defining an axial opening forming the end of internal passage **240**. At its proximal end tubular member **236** is joined in liquid-tight relation to annular mounting member **242** provided with internal shoulder **244**. Proximally of shoulder **244** the inner surface **246** of mounting member **242** is tapered so that the cavity formed thereby has a diameter which increases toward the proximal end of urethroscope **200**.

Tubular member **236** is held in place against annular mounting member **242** by collar **248**. Collar **248** is connected to the distal end of member **242** and encircles tubular member **236** immediately adjacent to member **242**. Mounting member **242** also contains inlet conduit **250**, which communicates with passage **240** through an opening formed adjacent the proximal end of tubular member **236** for the introduction, for instance, of an irrigating fluid through the interior of the sheath, into the body cavity.

As best shown in FIGURES 12, 13 and 15 winged connector **252** is joined to mounting member **242** by screw **254** and is yieldably urged toward mounting member **242** by spring **256**. Connector **252** coacts with pin **234** on fork **232** to hold sheath **202** and rigid light-carrier **204** in abutting relationship and form a liquid-tight joint between them. Fork **232** is pivotally connected by screw **230** as described above.

For removably connecting the urethroscope to a high intensity light source (not shown), a flexible light-carrier **258** is fitted with a plug-in connector **260**, shown cut away in FIGURE 11, for insertion into receptacle or jack **262** which is removably mounted on terminal support **220**. The end portion **264** of flexible light-carrier **258** is positioned in connector **260** and is anchored thereto, for instance, by use of epoxy resins as described above. The interior surface of jack **262** makes good surface-to-surface contact with the exterior surface of terminal support **220** and connector **260**. Jack **262** has annular recesses **266** for clamping engagement with annular springs **268** carried by terminal support **220** in slot **270** and by connector **260** in slot **272**.

In operation the urethroscope may be introduced into the body cavity and the fiber optic bundle **212** connected to a source of light. The internal cavity will then be illuminated by light emitted from the distal end **216** of optic fiber bundle **212**. The illuminated cavity may be visually observed through telescope **206**.

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.

What is claimed is:

1. In an endoscopic instrument for the examination of internal orifices the improvement comprising first and second rigid concentric tubes defining an annular space between them, a plurality of optic fibers disposed in said annular space, said fibers and said tubes being rigidly adhered together along substantially the entire length of

said instrument, the proximal ends of said optic fibers extending adjacent the proximal ends of said tubes being adapted for coupling to a light source and the distal ends of said optic fibers being adapted to illuminate the internal orifice.

2. In an endoscopic instrument for the examination of internal orifices the improvement comprising first and second rigid concentric tubes defining an annular space between them, a plurality of optic fibers disposed in said annular space, said fibers and said tubes being rigidly adhered together along substantially the entire length of said instrument, the distal ends of said optic fibers being formed into a solid annular ring adapted for illumination of the internal orifices, and the proximal ends of said optic fibers extending adjacent the proximal ends of said tubes being formed into a solid rod for coupling to a light source.

3. In a urethroscope comprising an elongated cylindrical endoscopic sheath, a light carrier disposed within the sheath and a telescope, the improvement in which the light carrier further comprises a rigid outer tube having a proximal end and a distal end, an annular mounting member joined to said outer tube adjacent the proximal end thereof, an inner tube concentric with said outer tube and defining an annular space therewith, the distal end of said inner tube being substantially coextensive with the distal end of said outer tube, a plurality of optic fibers disposed in said annular space, said fibers and said tubes being rigidly adhered together along substantially the entire length of said instrument, the proximal ends of said optic fibers extending adjacent the proximal ends of said tubes being adapted for coupling to a light source and the distal ends of said optic fibers being adapted to illuminate the internal orifice, a housing connected to said mounting member and encircling said proximal end of said inner tube and having a channel at an angle to the axis of said inner and outer tubes, the proximal ends of said optic fibers passing through said channel in said housing.

4. In a urethroscope comprising an elongated cylindrical endoscopic sheath, a light carrier disposed within the sheath and a telescope, the improvement in which the light carrier further comprises a rigid outer tube having a proximal end and a distal end, an annular mounting member joined to said outer tube adjacent the proximal end thereof, an inner tube concentric with said outer tube and defining an annular space therewith, the distal end of said inner tube being substantially coextensive with the distal end of said outer tube, a bundle of optic fibers substantially uniformly disposed in said annular space between said tubes, said fibers and said tubes being rigidly adhered together along substantially the entire length of said instrument, the distal end portion of said bundle being formed into a solid annulus and optically ground, a housing connected to said mounting member and encircling said proximal end of said inner tube and having a channel at an angle to the axis of said inner and outer tubes, the proximal end of said bundle passing through said channel in said housing and being formed into a solid rod recessed from the end of said channel.

