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(54) MEDICAL DEVICES FOR MINIMALLY INVASIVE SURGERIES AND OTHER INTERNAL PROCEDURES

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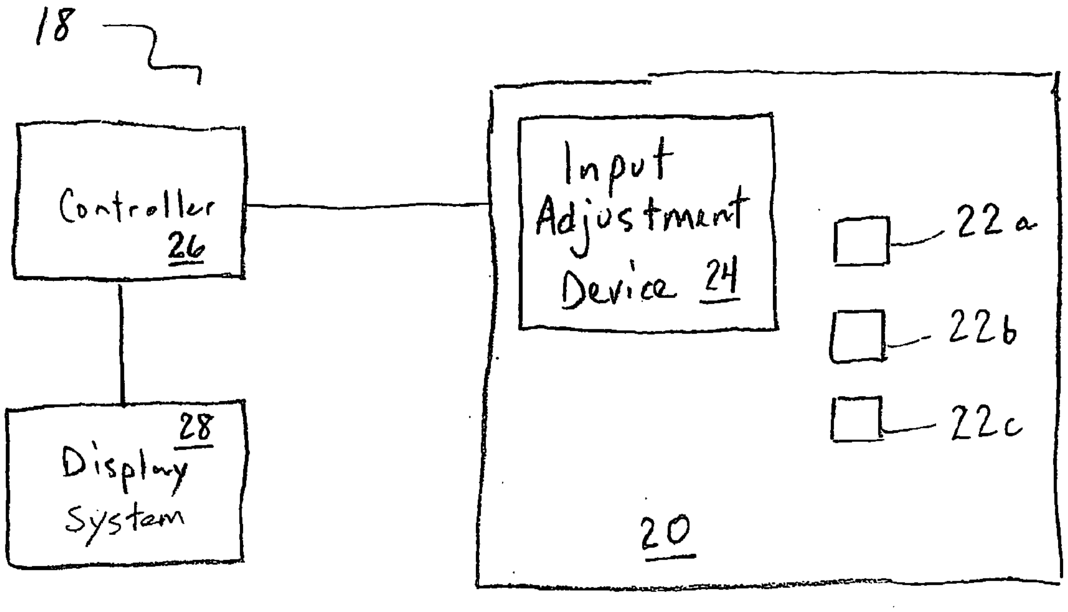
(57) **ABSTRACT**

Minimally invasive surgical devices and related tools are provided. The devices include image acquisition devices and forceps, scissors, clamps, ultrasound probes, lasers, cautery devices, staplers, knives, suturing devices, rivet drivers, ligation devices, aspiration devices, injection devices, biopsy devices, radiotherapy devices; and radioactive emitter loading devices. Other devices useful for internal procedures in a patient's body or for facilitating such procedures are also provided.



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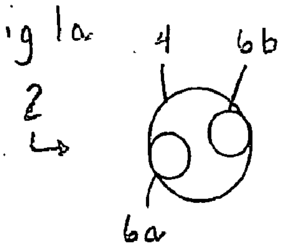
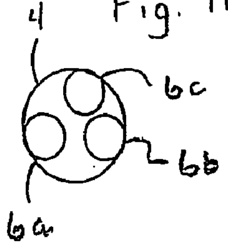


Fig. 1b



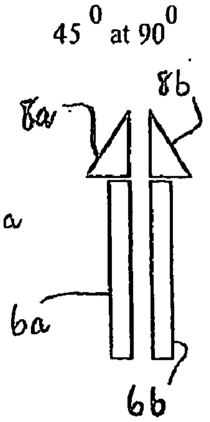
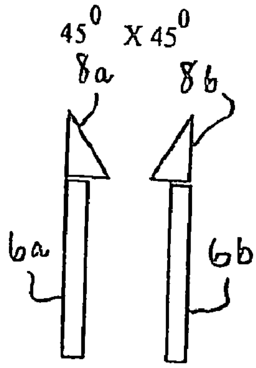


Fig 2a

Fig. 2b



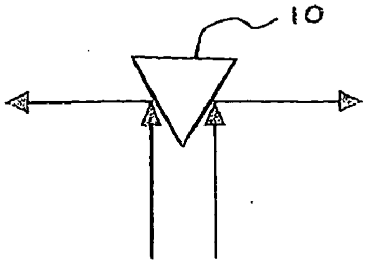


Fig. 2c

Fig. 3

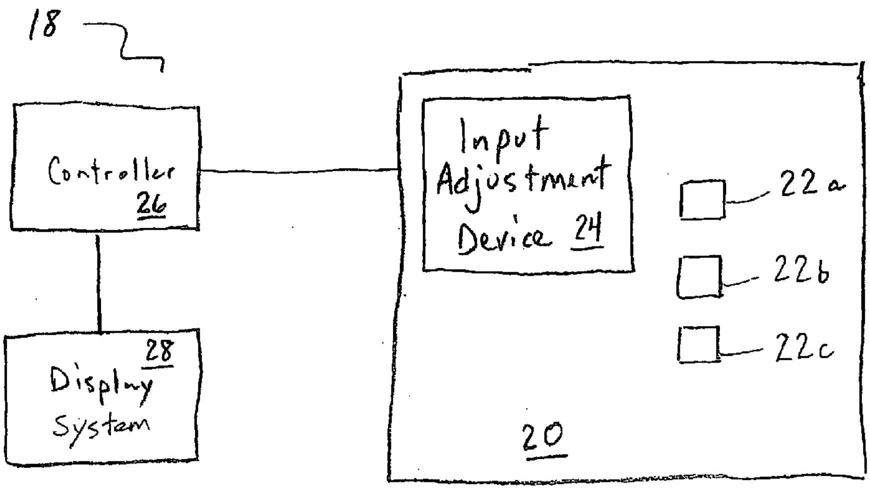
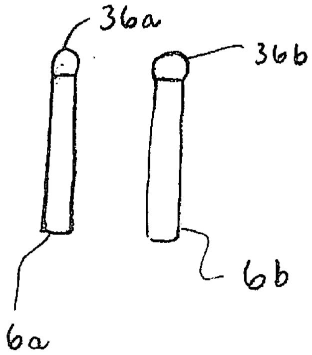


fig 4a



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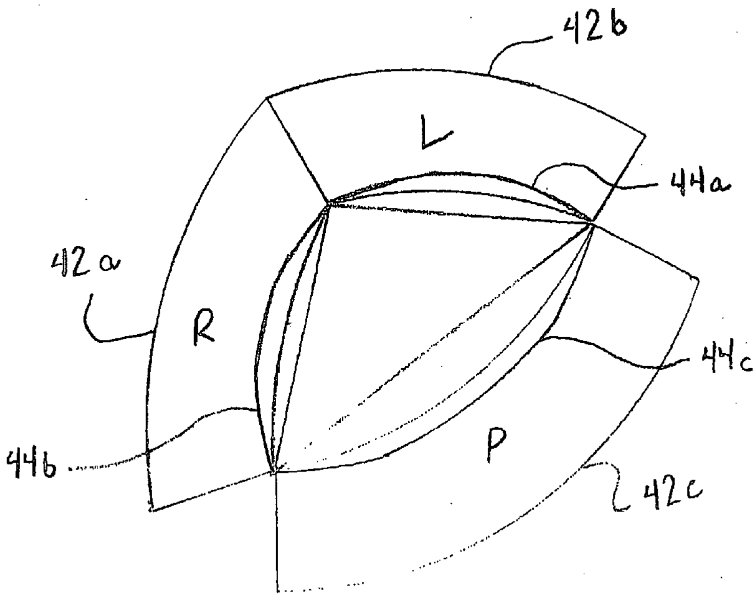

