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(54) **DETACHABLE IMAGING DEVICE, ENDOSCOPE HAVING A DETACHABLE IMAGING DEVICE, AND METHOD OF CONFIGURING SUCH AN ENDOSCOPE**

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(60) Provisional application No. 60/802,056, filed on May 19, 2006, provisional application No. 60/772,442, filed on Feb. 9, 2006, provisional application No. 60/761,475, filed on Jan. 23, 2006, provisional application No. 60/750,325, filed on Dec. 13, 2005.

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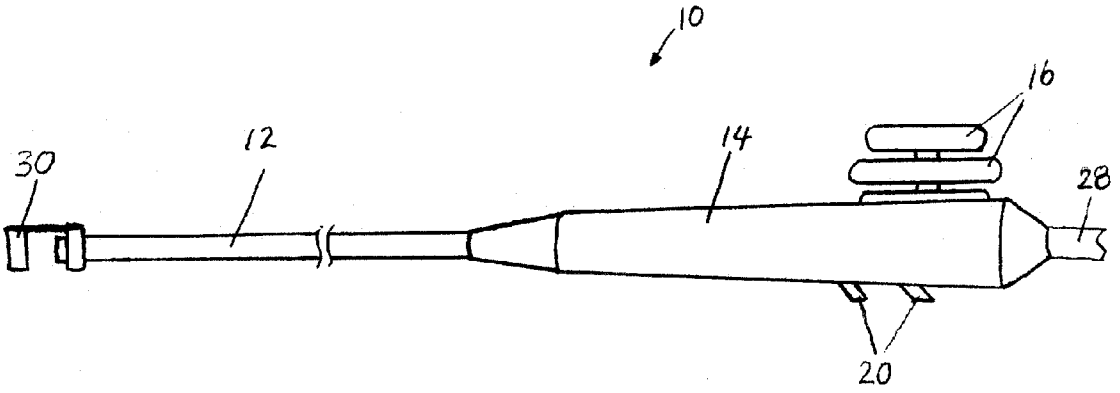
(57) **ABSTRACT**

An endoscope includes a detachable wireless imaging device and an insertion tube having a distal end region. The attachment of the detachable wireless imaging device detachably attaches the detachable wireless imaging device to the distal end region of the insertion tube.