5. A urethroscope comprising an elongated cylindrical endoscopic sheath having a proximal and a distal end, a first annular mounting member joined to said sheath adjacent said proximal end and having an annular wall defining a proximally tapered cavity communicating with the interior of said sheath, a collar engaging said sheath and said first member and forming a liquid-tight seal therewith, a conduit connected to said mounting member and communicating with the interior of said cavity; a light carrier further comprising a rigid outer tube having a proximal and a distal end, a second annular mounting member joined to said outer tube adjacent the proximal end thereof, and having a tapered outer surface adapted to uniformly engage the tapered cavity of said first annular member, an inner tube concentric with said outer tube and defining an annular space therewith, the distal end of said inner tube being substantially coextensive with the distal end of said outer tube, a bundle of optic fibers substantially uniformly disposed between said tubes, the distal end portion of said bundle being formed into a solid annulus, a housing connected to said proximal end of said outer tube, a terminal support connected to said housing and having a passage at an angle to the axis of said inner and outer tubes, the proximal end portion of said bundle passing through said passage in said terminal support and being formed into a solid rod recessed from the end of said passage; means to couple said sheath to said light carrier; a telescope assembly including a stem adapted to extend concentrically through said inner tube, and means to couple said telescope assembly to said light carrier.

6. In a proctoscope comprising an endoscopic sheath, telescope and insufflation means an improved endoscopic sheath comprising a rigid outer tube, an inner tube concentrically disposed within said outer tube and forming an annular space therewith, a plurality of optic fibers disposed in said annular space, said fibers and said tubes being rigidly adhered together along substantially the entire length of said instrument, the proximal ends of said optic fibers extending adjacent the proximal ends of said tubes being adapted for coupling to a light source and the distal ends of said optic fibers being adapted to illuminate the internal orifice.

7. In a proctoscope comprising an endoscopic sheath, telescope and insufflation means an improved endoscopic sheath comprising a rigid outer tube, an inner tube concentrically disposed within said outer tube and forming an annular space therewith, a bundle of optic fibers substantially uniformly disposed within the annular space between said inner and outer tubes and adapted to provide illumination, said fibers and said tubes being rigidly adhered together along substantially the entire length of said instrument, the distal end portion of said bundle being formed into a solid annulus and being substantially coextensive with the distal ends of said inner and outer tubes, means to support the proximal end portion of said bundle, the proximal end portion of said bundle extending adjacent the proximal ends of said tubes being formed into a solid rod adapted for connection to an external light source.

8. A proctoscope comprising a rigid outer tube having a distal and a proximal end, an inner tube concentrically

disposed within said outer tube and forming an annular space therewith, a bundle of optic fibers substantially uniformly disposed within said annulus between said inner and outer tubes, the distal end portion of said bundle being formed into a solid annulus and being substantially coextensive with the distal end of said inner and outer tubes, an annular mounting member joined to the proximal end of said outer tube, a mounting ring connected to said annular mounting member, a yoke surrounding said mounting member and having a passage therethrough, a collar connected to said yoke, the proximal end portion of said bundle being formed into a solid rod and supported by said collar and being recessed from said collar, and being adapted for connection to an external light source; a handle connected to said mounting ring; a telescope assembly connected to said mounting ring and held in spaced relation for vision through said inner tube; an insufflation cap enclosing the opening in said mounting ring, a conduit connected to said mounting ring and communicating with the interior of said ring and adapted for connection to an external insufflation fluid, and a valve in said conduit for controlling the flow of said insufflation fluid.

9. A light-conducting optic device comprising an outer tube, an inner tube disposed within said outer tube and defining an annular space therewith, a plurality of optic fibers disposed in said annular space, and a mounting member supporting each of said tubes at the proximal end and adapted for connecting said device to an endoscope disposed within said inner tube, said fibers throughout their extent being adhered together and substantially rigid, the distal ends of said optic fibers being formed into an annulus, the proximal ends of said optic fibers being gathered into a rod and supported by said mounting member at an angle to said tubes and adapted to be connected to an external source of light.

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