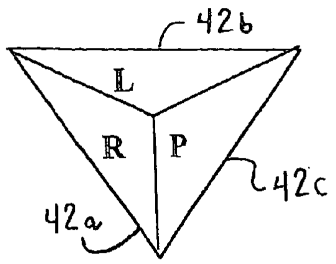

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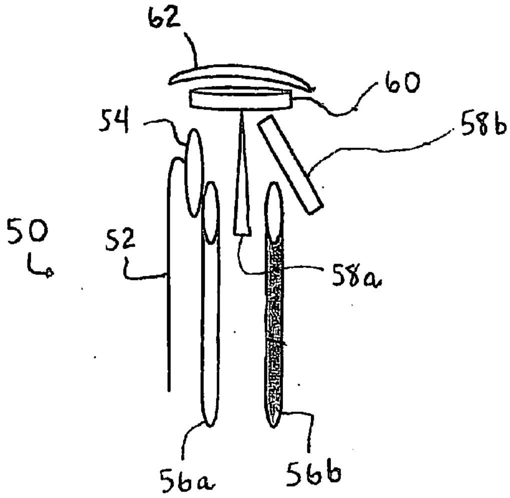
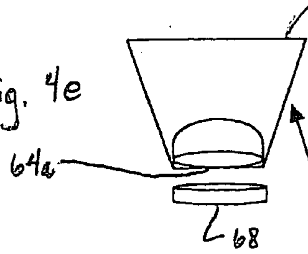


Fig. 4d

Fig. 4e



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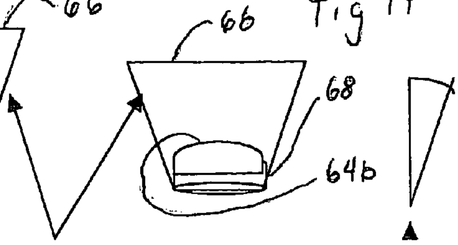

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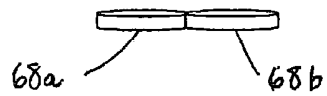

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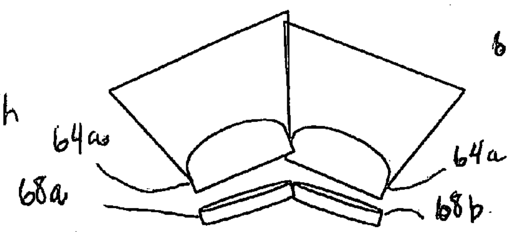

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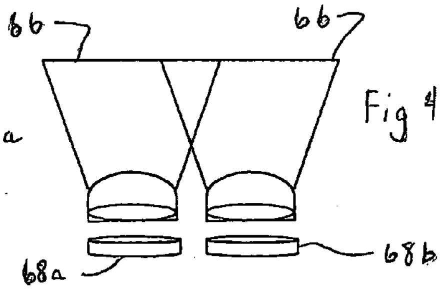

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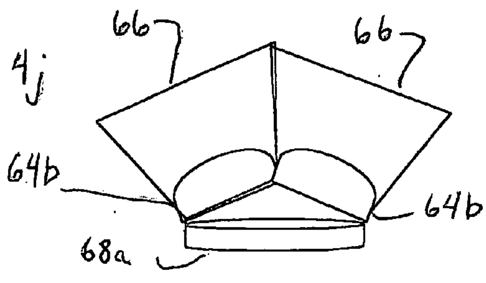

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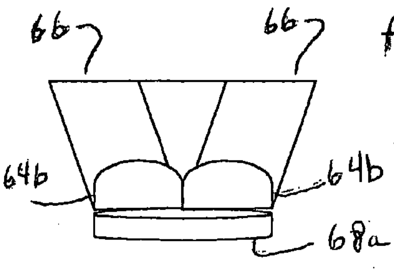

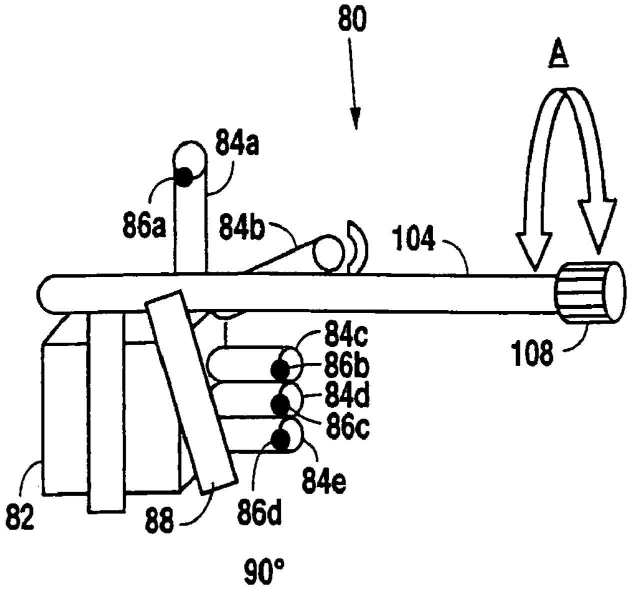

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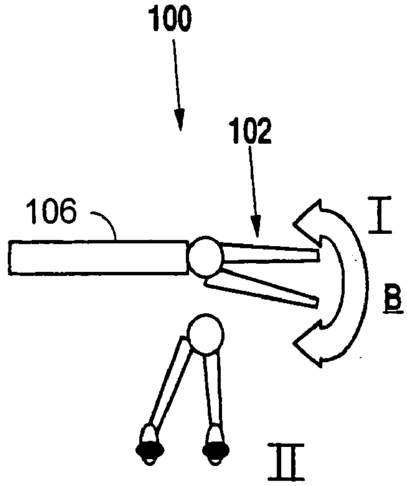

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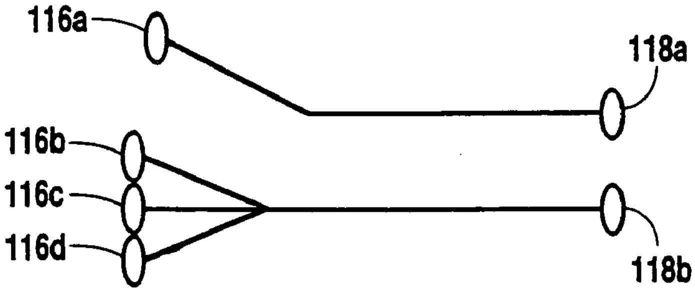

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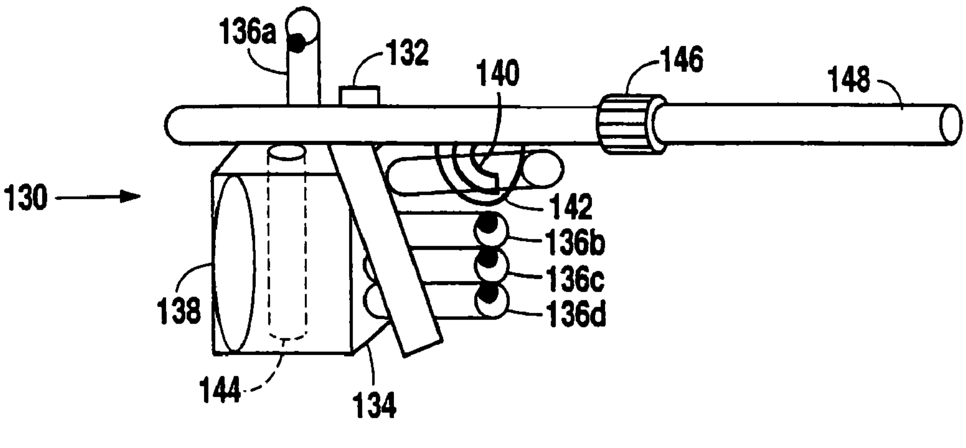

