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(54) **REUSABLE MINIATURE CAMERA HEAD**

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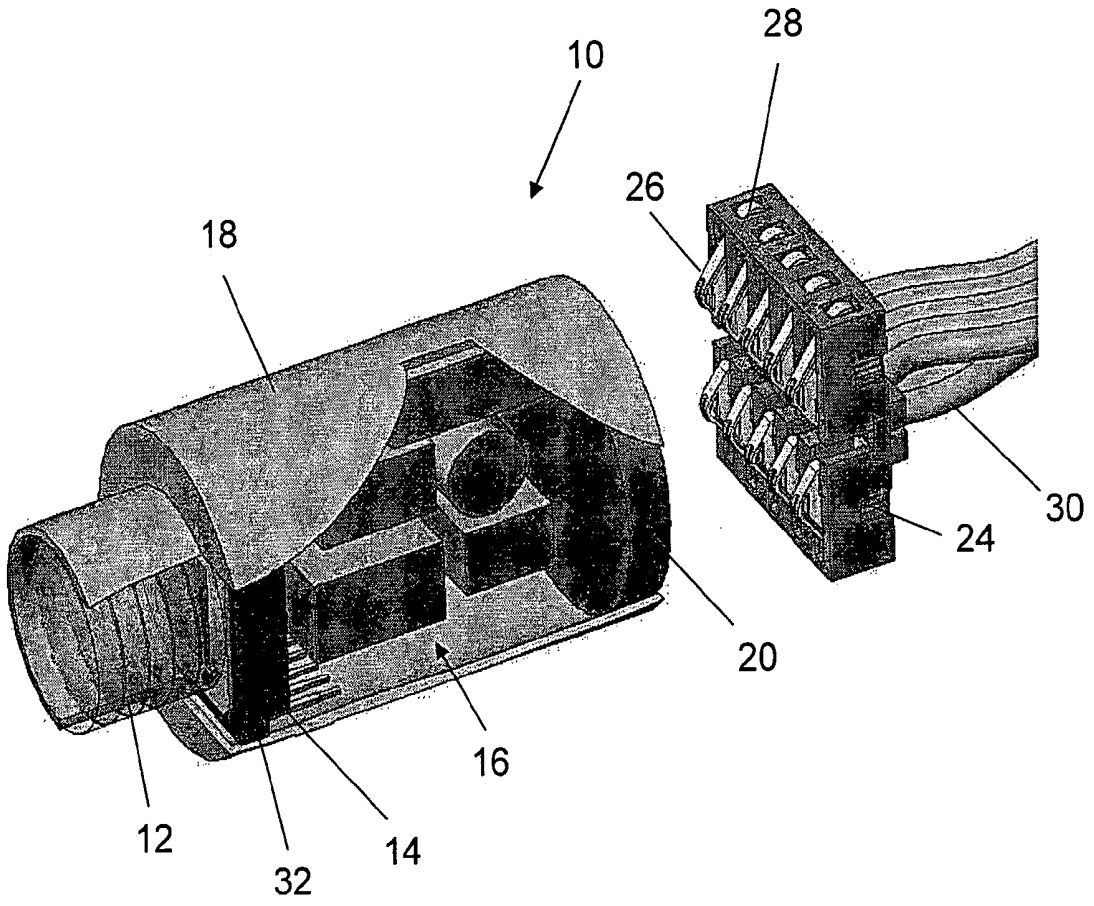
(57) **ABSTRACT**

The invention is a reusable miniature camera head (**10**) that can be attached to and detached from an object. The camera head comprises: a housing (**18**), a lens system (**12**), a solid-state sensor (**14**), components of an electronic driver (**16**), and an internal electrical connector (**20**) located at the proximal end of the housing and having a plurality of sockets (**22**) or pins (**110**) on its external face. The object has an external connector (**24**) for receiving the camera head. The internal and external electrical connectors comprise a plurality of pins or sockets arranged in matching patterns on opposing faces thereby allowing the camera head to be attached to or disconnected by engaging the two connectors. In preferred embodiments of the invention, the object to which the camera head is attached is an endoscopic or laparoscopic device, the solid-state sensor is a Charge Coupled Device (CCD), and the housing does not contain a printed circuit board.



