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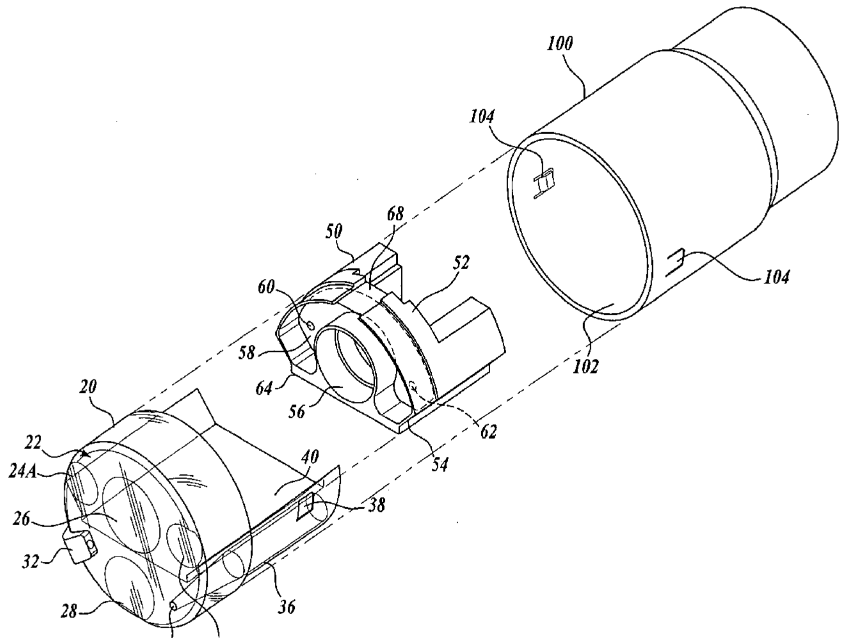
(54) **Title:** IMAGING ASSEMBLY WITH TRANSPARENT DISTAL CAP



(57) **Abstract:** An imaging assembly for use in a medical imaging device such as an endoscope or the like. In one embodiment, the imaging assembly includes a transparent distal cap that is shaped to receive an image sensor insert. The image sensor insert has a cooling channel that supplies a cooling liquid or gas to one or more illumination sources.

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IMAGING ASSEMBLY WITH TRANSPARENT DISTAL CAP

FIELD OF THE INVENTION

The present invention relates to medical devices, and in particular to medical devices that produce images of internal body tissues.

BACKGROUND

As an alternative to performing more invasive types of procedures in order to examine, diagnose, and treat internal body tissues, many physicians are using minimally invasive devices such as catheters and endoscopes to perform such tasks. Such medical devices are inserted into the body and routed to a point of interest in order to allow the physician to view and treat the internal body tissues. Generally such devices include some sort of image producing mechanism, such as a fiber optic imaging guide that transmits an image along a bundle of fibers to a proximal camera or eyepiece. Alternatively, video endoscopes or catheters include a small image sensor that produces images of the tissue electronically.

In a conventional endoscope, the distal tip of the device is often opaque and includes one or more windows or lenses that are used for the delivery of illumination light and an objective lens assembly for either transmitting an image to the proximal end of the endoscope or for focusing an image on an image sensor. While the opaque distal tips have generally been proven to work well, improvements can be made.

SUMMARY

The invention described here relates generally to an imaging assembly for a medical device and in particular, with respect to one embodiment, includes a transparent distal cap and an image sensor insert that is fitted into the distal cap. The image sensor insert includes a cooling channel that is thermally coupled to one or more illumination sources in the image sensor insert. In one embodiment, opaque shields may be added within the imaging assembly to prevent stray illumination light from leaking to the image sensor.

In one embodiment of the present invention, the imaging assembly is partially fitted within a metal ring of an articulation joint to shield circuitry in the imaging assembly.

In accordance with another embodiment of the present invention, the distal cap includes one or more molded lenses.

In accordance with another embodiment of the present invention, a thermistor is used to sense the temperature of the illumination sources. In one embodiment, the thermistor shares a common lead with the illumination sources and electronics that read a voltage across the thermistor compensate for a voltage on the common lead produced by current in the illumination sources.

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIGURE 1 is an exploded view of an imaging assembly in accordance with one embodiment of the present invention;

FIGURE 2 shows the imaging assembly of FIGURE 1 in an assembled configuration;

FIGURE 3 is a rear view of an image sensor insert that is a component of the imaging assembly in accordance with an embodiment of the present invention;

FIGURE 4 is a front isometric view of an image sensor insert in accordance with an embodiment of the present invention;

FIGURE 5 shows an imaging assembly including a distal cap, image sensor insert, and a circuit board in an assembled configuration in accordance with an embodiment of the present invention;

FIGURES 6A-6C illustrate a flex circuit and thermal clad circuit board used in an imaging assembly in accordance with an embodiment of the present invention;

FIGURE 7 illustrates how stray light from an illumination source can leak into an image sensor; and

FIGURE 8 illustrates how opaque sleeves can reduce the stray light in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION

As indicated above, the present invention is an imaging assembly for use in an endoscope or other medical imaging device. Although the disclosed embodiment of the invention is for use in an endoscope such as a colonoscope, bronchoscope, duodenoscope, and the like, it will be appreciated that the present invention is not limited to endoscopes but could be used in other medical imaging devices, such as catheters, for use in vascular, urinary, reproductive, ear, nose, and throat, applications, or the like.