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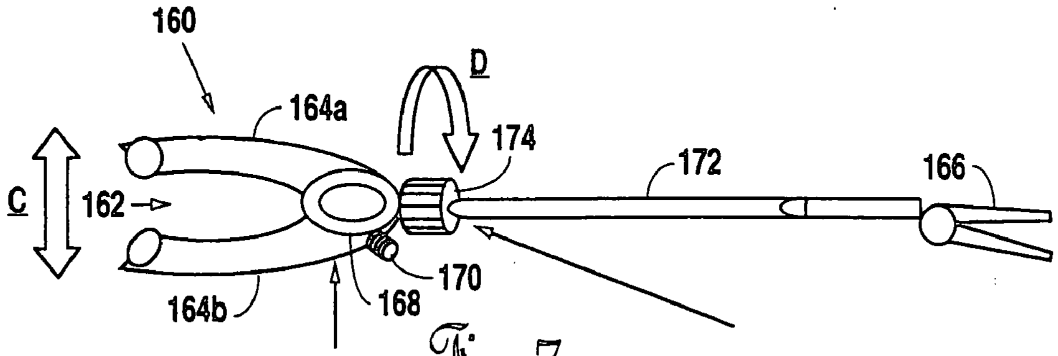

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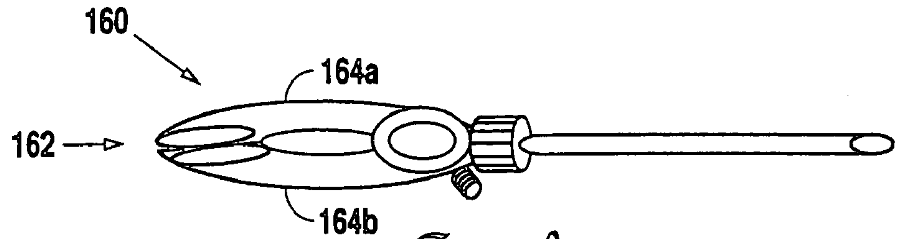

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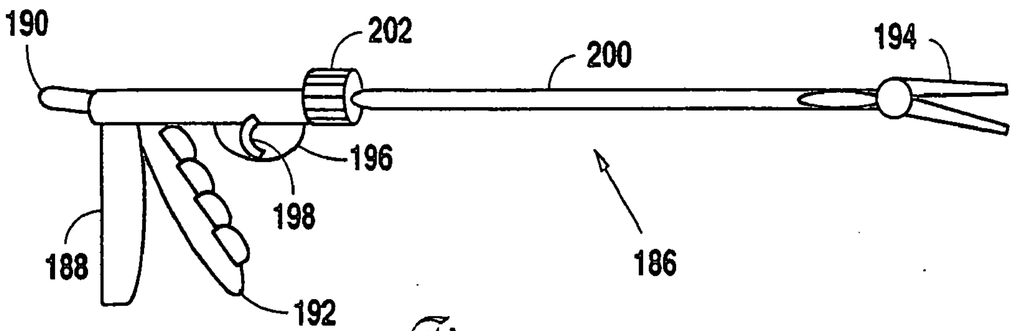

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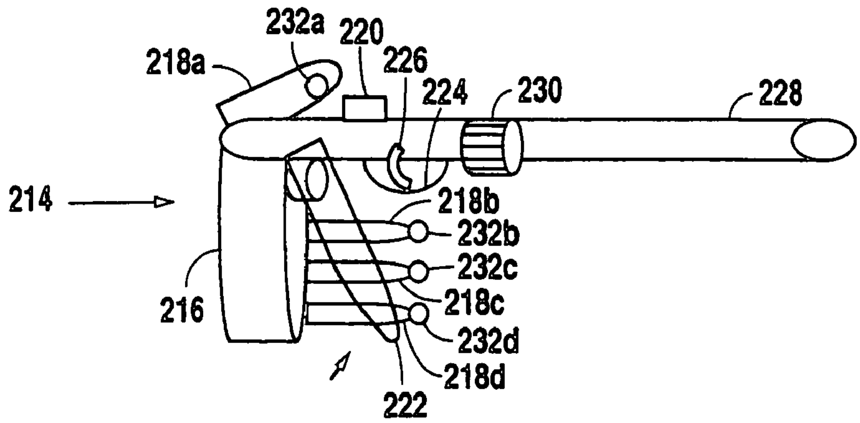

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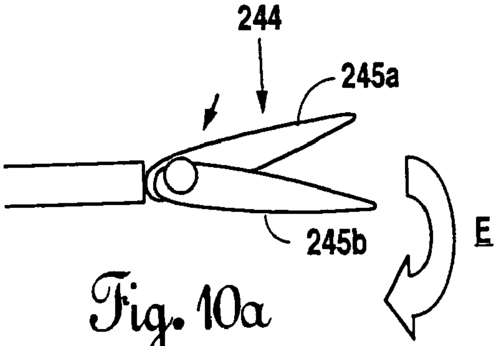

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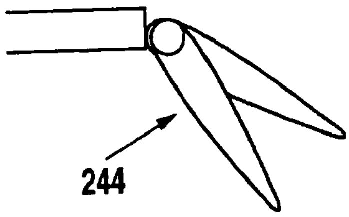

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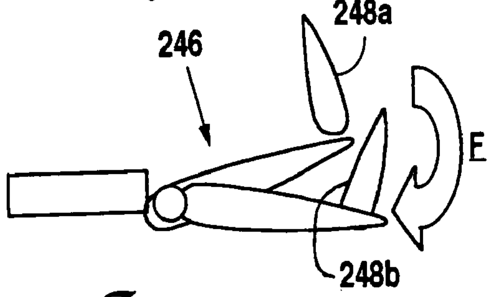

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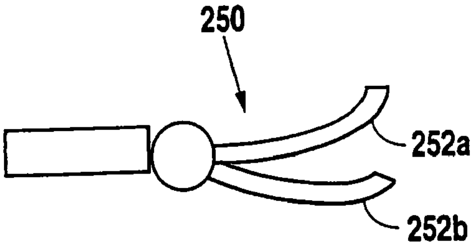

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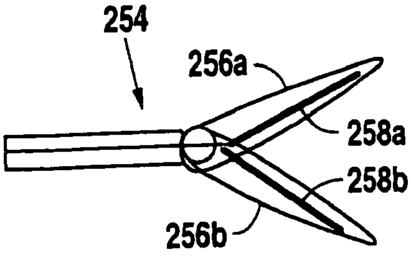

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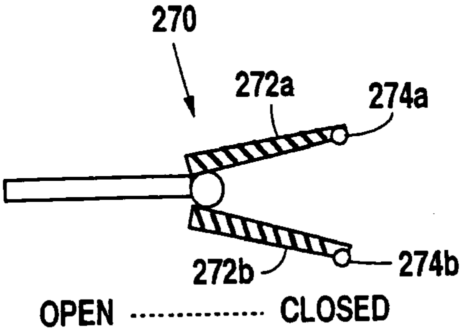

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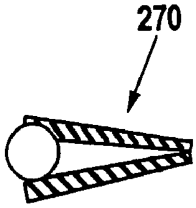

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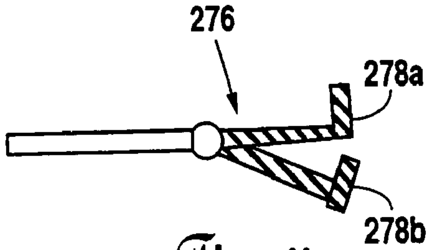

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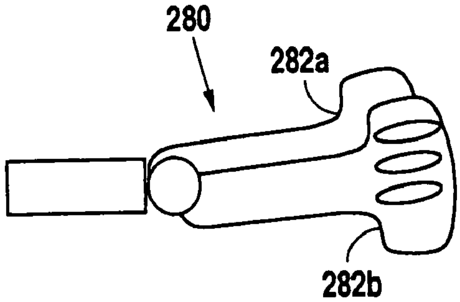