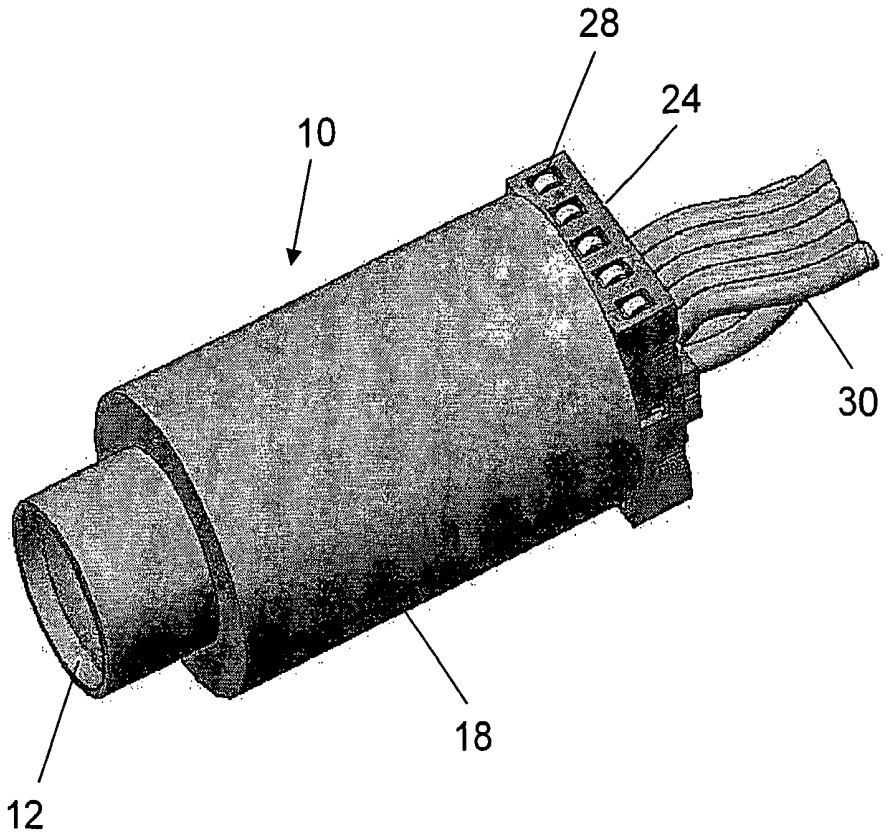


Fig. 1

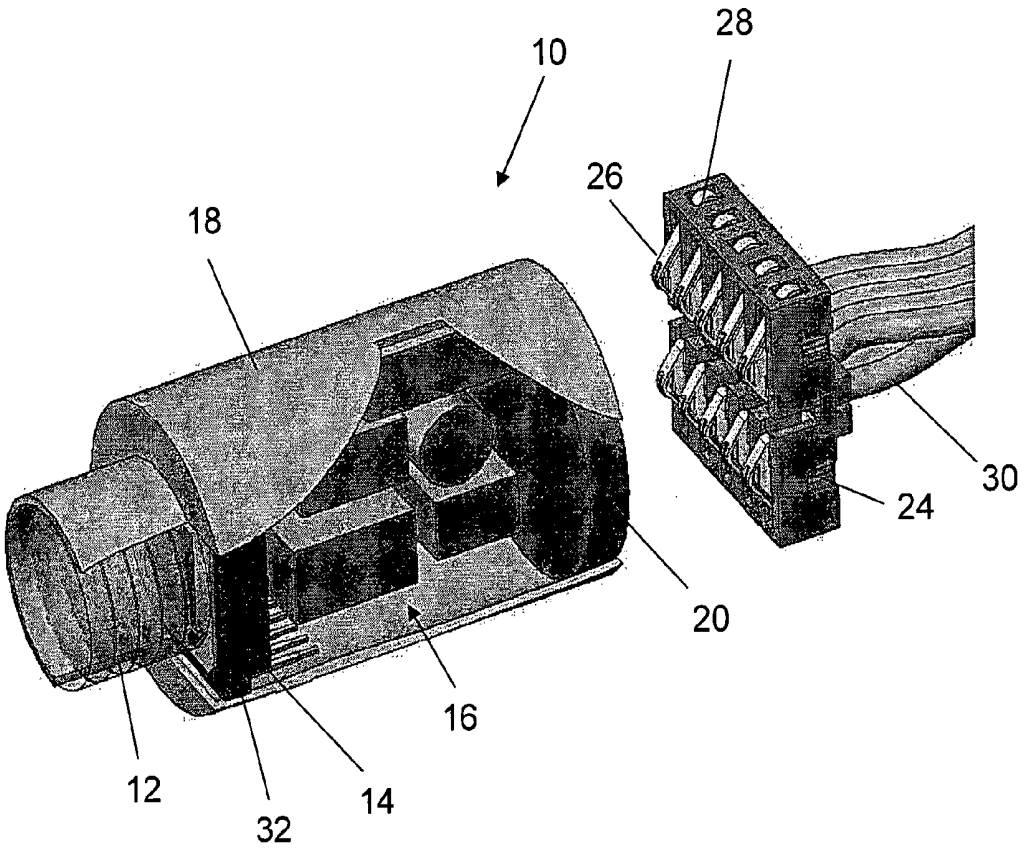


Fig. 2

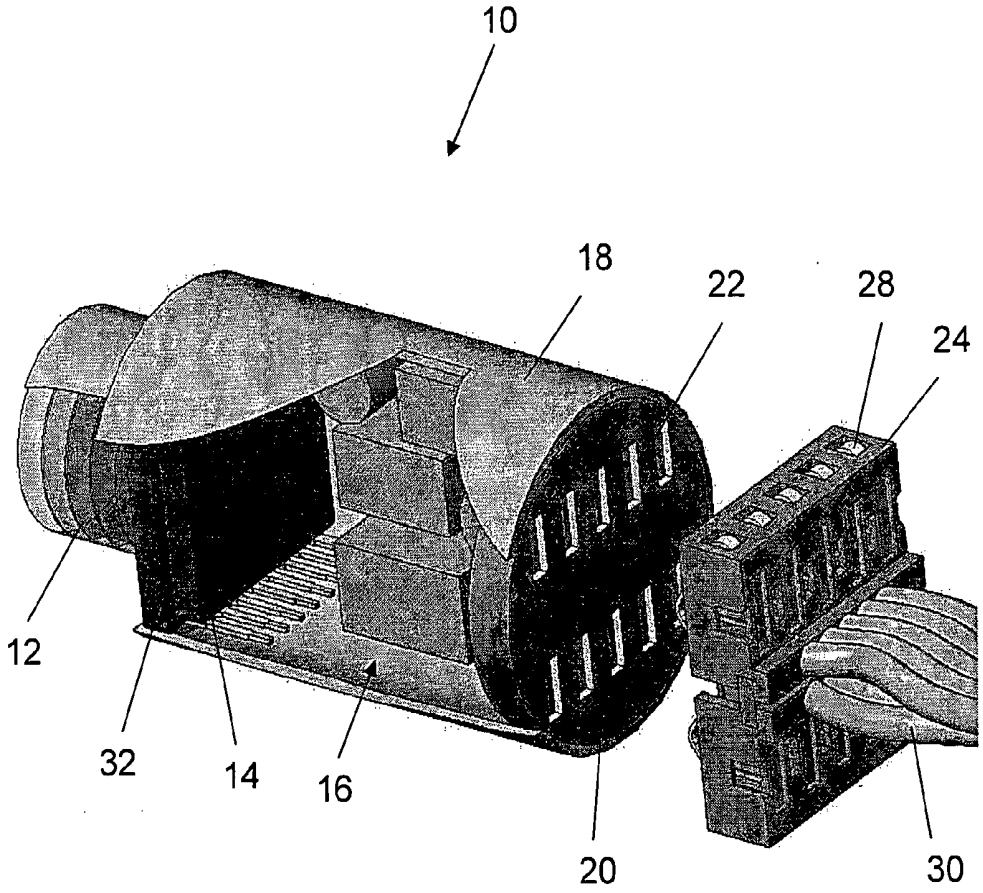


Fig. 3

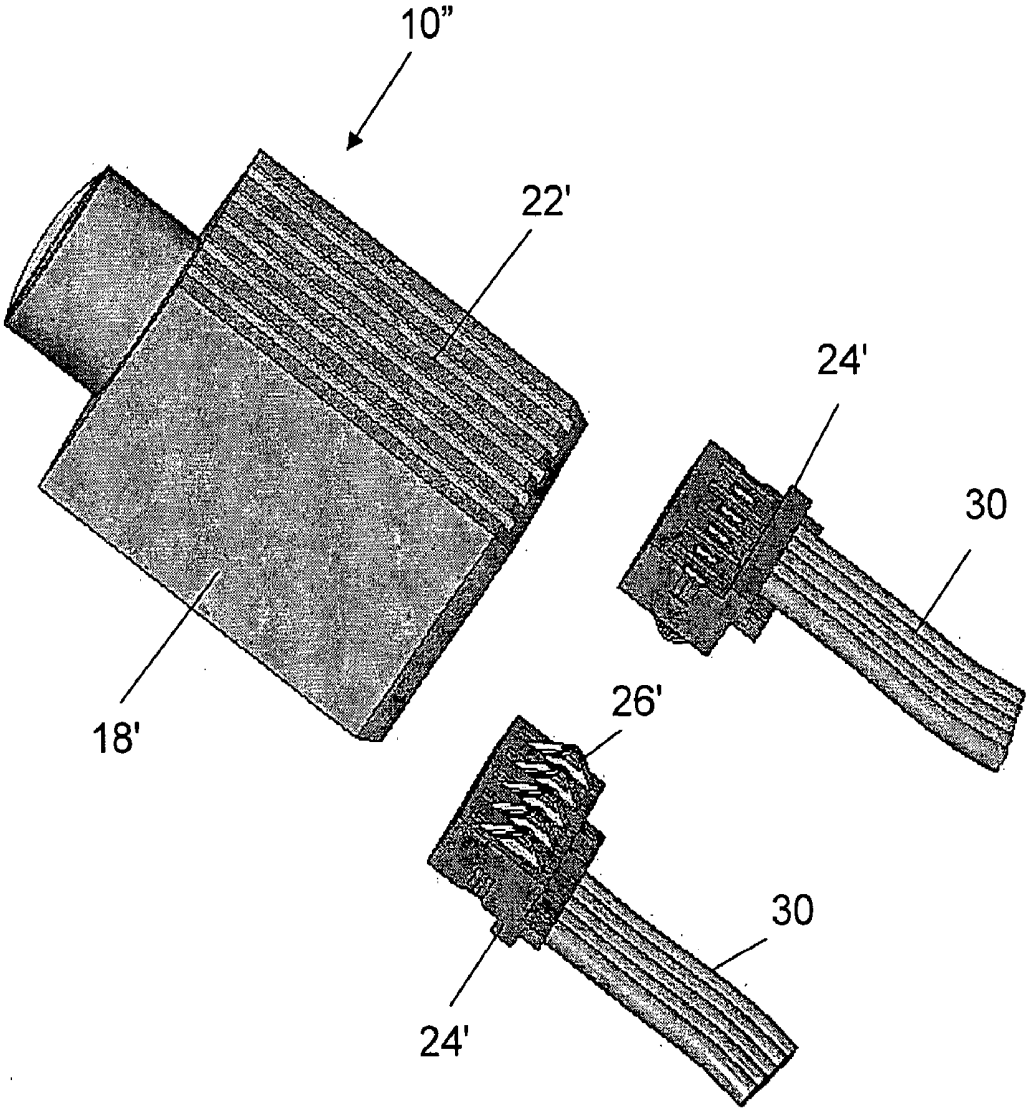


Fig. 4A

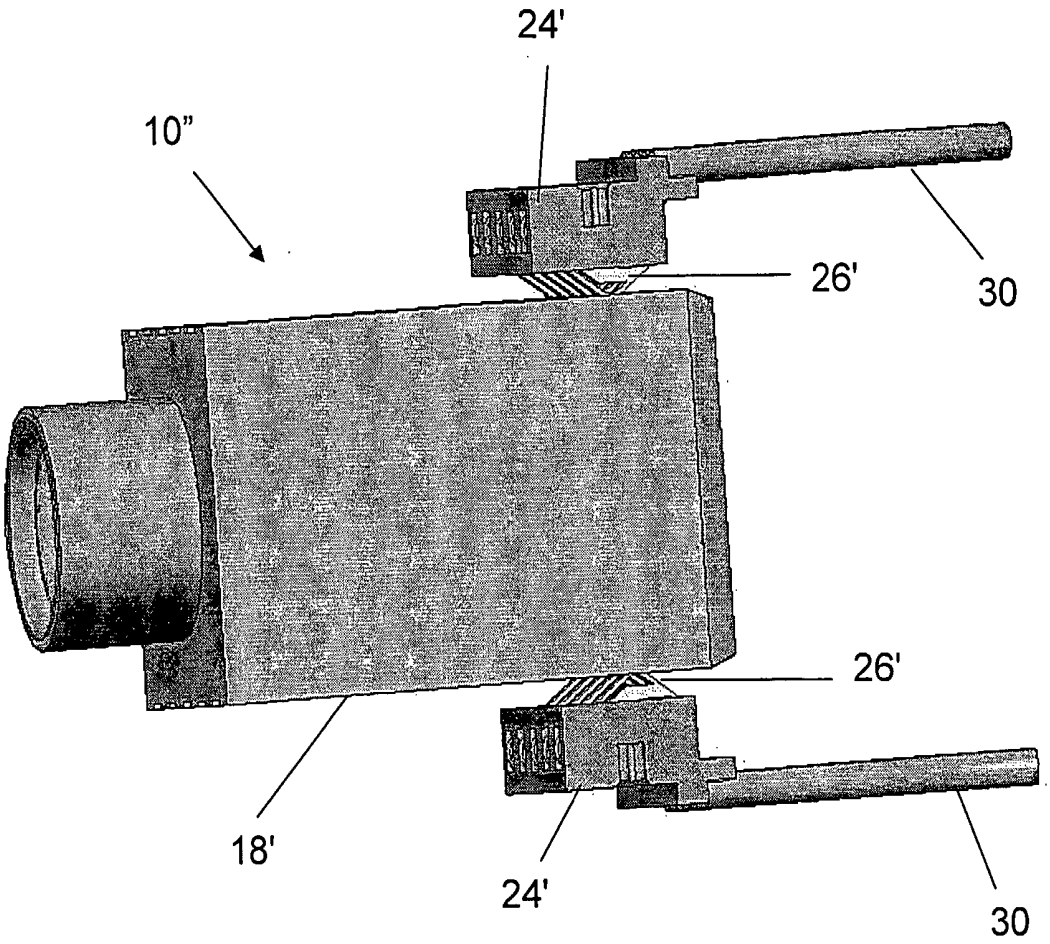


Fig. 4B

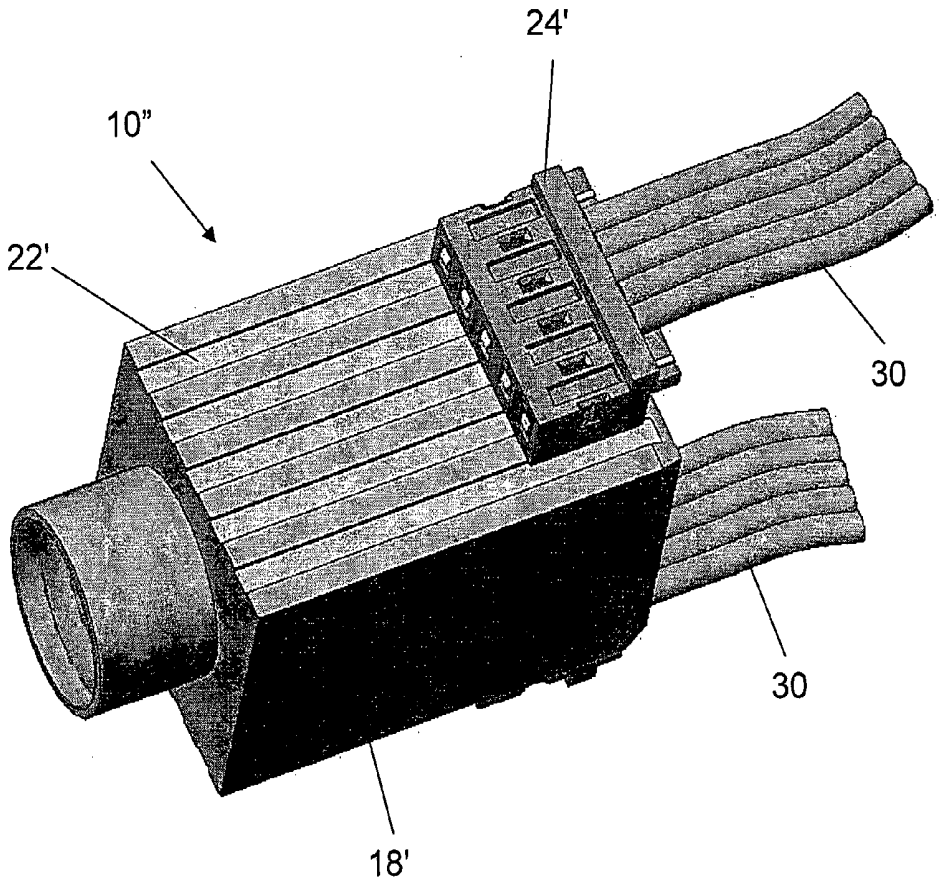


Fig. 4C

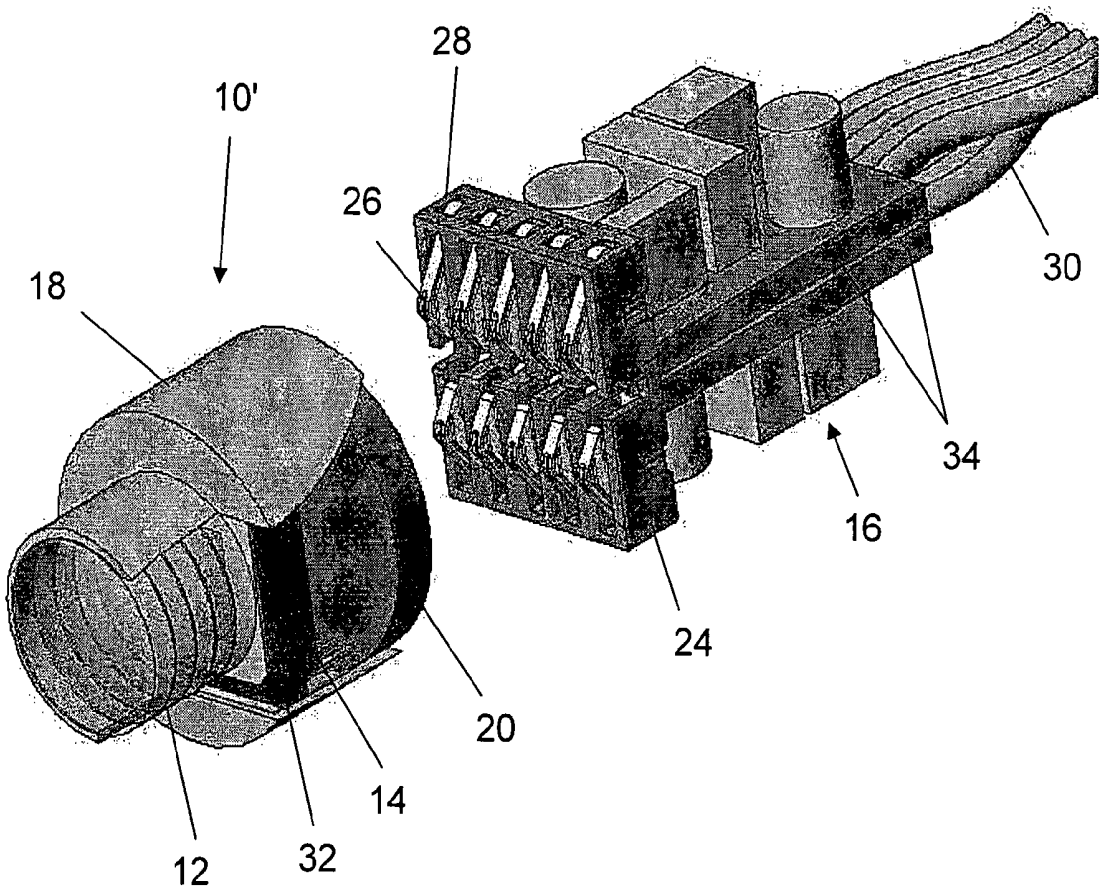


Fig. 5

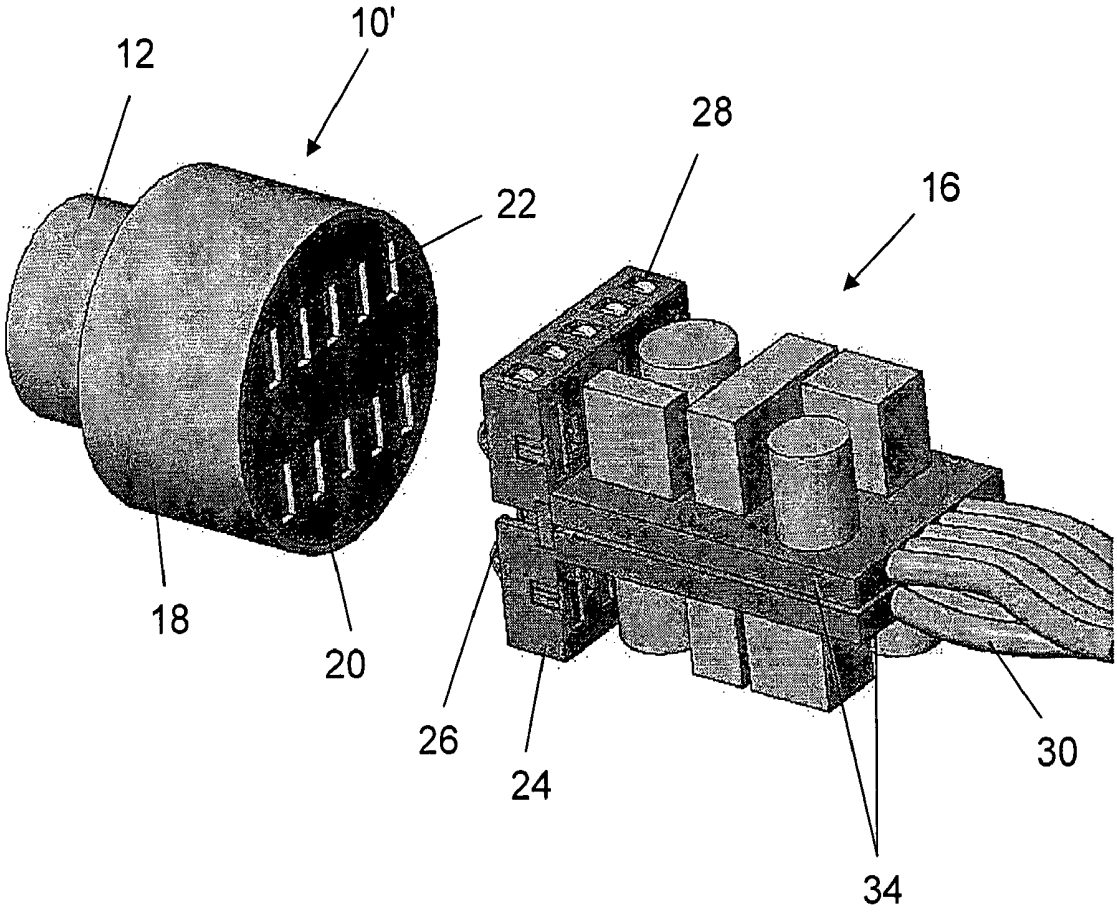
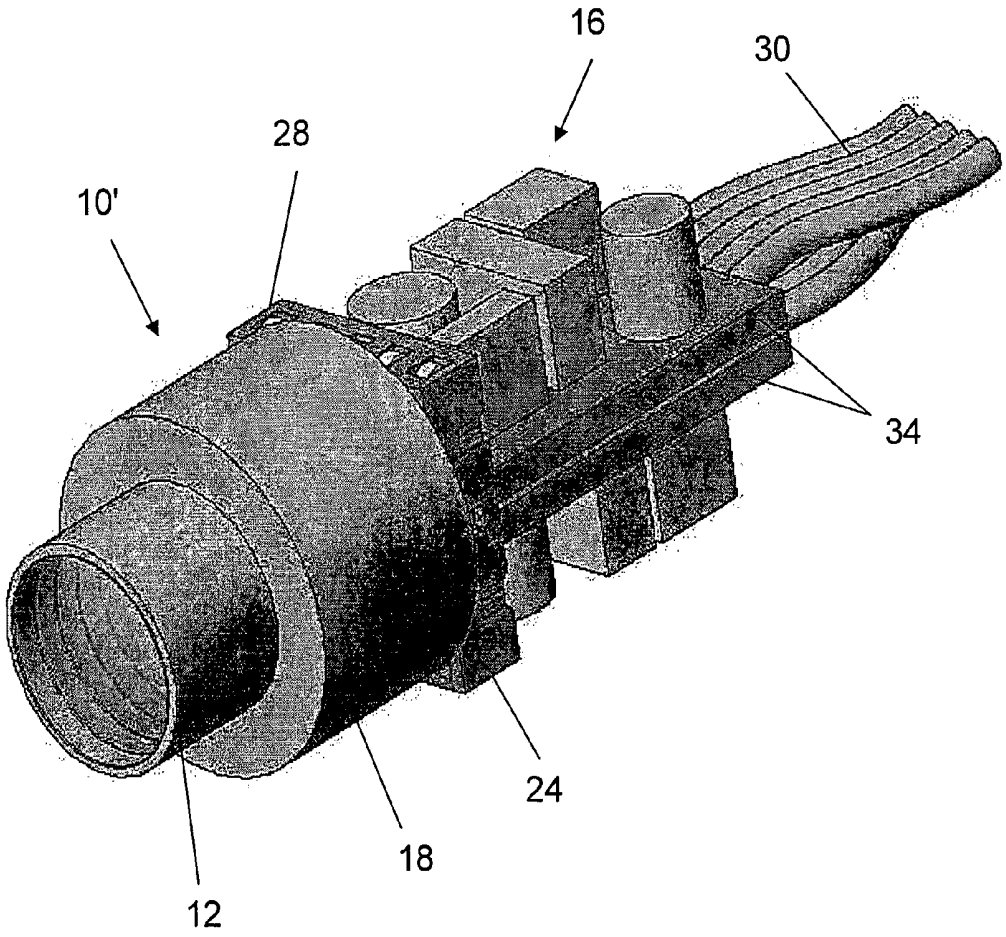