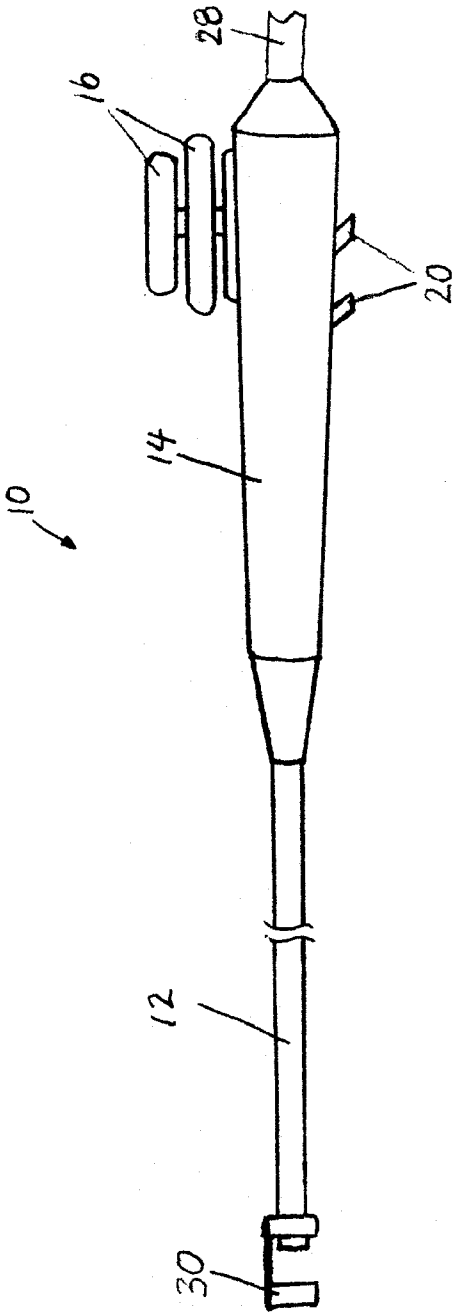


Figure 1

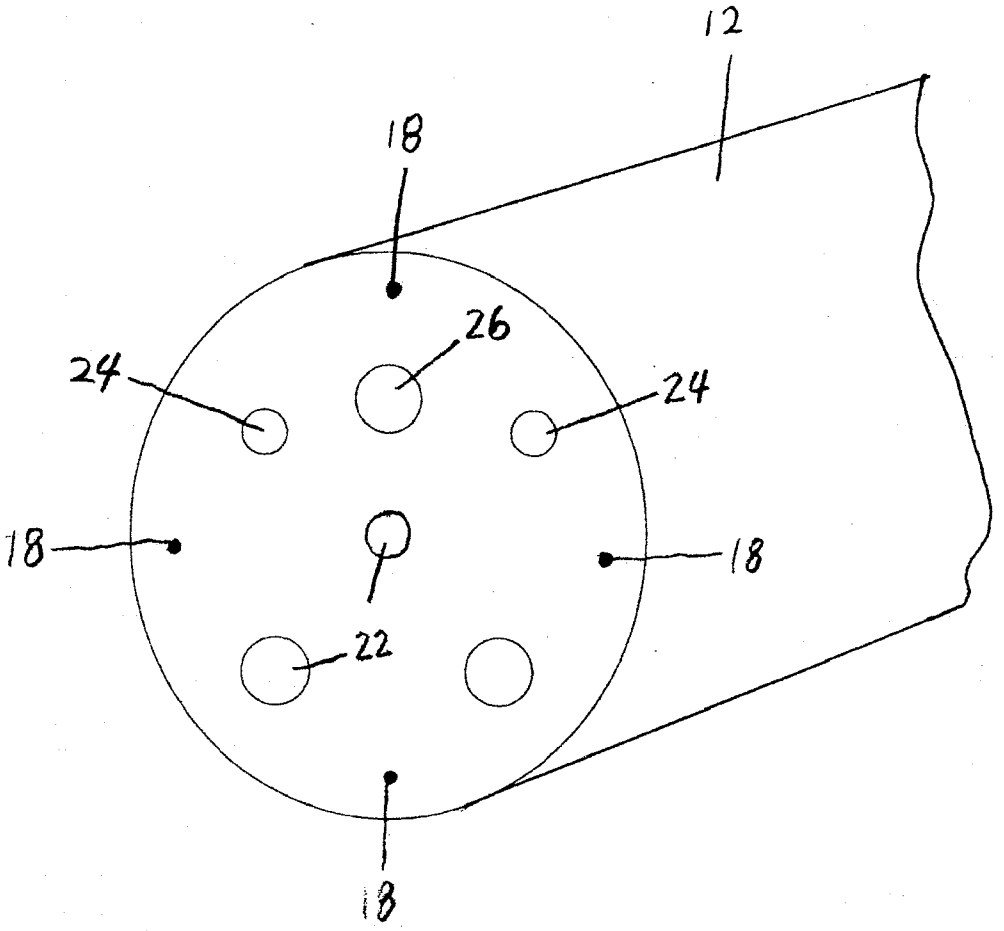


Figure 2

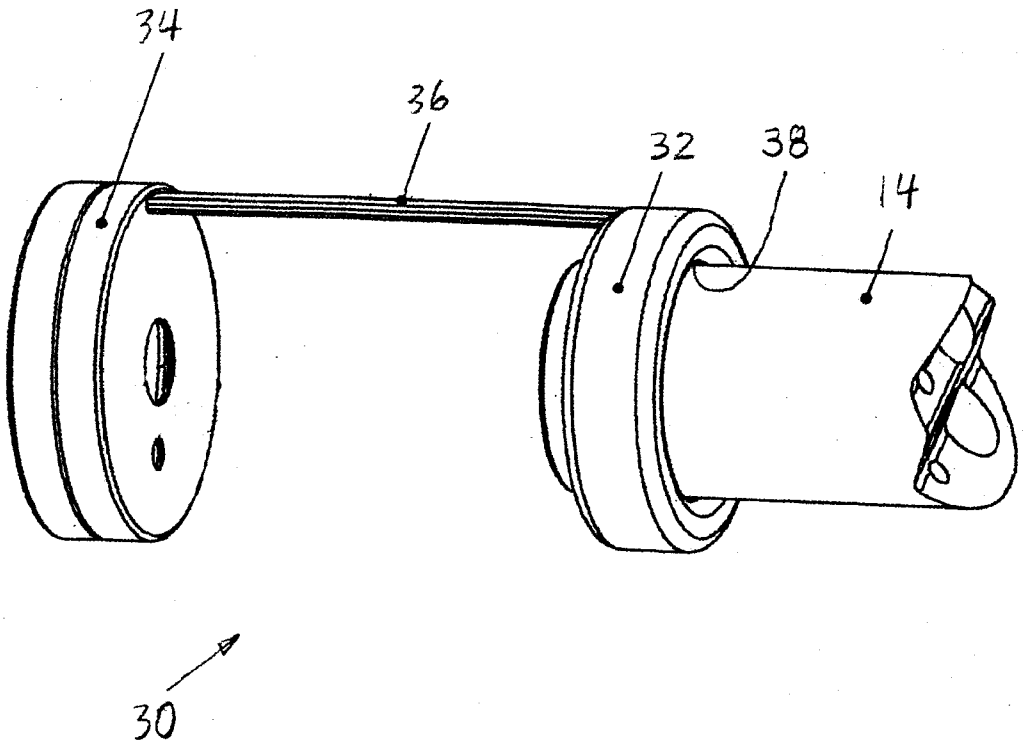
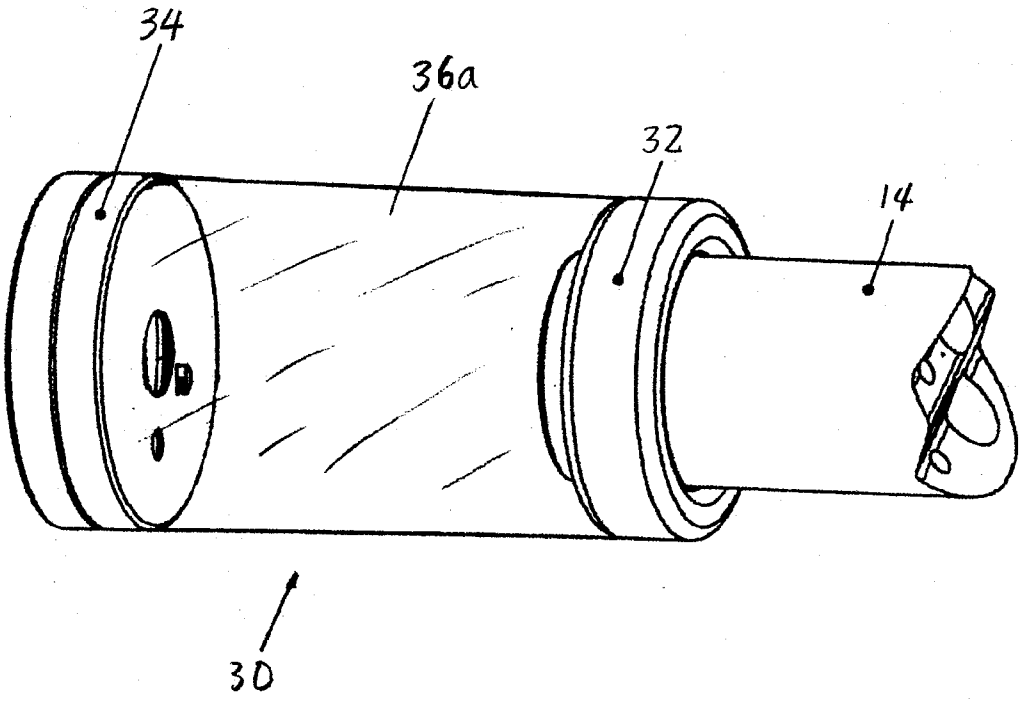


Figure 3



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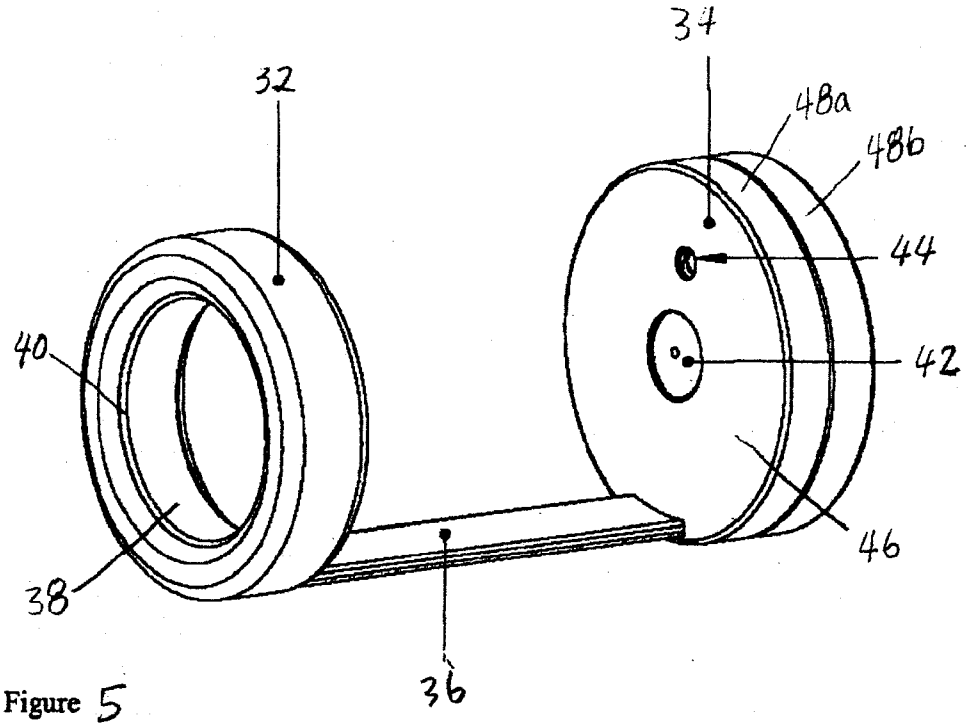