FIGURE 1 is an exploded view of an imaging assembly for an endoscope in accordance with an embodiment of the present invention. The imaging assembly includes a transparent distal cap 20 that is positioned at the distal end of the endoscope. An image sensor insert 50 is received within the cap 20. The distal cap 20 and the image sensor insert 50 are secured to a distal portion of the endoscope shaft. In one embodiment, the assembly is secured to the distal most ring 100 of an articulation joint of the type that includes a series of linked metal or conductive rings (not shown) that allow the endoscope to bend in a desired direction under tension of one or more control wires.

In one embodiment, the transparent distal cap 20 is made of a plastic material such as clear polycarbonate. The cap 20 has a distal face 22 having a number of features molded therein. The distal face 22 includes a pair of windows 24a and 24b that allow illumination from an illumination source, such as LEDs positioned behind the windows, to reach the tissue to be imaged by the endoscope. In the embodiment shown, the windows 24a, 24b are flat, circular areas of clear plastic. However, lenses could be molded into the distal cap to change the pattern of illumination light distribution if desired.

In the embodiment shown, the windows 24a and 24b extend all the way to the outer rim of the distal cap 20. This allows the rim to be made smaller and to be smoothly rounded in order to provide increased patient comfort and reduce the chance of injury to the patient.

Positioned generally between the windows 24a and 24b is an opening 26 that is provided to receive an objective lens assembly for the image sensor. Below the opening 26 for the lens assembly is an opening 28 that serves as an entrance to a working channel of the endoscope. In one embodiment, the rim of the cap 20 is beveled in the area of the opening 28 to the working channel to provide a rounded edge and improve patient comfort. A port 30 is adjacent the opening 28 to the working channel and is connected to a tube (not shown) in the endoscope for application of a jet wash liquid from the endoscope. A second port 32 is positioned at the end of a nozzle that extends smoothly out from the edge of the distal face 22 and bends over to distal face to direct water across the front face of the objective lens assembly that is within the opening 26 and/or the windows 24a, 24b that are in front of the illumination sources. In addition, air or a gas can be delivered from the port 32 for insufflation of the patient as needed.

The proximal end of the distal cap 20 includes a stepped region 36 having a diameter slightly smaller than the diameter of the distal region of the cap 20. Therefore, the proximal region 36 of the distal cap 20 can fit within an opening 102 of the distalmost ring 100 of the articulation joint. The side surface of the proximal region 36 also includes one or more notches 38 that receive corresponding tabs 104 on the ring 100 of the articulation joint. The ring 100 may cover the majority of the sensor circuitry disposed at the distal tip of the endoscope, thereby providing electrical shielding to the circuitry when this ring is connected to an electrical ground.

The proximal end of the cap 20 also includes a flat receiving surface 40 that is oriented in a direction generally perpendicular to the plane of the distal face 22. The receiving surface 40 divides the distal cap into an upper portion and a lower portion. As will be described in further detail below, the image sensor insert 50 is slideable on the receiving surface 40 such that the components it holds are positioned behind the distal face 22 of the cap 20.

The image sensor insert 50 comprises a generally semicircular component 50 with a rounded upper portion 52 and a generally flat bottom surface 54. The bottom surface 54 rests on the receiving surface 40 of the distal cap 20 while the rounded upper portion 52 fits behind the upper portion of the distal face 22 of the cap 20. In the center of the image sensor insert 50 is a cylindrical bore 56 into which an image sensor objective lens assembly (not shown) is fitted. The cylindrical bore 56 also includes a shoulder or lip therein to limit how far the objective lens assembly can be inserted into the bore 56 in order to aid in focusing the lens assembly. In addition, the shoulder or lip helps to prevent stray illumination light from reaching the image sensor.

In one embodiment, the image sensor objective lens assembly is formed in a lens barrel that secures the lenses and other components together as a group. The barrel is adhesively or otherwise secured in the cylindrical bore 56 at a position that focuses the light onto the image sensor. In another embodiment, the lenses and other components of the objective lens assembly can be held directly in the cylindrical bore 56 without a lens barrel.

Surrounding the bore 56 is a semicircular cooling channel 58 in which a cooling liquid or gas is passed. The cooling liquid or gas enters and exits at a pair of ports 60, 62 at opposite ends of the channel. The ports 60, 62 are coupled to tubes within the endoscope that deliver and return the cooling liquid or gas. A lip 64 surrounds the inner perimeter of the cooling channel 58 and provides a support for a circuit board that is seated within the channel 58, as will be described in further detail below. A channel or notch 68 extends proximally from the front of the image sensor insert 50 over the curved upper portion 52 of the image sensor insert 50 to allow passage of a current-carrying circuit or wires that carry current to the illumination devices and a thermistor on a circuit board, as will be described in further detail below.