Fig. 6



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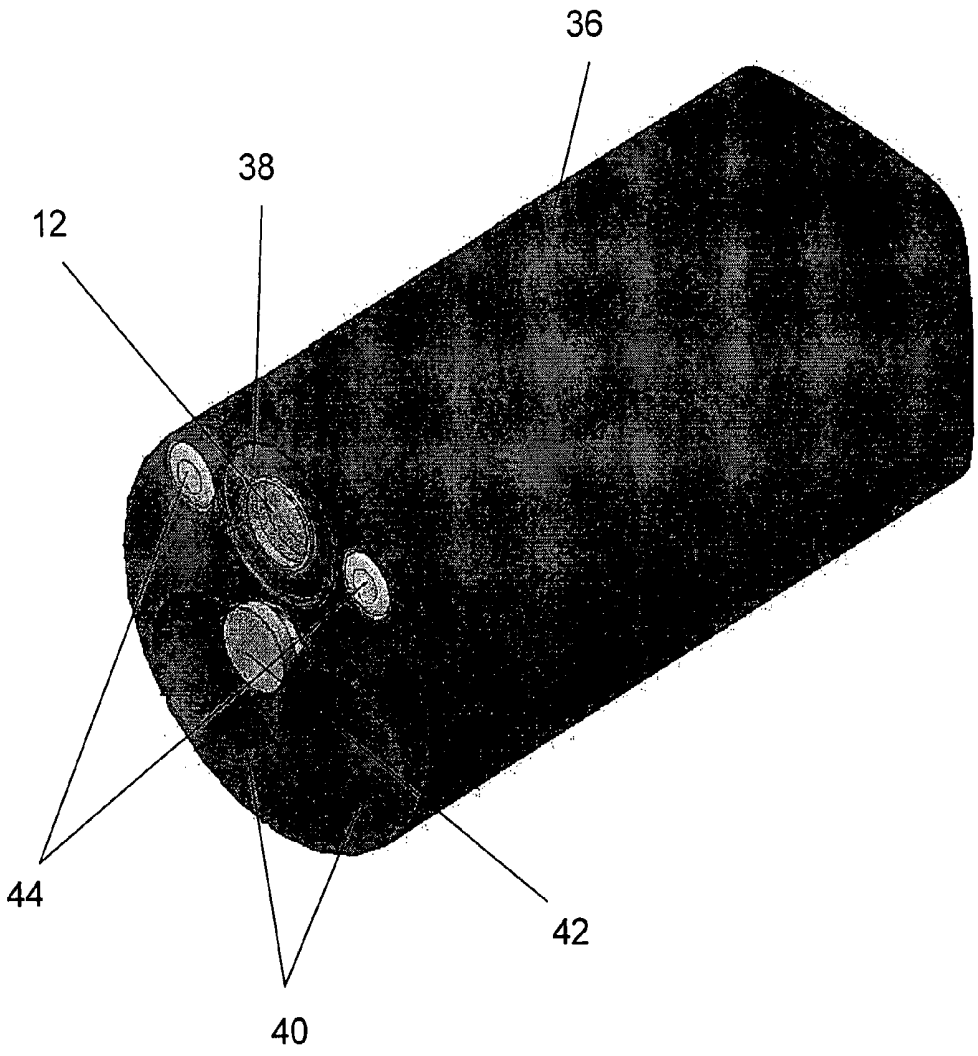


Fig. 8

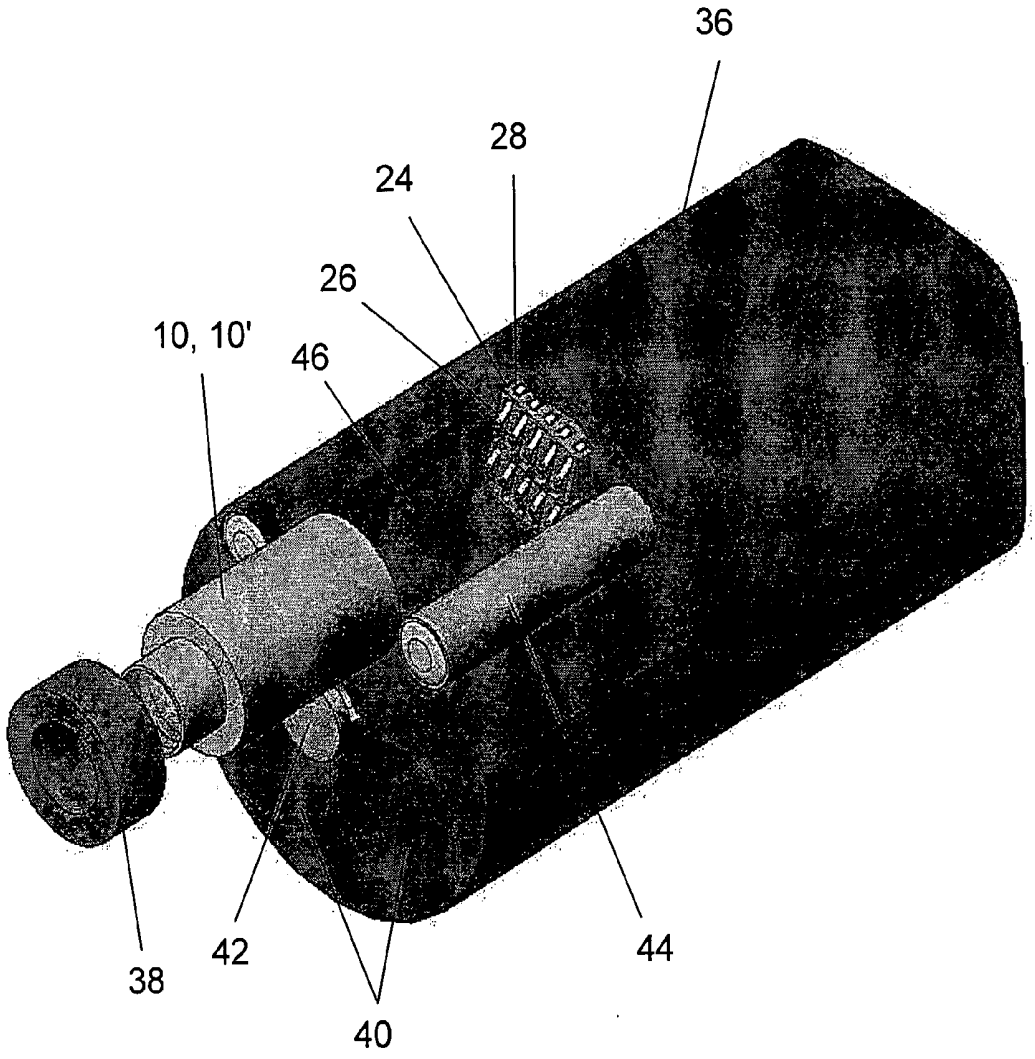


Fig. 9

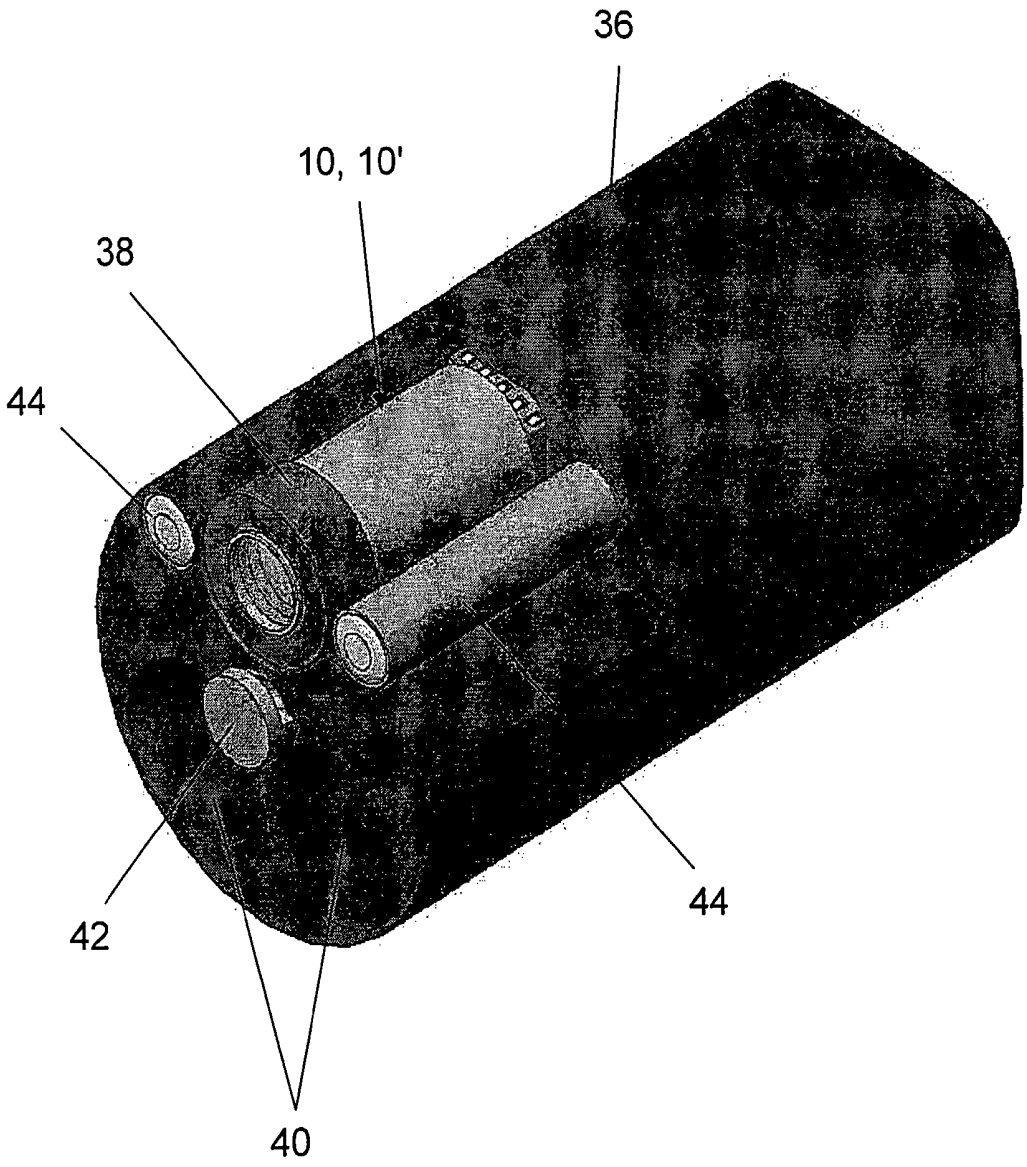
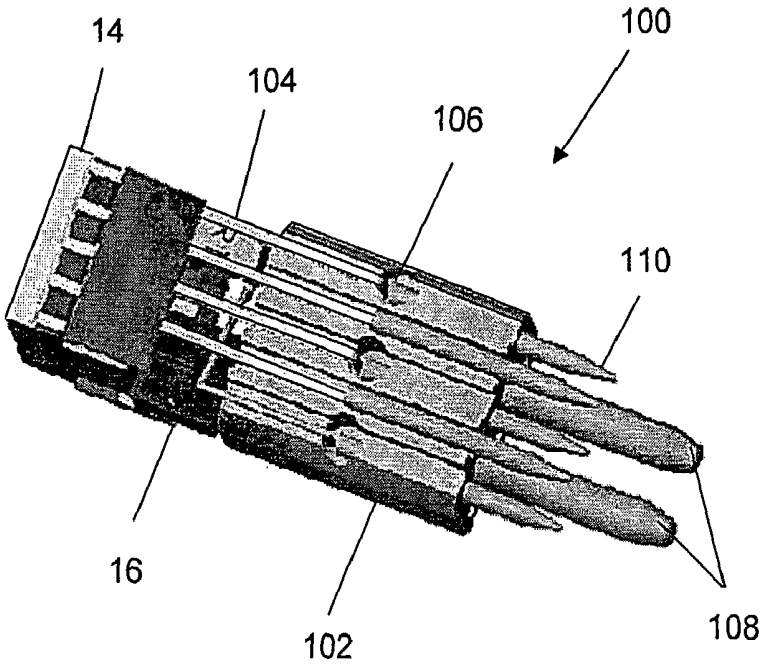


Fig. 10



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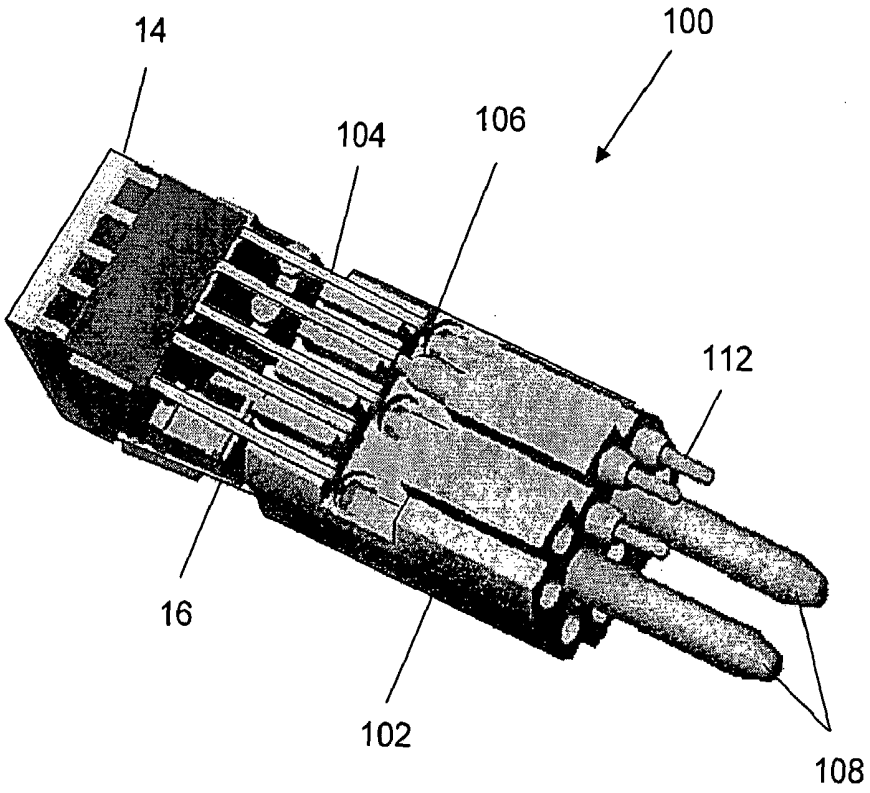