Figure 5

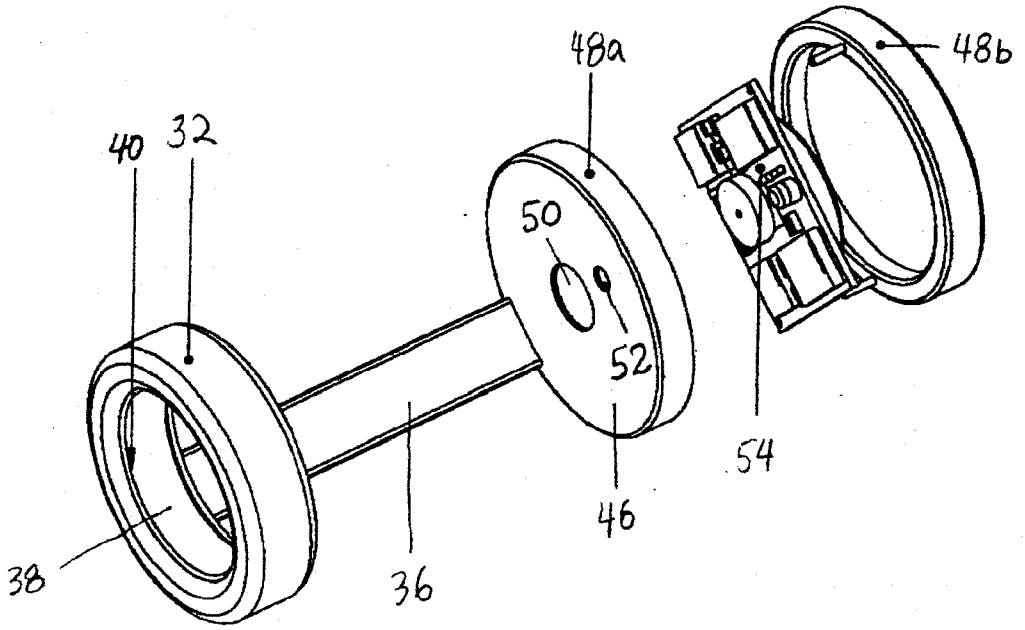


Figure 8

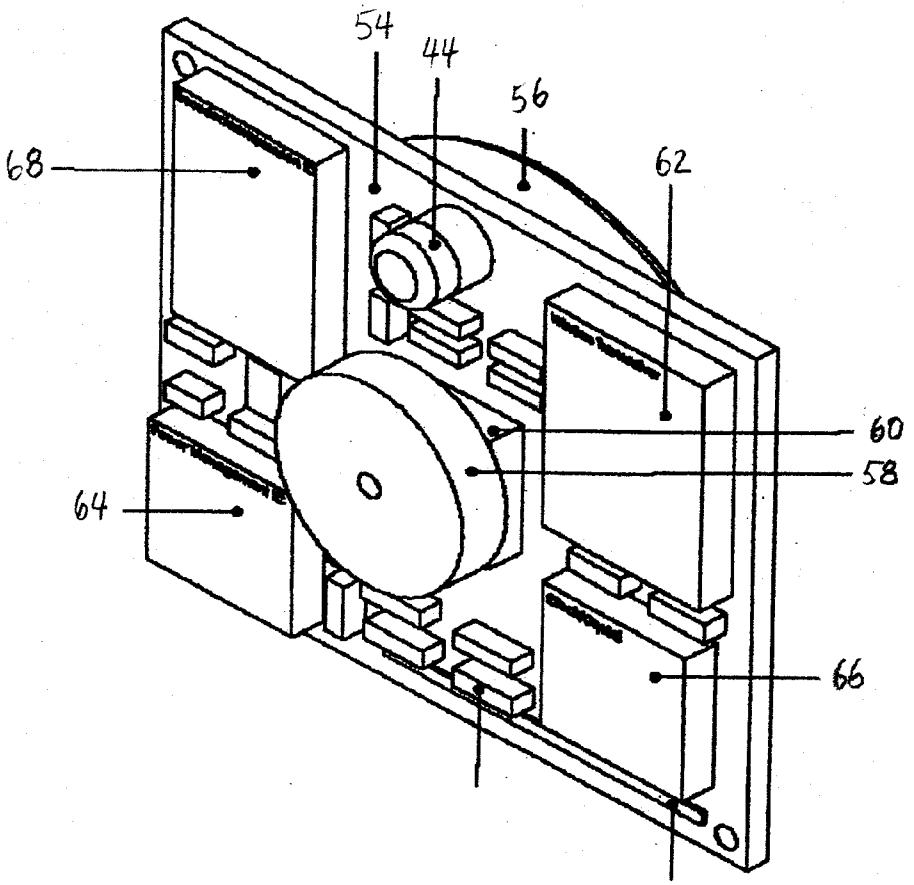
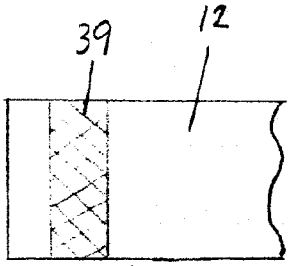


Figure 9



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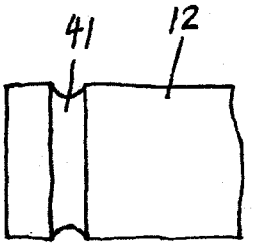