FIGURE 2 illustrates the distal cap 20 fitted within the distal ring 100 of an articulation joint. The tabs 104 on the ring fit within the corresponding notches 38 on the distal cap 20, thereby securing the two parts together.

In final assembly, an outer sheath (not shown) covers the articulation joint 100 and a seam 106 where the articulation joint meets the distal cap 20. In one embodiment, the sheath is made of a biocompatible polymer such as polyurethane or the like.

FIGURE 3 illustrates further detail of the image sensor insert 50 when viewed from the rear or proximal end. Positioned on either side of the image sensor insert is a pair of proximally extending legs 70 and 74. Each leg 70, 74 has a corresponding lumen 72, 76 therein that delivers a cooling liquid or gas to the two ports 60, 62 that open to the cooling channel 58. The lumen 76 is in fluid communication with the port 60 and the lumen 72 is in fluid communication with the port 62 as shown in FIGURE 1. Each of the legs 70, 74 also includes an inwardly facing step 78a, 78b that provides a support for a circuit board to be secured to the image sensor insert 50 as can be seen in FIGURE 5.

The image sensor insert 50 also includes a recessed, rectangular image sensor receiving surface 80 that is oriented in the same plane as the distal face 22 of the distal cap 20. The image sensor receiving surface 80 has a smaller circular or rectangular aperture 82 therein which opens to the cylindrical bore 56. The area surrounding the aperture 82 is generally flat so that an image sensor such as a CMOS or CCD imager (not shown) can be secured thereto with an adhesive or the like. In one embodiment, the aperture is larger than the area that forms the image on the image sensor so that no imaging pixels are wasted.

In the embodiment shown, one or more alignment bosses 86 are positioned at the sides of the image sensor receiving surface 80. The bosses 86 are configured as small semicircular protrusions on two sides of the image sensor receiving surface 80 and serve to align an image sensor positioned therein.

FIGURE 4 shows further detail of the image sensor insert 50 from the front or distal end. As indicated above, the image sensor insert has a shape that is designed to be slideably received behind the distal face of the distal cap 20. A raised lip 90 over the curved upper portion 52 of the insert 50 limits the depth to which the insert can be fitted into the distal cap 20. In the embodiment shown in FIGURE 4, a semicircular thermal clad circuit board 150 is shown seated on the rim 64 surrounding the cooling channel 58. The circuit board 150 supports one or more illumination LEDs 154 and 156 as well as a thermistor 158. The thermistor is generally positioned above the cylindrical bore 56 that receives the imager objective lens assembly.

In one embodiment, leads that provide power to the LEDs 154, 156 as well as leads that connect to the thermistor 158 are provided on a rigid circuit board or by direct connect wires. In another embodiment, leads that provide power to the LEDs 154, 156 as well as leads that connect to the thermistor 158 are included on a flex circuit. The flex circuit is secured to the circuit board 150 and extends over the top of the image sensor insert through the channel 68 as shown in FIGURES 1 and 3.

As will be appreciated by viewing the bottom of the image sensor insert 50 shown in FIGURE 4, the bottom of the image sensor insert 50 is generally flat and does not contain any openings in order to protect the image sensor and associated electronics from dirt, moisture, etc., during assembly and use. In one embodiment, the image sensor insert 50 is molded from a plastic material such as ABS acetyl butyl styrene.

FIGURE 5 shows the image sensor insert 50 fitted within the distal cap 20. In addition, a circuit board 160 is seated in the steps 78a, 78b of the image sensor insert as shown in FIGURE 3. In one embodiment, the circuit board 160 is bonded to the steps 78a, 78b of the proximally extending legs 70, 74 with an adhesive or the like. Also shown in FIGURE 5 are the lumens in the lower portion of the distal cap 20 that deliver the gas/water to the ports on the distal face. A lumen 42 delivers water to the lens wash port 32 and a lumen 44 delivers the insufflation gas to the port 32. A lumen 46 delivers water to the jet wash port 30.

FIGURE 6A shows a top side of a flex circuit 170 that provides power to the LEDs and connects to the thermistor. On the top of the flex circuit 170 is a series interconnect 172 that connects each of the illumination LEDs in series.

The bottom side of the flex circuit 170 is shown in FIGURE 6B. The bottom of the flex circuit includes a trace 174 that delivers current to the LEDs. A via 176 passes the current to the top side of the flex circuit and to the series interconnect 172. A second via 178 returns the current from the top side of the flex circuit to the bottom side of the flex circuit. A trace 180 returns the current delivered to the LEDs to its source electronics. The bottom side of the flex circuit also includes a pair of traces 182 that connect the thermistor to a circuit that measures the temperature of the distal tip. If the temperature is too high, the current to the illumination LEDs can be reduced or the procedure may be halted. It will be recognized that the pattern of traces on the flex circuit is exemplary of an embodiment of the present invention.