Fig. 12

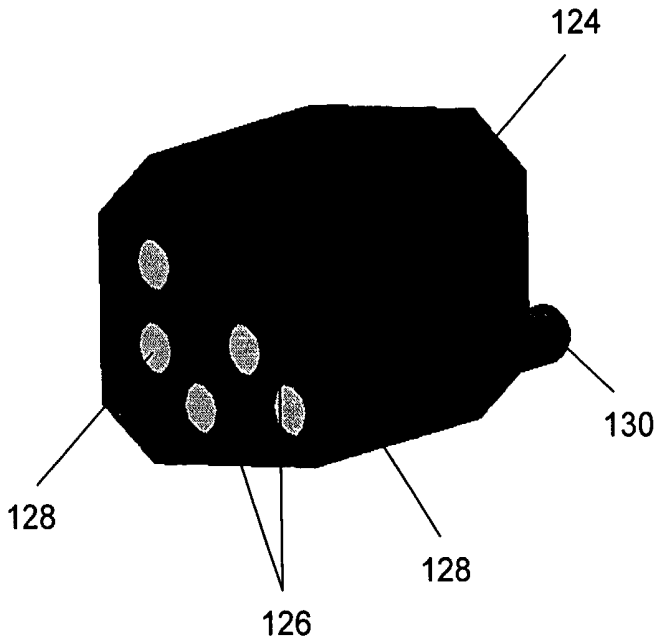

Fig. 13

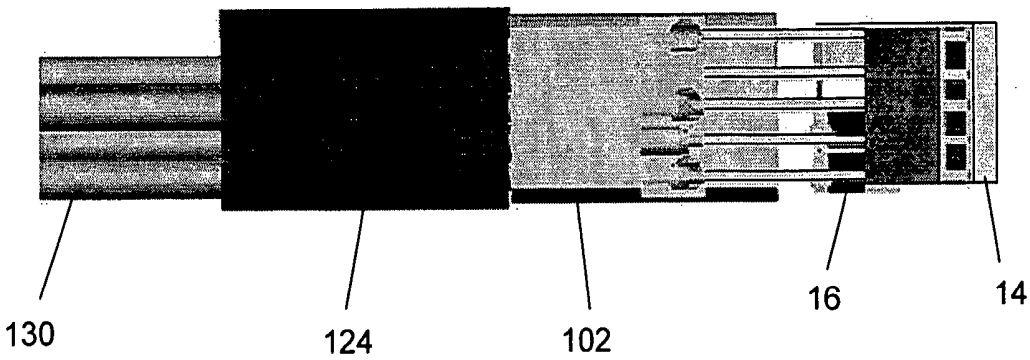

Fig. 14

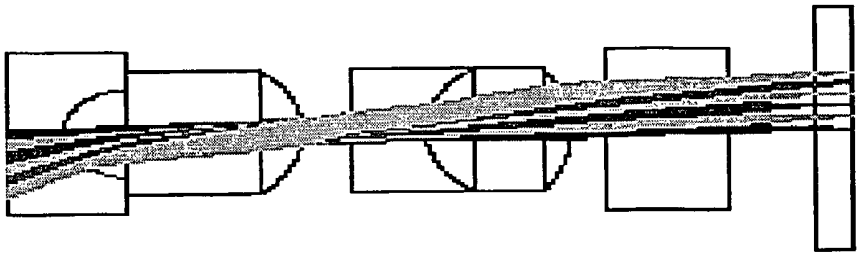

Fig. 15A

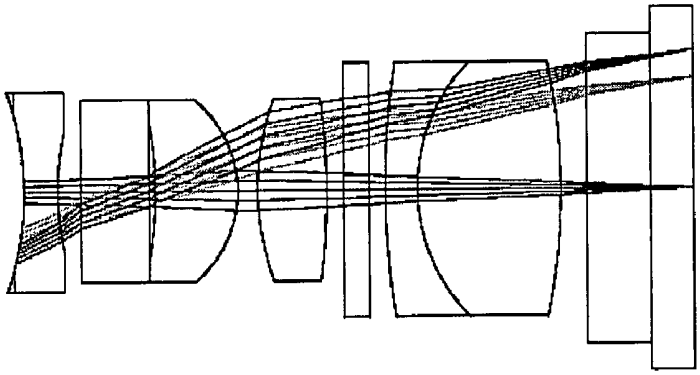

Fig. 15B

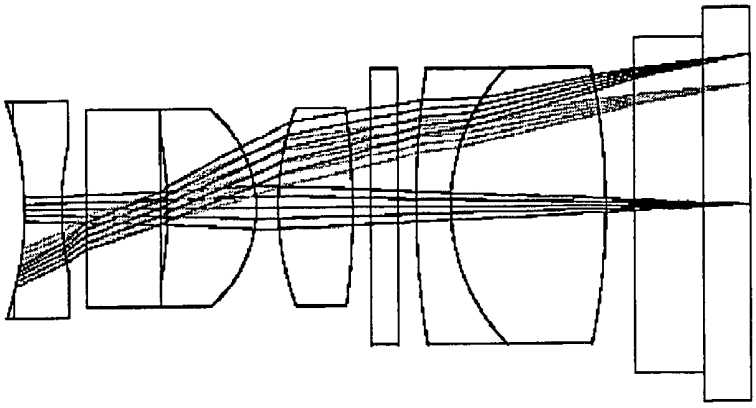

Fig. 15C

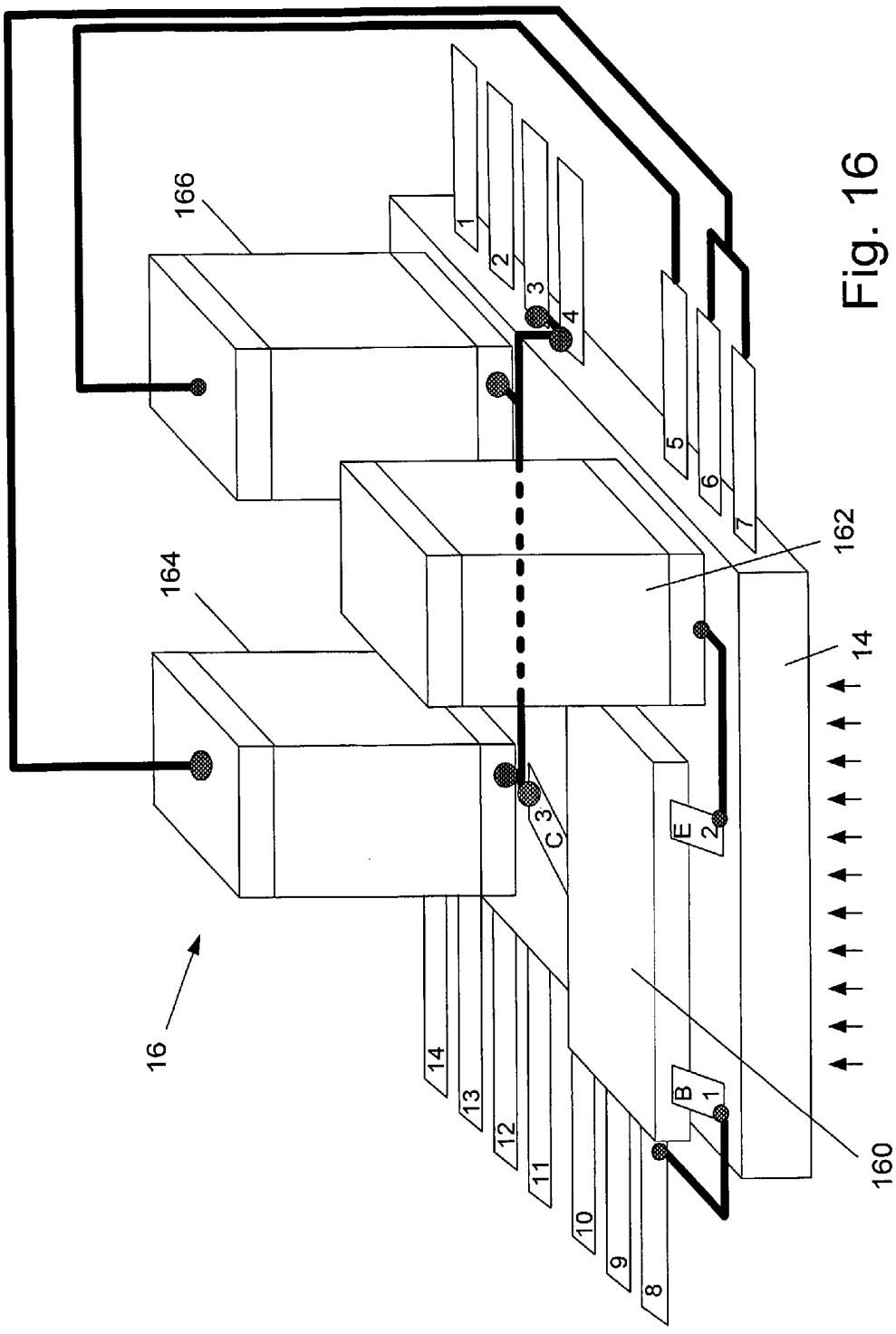

Fig. 16

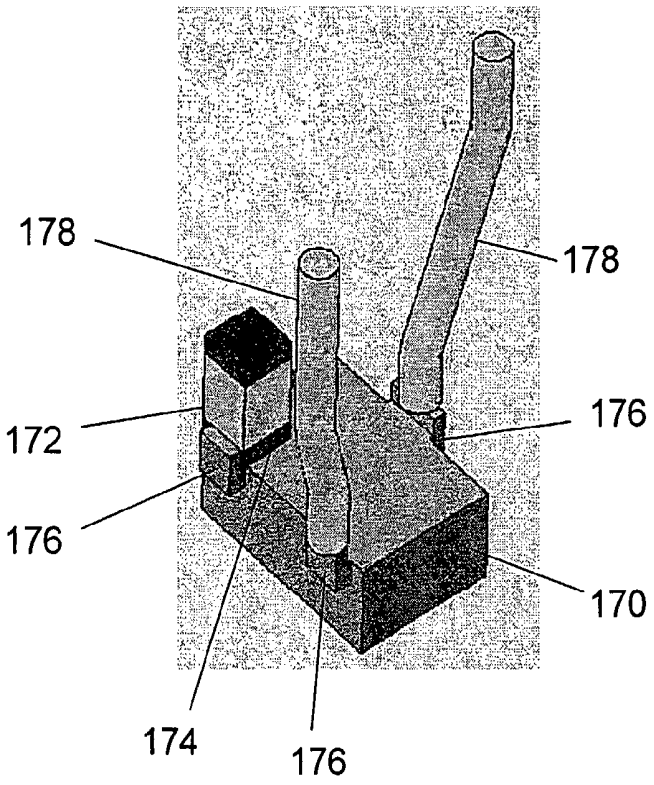

Fig. 17A

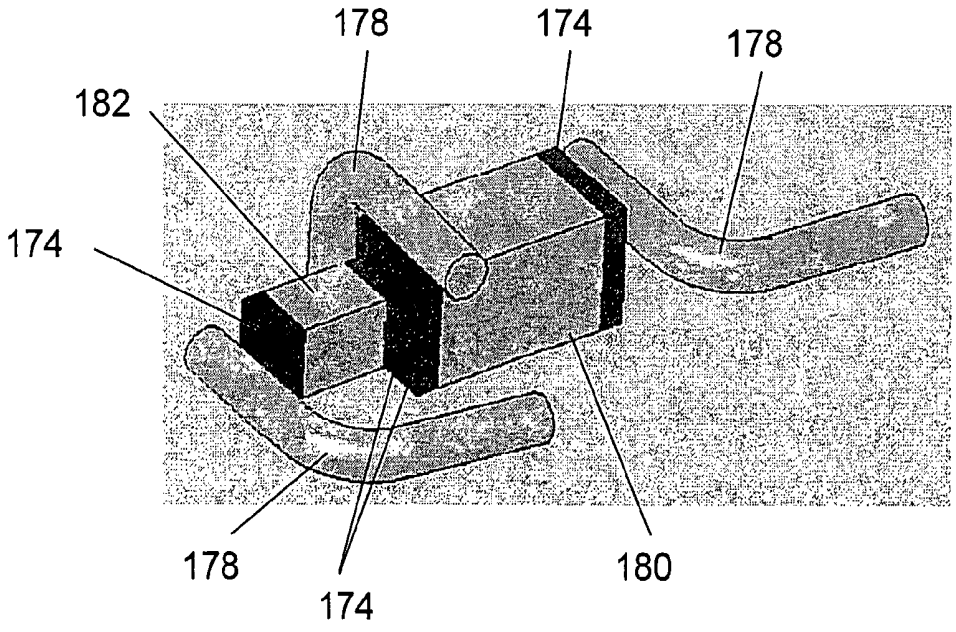

Fig. 17B

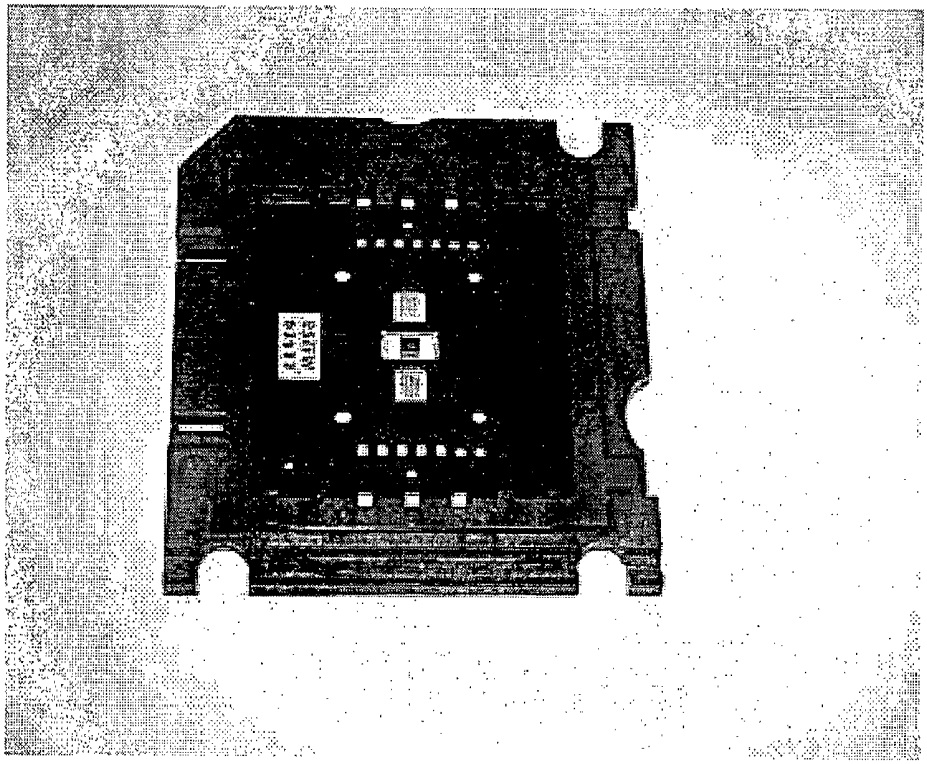

Fig. 18

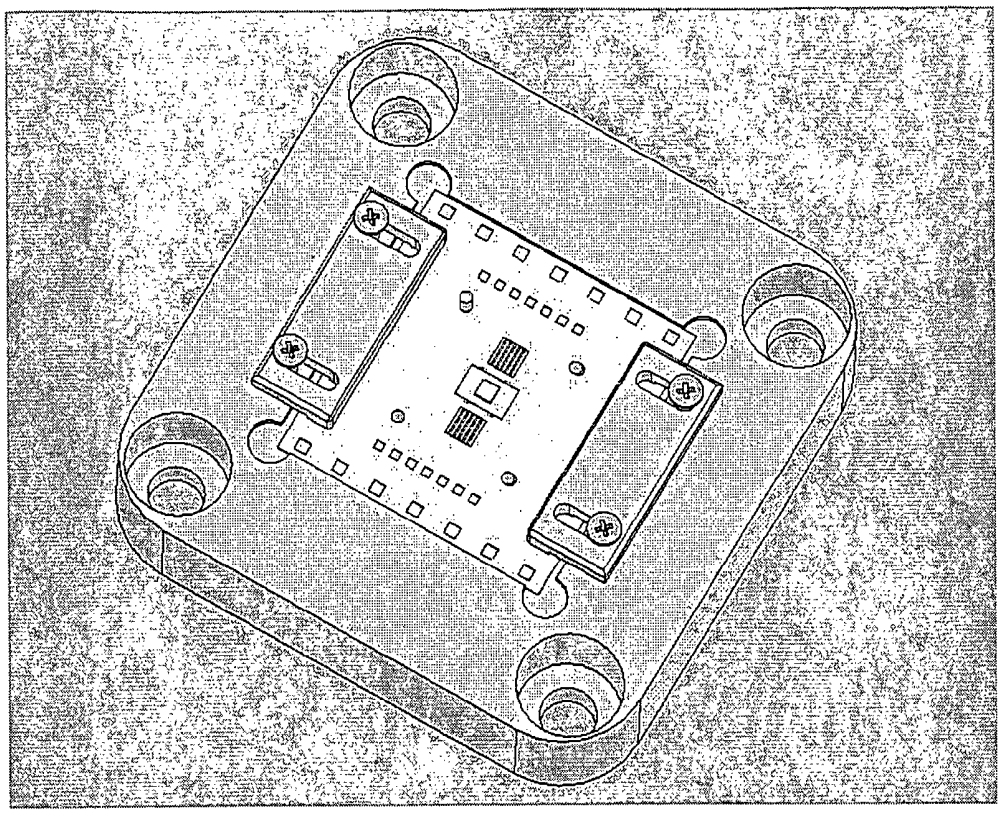

Fig. 19

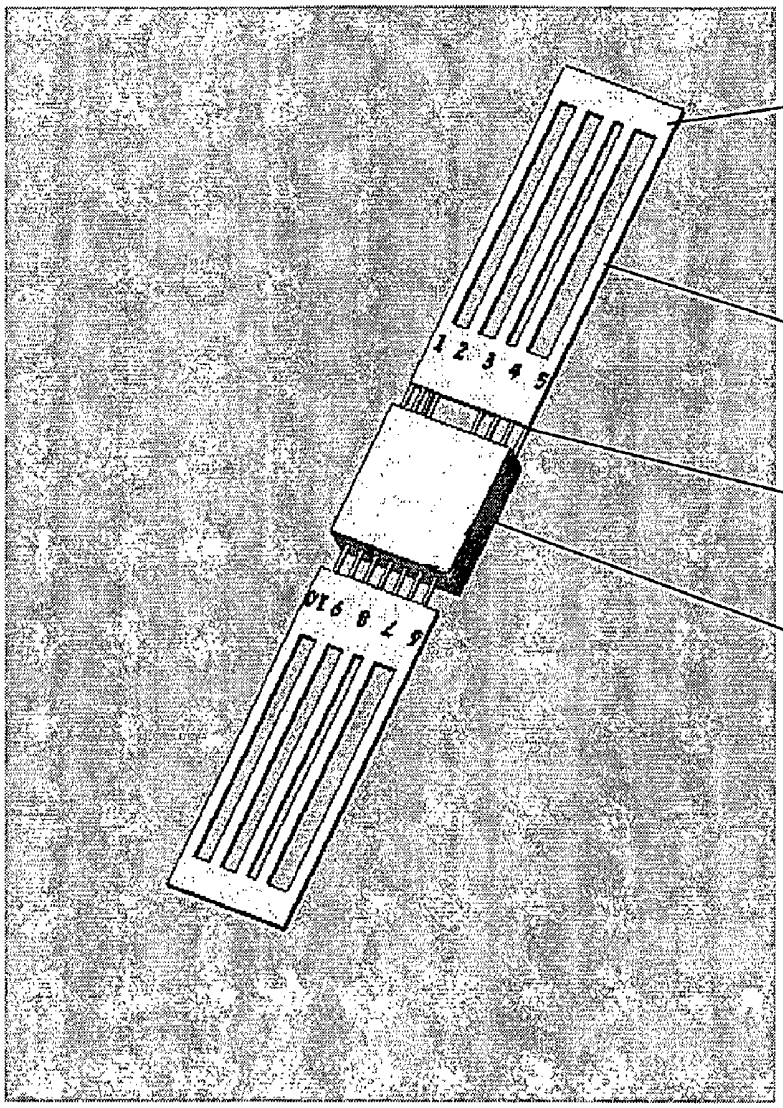

Fig. 20

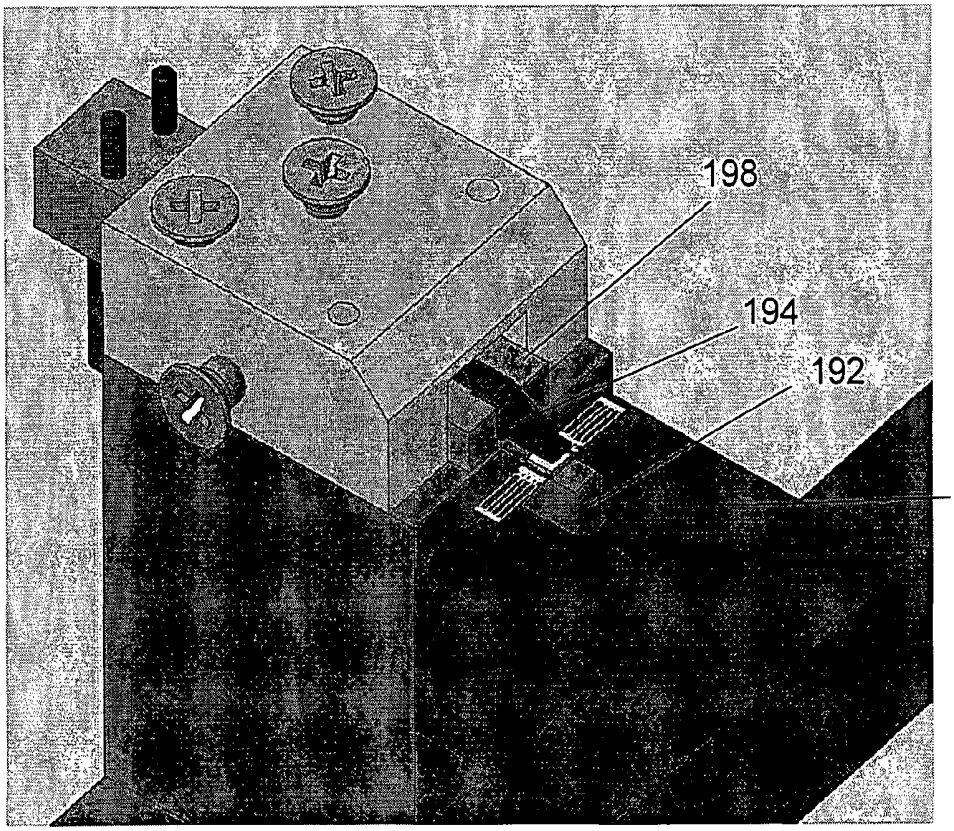

Fig. 21

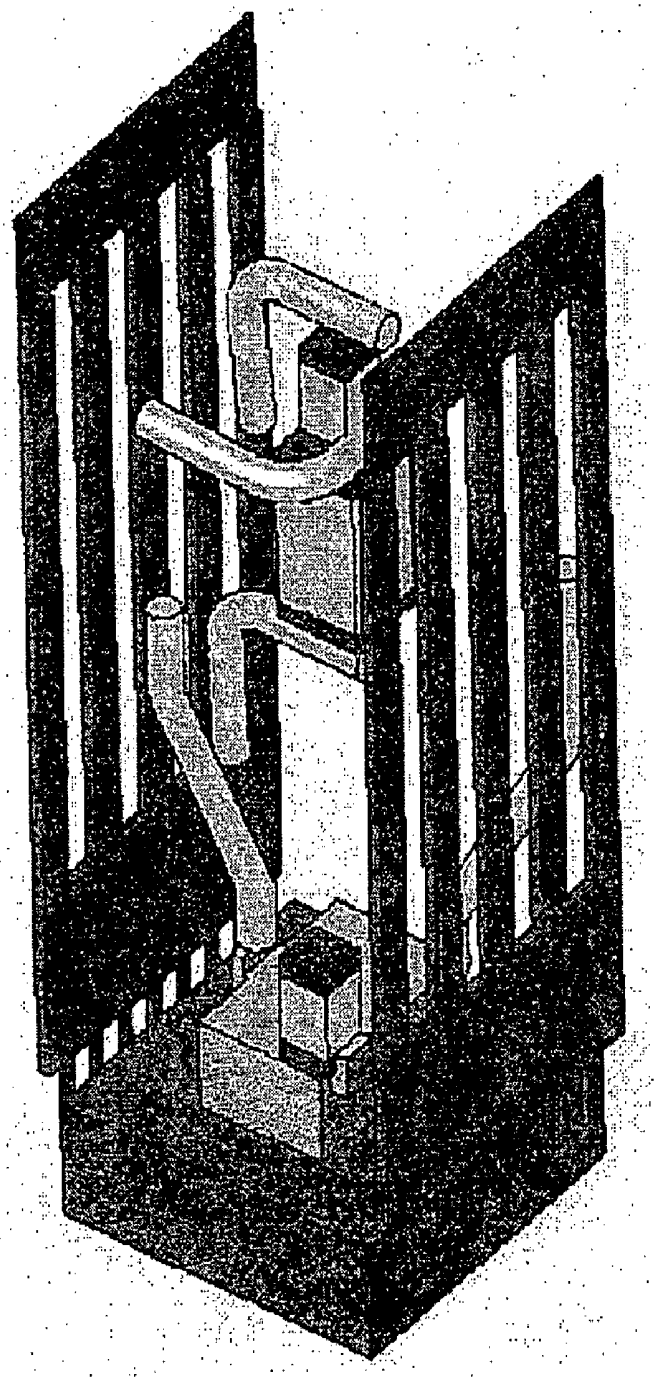

Fig. 22

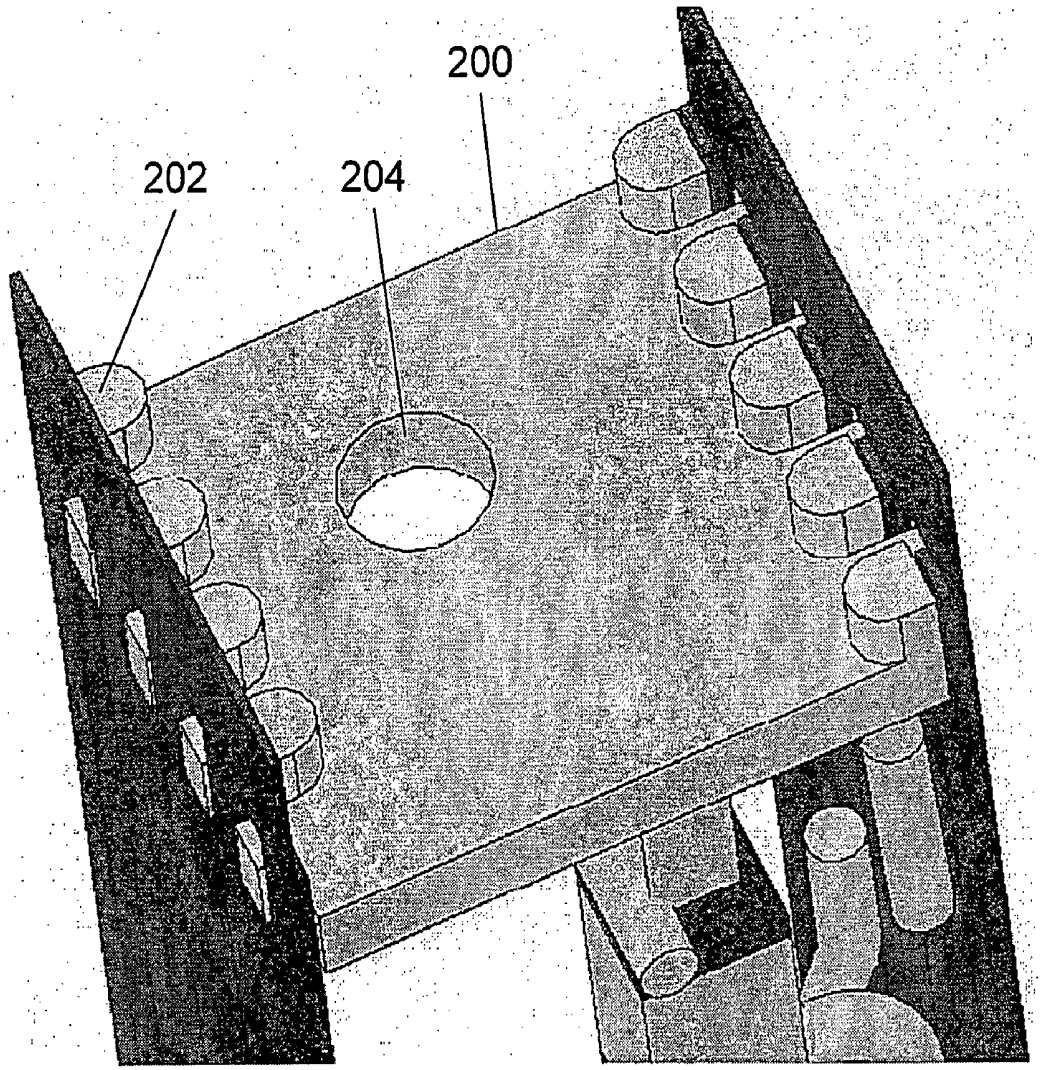

Fig. 23

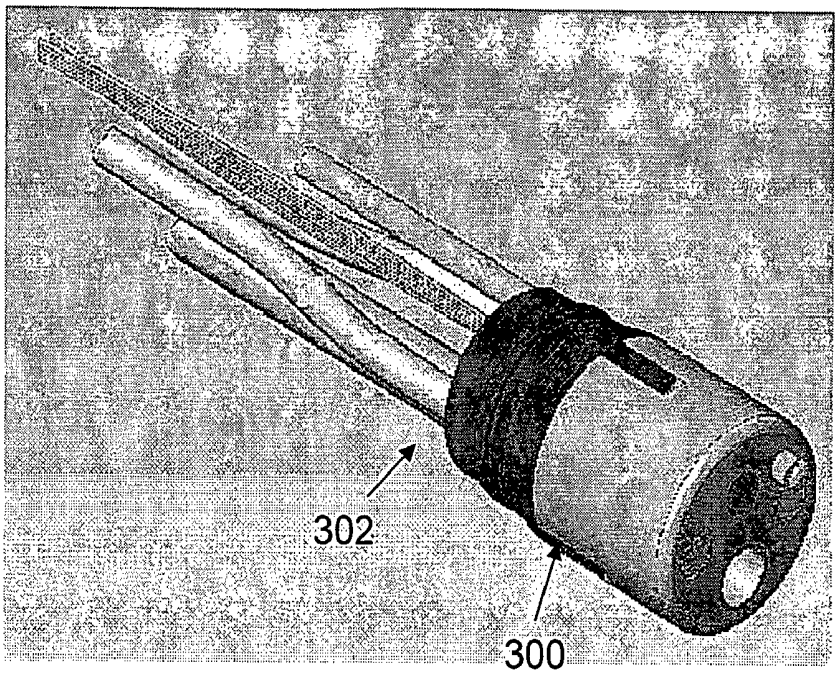

Fig. 24A

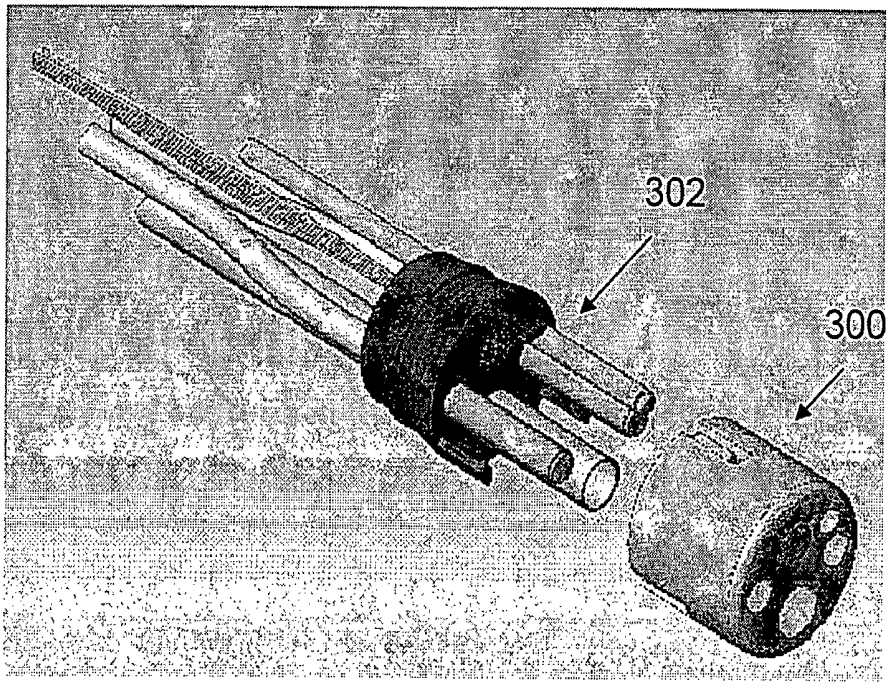

Fig. 24B

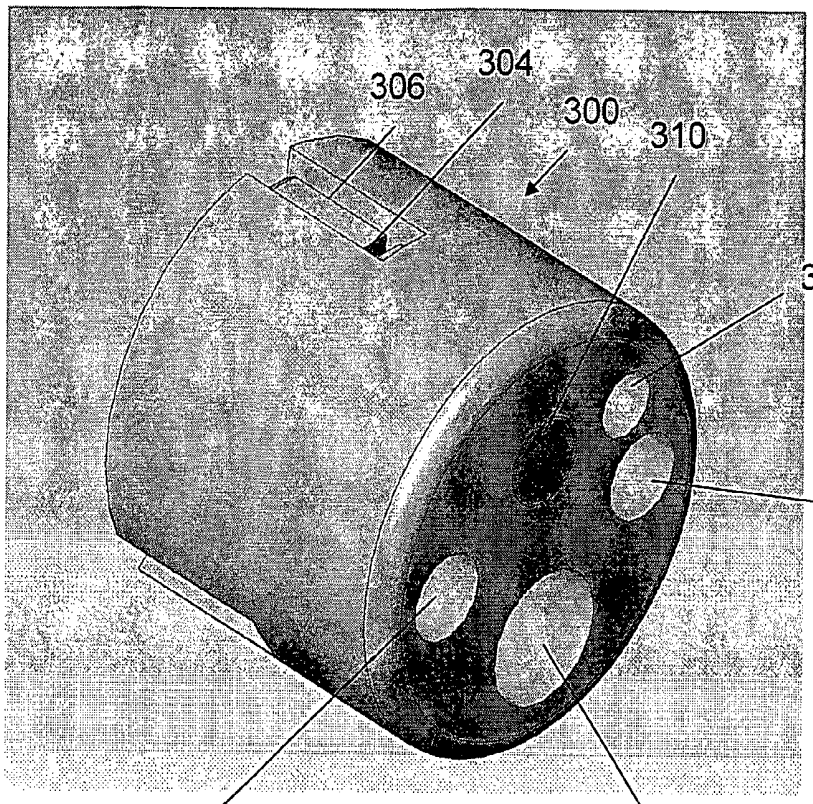

Fig. 25A

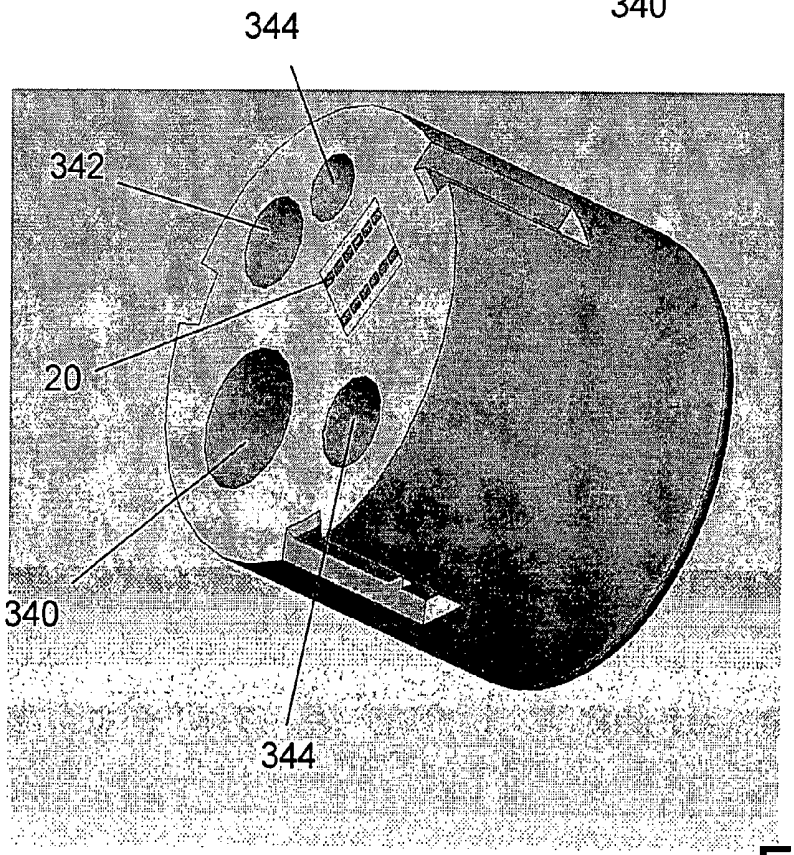

Fig. 25B

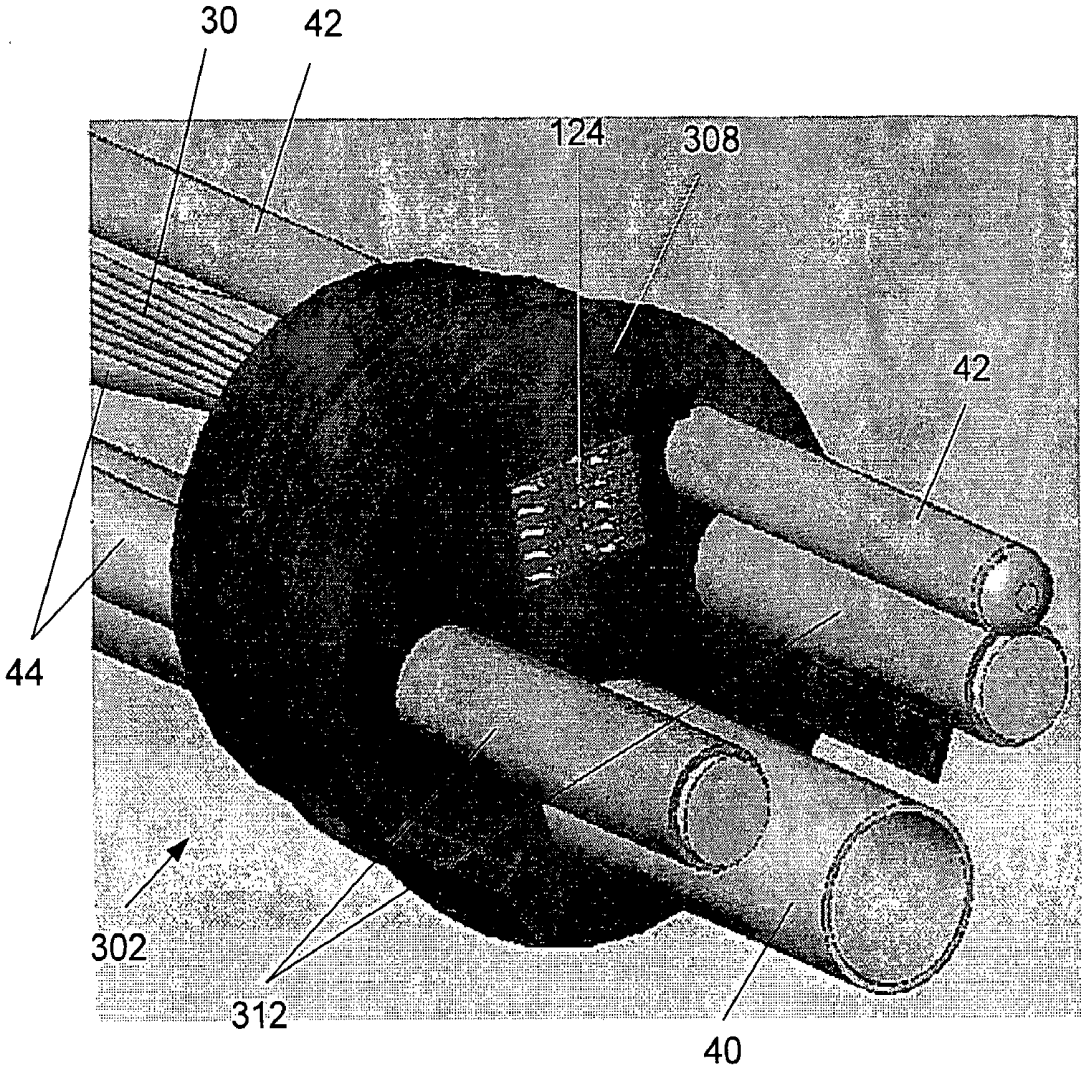

Fig. 26

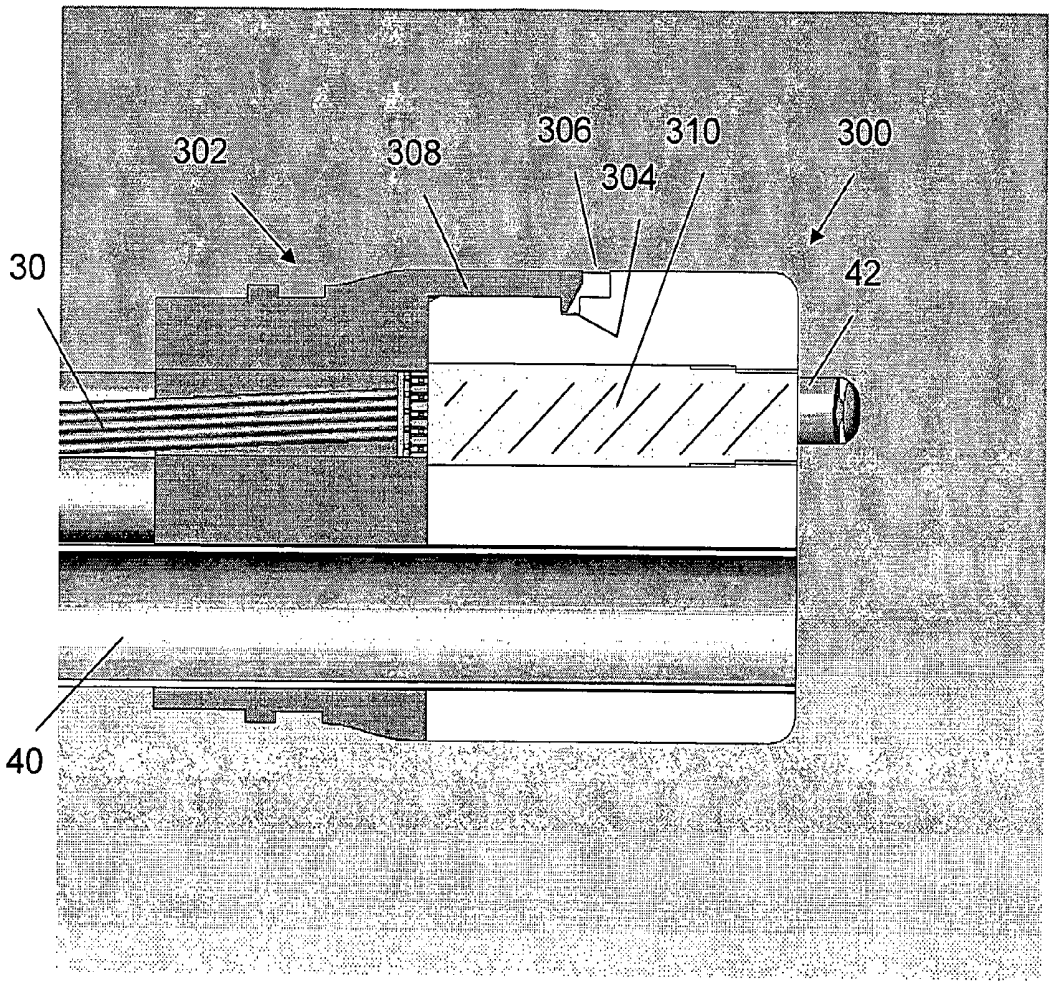

Fig. 27

REUSABLE MINIATURE CAMERA HEAD

FIELD OF THE INVENTION

[0001] The present invention relates to the field of remote imaging. Particularly the invention relates to a reusable miniature camera head that can be attached to and detached from an object.

BACKGROUND OF THE INVENTION

[0002] Minimal access diagnostics and/or therapy, e.g. laparoscopy, interventional flexible endoscopy, minimal access surgery, and percutaneous interventional radiology, are generally carried out within the body cavities or small incisions in the abdomen and therefore the person carrying out the procedure cannot directly view the operating field. For this reason, the ability to carry out such procedures is dependent on the imaging systems that display the images obtained by the camera sensor focused on the scene.

[0003] The imaging systems comprise a miniature camera head based on solid-state sensors, e.g. Charge Coupled Device (CCD) and permanently attached to the distal tip of the rigid, semi-rigid, or flexible endoscope and connected, usually by means of a cable that runs through the length of the endoscope, to a power supply, computing device for processing the signals from the CCD, and display means.

[0004] The high cost of rigid, semi-rigid, and flexible endoscopes dictates that they must be reused for numerous procedures. This in turn dictates that they must be sterilized between each procedure, which further increases the expense, since they must be built using special techniques and special materials to be able to withstand the harsh chemicals and/or high temperatures and/or washing machines of the sterilization and cleaning procedure.