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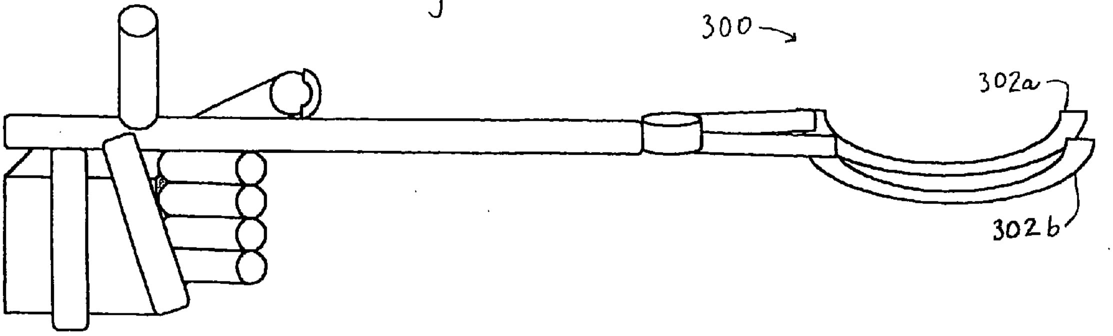

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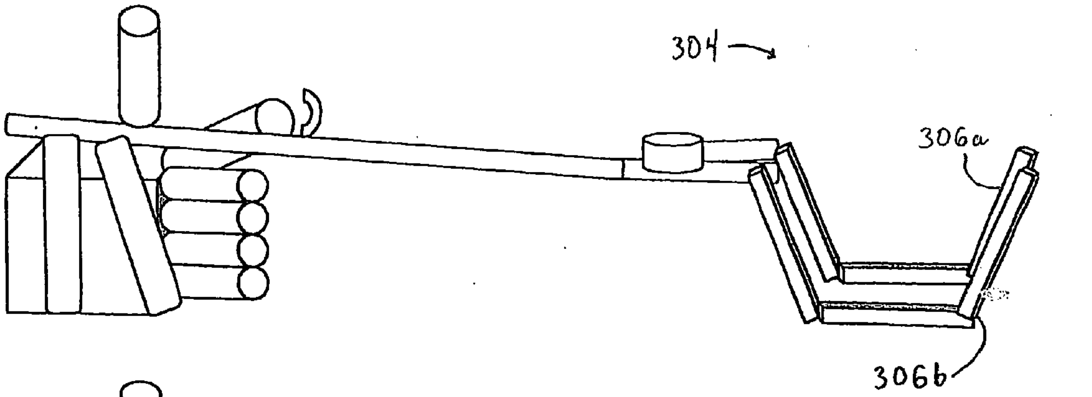

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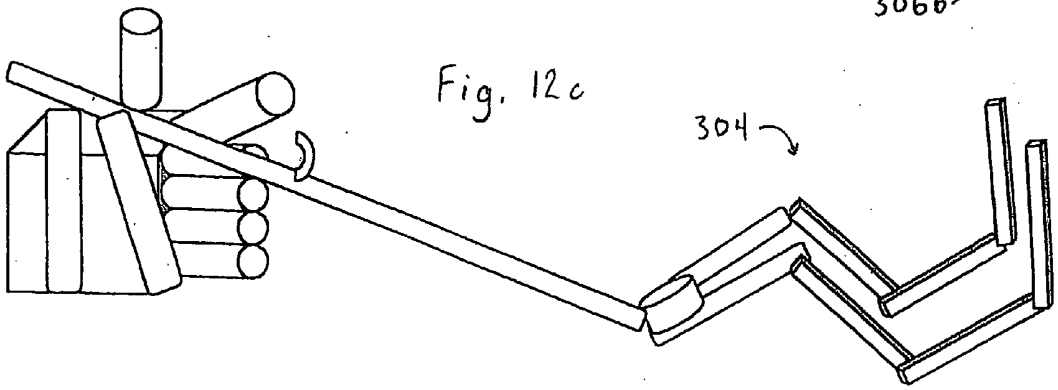

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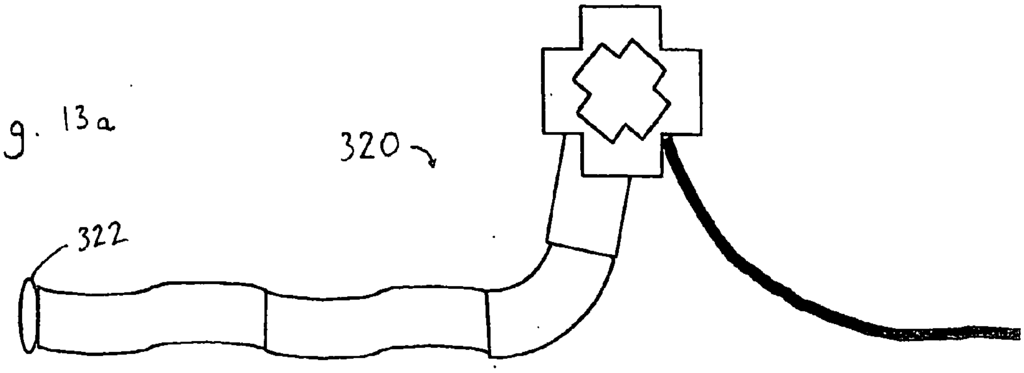

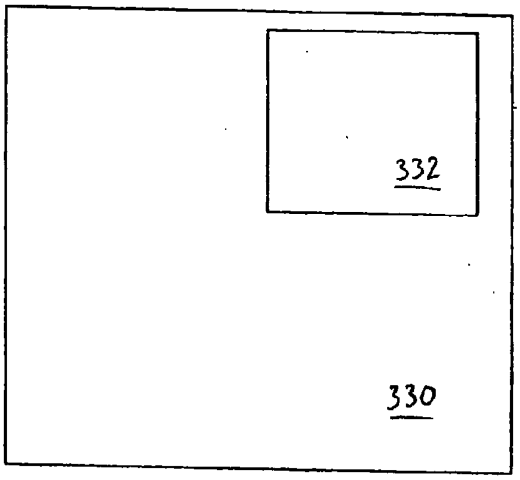

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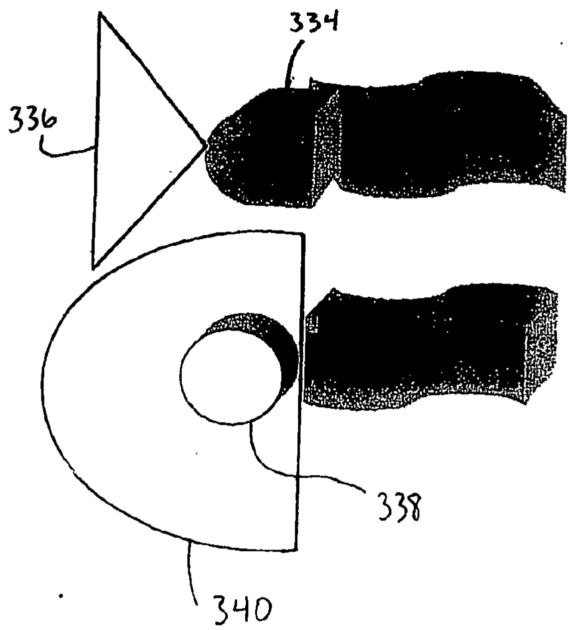
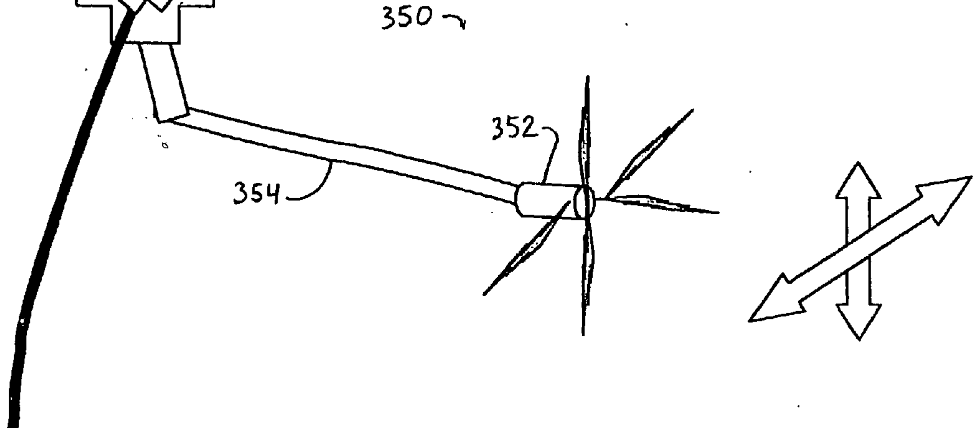