Figure 7

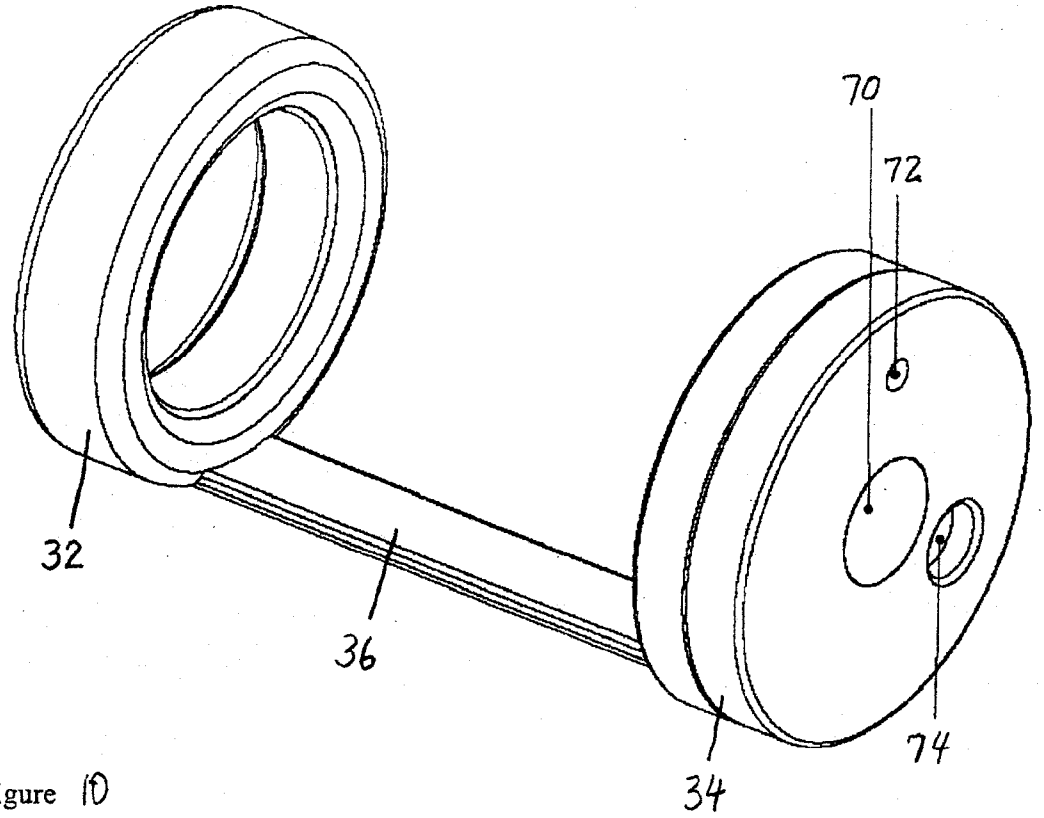

Figure 10

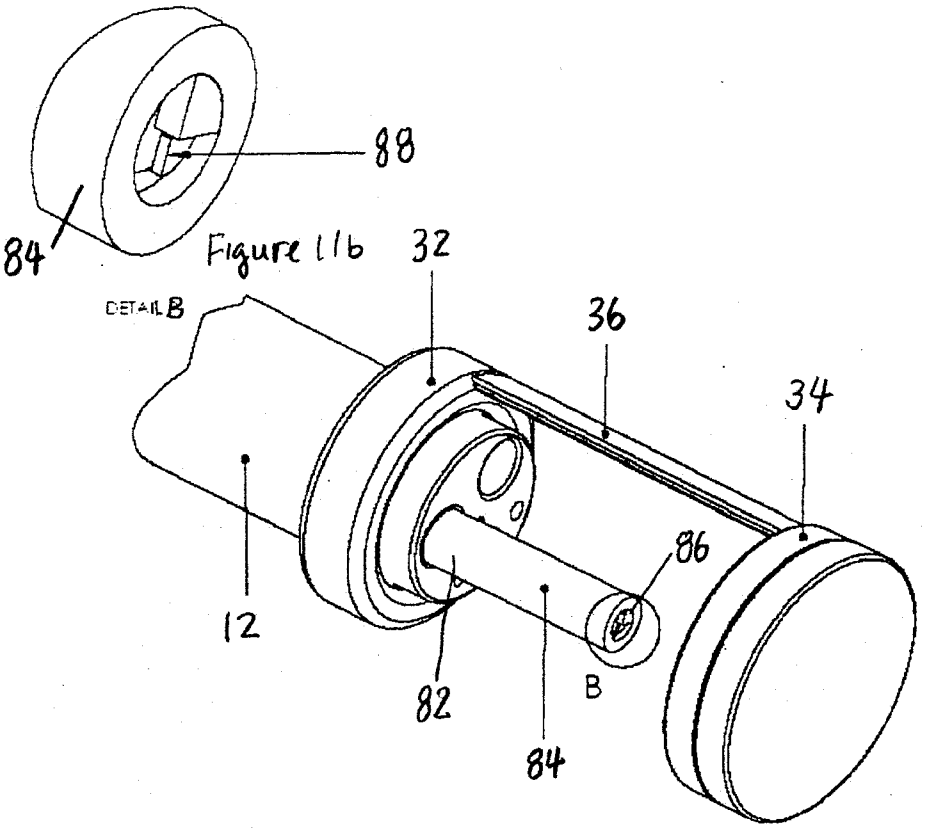

Figure 11a

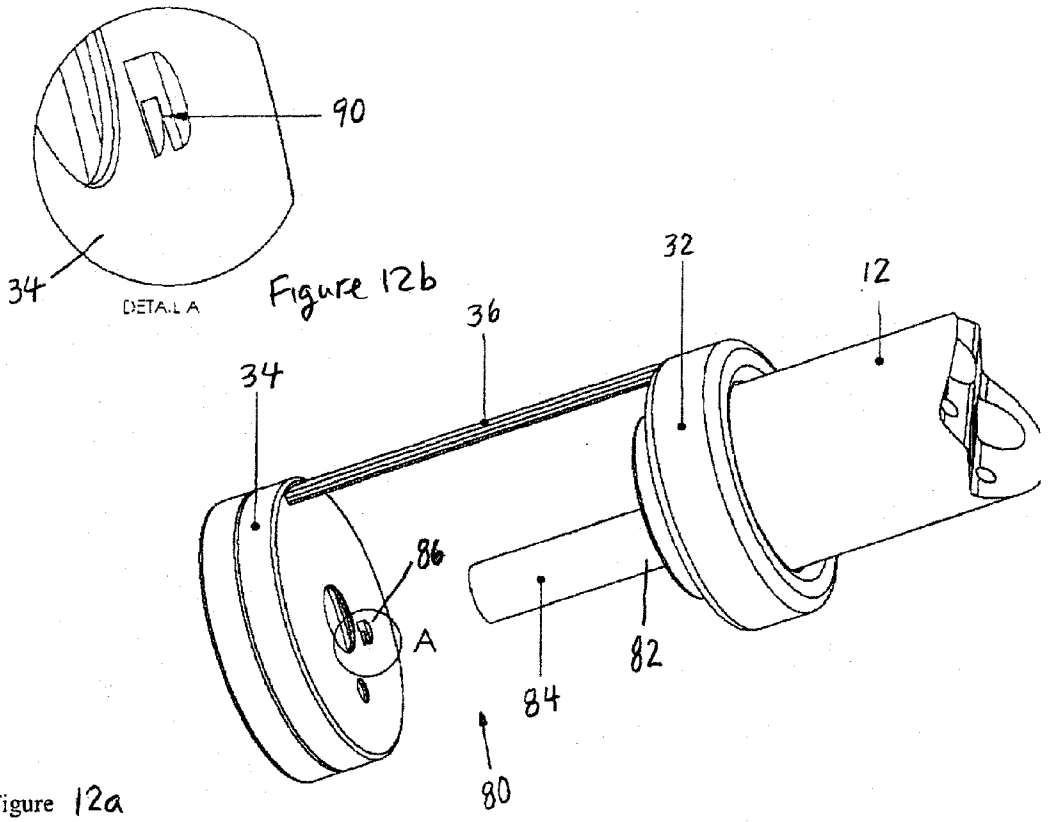

Figure 12a

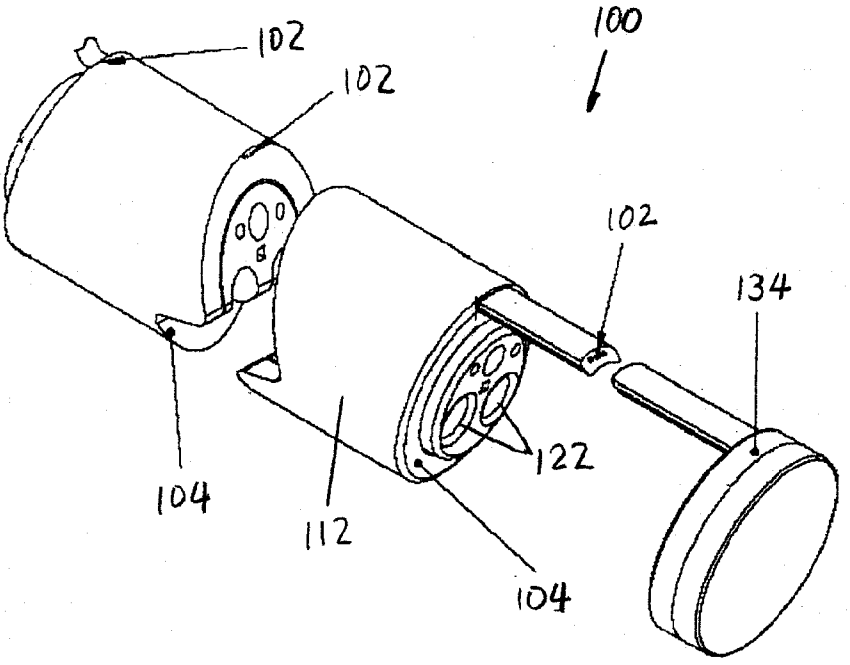

Figure 13

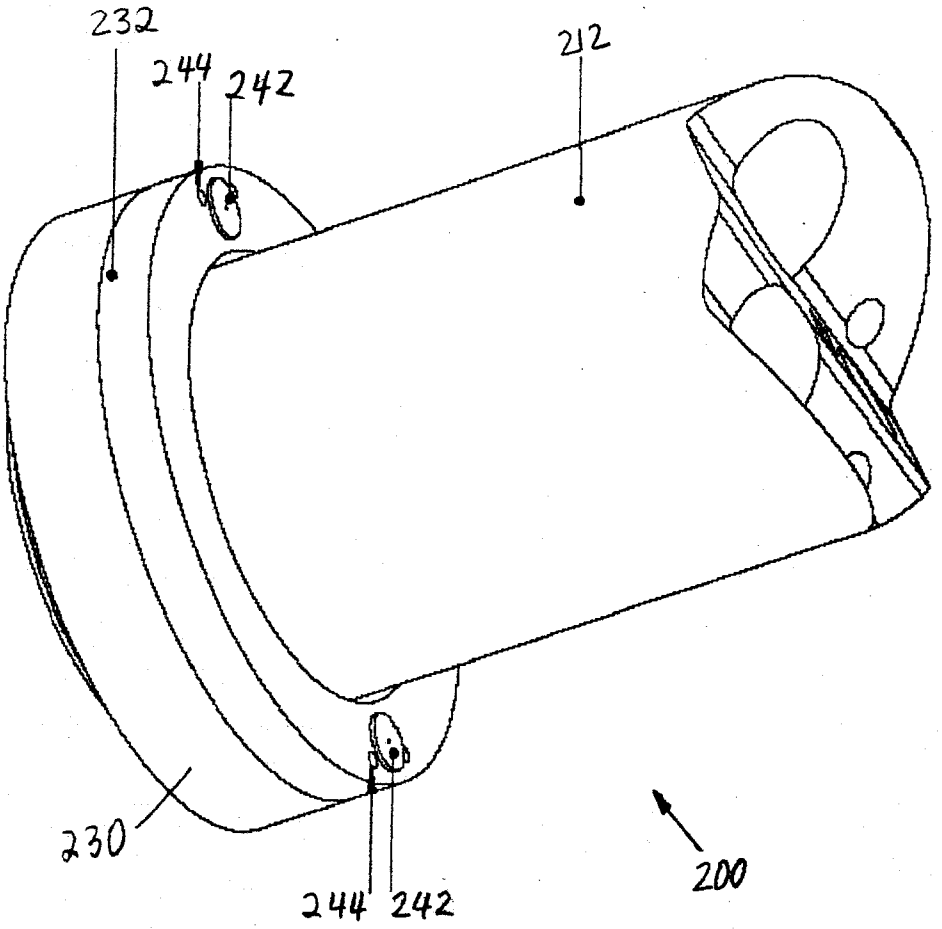

Figure 14

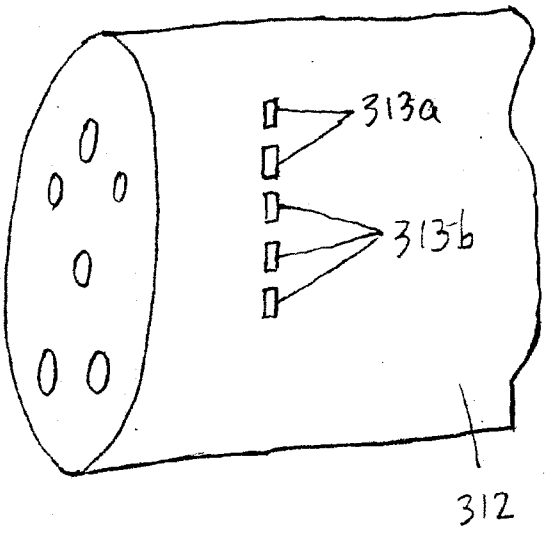

Figure 15

DETACHABLE IMAGING DEVICE, ENDOSCOPE HAVING A DETACHABLE IMAGING DEVICE, AND METHOD OF CONFIGURING SUCH AN ENDOSCOPE

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/750,325, filed Dec. 13, 2005, the entire disclosure of which is incorporated herein by reference.