FIGURE 6C illustrates the thermal clad circuit board 150 on which the illumination LEDs and thermistor are mounted. As described above, the thermal clad circuit includes two pairs of pads 190, 192 upon which the illumination LEDs are bonded. The circuit board also includes interconnects 194 for connecting the power to the LEDs. In addition, the circuit board includes a pair of pads 196 positioned between the LEDs upon which the thermistor is bonded. The rear surface of the circuit board 150 is clad with a heat conductive material such as copper, gold, silver, aluminum or other biocompatible material to transfer heat from the LEDs to the cooling liquid or gas flowing in the cooling channel 58. In some embodiments, the front surface of the circuit board 150 may be coated with a reflective material such as aluminum to direct light emitted from the LEDs distally.

As shown in FIGURE 5, the other end of the flex circuit 170 is preferably inserted into a zero insertion force flex connector 200 on the circuit board 160. The zero insertion force connector 200 provides a simple way to assemble the distal tip without the use of complicated soldering operations or jumpers. In one embodiment, the thermistor and the LEDs share a common return lead extending from the circuit board 160 in the distal tip to external electronics in a remotely located control cabinet in order to reduce the number of wires in the endoscope. However, current from the LEDs can induce a voltage on this common lead that is read at the control electronics as appearing across the thermistor. This increased voltage can therefore make it appear as if the thermistor is cooler than it actually is. To compensate for this, the electronics can compare the voltage across the thermistor with a reference voltage that is based on the maximum drive current of the LEDs and the resistance of the common lead. Alternatively, the thermistor can have its own power and return leads to obtain more accurate readings from the thermistor.

As it will be appreciated from the above, the present invention provides a simple assembly for housing the imaging components of an imaging endoscope or other medical imaging device. Because the distal cap is made of a transparent plastic material, more light provided by the illumination components is able to reach the target tissue. Furthermore, because the distal tip is transparent, adhesive connections within the assembly can be cured by the application of curing energies, such as ultraviolet light, into the distal tip.

Although the present invention is described with respect to its currently preferred embodiments, it will be appreciated by those skilled in the art that changes could be made. For example, it is possible to place other components on the circuit board 150. For example, it may be desirable to place one or more additional LEDs on the board or elsewhere in the distal cap 20 to facilitate transillumination. Transillumination involves lighting the distal tip of an endoscope or catheter so that it can be seen from outside the body. A light source used for transillumination should have good tissue penetration such as red LEDs. The light source may be pulsed or strobed to aid in its detection. Power to the transillumination LEDs can be provided through the flex circuit. During transillumination, it may be desirable to darken the ambient light surrounding the patient and to disable any flickering light sources such as video display screens or the like in order to detect the light emitting from the distal tip.

In some situations, light from the illumination sources may leak to the image sensor when a transparent distal cap is used. For example, FIGURE 7 illustrates a transparent distal cap 250 on an endoscope or other medical device. The distal tip includes LED illumination sources 252 and 254. Light from those sources can reflect off the surfaces of the distal cap and otherwise leak to an image sensor 260.

In accordance with another aspect of the present invention, opaque shields 270, 272, 274 are added in front of the illumination sources and/or the image sensor to reduce the light leakage and prevent light from escaping in a direction other than through the windows in the distal cap. The opaque shield 274 in front of the image sensor 260 reduces light leaking indirectly to the image sensor. The opaque shields may be molded cylinders or other shapes and made from a black or other opaque plastic material. Alternatively, the shields may be made from an opaque film or coating placed in the cavities of the distal end cap. With the shields in place, only illumination light that is reflected off a tissue sample reaches the image sensor.

Although the present invention has been described with respect to disclosed embodiments, it will be appreciated that changes may be made without departing from the scope of the invention. For example, the illumination sources may comprise incandescent lights or fiber optic light guides to deliver light produced from an external source. Therefore, it is intended that the scope of the invention be determined from the following claims and equivalents thereof.

CLAIMS

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An assembly for an imaging medical device, comprising:

a transparent distal cap;

an image sensor insert that is fitted within the transparent distal cap, the image sensor insert including:

one or more illumination sources;

a cooling channel for removing heat from the illumination sources;

one or more imaging lenses; and

an image sensor.

2. The assembly of Claim 1, wherein the image sensor insert also includes a thermistor thermally coupled to the illumination sources.

3. The assembly of Claim 2, wherein the thermistor is positioned between the illumination sources.

4. The assembly of Claim 1, wherein the illumination sources are LEDs.

5. The assembly of Claim 4, wherein the image sensor insert includes a flex circuit that delivers current to the LEDs.

6. The assembly of Claim 5, wherein the image sensor insert includes a channel positioned over the image sensor insert in which the flex circuit is positioned.

7. The assembly of Claim 1, wherein the transparent distal cap is molded of a clear plastic material.

8. The assembly of Claim 1, wherein the transparent distal cap includes integral windows positioned in front of the illumination sources, wherein the windows have an edge that extends to a rounded edge of the distal cap.