Fig. 13c

Fig. 14a



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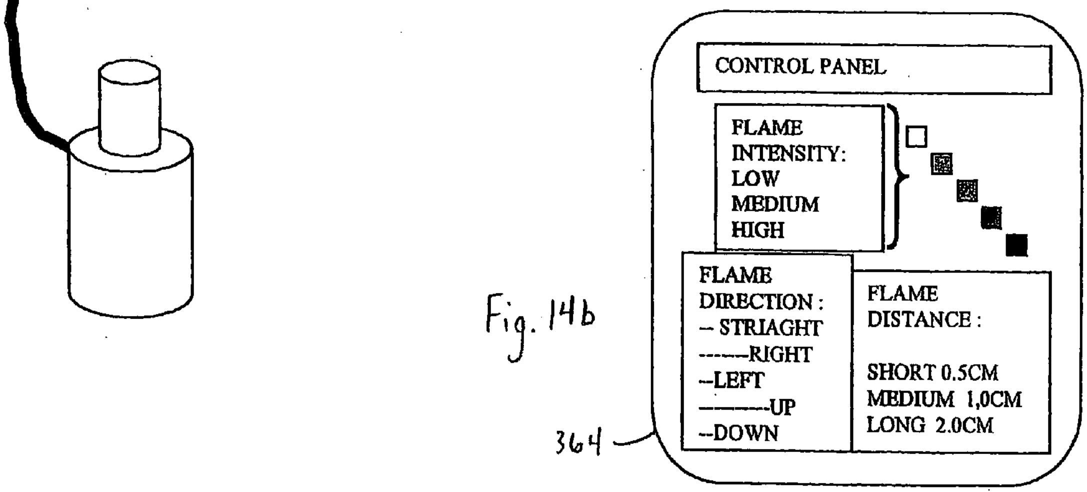

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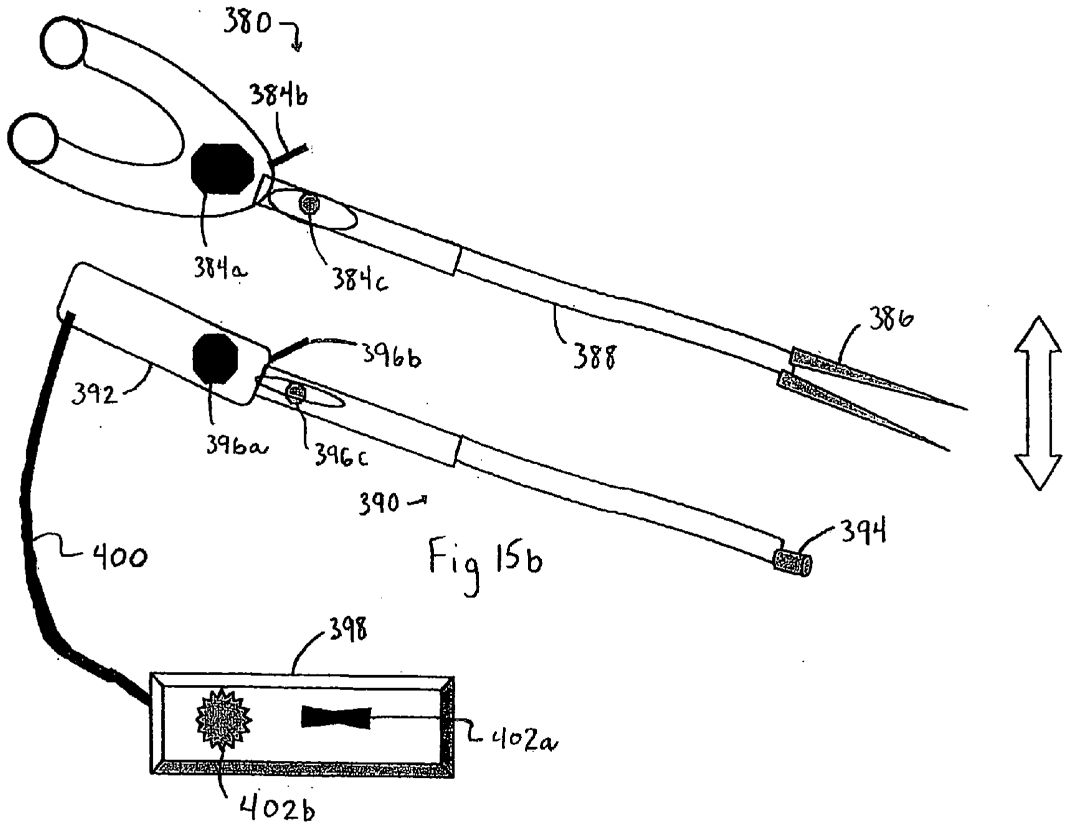
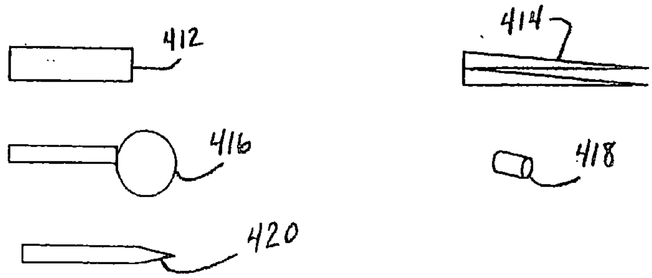
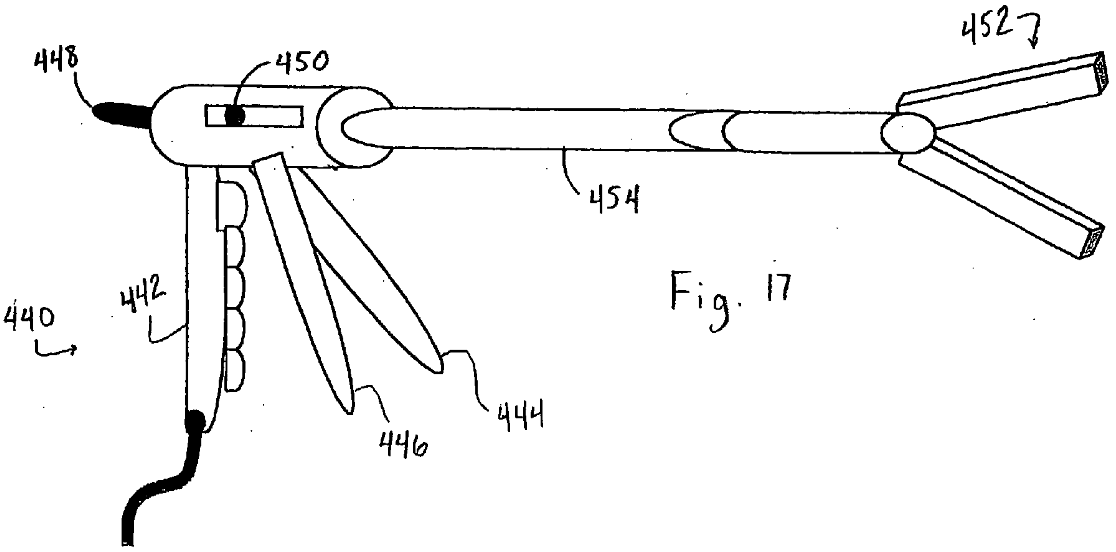