[0002] This application also claims the benefit of U.S. Provisional Patent Application No. 60/761,475, filed Jan. 23, 2006, the entire disclosure of which is incorporated herein by reference.

[0003] This application also claims the benefit of U.S. Provisional Patent Application No. 60/772,442, filed Feb. 9, 2006, the entire disclosure of which is incorporated herein by reference.

[0004] This application further claims the benefit of U.S. Provisional Patent Application No. 60/802,056, filed May 19, 2006, the entire disclosure of which is incorporated herein by reference.

[0005] The entire disclosure of U.S. patent application Ser. No. 11/215,660, filed Aug. 29, 2005, is incorporated herein by reference.

TECHNICAL FIELD OF THE INVENTION

[0006] The present invention relates to a detachable imaging device, an endoscope having a detachable imaging device, and a method of configuring an endoscope with a detachable imaging device.

BACKGROUND OF THE INVENTION

[0007] An endoscope is a medical device comprising a flexible tube and a camera mounted on the distal end of the tube. The endoscope is insertable into an internal body cavity through a body orifice to examine the body cavity and tissues for diagnosis. The tube of the endoscope has one or more longitudinal channels, through which an instrument can reach the body cavity to take samples of suspicious tissues or to perform other surgical procedures such as polypectomy.

[0008] There are many types of endoscopes, and they are named in relation to the organs or areas with which they are used. For example, gastroscopes are used for examination and treatment of the esophagus, stomach and duodenum; colonoscopes for the colon; bronchoscopes for the bronchi; laparoscopes for the peritoneal cavity; sigmoidoscopes for the rectum and the sigmoid colon; arthroscopes for joints; cystoscopes for the urinary bladder; and angioscopes for the examination of blood vessels.

[0009] Each endoscope has a single forward viewing camera mounted at the distal end of the endoscope to transmit an image to an eyepiece or video camera at the proximal end. The camera is used to assist a medical professional in advancing the endoscope into a body cavity and looking for abnormalities. The camera provides the medical professional with a two-dimensional view from the distal end of the endoscope. To capture an image from a different angle or in a different portion, the endoscope must be repositioned or moved back and forth. Repositioning and movement of the endoscope prolongs the procedure and causes added discomfort, complications, and risks to the patient. Additionally, in an environment similar to the lower gastro-intestinal tract, flexures, tissue folds and unusual geometries of the organ may prevent the endoscope's camera from viewing all areas of the organ. The unseen area may cause a potentially malignant (cancerous) polyp to be missed.

[0010] This problem can be overcome by providing an auxiliary camera, which presents an image of the areas not viewable by the endoscope's main camera. The auxiliary camera can be oriented backwards to face the main camera. This arrangement of cameras can provide both front and rear views of an area or an abnormality. In the case of polypectomy where a polyp is excised by placing a wire loop around the base of the polyp, the camera arrangement allows better placement of the wire loop to minimize damage to the adjacent healthy tissue.

[0011] Unfortunately, most of the endoscopes currently in use do not have such an auxiliary camera. To replace these existing endoscopes with new endoscopes with auxiliary cameras is expensive. Therefore, it is desirable to provide the existing endoscopes with retrofit auxiliary cameras. Additionally, to avoid the costs of modifying existing endoscopes, it is desirable to provide retrofit auxiliary cameras that do not require significant modification of the existing endoscopes.

[0012] Although a channel of an endoscope can be used to accommodate an auxiliary camera that does not require modification of the endoscope, the loss of a channel may impair the endoscope's ability to perform all of its designed functions. Thus the ability of the retrofit auxiliary camera to function without using an endoscope channel is desirable.

SUMMARY OF THE INVENTION

[0013] According to some aspects of the present invention, a retrofit auxiliary camera is provided that does not require significant modification of an existing endoscope or use of a channel of the endoscope, thereby avoiding the costs of modifying the endoscope and preserving all of the endoscope's designed functions.

[0014] In accordance with one aspect of the invention, a detachable imaging device can be attached to a distal end region of an endoscope's insertion tube. The detachable imaging device includes an attachment that can detachably attach the imaging device to the distal end region of the endoscope's insertion tube. The detachable imaging device includes also a wireless imaging element connected to the attachment.

[0015] In accordance with another aspect of the invention, an endoscope includes a detachable imaging device and an insertion tube having a distal end region. The detachable imaging device includes an attachment that detachably attaches the detachable imaging device to the distal end region of the insertion tube, and a wireless imaging element connected to the attachment.

[0016] In accordance with a further aspect of the invention, a method of configuring an endoscope includes attaching an attachment of a detachable imaging device of an endoscope to a distal end region of the insertion tube of the endoscope.

[0017] In accordance with one embodiment of the invention, the attachment includes a ring. Preferably, the ring has an inner diameter that is designed to provide a friction fit between the inner surface of the ring and a cylindrical outer surface of the distal end region of the insertion tube of the endoscope. The inner diameter of the ring may be slightly smaller than the outer diameter of the distal end region of the insertion tube to provide the friction fit. Also the inner surface of the ring may include a rubber or silicon surface.

[0018] In accordance with another embodiment of the invention, the detachable imaging device includes a link that connects the imaging device to the attachment. Preferably, the link is flexible.

[0019] In accordance with yet another embodiment of the invention, the detachable imaging device includes an external control box that is configured to adjust parameters of the wireless imaging element.

[0020] In accordance with another embodiment of the invention, the detachable imaging device includes an external control box that is configured to send images from the wireless imaging element to a patient records database.

[0021] In accordance with still another embodiment of the invention, the detachable imaging device includes a support mechanism that increases the rigidity of the detachable imaging device and reduces the bending of the link.

[0022] In accordance with yet still another embodiment of the invention, the wireless imaging element includes an imaging unit and/or a light source. The imaging unit may be mounted on the proximal end of the wireless imaging element and faces towards a main imaging device mounted on the distal end of the insertion tube. Preferably, the imaging unit and the main imaging device provide different views of the same area. To reduce light interference, the imaging element and the main imaging device and their light sources may be turned on and off alternately. Preferably the imaging element and the main imaging device and their light sources are turned on and off at a sufficiently high frequency that the eyes do not sense that the imaging element and the main imaging device and their light sources are intermittently turned on and off.

[0023] The wireless imaging element may include another imaging unit, which is mounted on the distal end of the wireless imaging element and faces in the same direction as the main imaging device. The wireless imaging element may also include another light source, which is mounted on the distal end of the wireless imaging element and faces in the same direction as the main imaging device.

[0024] In accordance with a further embodiment of the invention, the wireless imaging element includes a channel aligned with a channel of the insertion tube. This channel of the wireless imaging element may extend from the proximal end of the wireless imaging element to the distal end of the wireless imaging element.

[0025] In accordance with a still further embodiment of the invention, the wireless imaging element includes a housing that is used to accommodate the wireless imaging unit. Preferably, the housing includes two housing elements that sealingly form the housing.

[0026] In accordance with a yet still further embodiment of the invention, the detachable imaging device includes a link that connects the imaging device to the attachment. Preferably, the link, attachment, and one of the housing elements form a unitary unit.

[0027] In accordance with another embodiment of the invention, the wireless imaging element is accommodated within the attachment. In some embodiments, the detachable imaging device includes two or more wireless imaging elements, and the wireless imaging elements are mounted on at least one of the distal end, proximal end and side of the attachment.

[0028] Although certain aspects of the present invention have been discussed so far in terms of a retrofit auxiliary imaging device, it should be emphasized that the present invention is not limited to a retrofit auxiliary imaging device. On the contrary, a detachable imaging device of the present invention may be manufactured as an original part of an endoscope. If the detachable imaging device is needed to provide a rear or retrograde view of an abnormality, the detachable imaging device is installed on the end region of the insertion tube. Alternatively, if the detachable imaging device is not needed, the endoscope can be used without the detachable imaging device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIG. **1** shows an endoscope according to one embodiment of the present invention.

[0030] FIG. **2** is a view of the distal end of the insertion tube of the endoscope of FIG. **1**.

[0031] FIG. **3** is a perspective view of a detachable imaging device of the endoscope of FIG. **1**.

[0032] FIG. **4** shows a transparent link connecting the attachment and the imaging element of a detachable imaging device.

[0033] FIG. **5** is another perspective view of the detachable imaging device of FIG. **3**.

[0034] FIG. **6** is a view of a distal end region of the insertion tube having a tacky surface.

[0035] FIG. **7** is a view of a distal end region of the insertion tube having a circular groove.

[0036] FIG. **8** is an exploded perspective view of the imaging element housing.