9. The assembly of Claim 1, further including a transillumination light source positioned behind the transparent distal cap that produces light to locate the distal tip of the medical device.

10. The assembly of Claim 9, wherein the transillumination light source is an LED.

11. The assembly of Claim 10, wherein the transillumination LED produces red light.

12. The assembly of Claim 1, wherein the image sensor insert is generally semicircular in shape and includes a central cylindrical bore for holding the one or more imaging lenses.

13. The assembly of Claim 7, wherein the cylindrical bore includes a stop that limits the depth of insertion of the imaging lenses in the bore.

14. An imaging assembly, comprising:

a distal cap having a distal face, one or more ports that deliver air/gas and a liquid out of the distal face, the tip further comprising a flat receiving surface that bisects the distal cap into an upper and lower semicircular section, and one or more lumens in the lower semicircular section that are fluidly coupled to the one or more ports in the distal face; and

an image sensor insert that is shaped to fit within the upper semicircular section of the distal cap, wherein the image sensor insert supports one or more illumination sources and an image sensor.

15. The imaging assembly of Claim 14, wherein the illumination sources are LEDs and the image sensor insert includes a cooling channel that passes a cooling liquid or gas that is thermally coupled to the one or more illumination LEDs.

16. The imaging assembly of Claim 15, wherein the image sensor insert includes a pair of proximally extending legs having lumens therein that are in fluid communication with the cooling channel.

17. The imaging assembly of Claim 16, wherein the pair of proximally extending legs supports a circuit board positioned between the legs.

18. The imaging assembly of Claim 15, wherein the image sensor insert includes a thermistor thermally coupled to the one or more illumination LEDs.

19. The imaging assembly of Claim 18, wherein the one or more illumination LEDs and thermistor are mounted on a circuit board that is in contact with the cooling channel within the image sensor insert.

20. The imaging assembly of Claim 14, wherein the one or more illumination sources are LEDs that are mounted on a circuit board that includes a coating to reflect light produced by the illumination LEDs.

21. A imaging assembly for use in a medical device, including:

a distal cap that includes:

one or more illumination LEDs;

an imager for producing electronic signals representative of tissue illuminated with light from the illumination LEDs; and

a thermistor thermally coupled to the one or more illumination LEDs, wherein the one or more illumination LEDs and the thermistor share a common lead for carrying current from the LEDs and thermistor to a remote control console;

the remote control console including circuitry for reading a voltage across the thermistor in order to measure the temperature of the distal cap, and wherein the circuitry compensates for a voltage from the voltage read across the thermistor due to current in the common lead from the illumination LEDs.

22. An imaging assembly for use in a medical device, including:

a transparent distal cap;

one or more illumination sources and an image sensor positioned behind a front face of the distal cap; and

one or more opaque shields within the transparent distal cap that shield the image sensor from light produced by the illumination sources.

23. An assembly for an imaging medical device, comprising:

a distal cap having a distal face and a proximal end;

an image sensor insert that is fitted within the distal cap, the image sensor insert including:

one or more illumination sources;

a cooling channel for removing heat from one or more illumination sources;

a bore in which one or more imaging lenses are positioned;

an image sensor and a circuit board including circuitry for transmitting signals produced by the image sensor to remotely located electronics;

an articulation joint comprising a number of individual rings including a distal most ring, wherein the proximal end of the distal cap is sized to fit at least partially within the distal most ring.

24. The assembly of Claim 23, wherein the distal most ring of the articulation joint is electrically grounded and shields the image sensor circuitry of the image sensor insert.