Fig 15b

Fig. 16





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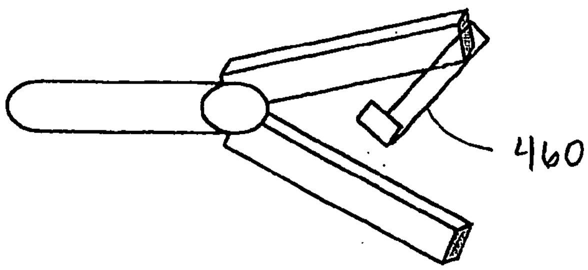

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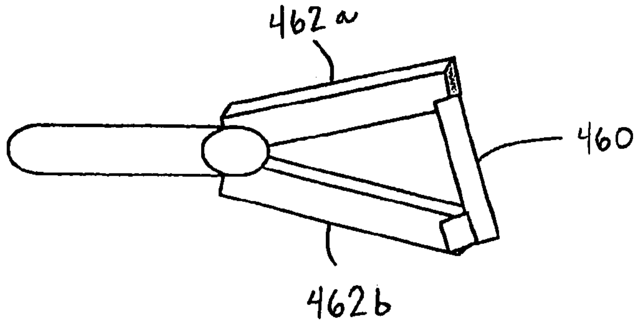

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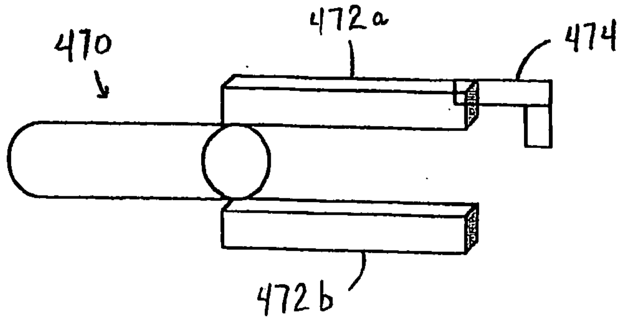

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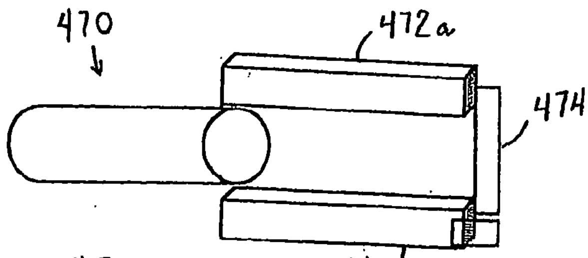

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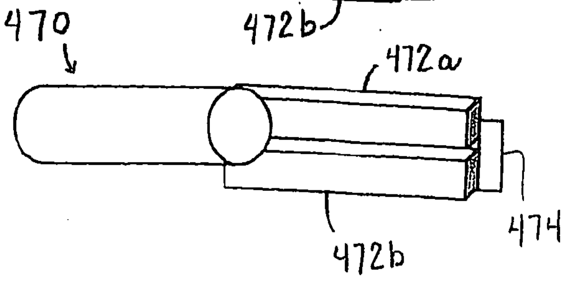
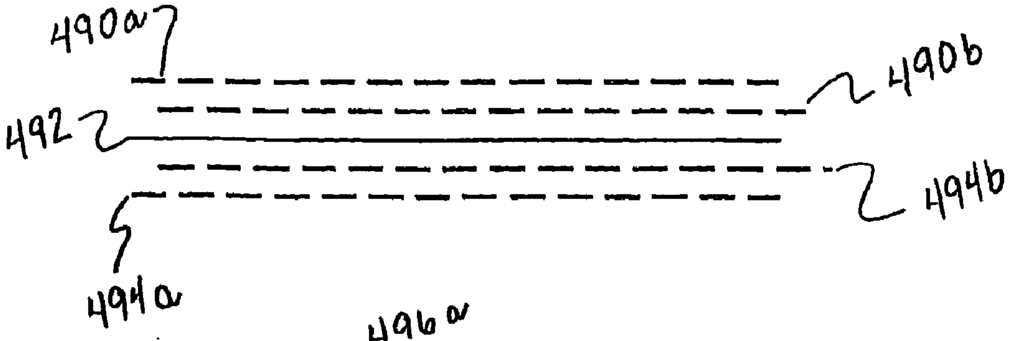
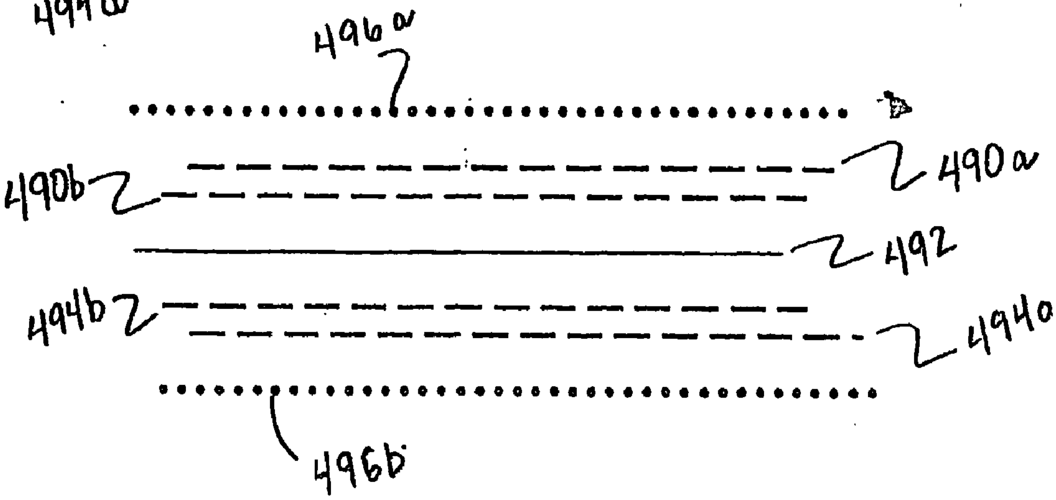


Fig. 19c

Fig. 20a





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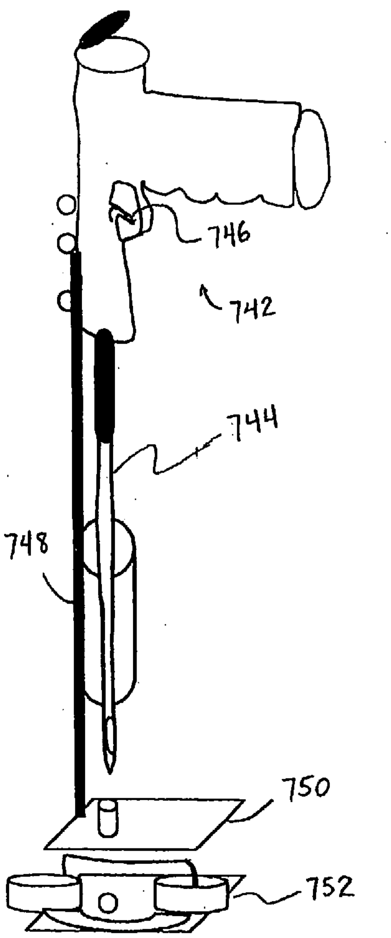
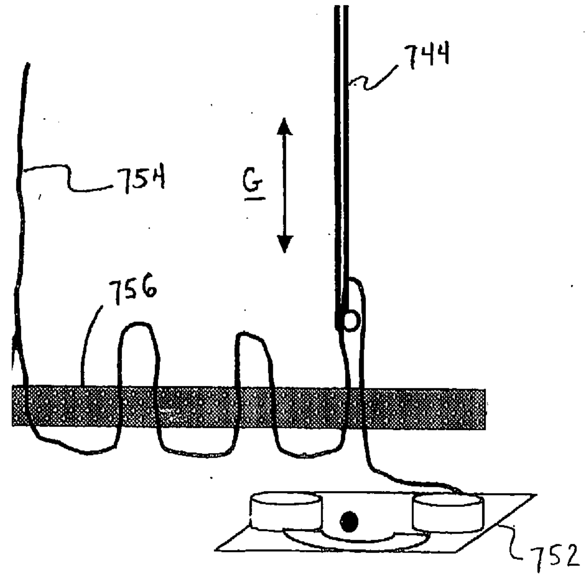