[0037] FIG. **9** is a perspective view of the imaging element printed circuit.

[0038] FIG. **10** is a perspective view of a detachable imaging device with a forward viewing imaging unit, a forward facing light source, and a channel.

[0039] FIGS. **11***a*, **11** *b*, **12***a*, and **12***b* show a support mechanism of an endoscope of the present invention.

[0040] FIG. **13** shows an endoscope according to another embodiment of the present invention.

[0041] FIG. **14** shows an endoscope according to a further embodiment of the present invention.

[0042] FIG. **15** shows an insertion tube having a connector for connecting a detachable imaging device to the wires in the insertion tube.

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[0043] FIG. **1** illustrates an exemplary endoscope **10** of the present invention. This endoscope **10** can be used in a variety of medical procedures in which imaging of a body tissue, organ, cavity or lumen is required. The types of procedures include, for example, anoscopy, arthroscopy, bronchoscopy, colonoscopy, cystoscopy, EGD, laparoscopy, and sigmoidoscopy.

[0044] As shown in FIG. **1**, the endoscope **10** may include an insertion tube **12** and a control handle **14** connected to the insertion tube **12**. The insertion tube **12** may be detachable from the control handle **14** or may be integrally formed with the control handle **14**. The diameter, length and flexibility of the insertion tube **12** depend on the procedure for which the endoscope **10** is used. The insertion tube **12** may be made from or coated with a lubricious material to allow for easy insertion into and easy extraction from a patient.

[0045] The control handle **14** may include one or more control knobs **16** that are attached to control cables **18** (FIG. **2**) for the manipulation of the insertion tube **12**. Preferably,

the control cables **18** are symmetrically positioned within the insertion tube **12** and extend along the length of the insertion tube **12**. The control cables **18** may be anchored at or near the distal end of the insertion tube **12** such that the rotation of the control knobs **16** moves or bends the insertion tube **12** up and down and/or side to side. In some embodiments, a clutch or breaking component (not shown) may be included with the control knobs **16** to prevent the knobs **16** from being inadvertently rotated such that rotation can only be caused by application of a certain degree of torque to the control knobs **16**.

[0046] Preferably, the control handle **14** has one or more ports and/or valves. In the embodiment illustrated in FIG. **1**, the control handle **14** has two ports and/or valves **20**. The ports and/or valves **20** are in communication with their respective channels **22** (FIG. **2**) extending through the insertion tube **12**. "Y" junctions can be used to designate two ports to a single channel or one port to two channels. The ports and/or valves **20** can be air or water valves, suction valves, instrumentation ports, and suction/instrumentation ports. In some embodiments, one of the channels can be used to supply a washing liquid such as water for washing. A cap (not shown) may be included at the opening of the washing channel to divert the washing liquid onto a lens of an imaging device for cleaning. Another channel may be used to supply a gas, such as CO_2 or air into the organ. The channels may also be used to extract fluids or inject fluids, such as a drug in a liquid carrier, into the body. Various biopsy, drug delivery, and other diagnostic and therapeutic devices may also be inserted via the channels to perform specific functions. In some embodiments, various tools may be used with the endoscope **10**, such as a retractable needle for drug injection, hydraulically actuated scissors, clamps, grasping tools, electrocoagulation systems, ultrasound transducers, electrical sensors, heating elements, laser mechanisms and other ablation means.

[0047] As illustrated in FIG. **2**, the insertion tube **12** may additionally include one or more light sources **24**, such as light emitting diodes (LEDs) or fiber optical delivery of light from an external light source, and an imaging device **26**. The imaging device **26** may include, for example, a lens, single chip sensor, multiple chip sensor or fiber optic implemented devices. The imaging device **26**, in electrical communication with a processor and/or monitor, may provide still images or recorded or live video images. Each light source **24**, individually, can be turned on or off. The intensity of each can be adjusted to achieve optimum imaging.

[0048] An accessory outlet **28** (FIG. **1**) at a proximal end of the control handle **14** provides fluid communication between the air, water and suction channels and the pumps and related accessories. The same outlet or a different outlet can be used for electrical lines to light and imaging components at the distal end of the insertion tube **12**.

[0049] As illustrated in FIGS. **1** and **3**, the endoscope **10** preferably includes a detachable imaging device **30** attached to the distal end region of the endoscope's insertion tube **14**. The detachable imaging device **30** includes an attachment **32** for detachably attaching the imaging device **30** to the distal end region of the insertion tube **14**, a wireless imaging element **34**, and a link **36** connecting the wireless imaging element **34** to the attachment **32**.

[0050] In this embodiment, which is also shown in FIG. **5**, the attachment **32** is configured as a ring. Preferably, the attachment **32** has an inner diameter that is designed to provide a friction fit between the inner surface **38** of the attachment **32** (FIG. **5**) and a cylindrical outer surface of the distal end region of the insertion tube **14**. This may mean that in the pre-install condition the inner diameter of the attachment **32** is smaller than the outer diameter of the distal end region of the insertion tube **14**. When the attachment **32** is slid on the insertion tube **14**, the inner surface **38** of the attachment **32** compresses against the outer surface of the insertion tube **14** to provide the friction fit. To secure the attachment **32** on the insertion tube **32**, the inner surface **38** of the attachment **32** may include a tacky and/or elastic surface. In some embodiments, this surface may be the surface of a rubber or silicon inner ring **40** (FIG. **5**). The rubber or silicon inner ring **40** may be attached to the rest of the attachment **32** by means of an adhesive, welding, mechanical over molding, or snaps. Alternatively, the attachment **32** may be made entirely from rubber or silicon. In general, the attachment can be made from any compressive rubber or polymer or a combination thereof.

[0051] In some cases such as when the detachable imaging device **30** is made as an original part of the endoscope **10** (i.e., not as a retrofit device), the distal end region of the insertion tube **14** may have one or more features that help retain the detachable imaging device **30**. For example, as shown in FIG. **6**, the distal end region of the insertion tube **14** may include a tacky surface **39** that engages with the tacky inner surface **38** of the attachment **32** to enhance the friction fit between the attachment **32** and the insertion tube **14**. Alternatively or additionally, as shown in FIG. **7**, the distal end region of the insertion tube **14** may include a circular groove **41** around the distal end region of the insertion tube **14** for receiving the attachment **32**. In general, the distal end region of the insertion tube **14** may include any features that enhance the attachment of the detachable imaging device **30** to the distal end region of the insertion tube **14**.

[0052] In general, the attachment may be of any suitable configuration that can detachably attach the detachable imaging device **30** to the distal end region of the insertion tube **14**. For example, the attachment may be an elastic tube that can be elastically wrapped around the distal end region of the insertion tube **14**. Alternatively, the attachment may include one or more screws that can be screwed to attach the imaging device to the distal end region of the insertion tube **14** or unscrewed to detach the imaging device from the distal end region of the insertion tube **14**. The attachment may also be similar to the way by which a suction cap for endoscopic mucosal resection is attached to a colonoscope. In general, a suitable attachment may use one or more of, for example, a clamp arrangement, a snap fit, a plastic friction fit, or bonding.

[0053] The link **36** connects the imaging device **34** to the attachment **32**. In the illustrated embodiment, the link **36** is a generally elongated, flat, straight bar, although the link may be configured in any suitable manner. For example, the link may be curved and may have a circular or square cross-section. The link may comprise one pole, as shown in FIG. **3**, or two or more poles to enhance support to the imaging element **34**. In some embodiments, the link may be made from a transparent material, and as shown in FIG. **5** the transparent link may be a transparent tube **36***a* connected to the circumferences of the attachment **32** and imaging element **34**. Preferably, the link **36** is suitably flexible to make it easier for the imaging device to negotiate and accommodate the flexures along the body cavity.

[0054] Preferably, the wireless imaging element **34** has an imaging unit **42** and a light source **44** such as an LED, as shown in FIG. **5**. In this embodiment, the imaging unit **42** and

light source **44** are placed on the proximal end **46** of the wireless imaging element **34**, although they may be placed at any suitable locations on the imaging element **34**, including on the distal end or side of the imaging element **34** or both. Preferably, the imaging unit **42** faces backwards towards the main imaging device **26** and is oriented so that the imaging unit **42** and the main imaging device **26** can be used to provide different views of the same area. In the illustrated embodiment, the imaging unit **42** provides a retrograde view of the area, while the main imaging device **26** provides a front view of the area.