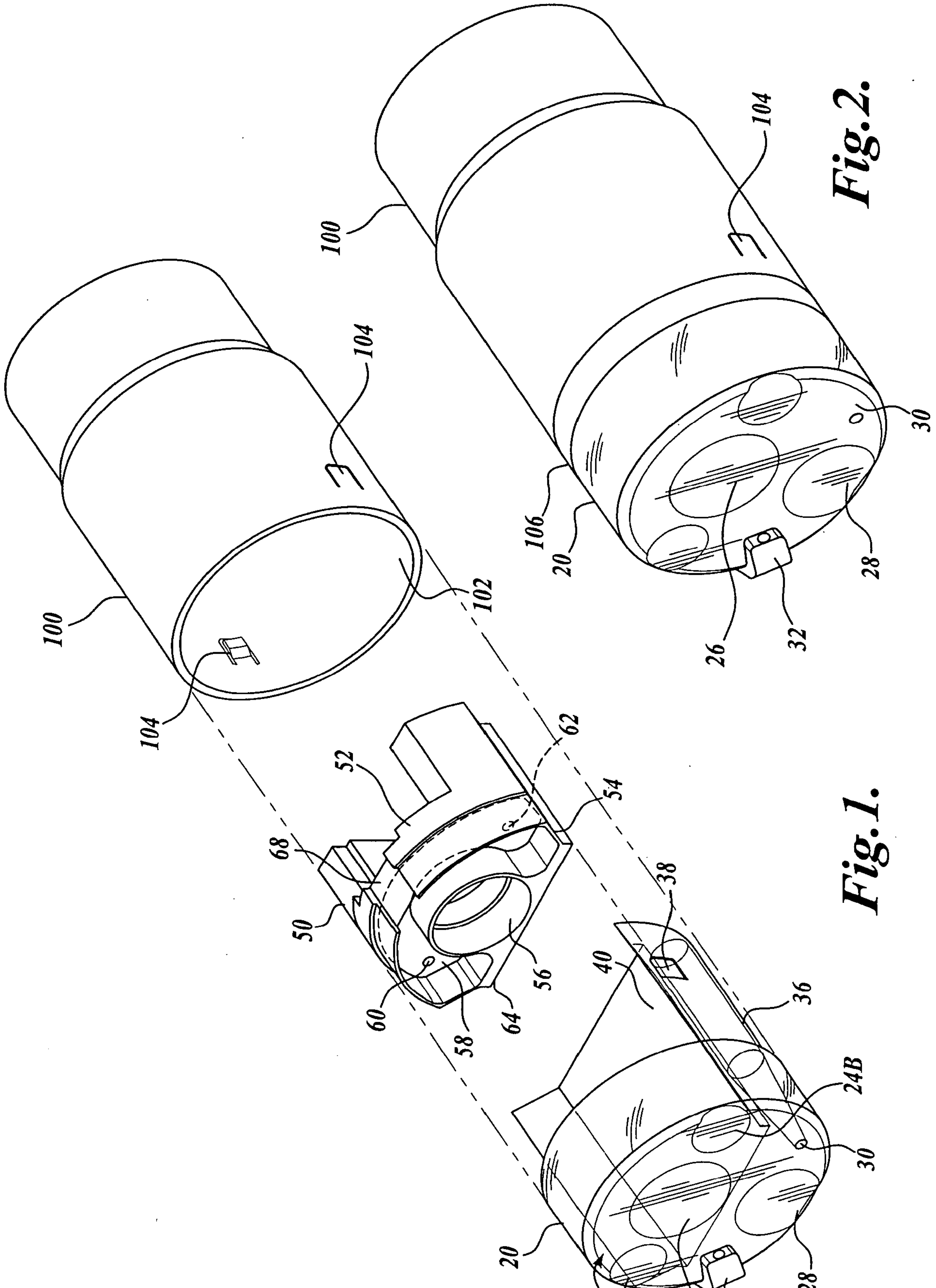
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Fig.2.

Fig.1.

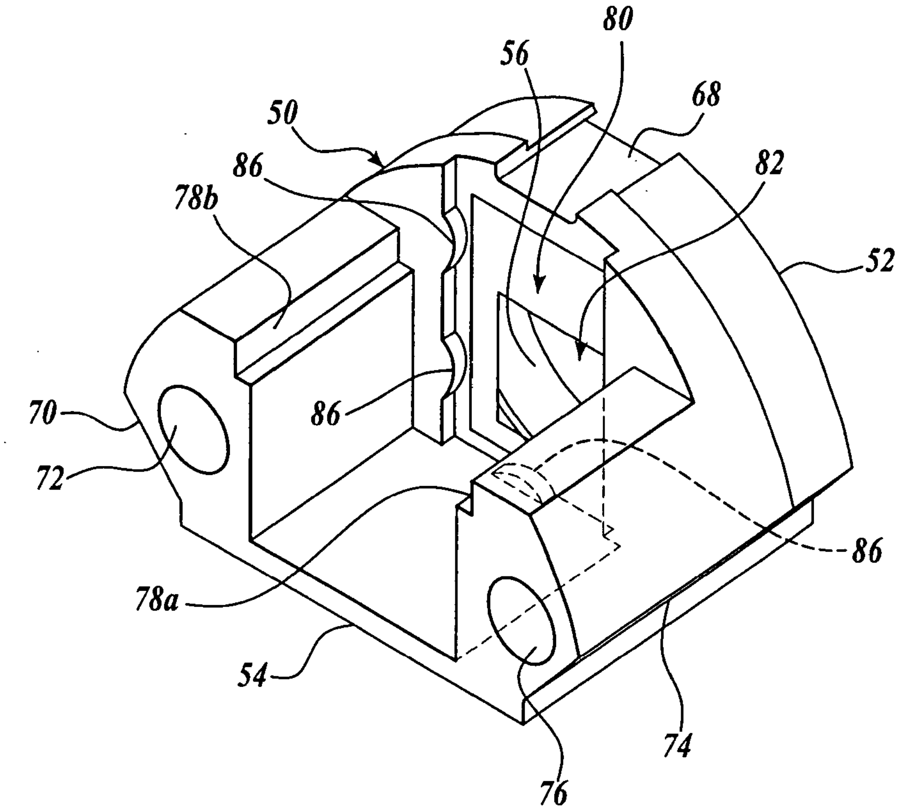
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Fig.3.