[0005] The camera assembly is by far the most expensive part of an endoscope and a significant reduction in the cost of the endoscopes and the procedures carried out using them could be achieved, if a way could be found to separate the camera head from the device after each use, discard the rest of the device, sterilize or clean the camera head only, and then attach it to a new rigid, semi-rigid, or flexible endoscope for the next procedure.

[0006] In co-pending International Patent Application WO2005/002210 by the same applicant, the description of which, including reference cited therein, is incorporated herein by reference in its entirety, there are described methods for producing an imager assembly for a miniature camera head. As the size of the CCD sensor on which the camera is based becomes smaller, a number of technical and practical problems have become apparent to the inventors. These problems are centered round the fact that the motivation behind using ever smaller sensors is to be able to produce smaller diameter endoscopes, which will be able to enter smaller diameter lumens in order to enable new therapeutic and diagnostic techniques. When the size of the CCD sensor becomes smaller than that disclosed in the above mentioned patent application, the size of the components of the electronic driver of the camera becomes the limiting factor that has to be overcome. Additionally, from a practical point-of-view, the detachable camera heads become so small that it is difficult to handle them.

[0007] It is a purpose of the present invention to provide a miniature camera head that is smaller than any camera head that is presently available.

[0008] It is another purpose of the present invention to provide a detachable miniature camera head that can be attached to and detached from a rigid, semi-rigid, or flexible endoscope.

[0009] It is an additional purpose of the present invention to provide solutions to the problems that have arisen in trying to reduce the diameter of rigid, semi-rigid, and flexible endoscopes.

[0010] Further purposes and advantages of this invention will appear as the description proceeds.

SUMMARY OF THE INVENTION

[0011] The present invention is a reusable miniature camera head that can be attached to and detached from an object. The camera head comprises:

[0012] a housing;

[0013] a lens system at the distal end of the housing;

[0014] a solid-state sensor located adjacent to the lens system;

[0015] components of an electronic driver; and

[0016] an internal electrical connector located at the proximal end of the housing and having a plurality of pins or sockets on its external face.

[0017] The camera head is attached to or disconnected from the object by engaging or disengaging the internal electrical connector in or from an external electrical connector that is fixedly attached to the object. The external electrical connector comprises a plurality of sockets or pins arranged on its face in a pattern matching that of the sockets or pins on the internal connector