[0055] Since the main imaging device **26** and the imaging unit **42** of the detachable imaging device **30** face each other, the light source **24**, **44** of one imaging device **26**, **30** interferes with the other imaging device **30**, **26**. To reduce the interference, polarizer filters may be used with the imaging devices **26**, **30** and light sources **24**, **44**. The main imaging device **26** and its light sources **24** may be covered by a first set of polarizer filters of the same orientation. And the wireless imaging unit **42** and light source **44** may be covered by a second set of polarizer filters orientated at 90° relative to the first set of polarizer filters. The use of polarizer filters to reduce light interference is well known and will not be described in detail herein.

[0056] As an alternative to polarizer filters, the imaging devices **26**, **30** and their light sources **24**, **44** may be turned on and off alternately to reduce or prevent light interference. In other words, when the main imaging device **26** and its light sources **24** are turned on, the imaging unit **42** and its light source **44** are turned off. And when the main imaging device **26** and its light sources **24** are turned off, the imaging unit **42** and its light source **44** are turned on. Preferably, the imaging devices **26**, **30** and their light sources **24**, **44** are turned on and off at a sufficiently high frequency that eyes do not sense that the light sources are being turned on and off.

[0057] The imaging element **34** may include a switch (not shown) that is used to connect power to the circuitries of the imaging element **34**. When the switch is turned on, the circuitries of the imaging element **34** are activated and the imaging unit **42** starts capturing images and transmitting image signals. The switch can be a membrane switch mounted on the imaging element **34**. The switch may be sealed with a biocompatible film (not shown), which can encase the imaging element or a section thereof to fully seal the switch.

[0058] In some embodiments, a wireless switch may be provided in placement of, or in addition to, the manual switch. The wireless transceiver of the imaging device **34** may continually search for a wireless enable signal from a particular address device or at a particular frequency. This signal enables a logic command to all the circuits in the imaging device **34** to switch from a low current sleep mode to a full current operating mode.

[0059] The wireless imaging element **34** preferably includes a housing **48***a*, **48***b* for accommodating the wireless imaging unit **42** and light source **44**. The housing **48***a*, **48***b* of the wireless imaging element **34** preferably includes two housing elements **48***a*, **48***b*. The housing elements **48***a*, **48***b* preferably have features, such as pins and sockets, which allow the wireless imaging unit **42** and light source **44** to be securely mounted within the housing elements **48***a*, **48***b*. The housing elements **48***a*, **48***b* are sealingly attached to each other to maintain biocompatibility of the wireless imaging element **34** and prevent contaminants from entering the wireless imaging element **34**. The housing elements **48***a*, **48***b* may be sealingly attached to each other in any suitable manner, including ultrasonic or friction welding or adhesive bonding. The housing **48***a*, **48***b* may include windows **50**, **52** for the imaging unit **42** and light source **44**, respectively. Preferably, each window **50**, **52** is sealed with a thin clear cover that is attached to the housing **48***a*, **48***b*. In some embodiments, the windows **50**, **52** may be the polarizer filters described previously.

[0060] In a preferred embodiment, a housing element **48***a*, the link **36**, and the attachment **32** form a unitary unit made by means of, for example, injection molding. The other housing element **48***b* may be separately formed by means of, for example, injection molding. Preferably, the molded units are fabricated from a biocompatible material such as a biocompatible plastic. Alternatively, the housing elements **48***a*, **48***b*, the link **36**, and the attachment **32** may be made as separate parts from the same material or different materials and then attached to one another to form the wireless imaging device **10**.

[0061] In the preferred embodiment shown in FIGS. **8** and **9**, the circuitry for the wireless imaging unit **42** is formed on a printed circuit board (PCB) **54**. The circuitry for the light source **44** may also be formed on the PCB **54**. In this preferred embodiment, the circuitries for the imaging unit **42** and light source **44** are mounted on one side of the PCB **54**, and a power source **56**, such as a button battery cell, is clipped onto the other side of the PCB **54**. The wireless imaging element **34** may include a lens **58**, image sensor **60**, wireless transceiver **62**, power management unit **64**, clock or crystal **66**, and signal processing unit **68** as required by wireless communication. The positive and ground power clips (not shown) holding the power source **56** are connected to the power and ground planes of the PCB **54** respectively to supply power to the circuitries on the PCB **54**.

[0062] The image sensor **60** may be any suitable device that converts light incident on photosensitive semiconductor elements into electrical signals. Such a device may detect color or black-and-white images. The signals from the sensor are digitized and used to reproduce the image. Two commonly used types of image sensors are Charge Coupled Devices (CCD) such as LC 99268 FB produced by Sanyo of Osaka, Japan and Complementary Metal Oxide Semiconductor (CMOS) camera chips such as the OVT 6910 produced by OmniVision of Sunnyvale, Calif.

[0063] The image data acquired by the image sensor **60** are transmitted to the signal processing unit **68** for processing. The processing may include one or more of multiplexing, encoding into radio frequencies, and compression. The wireless protocol used for image data transmission preferably is approved for medical use and meets the data rate requirements for the image sensor output. Suitable wireless protocols include, for example, the 802.11 and Bluetooth standards. The Bluetooth standard operates in the industrial, scientific and medical band (ISM band), has low transmit power, and causes minimal interference. The output formats for the image sensor **60** and the integrated circuits for image signal processing are well known in the electronics industry and are not explained in further detail. Once the image signal is converted to a suitable format, the wireless transceiver **62** transmits the data to an external control box over the operation frequency. Examples of wireless frequency bands used for similar devices include the 900 MHz and 2.4 GHz bands. Once received by a wireless receiver or transceiver of the external control box, the image signal is fed to a signal pro-

cessing circuit which converts it to a video signal such as NTSC composite or RGB. This video signal is then sent to a suitable connector for output to a display device such as a monitor or television. In some embodiments, the images from the detachable imaging device **30** and from the main imaging device **26** can be shown together on the same display device.

[0064] The external control box may include a PCB mounted circuitry in a housing which transmits, receives and processes wireless signals. The external control box has one or more of a wireless transceiver, AC receptacle, decoding circuitry, control panel, image and signal processing circuitry, antenna, power supply, and video output connector.

[0065] The external control box may also be used as an interface to the patient records database. A large number of medical facilities now make use of electronic medical records. During the procedure relevant video and image data may need to be recorded in the patient electronic medical records (EMR) file. The signal processing circuit can convert image and video data to a format suitable for filing in the patient EMR file such as images in .jpeg, tif, or .bmp format among others. The processed signal can be transmitted to the medical professional's computer or the medical facilities server via a cable or dedicated wireless link. A switch on the control panel can be used to enable this transmission. Alternatively the data can be stored with a unique identification for the patient in electronic memory provided in the control box itself. The signal processing circuit can be utilized to convert the video and image data to be compatible with the electronic medical records system used by the medical professional. The processing may include compression of the data. A cable or a wireless link may be used to transmit the data to a computer.

[0066] The image and signal processing circuitry of the external control box includes one or multiple integrated circuits and memory as needed along with associated discrete components. This circuit allows the video signals to be processed for enhancing image quality, enabling still images to be extracted from the video and allow conversion of the video format to provide multiple output formats. These functions can be interfaced for access via the control panel.

[0067] The external control box may be used to adjust the parameters of the imaging sensor **60**. Preferably, the image sensor **60** allows different parameters such as brightness, exposure time and mode settings to be adjusted. These parameters may be adjusted by writing digital commands to specific registers controlling the parameters. These registers can be addressed by their unique numbers and digital commands can be read from and written to these registers to change the parameters. The control box is used to control these parameters by transmitting data commands to these registers through the wireless protocol. The signal processing circuit on the detachable imaging device **30** receives and then decodes these signals into commands and feeds them to the image sensor. This allows the various parameters to be adjusted.

[0068] In some embodiments of the present invention, the power source **56** of the detachable imaging device **30** is a rechargeable power source. The rechargeable power source can be recharged in any suitable manner. For example, the rechargeable power source may be recharged via pins provided on the detachable imaging device. The pins preferably are made from a biocompatible material and retain its biocompatibility after sterilization up to a required number of times.

[0069] Alternatively, the rechargeable power source may be charged via inductive charging. One advantage of inductive charging is that it does not required physical contact between the charger and the detachable imaging device. This allows the detachable imaging device to be fully sealed without any circuit components or metals such as the charge pins being exposed to body liquids.