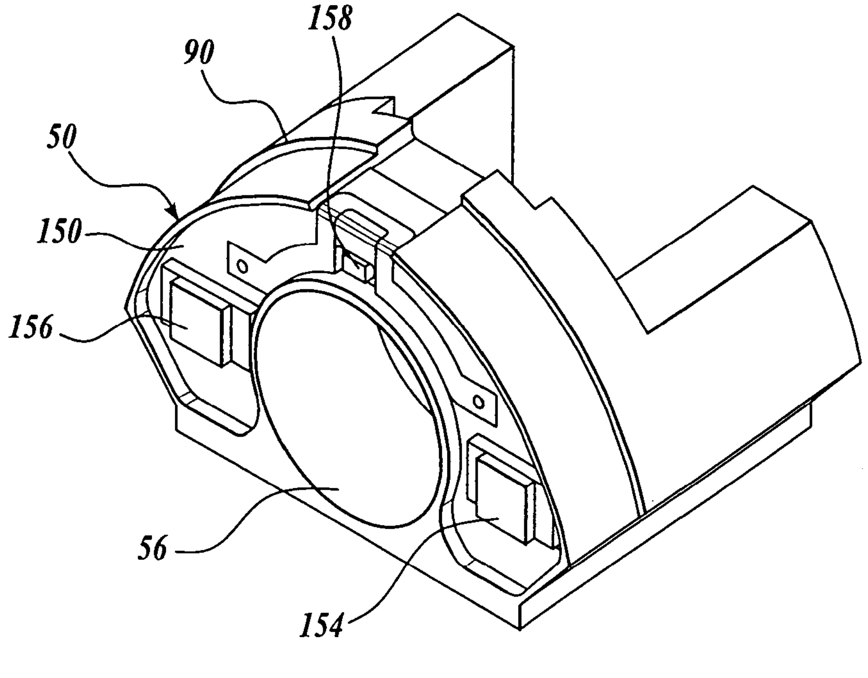
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Fig.4.

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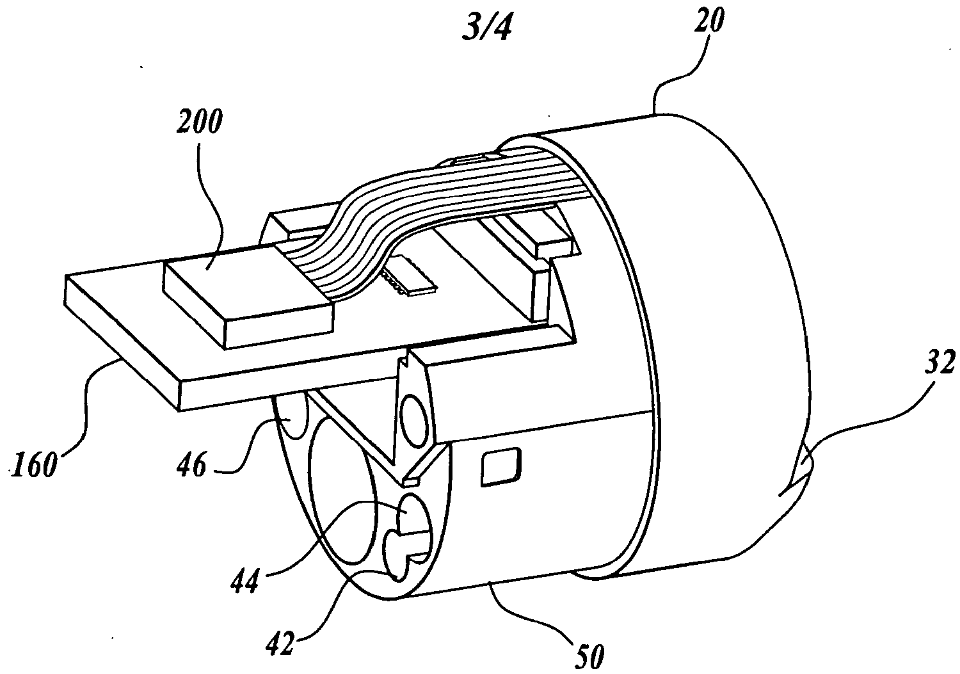

Fig. 5.

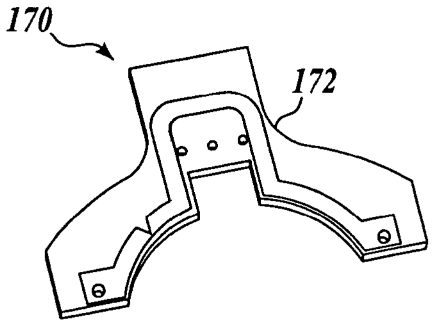

Fig. 6A.

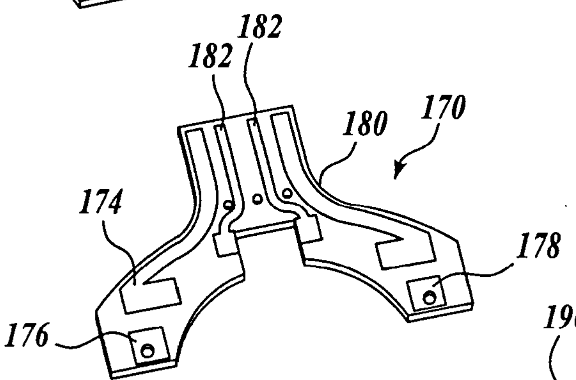

Fig. 6B.