[0018] The camera head of the invention can be based on the use of any type of semi-conductor detector, e.g. an Intensified Charge Coupled Device (ICCD); an Electron Multiplying Charge Coupled Device (EMCCD); or a Complementary Metal Oxide Semiconductor (CMOS) device, that is sensitive to radiation in any radiation band, e.g., X-ray, visible, or Near Infra Red (NIR). In preferred embodiments of the camera head of the invention the solid-state sensor is a Charge Coupled Device (CCD). In some embodiments at least some of the components of the electronic driver are located outside of the housing. In preferred embodiments, especially useful in cameras comprising very small CCDs, the housing does not contain a PCB and at least some of the components of the electronic driver are attached directly to the back of the CCD.

[0019] In typical applications, the object to which the camera head of the invention is attached is a rigid, semi-rigid, or flexible endoscope or catheter.

[0020] Henceforth in this application whenever the word endoscope is used it is to be understood in the broadest sense as including all types of rigid, semi-rigid, and flexible endoscopes, including laparoscopes with and without articulation sections, borescopes, catheters, etc.

[0021] In preferred embodiments of the invention, the camera head can be sterilized either chemically or in an autoclave. In other preferred embodiments of the invention, the camera head is a permanent part of a sterilizable distal

tip, which can be detached and reattached to the insertion tube of an endoscopic or laparoscopic device.

[0022] The housing can have metallic electricity conducting strips arranged on its outside surface and the external electrical connector has metallic contacts arranged in such a way that they will engage the conducting strips when the housing is pushed into contact with the electrical connector. Preferably the housing hermetically isolates the lens system, sensor, and components of the driver from the surrounding environment and is fabricated from a material selected from the group comprising: titanium, stainless steel, and polymers.

[0023] In some embodiments of the camera head of the invention, circuitry is printed on the surface of one or more ceramic or polymer printed circuit boards (PCBs) and some or all of the components of the electronic driver are mounted on the PCBs. The electronic driver typically includes an amplifying component comprised of an N-channel field effect transistor (FET) or an amplifier circuit, wherein the amplifier circuit can be a Maxim operational amplifier that includes several amplifying stages. Some or all of the resistive components of the electronic driver can be implemented by utilizing burn resistors.