Fig. 21a

Fig 21b



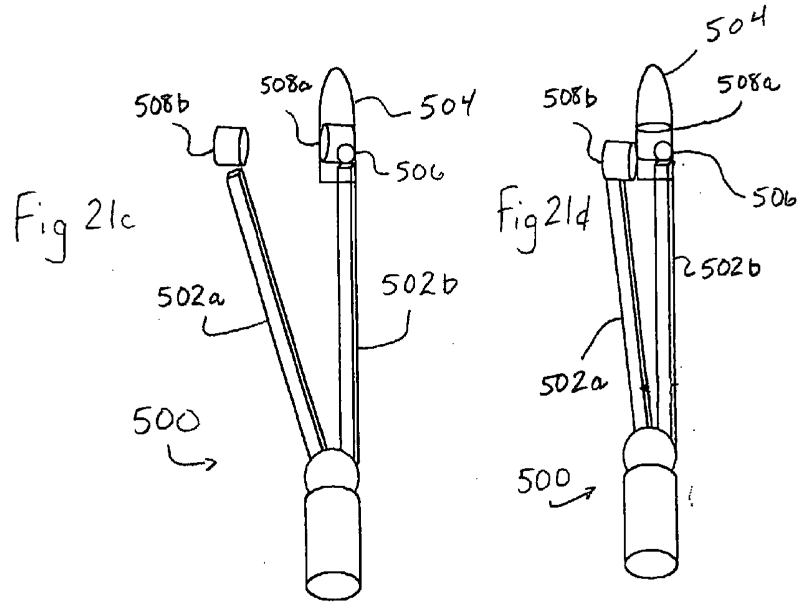

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Fig 21c
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Fig 21d
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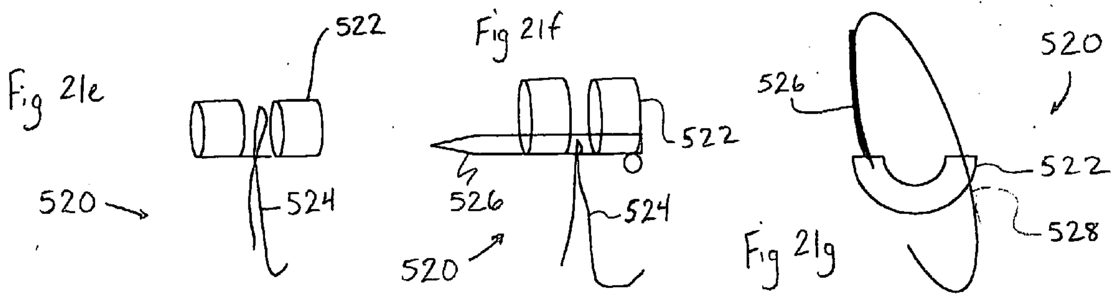
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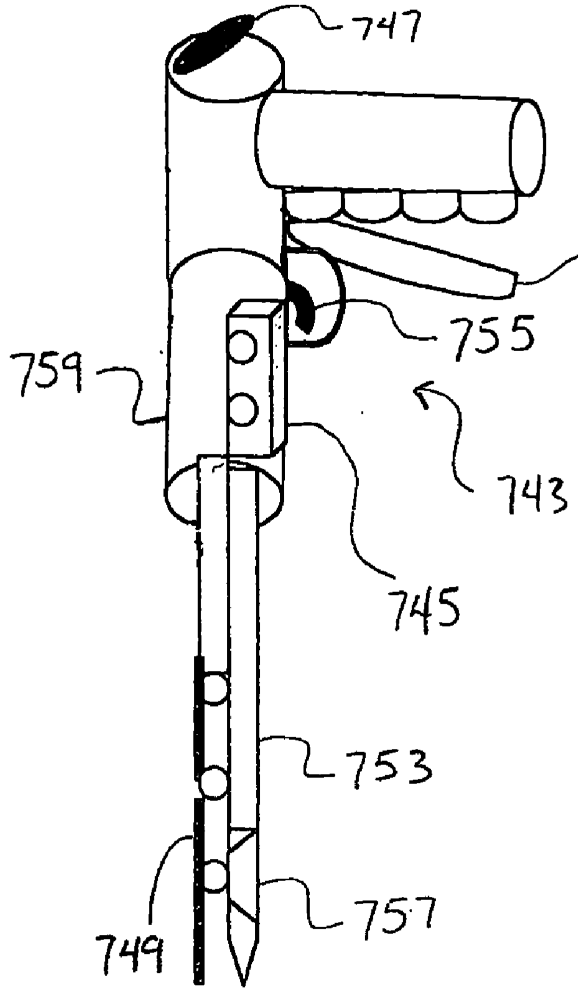
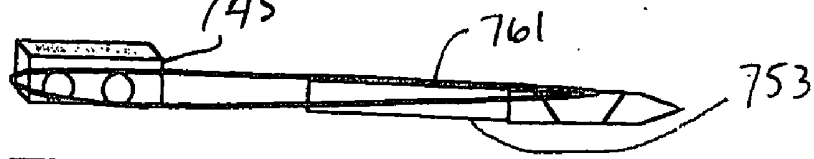


Fig 21h

Fig 21i



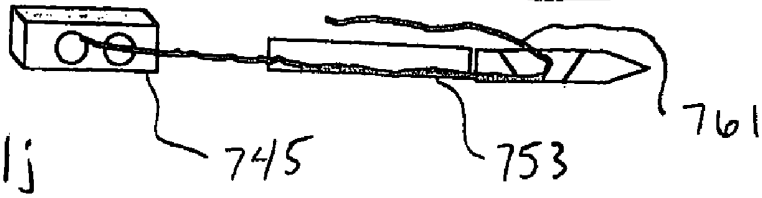
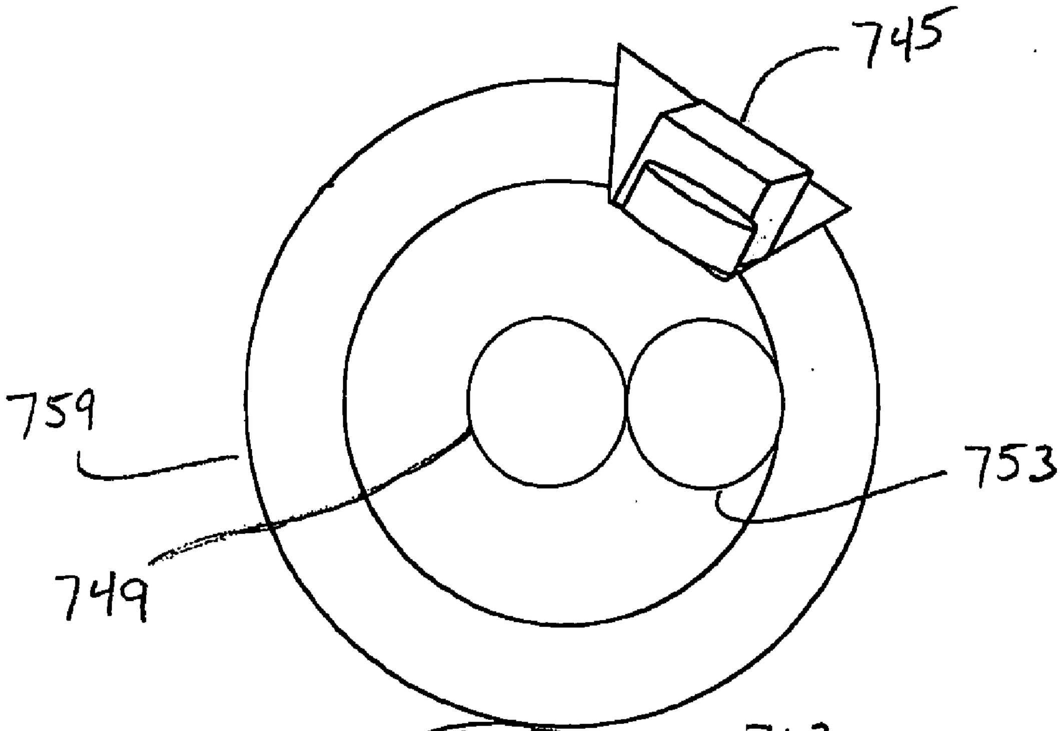
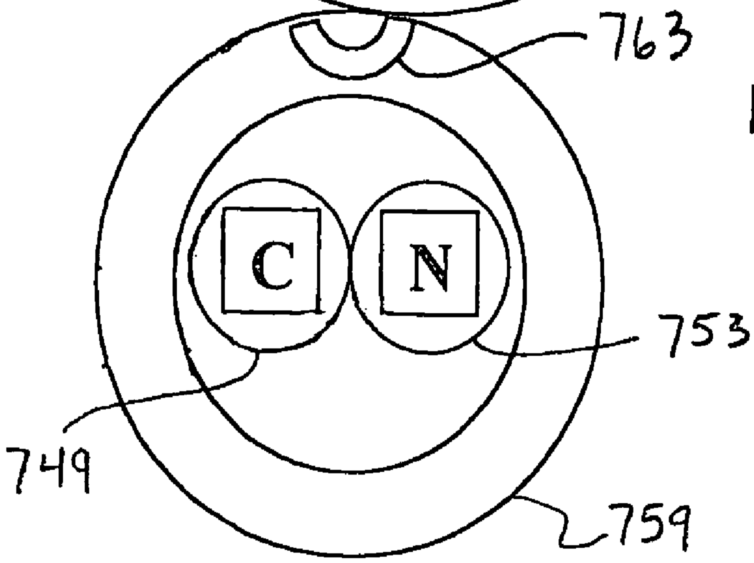