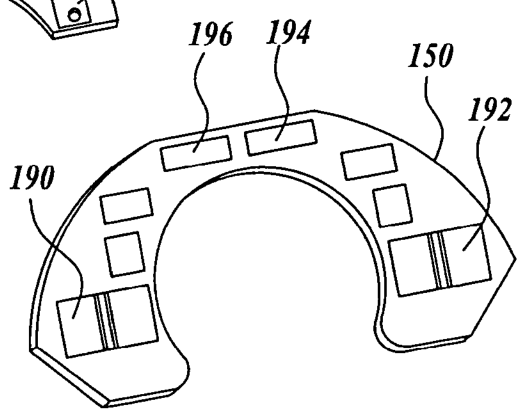

Fig. 6C.

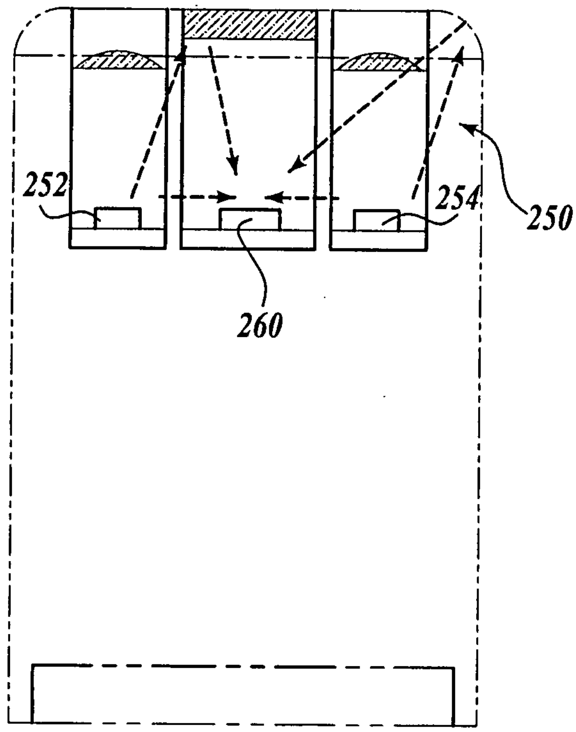

Fig. 7.

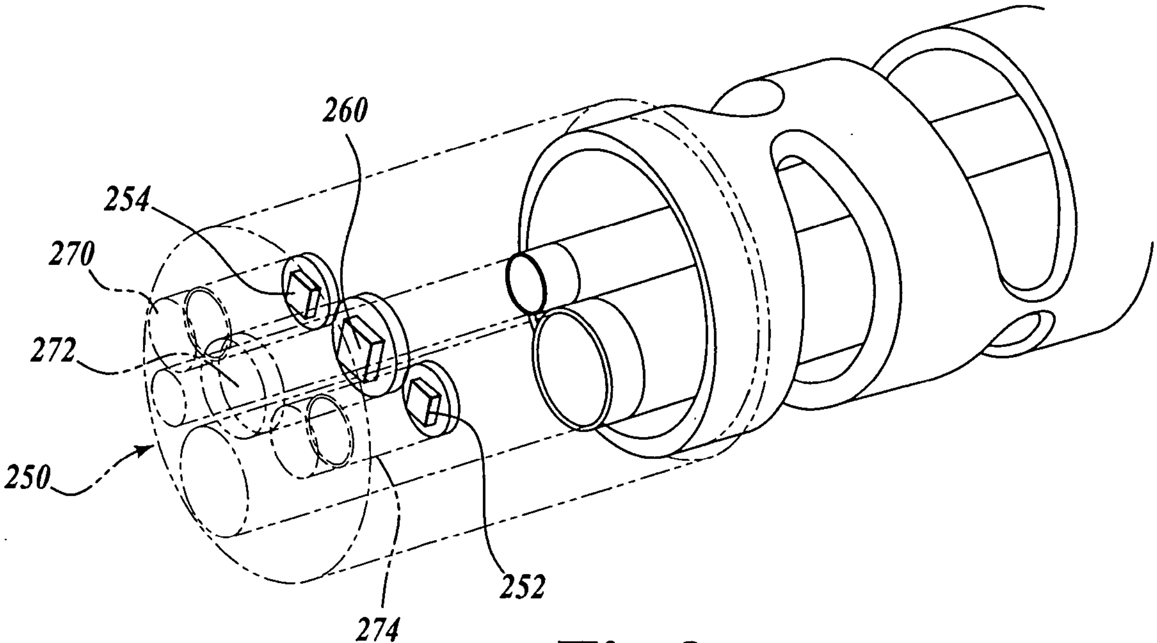

Fig. 8.