[0024] The lens system of the invention typically comprises a plurality of lens that together form an image with a field of view of between 60 and 160 degrees.

[0025] In preferred embodiments of the invention, the lens system is designed for carrying out a procedure selected from the following group:

[0026] (a) a gastroscopy procedure by forming an image with a field of view of 120 to 140 degrees;

[0027] (b) an ERCP procedure by forming an image with a field of view of 120 to 140 degrees in the motherscope and by forming an image with a field of view of 100 degrees in the baby scope;

[0028] (c) a colonoscopy procedure by forming an image with a field of view of 120 to 140 degrees;

[0029] (d) a gynecology procedure by forming an image with a field of view of 100 to 120 degrees;

[0030] (e) a bronchoscopy procedure by forming an image with a field of view of 80 to 100 degrees;

[0031] (f) an ENT procedure by forming an image with a field of view of 80 to 100 degrees; and

[0032] (g) a transgastric procedure by forming an image with a field of view of 100 to 140 degrees in the motherscope and by forming an image with a field of view of 100 to 120 degrees in the baby scope

[0033] In preferred embodiments of the camera head of the invention, the diagonal size of the CCD chip is in the range from approximately 1.01 mm to approximately 2.84 mm and the diameter of the distal tip of the rigid, semi-rigid, or flexible endoscope is in the range from approximately 1.6 mm to approximately 3.5 mm.

[0034] All the above and other characteristics and advantages of the invention will be further understood through the following illustrative and non-limitative description of preferred embodiments thereof, with reference to the appended drawings in which like parts are designated by the same reference number.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] FIGS. **1** to **3** show a first embodiment of the reusable camera head of the invention;

[0036] FIGS. **4**A to **4**C show an embodiment of the camera head of the invention comprising external electric connectors;

[0037] FIGS. **5** to **7** show another embodiment of the reusable camera head of the invention;

[0038] FIG. **8** shows the distal end of a disposable endoscope comprising a camera of the invention;

[0039] FIG. **9** and FIG. **10** show the distal end of the endoscope of FIG. **8** with part of the sheath removed;

[0040] FIGS. **11** to FIG. **14** show another embodiment the camera head of the invention;

[0041] FIG. **15**A, FIG. **15**B, and FIG. **15**C show respectively examples of configurations of the lens systems having 100 degree, 120 degree and 140 degree fields of view;

[0042] FIG. **16** schematically shows a typical arrangement of a driver for the camera head of the invention that does not comprise a PCB;

[0043] FIG. **17**A and FIG. **17**B show the electronic components assembly for a camera head comprising a 1/15" CCD chip;

[0044] FIG. **19** shows the 1/15" CCD chip secured in a special jig; for removing the excess tape;

[0045] FIG. **20** shows the CCD chip, legs, and wire terminals after most of the CCD tape has been cut away;

[0046] FIG. **21** shows the CCD chip held in an especially designed holding jig;

[0047] FIG. **22** shows how the wires from the electronic sub-assembly and the two capacitors are attached to the CCD wire terminals by soldering;

[0048] FIG. **23** shows how an electrically insulating pad support is electrically connected to the driver assembly by soldering the pads to the CCD wire terminals;

[0049] FIG. **24**A and FIG. **24**B show respectively the detachable distal tip of the invention attached to and detached from the distal end of an insertion tube of an endoscope;

[0050] FIG. **25**A and FIG. **25**B are perspective views showing the detachable distal tip of the invention;

[0051] FIG. **26** is a perspective view showing the distal end of an insertion tube of an endoscope adapted to mate with the detachable distal tip of the invention; and

[0052] FIG. **27** is a cross-sectional view taken along the longitudinal axis of FIG. **24**A.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0053] FIGS. **1** to **3** show a first embodiment of the reusable camera head **10** of the invention. Referring first to

FIG. **1**, camera head **10** is a closed housing **18**, preferably cylindrically shaped, with a lens system **12** at its front end. The camera head **10** is shown in FIG. **1** attached to external electrical connector **24**. External electrical connector **24** has around its outer perimeter clasps **28**, which can be for example leaf springs, which are used to hold external electric connector in position in a socket at the distal end of the endoscope. Signal transmission and electric power supply wires **30** are attached to the back face of external electrical connector **24** and are in electrical contact with a plurality of pins **26** (see FIG. **2**) arranged in a pattern on the front face of connector **24**.

[**0054**] FIG. **2** and FIG. **3** show the camera head **10** with part of the housing **18** removed to reveal the interior of the camera head. The camera head **10** is shown disconnected from the external electrical connector **24** in these figures. Generally, in all of the figures herein, the internal electrical connections between components of the camera head are not shown for clarity.

[**0055**] Inside of the housing **18** is a front wall **32** that supports the lens system **12** on its front face and the CCD **14** on its rear face. The lens system **12** is of conventional design for endoscopic or laparoscopic instruments. The lenses are made of material that can withstand repeated sterilization, particularly autoclaving, procedures. Suitable examples are, for example N-SK10 and N-SF8 optical glasses supplied by Schott Glass Technologies or glasses with Tg>530 centigrade. The lens system typically comprises a plurality of lens that together (depending on the combination of lenses used) form an image with a field of view of between 60 and 160 degrees and depth of focus suitable from 1 mm to 100 mm in front of the camera head and project the acquired image on the face of the CCD. Examples of configurations of the lens systems having 100 degree, 120 degree and 140 degree fields of view are shown in FIG. **15**A, FIG. **15**B, and FIG. **15**C respectively. The field of view of the lens system of the camera is selected according to the type of procedure to be carried out by the endoscope to which the camera will be attached. Some procedures are performed using two endoscopic devices: a "mother scope" which is used to gain access to the region of the procedure within the body and a second, smaller diameter, "baby scope" that is used to carry out the procedure. The field of view of the baby scope is typically smaller than that of the mother scope. Examples of various procedures in the visible radiation band and the corresponding field of view are shown in Table 1.

TABLE 1

Procedure	Field of view
Gastroscopy (EGD)	120–140
ERCP	120–140 (mother scope) 100 (baby scope)
Colonoscopy	120–140
Gynecology	100–120
Bronchoscopy	80–100
Transgastric	100–140 (mother scope) 120–100 (baby scope)
ENT	80–100

[**0056**] Similar tables can be constructed for procedures carried out while observing in bands other than the visible, for example, for angiography where the CCD would be sensitive in the x-ray band.

[**0057**] Examples of commercially available CCD chips **14** for use in camera head **10** are ICX256/7FKW CCD (1/10" diagonal) manufactured by Sony, and LC99267FSB CCD (1/9") by Sanyo. Sony has also developed a 1/15" CCD sensor (ICX421FKZ). Sensors having CCD chips with even smaller diagonal dimensions are presently being designed. In preferred embodiments of the invention, the lens system **12** is attached to the face of the CCD **14** using a heat resistant optically transparent adhesive that has a thermal expansion coefficient that will prevent damage to the camera head during sterilization procedures carried out in an autoclave.

[**0058**] Also shown inside the housing of camera head **10** are electronic components of electronic driver **16**. For the larger sized CCD chips, as is done in prior art camera heads, some or all of the components of driver **16** can be mounted on one or more ceramic or polymer, for example Teflon, printed circuit boards (PCBs) **34** (shown in FIG. **5**, but not seen in FIG. **2** or FIG. **3**). Circuitry is printed on the surface of the PCB and the electronic components, which include an amplifying component, are attached. An N-channel field effect transistor (FET) is usually used as an amplifying component in driver designs. In a preferred embodiment of the invention, an amplifier circuit such as a Maxim operational amplifier that includes several amplifying stages implements the amplifying element. In order to reduce the physical dimensions of driver **16**, the resistive components may be implemented by utilizing burn resistors. The burn-resistors are created in the PCB conducting lines, and serve as electrical links between the electrical components. In this way the space consumed by the resistive components becomes negligible.

[**0059**] In the preferred embodiment of the detachable camera head, especially for those comprising the smallest sized CCD chips, no PCB is used in the camera head. The components of the driver are attached directly to the back surface of the CCD chip, to the connector, or to the inside walls of the housing. A typical arrangement of driver **16** for the camera head of the invention that does not use a PCB is schematically shown in FIG. **16**. On the back of the CCD chip **14** (1/10"—ICX257FKW) are glued transistor **160** (2S2029 ROHM), resistor **162** (51 Ohm), capacitor **164** (1 nF, 50 V), and capacitor **166** (100 nF, 16V). The internal connections are shown in FIG. **16**. The fourteen tabs on the CCD chip and the top electrode of the resistor are connected to the internal electrical connector **20** (see FIG. **2**). It is stressed that the arrangement shown in FIG. **16**, and especially the component numbers and parameters given in parenthesis, are given merely to illustrate one way of implementing driver **16** and is not meant to limit the invention in any way. An example of another method of assembly of a miniature camera comprising a 1/10" CCD chip will be described hereinbelow.

[**0060**] Referring again to FIG. **2** and FIG. **3**, all signal transmission lines and electrical supply wires to and from the driver **16** and CCD **14** are connected to contacts on the inside face of internal electric connector **20**. The contacts on the inner face of internal electric connector **20** are in electrical contact with a plurality of sockets **22** arranged in a pattern on the outside face of connector **20**. The pins **26** on the front face of external electric connector **24** fit into the sockets **22** on the outside face of internal electric connector **20**, thus establishing electrical continuity between the components inside housing **18** of reusable camera head **10** and

signal transmission and electric power supply wires **30** in the endoscope, the distal ends of which are electrically connected to the pins in external electric connector **24**. In addition, since the external electrical connector is fixedly attached to the endoscope by means of clasps **28**, the pins **26** and sockets **22** act as a "quick connector" for attaching the camera head **10** to the endoscope.

[**0061**] For the electrical connectors shown in FIG. **2** and FIG. **3**, the pins and sockets are arranged internally on the faces of the respective connectors. In FIGS. **4**A to **4**C is shown another arrangement for making the electrical contact between the interior of the camera head and its exterior. As seen in FIG. **4**A, the housing **18'** of camera head **10"** has a rectilinear shape. Housing **18'** is made of an electrically insulating material and in the planar upper and lower surfaces are longitudinal slots containing metal electricity conducting strips **22'** that are electrically connected to the inside. The external electrical conductor is in two parts **24'** that are fixedly attached to the walls of a socket in the distal end of the endoscope and spaced apart such that camera head **10"** can be inserted between them. On the face of each part **24'** of the external electric conductor are metallic contacts **26'** that are arranged in a matching pattern to the conducting strips **22'** on the top and bottom surfaces of housing **18'** and to the signal transmission and electric power supply wires **30**. Metallic contacts **26'** are preferably leaf springs that will provide electrical contact and also will act as a "quick connector" holding the camera head at the distal tip when it has been pushed into place and allowing it to be detached easily simply by pulling it away from the endoscope.

[**0062**] FIGS. **4**B and **4**C show Camera head **10'** held in place between the two parts **24'** of the external electric connector. The arrangement shown in FIGS. **4**A to **4**C can be utilized to reduce the lateral dimensions of the camera head under certain conditions.

[**0063**] The housing **18** completely surrounds the components of camera head **10**, thereby hermetically isolating the components of the camera head, except for the front surface of the first lens in the optical system and the outer face of the electrical connector **22**, from contact with the surrounding environment. Thus, as long as all the components of the camera head are heat resistant up to the temperatures reached in an autoclave, no special precautions have to be taken when using the camera or during the sterilization procedure. The housing must be resistant to sterilization solutions such as CIDEX and EtO and autoclave sterilization at 134° C. and pressure of 2.3 bar. Suitable materials from which the housing can be fabricated are, for example, titanium, stainless steel, or a polymer, such as Teflon or one of its derivatives.

[**0064**] FIGS. **5** to **7** show another embodiment of the reusable camera head **10'** of the invention. In this embodiment, electronic driver **16** is not inside of housing **18** of the reusable camera head **10'**, but is located proximally of the external electrical connector **24**. This makes the driver **16**, part of the disposable endoscope and therefore the components can be made having less strict tolerances and are therefore less expensive than those of the embodiment described hereinabove. This follows not only because the driver does not have to be able to survive the elevated temperature of autoclave sterilization, but also because the requirements of circuit stability, etc. are much less stringent for a unit that is only required to work once than for a unit which is designed to operate repeatedly over many thousands of cycles. Skilled persons will also realize that the driver **16** can be produced as an ASIC component, greatly reducing the cost of the camera head. Additionally, the cable that is used to connect between the external connector and the video processor in the present invention can be designed to a much lower standard than is possible with prior art cameras.

[**0065**] FIGS. **11** to **14** show another way of implementing the camera head of the invention. In this embodiment of the camera head **100**, the internal connector is replaced with a separate insulating conductor support **102**. The camera head is shown without the lens system mounted on the CCD **14** and with the housing that surrounds and protects it removed. The components of driver **16** are attached to the CCD **14** or the conductor support **102** without the use of a PCB as described with reference to FIG. **16**. In FIGS. **11** and **12** the CCD **14** has ten tabs connected to CCD conductors **104**, which extend to and are bent into slot **106** in the top of conductor support **102**. Projecting out of the proximal face of the conductor support **102** are two guide pins **108** for aligning the conductor support **112** with a matching connector **124** (FIG. **13**) and for guiding the ten pins on the conductor support **112** into matching bores on the face of the connector **124**. FIG. **11** shows an embodiment in which the ten pins **110** are rigid and slide into a metal sheath lining the inside of the bores on the face of connector **124**. In this embodiment the end of each pin is pushed against the bent end of the corresponding CCD conductor **104** in slot **106** and soldered to it. FIG. **12** shows an embodiment in which spring probes **112** are installed in the conductor support **102**. In this case, it is not necessary to solder the CCD conductors to the probes, since the force exerted by the compressed springs in the probe **102** when it is inserted into the bore in connector **124** will be sufficient to provide electrical continuity. In FIG. **13** is shown a connector **124** for use with the embodiment shown in FIG. **12**. A ten-conductor camera cable **130** is attached to the proximal face of connector **124**. On the distal face of connector **124** can be seen ten bores **126** comprising metallic cores against which the ends of the spring probes **112** are compressed as the guiding pins **108** are pushed into the two guiding bores **126**. In order to ensure good electrical connection between the contacts on the internal and external connectors, a conducting layer, for example, GB MATRIX TYPE by Shin-Etsu Chemical Co., Ltd. Can be attached between connectors **102** and **124** (shown in FIG. **14**), e.g. by attaching it to the distal face of connector **124** (FIG. **13**). FIG. **14** is a side view showing the conductor support **102** with its attached CCD assembly connected to camera cable **130** by means of cable connector **124**. FIG. **8** shows the distal end of a disposable endoscope **36** comprising a camera head **10**,**10'** of the invention. The choice of a disposable endoscope is merely for illustrative purposes and the camera head of the invention can also be used with any type of endoscope. The endoscope need not be disposable after a single use, but the entire device or some of its components can be sterilized separately from the camera head and reused for subsequent procedures.

[**0066**] Shown on the distal face of endoscope **36** is the surface of the first lens of lens system **12**; a gasket **38**, which surrounds the lens system to prevent liquids from entering the interior of endoscope; two light fibers **44**, which illuminate the area viewed by the camera; an irrigation nozzle **42**,

to clean the lenses; and two working channels **40**, through which the surgeon/gastroenterologist can insert the tools necessary to carry out the procedure. The endoscope shown in FIG. **8** is illustrative only and the reusable camera head of the invention can be attached to rigid, semi-rigid, or flexible endoscopes comprising many different configurations and accessories. As specific examples, the endoscope can comprise only a single working channel or the illumination can be provided by a single fiber, which ends in a light ring around the perimeter of the distal face.

[**0067**] FIG. **9** and FIG. **10** show the distal end of the endoscope **36**, with part of the sheath removed. From these two figures, it can be seen how the camera head **10**,**10'** is slid into (and out of) socket **46** in the distal end of endoscope **36** and is pushed into (and out of) the external electrical connector **24** that is attached to the endoscope.