[0070] In operation, the power switch may be turned on first to activate the detachable imaging device **30**. At this point, the detachable imaging device **30** begins transmitting captured digital images wirelessly to the external control box. The control box then processes the image signals and sends them to a display so that a medical professional can visualize the images in real time. Once the detachable imaging device **30** is turned on, it can be attached to the distal end region of the endoscope's insertion tube **12**, as shown in FIGS. **1** and **2**. At this point, the main imaging device **26** provides a front view of an area, while the detachable imaging device **30** provides a rear or retrograde view of the same area. During the medical procedure, the endoscope is inserted into a patient with the detachable imaging device **30** attached to the distal end region of the insertion tube **12**. The medical professional can simultaneously visualize images from the main imaging device **26** and from the attached imaging device **30**. Lesions hidden from the main imaging device **26** behind folds and flexures can now be viewed by the medical professional from the images provided by the detachable imaging device **30**. When the procedure is complete, the endoscope is removed from the patient, and the detachable imaging device **30** can be detached from the distal end region of the endoscope's insertion tube **12**.

[0071] The control panel of the external control box can be used to adjust the parameters of the detached imaging device **30** to achieve an optimum image quality. Still images can be obtained using the control panel. During the procedure, relevant video and image data may be recorded in the patient's electronic medical records (EMR) file.

[0072] The wireless imaging element **34** may additionally include a forward viewing imaging unit **70** and a forward facing light source **72**, as shown in FIG. **10**. This forward viewing imaging unit **70** allows more effective navigation of the endoscope **10**. Additionally, to allow an accessory to reach the area in front of the wireless imaging element **34**, the wireless imaging element **34** may be configured so as not to obstruct one or more channels **22** of the insertion tube **12**. For example, the wireless imaging element **34** may be made small enough so that it does not obstruct one or more channels **22** of the insertion tube **12**. Alternatively, the wireless imaging element **34** may include a channel **74** (FIG. **10**) aligned with a channel **22** of the insertion tube **12**. This channel **74** allows an accessory to reach the area in front of the wireless imaging element **34**.

[0073] The endoscope **10** may further include a support mechanism, which increases the rigidity of the detachable imaging device **30** during insertion of the endoscope **10** into the body. This support mechanism preferably reduces or eliminates the bending of the link **36** of the detachable imaging device **30** during insertion. An embodiment **80** of the support mechanism is shown in FIGS. **11***a*, **11** *b*, **12***a*, and **12***b*. The exemplary support mechanism **80** includes a rod **82** that is rigid at its distal end region **84** but is otherwise flexible. The exemplary support mechanism **80** may further include a locking mechanism **86** that locks the distal end of the rod **82** to the wireless imaging element **34**. As shown in FIGS. **11***b*

and **12***b*, the lock mechanism **86** includes mating grooves **88**, **90** that are disposed on the distal end of the rod **82** and the wireless imaging element **34**, respectively. The grooves **88**, **90** can be interlocked by applying a torque to turn the rod **82** at the proximal end of the insertion tube **12**, and can be unlocked by applying a torque in the opposite direction. The proximal end (not shown) of the rod **82** can be locked to the channel entry port to secure the locking mechanism **86** in the locked position.

[0074] Before the insertion of the endoscope **10** in the body, the rod **82** is introduced from the proximal end of the insertion tube **12** into a channel **22** of the insertion tube **12**, and the locking mechanism **86** locks the distal end of the rod **82** to the wireless imaging element **34**. At this position, the rigid distal end region **84** of the rod **82** keeps the detachable imaging device **30** rigid. After the insertion of the endoscope **10** in the body, the locking mechanism **86** can be unlocked, and the rod **82** can be retracted from the channel **22** of the insertion tube **12**.

[0075] In some embodiments of the present invention, as shown in FIG. **13**, an endoscope **100** may include a detachable imaging device **134** that uses wires **102** to communicate with the external control box, including transmitting video signals to the external control box and receiving power and control signals from the external control box. With this arrangement, the operation of the detachable imaging device **134** is not limited by battery life. As shown in FIG. **13**, the wires **102** may be embedded in a sheath **104** which slides over the insertion tube **112** of the endoscope **100**. This allows the channels **122** of the insertion tube **112** to be used by accessories and the endoscope **100** to retain all of its designed functions. Preferably, the sheath **104** is made from a biocompatible material such as latex, silicon and medical grade rubbers which are flexible enough to not restrict the movement of the insertion tube **112** and firmly grip the outer surface of the insertion tube **112**. Alternatively this sheath **104** may replace the outer covering of the insertion tube **112** so that it would serve the dual function of covering the insertion tube **112** and the wires **102** without increasing the diameter of the insertion tube **112**.

[0076] FIG. **14** illustrates additional embodiment **200** of the present invention that includes an insertion tube **212** and an attachment **232** mounted on the distal end region of the insertion tube **212**. This attachment **232** may have some or all of features of the attachment **32** shown in FIGS. **3** and **5**. Additionally, the attachment **232** is configured to accommodate one or more imaging units **242** and light sources **244** of the endoscope **200**. In other words, the entire detachable imaging device **230** is mounted on the distal end region of the insertion tube **212** and does not extend beyond the distal end of the insertion tube **212**. The imaging units **242** and light sources **244** may be mounted at any suitable locations on the attachment **232** and may be oriented in any directions. In this embodiment, the imaging units **242** and light sources **244** are placed on a proximal end of the attachment **232** and face backwards, although they may be alternatively or additionally placed on a distal end and/or side of the attachment **232** and face forwards and/or sideways. The imaging units **242** and light sources **244** may be evenly spaced around the attachment **232**. The images from the imaging units **242** may be incorporated or combined to form a larger or more complete view of the body cavity such as a 360° view of the body cavity. One advantage of the embodiment shown in FIG. **14** is the reduction or elimination of the mutual light interference between the main imaging device **26** and the imaging units **242** on the attachment **232** because the imaging units **242** and light sources **244** are placed behind the main imaging device and light sources on the distal end of the insertion tube **212**.

[0077] In a further embodiment of the present invention, an endoscope includes an insertion tube and a detachable imaging device detachably attached to the distal end region of the insertion tube. In this embodiment, the detachable imaging device communicates with the external control box via wires embedded in the insertion tube for power supply and/or data communication. The term "wires" is broadly defined to include any power and communication lines, such as metal wires and fiber optic cables. Preferably, as shown in FIG. **15**, the insertion tube **312** has one or more connectors **313** for connecting the detachable imaging device to the wires in the insertion tube. In some embodiments, the one or more connector may be placed in the distal end region of the insertion tube. The one or more connectors may include one ore more power couplings **313***a* for providing power from the endoscope's base to the detachable imaging device and/or one or more video couplings **313***b* for coupling video images from the detachable imaging device to the base.

[0078] While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that changes and modifications can be made without departing from this invention in its broader aspects. Therefore, the appended claims are to encompass within their scope all such changes and modifications as fall within the true spirit and scope of this invention.

1-51. (canceled)

52. A detachable imaging system attachable to a distal end region of a colonoscope, the detachable imaging system comprising an imaging device, the imaging device comprising:

an imaging element, comprising a light source and an imaging unit mounted on a side of the imaging element; and

an attachment configured to detachably attach the imaging element to an outer surface of the distal end region of a colonoscope.

53. The detachable imaging system of claim **52**, wherein the attachment comprises an inner surface that is configured to detachably attach to the outer surface of the distal region of the colonoscope.

54. The detachable imaging system of claim **53**, wherein the inner surface of the attachment is further configured to form a friction fit with the distal region of the colonoscope.

55. The detachable imaging system of claim **52**, wherein the attachment comprises a elastic tube or a screw.

56. The detachable imaging system of claim **52**, wherein the imaging element is a wireless imaging element.

57. The detachable imaging system of claim **52**, wherein the imaging element comprises a housing with a window for the imaging unit.

58. The detachable imaging system of claim **52**, further comprising an external control box configured to adjust parameters of the imaging device.

59. The detachable imaging device of claim **58**, further comprising wires to provide communication between the imaging system and the external control box.

60. The detachable imaging system of claim **59**, wherein the wires are embedded in a sheath configured to slide over the colonoscope.

61. The detachable imaging system of claim **52**, wherein the imaging device is configured to attach to the distal end region of the colonoscope, without extending beyond a distal end of the colonoscope.

62. The detachable imaging system of claim **61**, wherein the imaging unit and the light source are mounted on a side of the attachment.

63. The detachable imaging system of claim **62**, wherein the imaging unit is a first imaging unit of a plurality of imaging units, and the light source is a first light source of a plurality of light sources.

64. The detachable imaging system of claim **63**, wherein the plurality of imaging units and the plurality of light sources are evenly spaced around the attachment.

65. The detachable imaging system of claim **63**, wherein the imaging system is configured to combine images from the plurality of imaging units into a larger view.

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