[**0068**] Referring to FIGS. **8** to **10**, the working channels **40** have a diameter of 0.8-1.2 mm, the light fibers **44** a diameter of 0.3-0.6 mm, and the diameter of the camera head is 3 mm. The external diameter of the endoscope is less than 5 mm and if the endoscope has only one working channel it will have an external diameter of up to 4 mm. In table 2 are shown dimensions for endoscopes that will use detachable camera heads without a PCB and the CCD's presently available or under development.

TABLE 2

Tip diameter (mm)	Light fibers OD (mm)	Irrigation channel (mm)	Camera head Min diagonal size (mm)	CCD chip size (inches)
3.5	1.17	0.6	2.54	1/10
3.0	0.7	0.4	1.69	1/15
2.3	0.6	0.3	1.41	1/18

[**0069**] The presently preferred embodiment of the assembly procedure for the miniature camera head of the invention will now be described. The procedure described herein pertains to the 1/10" CCD chip but is provided merely to illustrate the invention and is not intended to limit the scope of the invention in any manner. For example, it is expected that the same procedure will be used mutatis mutandis with a 1/15" and smaller CCD chips. The CCD chip has the shape of a square having sides of approximately 1.8 mm length. Therefore only a transistor and a resistor are attached directly to the CCD chip and the two capacitors, which comprise the remainder of the electronic driver are added to the assembly at a later stage.

[**0070**] Because of the small size of the components and also to insure the accuracy of the assembly, the components are handled either manually using micro tweezers or a vacuum pick-and-place device or automatically with an automatic pick-and-place machine and the assembly is carried out using a stereomicroscope such as Nikon SMZ 800.

[**0071**] The first stage of the procedure is the assembly of the electronic components. The transistor (e.g. type 2sa2029, pack 0402) is placed on a flat surface using, for example, micro tweezers. Next UV glue, such as Loctite type 3494 is applied on one side of the transistor. To insure accurate application of the glue, a glue dispenser, for example an ESD 1400 glue dispenser, is used. After the glue is cured using a UV light curing system such as Dymax blue wave 50, a resistor (e.g. 39 ohm, pack 0201) is placed on the transistor. FIG. **17**A shows the electronic components assembly. In the figure it can be seen how the five-sided termination **174** at one end of resistor **172** is pushed into contact with one of the three conducting legs **176** of transistor **170**. After another layer of UV glue is applied and cured, the electronic components are connected to each other and to jumper wires **178** using precision soldering devices, e.g. manual soldering stations like Weller MT 1500 or a high-power diode laser such as one of those produced by Dilas GmbH systems.

[**0072**] Now, using the soldering device, the two capacitors are soldered to each other and to jumper wires as shown in FIG. **17**B. Capacitor **180** has a capacitance of 100 nF and capacitor **182** has a capacitance of 1 nF.

[**0073**] The next stage of the procedure is to prepare the CCD so that the electronic components can be attached to it. FIG. **18** shows the 1/10" CCD chip (Sony ICX257) with a plastic holder surrounding the tape, as it is supplied by the manufacturer. The plastic holder surrounding the tape is removed from the CCD component and the CCD tape is secured in a specially designed jig (shown in FIG. **19**). Initially the CCD tape is secured with the photosensitive side of the chip facing upwards and a glass spacer, to which the lens system will eventually be attached, is glued to the CCD's glass side using optical glue such as 140-M light curing glue by DYMAX Corporation.

[**0074**] The CCD is now released from the jig, turned over such that the glass is at the bottom, and it is replaced in the special jig. Most of the CCD tape is now cut away using a scalpel. FIG. **20** shows the results of this operation comprising the CCD chip **184** with its legs **186** and CCD wire terminals **188**. A small strip of the CCD tape **190** is left to maintain the mechanical integrity of the chip.

[**0075**] The chip is now transferred to the especially designed holding jig shown in FIG. **21**. The chip is centered on chip support **192** and held firmly in place by tongue **194**. Z stage **196** is now raised past the chip support **196** causing CCD legs **186** to bend upwards around the sides of tongue **194** until they are bent into the configuration shown in FIG. **22**. Referring again to FIG. **21**, side walls **198** are advanced out of the interior of the holding jig to support the CCD wire terminals **188**. The Z stage is now moved upwards until it releases the CCD legs. The tongue **194** is now retracted into the jig and repositioned 0.3 mm from the edge of the CCD chip in order to clamp the chip in place while leaving room to attach the electronic components. The holding jig is now moved to the micromanipulator table where the electronic assembly will be completed.

[**0076**] The previously prepared electronic components assembly (FIG. **17**A) is placed on the CCD and secured to it by using UV glue such as 204-CTH by DYMAX Corporation using a precise glue dispenser such EFD ULTRA 1400+ micros dispense pen system and UV light curing system. The wires from the electronic sub-assembly and the two capacitors (FIG. **17**B) are attached to the CCD wire terminals by soldering as shown in FIG. **22**. The next step in the assembly procedure is shown in FIG. **23**. An electrically insulating pad support **200** comprising nine electrically conducting pads **202** and a hole **204** is placed between the CCD wire terminals above the capacitors and electrically connected to the driver assembly by soldering the pads to the CCD wire terminals. Finally, one wire is passed through

hole **204** and soldered to the resistor and nine more wires are soldered to each of the pads **202**. Once the electrical connections have been completed the entire assembly, from the back of the CCD to the top of the pads, is encapsulated using UV glue.

[**0077**] The encapsulated CCD is now turned over and a lens holder comprising a typically cylindrically shaped sleeve and the remainder of the elements of the lens system is glued to the CCD on the side where the glass is located. The encapsulated CCD is now placed into a suitably shaped titanium or stainless steel housing with the lens holder preferably projecting out of the front end of the housing. The ten wires at the top of the assembly are threaded through the titanium housing and the titanium housing is sealed to the lens-housing holder using biocompatible epoxy, for example EPO-TEK 353 ND.

[**0078**] Next, the 10 wires are connected by soldering or crimping to ten male micro connectors in a conductor support. The connectors comprise special pins such as Mill-Max Mfg. Corp cat. no. 8210 or Interconnect Devices, Inc. IDINET penta 0.

[**0079**] Finally the housing is filled with epoxy and closed by placing the connector support in its proximal end. Any excess glue is then wiped off to complete the creation of a totally closed (encapsulated) structure.

[**0080**] The housing of a camera head assembled according to the above described procedure and based on a 1/10' CCD will be on the order of 3-4 mm in diameter. From a practical point-of-view handling such a small camera head, for example when removing it from an endoscope, sterilizing it, or reattaching it to the same or another endoscope for another procedure will be an awkward procedure for the practitioner to carry out. To overcome this problem, in a preferred embodiment of the invention, the miniature camera head will be a permanent part of a sterilizable distal tip, which can be detached and reattached to the insertion tube of an endoscopic or laparoscopic device.

[**0081**] FIG. **24**A and FIG. **24**B show respectively the detachable distal tip of the invention **300** attached to and detached from the distal end of an insertion tube of an endoscope. In these and the following figures, the sheath surrounding the insertion tube and the articulation section, if the endoscope comprises one, is not shown.

[**0082**] FIGS. **25**A and **25**B are perspective views showing the distal and proximal faces respectively of the detachable distal tip of the invention. Distal tip of the invention **300** is made of a monolithic block of biocompatible material, e.g. a plastic polymer, stainless steel and Titanium. A number of bores through which the various channels of the endoscope pass to the distal tip pass longitudinally through the distal tip. In the figures can be seen bores for the working channel **340**, irrigation channel **342**, and two light channels **344**. A miniature camera head **310** of the type described hereinabove is embedded into distal tip **300** with the front lens of camera flush with the distal end of the distal tip and the internal connector **20** of the camera flush with the proximal end. In the outer surface of proximal end of distal tip **300** are several grooves **306**, each having a slot **304** at its distal end that are used for fastening distal tip **300** to insertion tube **302** as will be described hereinbelow.

[**0083**] FIG. **26** is a perspective view showing the distal end of an insertion tube of an endoscope **308** adapted to mate with the detachable distal tip of the invention. The interface between the distal end of the insertion tube **302** and the detachable distal tip **300** must be designed such that continuity of the various channels in the insertion tube will be preserved until the distal face. This is accomplished by extending the tubes that define these channels through the insertion tube such that they project out from the distal face. As can be seen in the figures, the irrigation channel **42**, working channel **40**, and two channels for the optical fibers **312** will slide into matching bores **342**, **340**, and **344** respectively in the distal tip. As a result when pressed together the extended channels slip tightly into the bores forming a tight seal between the insertion tube as well as providing mechanical strength to the connection between the two parts. To prevent possible damage to the optical fibers when the distal tip is attached or detached, channels **312** can be metal tubes with electro polished interiors or metal tubes filed with Grin lenses to diffuse the light and, if necessary, lenses at the distal end to properly distribute the light in the field of view of the camera. The optical fiber light guides in the insertion tube can end at the interface and light exiting the fibers coupled into the proximal ends of channels **312**, thereby providing optical continuity from the light source located proximally of the endoscope to the distal face. It is also possible to use light emitting diodes (LEDs) oor polymer light emitting diodes (PLEDs) located at the distal end of the insertion tube instead of illumination fibers. The internal electrical connector **20** of the camera **30** located on the proximal end of the distal tip **300** is forced into electrical contact with the external electrical connection **124** on the distal end of the insertion tube **302**, thereby permitting transfer of electrical power and signals to/from the camera head from/to the peripheral equipment at the proximal end of the endoscope as has been described hereinabove. Because of the very small size of the contacts on the camera head and distal end of the insertion tube, there is a possibility that good electrical connection might not be established; therefore it is preferred to use a matrix type conducting layer at the interface between the contacts as described hereinabove.

[**0084**] FIG. **27** is a cross-sectional view taken along the longitudinal axis of FIG. **24**A. In this figure it can be clearly seen how clasps **308**, on the distal end of the insertion tube **302**, fit into grooves **306** on distal tip **300** and snap into slots **304** to hold the distal tip in place.

[**0085**] Although embodiments of the invention have been described by way of illustration, it will be understood that the invention may be carried out with many variations, modifications, and adaptations, without departing from its spirit or exceeding the scope of the claims. In particular it is to be understood that, although the camera head of the invention has been described herein for use in endoscopy and laparoscopy, it is equally well-suited for use with any other type of probe or device in any conceivable application requiring the use of a miniature camera.

1. A reusable miniature camera head that can be attached to and detached from an object, said camera head comprising:

a housing;

a lens system at the distal end of said housing;

a solid-state sensor located adjacent to said lens system;

components of an electronic driver; and

an internal electrical connector located at the proximal end of said housing;

an external connector attached to said object

wherein, at least some of the wire terminals of said solid state sensor are directly electrically connected to electrical contacts on said internal electrical connector and said camera head is attached to or disconnected from said object by sliding electrical contacts on the proximal face of said internal electrical connector into or out of matching electrical contacts on the distal face of said external electrical connector;

characterized in that at least some of said components of an electronic driver are glued directly to the back of said solid-state sensor.

2. A camera head according to claim 1, wherein the solid-state sensor is selected from the following group:

a Charge Coupled Device (CCD);

an Intensified Charge Coupled Device (ICCD);

an Electron Multiplying Charge Coupled Device (EMCCD); and

a Complementary Metal Oxide Semiconductor (CMOS) device.

3. A camera head according to claim 1, wherein at least some of the components of the electronic driver are located outside of the housing.

4. A camera head according to claim 2, wherein the housing does not contain a PCB and at least some of the components of the electronic driver are attached directly to the back of the CCD.

5. A camera head according to claim 1, wherein the object is a rigid, semi-rigid, or flexible endoscope.

6. A camera head according to claim 1, wherein said camera head can be sterilized.

7. A camera head according to claim 6, wherein the sterilization is carried out in an autoclave.

8. A camera head according to claim 6, wherein the sterilization is carried out using chemicals.

9. A camera head according to claim 1, wherein said camera head is a permanent part of a sterilizable distal tip, which can be attached and detached to the distal end of the insertion tube of an endoscopic or laparoscopic device.

10. A camera head according to claim 1, wherein the housing has metallic electricity conducting strips arranged on its outside surface and the external electrical connector has metallic contacts arranged in such a way that they will engage said conducting strips when said housing is pushed into contact with said electrical connector.

11. A camera head according to claim 1, wherein the housing hermetically isolates the lens system, sensor, and components of the driver from the surrounding environment.

12. A camera head according to claim 1, wherein the housing is fabricated from a material selected from the group comprising:

titanium;

stainless steel; and

polymers.

13. A camera head according to claim 1, wherein circuitry is printed on the surface of one or more ceramic or polymer printed circuit boards (PCBs) and some or all of the components of the electronic driver are mounted on said PCBs.

14. A camera head according to claim 1, wherein the electronic driver includes an amplifying component selected from:

an N-channel field effect transistor (FET); or

an amplifier circuit.

15. A camera head according to claim 14, wherein the amplifier circuit is a Maxim operational amplifier that includes several amplifying stages.

16. A camera head according to claim 1, wherein some or all of the resistive components of the electronic driver are implemented by utilizing burn resistors.

17. A camera head according to claim 1, wherein the lens system comprises a plurality of lens that together form an image with a field of view of between 60 and 140 degrees.

18. A camera head according to claim 17, wherein the lens system is designed for carrying out a procedure selected from the following group:

(a) a gastroscopy procedure by forming an image with a field of view of 120 to 140 degrees;

(b) an ERCP procedure by forming an image with a field of view of the camera head of the invention 120 to 140 degrees in the motherscope and by forming an image with a field of view of 100 degrees in the baby scope;

(c) a colonoscopy procedure by forming an image with a field of view of 120 to 140 degrees;

(d) a gynecology procedure by forming an image with a field of view of 100 to 120 degrees;

(e) a bronchoscopy procedure by forming an image with a field of view of 80 to 100 degrees;

(f) an ENT procedure by forming an image with a field of view of 80 to 100 degrees; and

(g) a transgastric procedure by forming an image with a field of view of 120 to 140 degrees in the motherscope and by forming an image with a field of view of 100 to 120 degrees in the baby scope.

19. A camera head according to claim 1, wherein the diagonal size of the CCD chip is in the range from approximately 1.01 mm to approximately 2.54 mm.

20. A camera head according to claim 19, wherein the diameter of the distal tip of the endoscope is in the range from approximately 1.6 mm to approximately 3.5 mm.

21. A camera head according to claim 17, wherein the first lens is glued to the CCD.

* * * * *

专利名称(译)	可重复使用的微型摄像头		
公开(公告)号	US20070182842A1	公开(公告)日	2007-08-09
申请号	US11/597760	申请日	2005-05-30
[标]申请(专利权)人(译)	MEDIGUS		
申请(专利权)人(译)	MEDIGUS LTD.		
当前申请(专利权)人(译)	MEDIGUS LTD.		
[标]发明人	SONNENSCHEIN ELAZAR SONNENSCHEIN MINELU GOVRIN AMIR SHEINBERG SHAI		
发明人	SONNENSCHEIN, ELAZAR SONNENSCHEIN, MINELU GOVRIN, AMIR SHEINBERG, SHAI		
IPC分类号	H04N5/225 A61B1/00 A61B1/04 A61B1/05 G02B23/24		
CPC分类号	A61B1/00124 A61B1/042 A61B1/051 H04N2005/2255 G02B23/2423 G02B23/2484 H04N5/2251 A61B1/053		
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外部链接	Espacenet USPTO		

摘要(译)

本发明是一种可重复使用的微型摄像头（10），其可以附接到物体上或从物体上拆下。摄像头包括：壳体（18），透镜系统（12），固态传感器（14），电子驱动器（16）的部件，以及位于近端的内部电连接器（20）。壳体和在其外表面上具有多个插座（22）或销（110）。该物体具有用于接收摄像头的外部连接器（24）。内部和外部电连接器包括在相对面上以匹配图案布置的多个销或插座，从而允许摄像头通过接合两个连接器而连接或断开。在本发明的优选实施例中，相机头所附着的物体是内窥镜或腹腔镜装置，固态传感器是电荷耦合装置（CCD），并且壳体不包含印刷电路板。