Fig 21j

Fig. 21k





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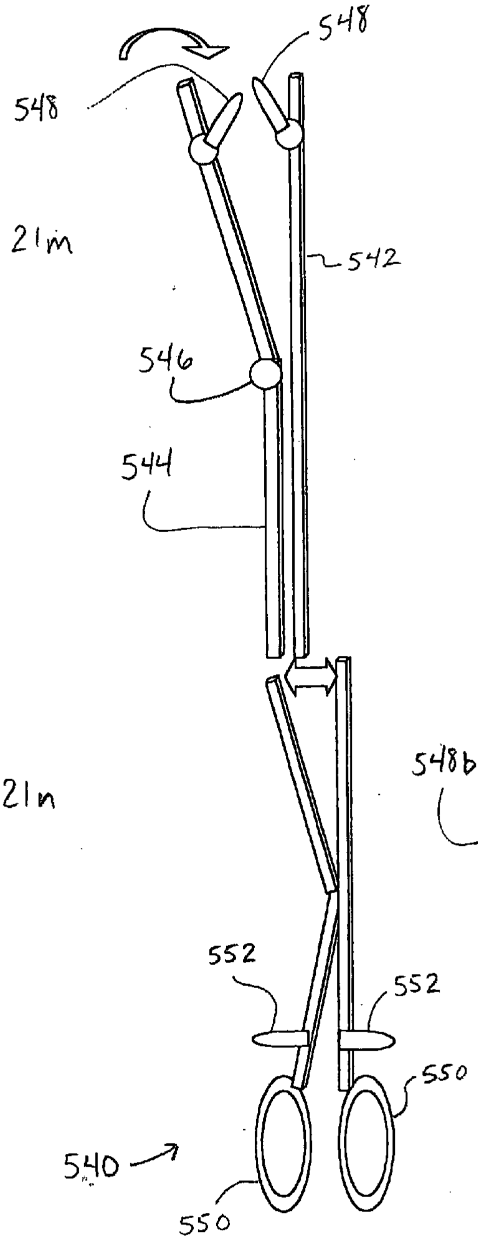
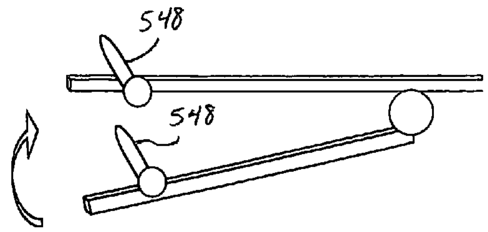


Fig 21m

Fig 21n

Fig 21o



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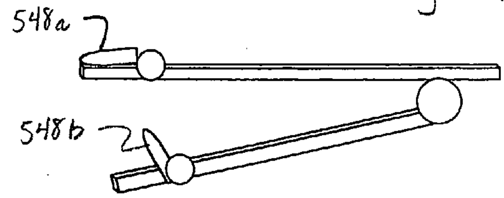


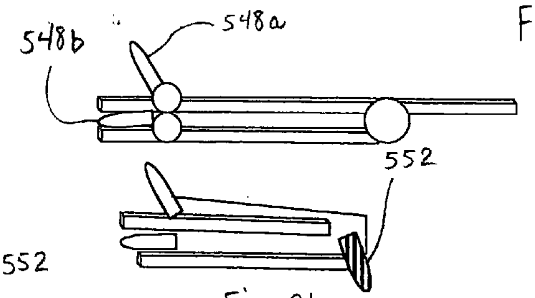


Fig 21q

Fig 21r

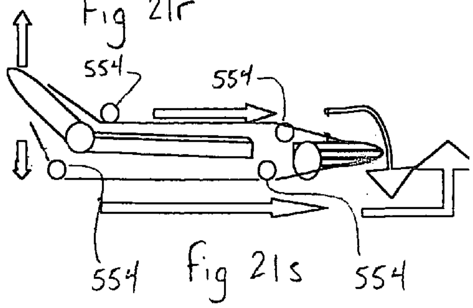
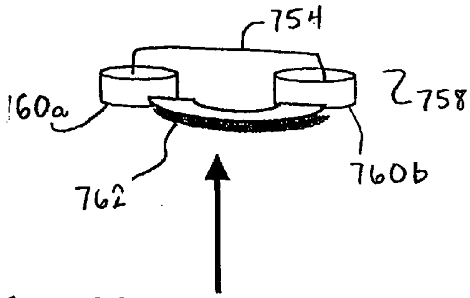


Fig 21s

Fig. 22a



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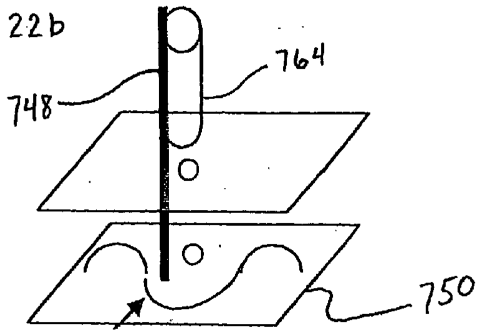

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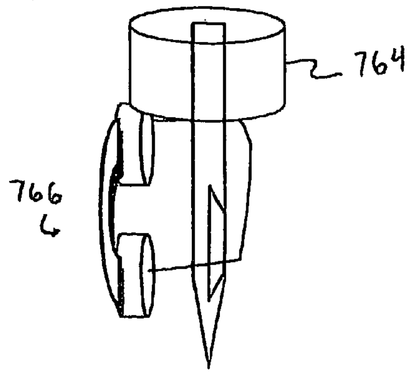
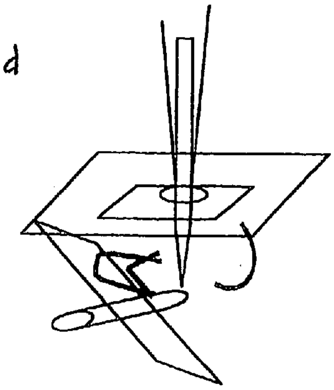


Fig. 22d



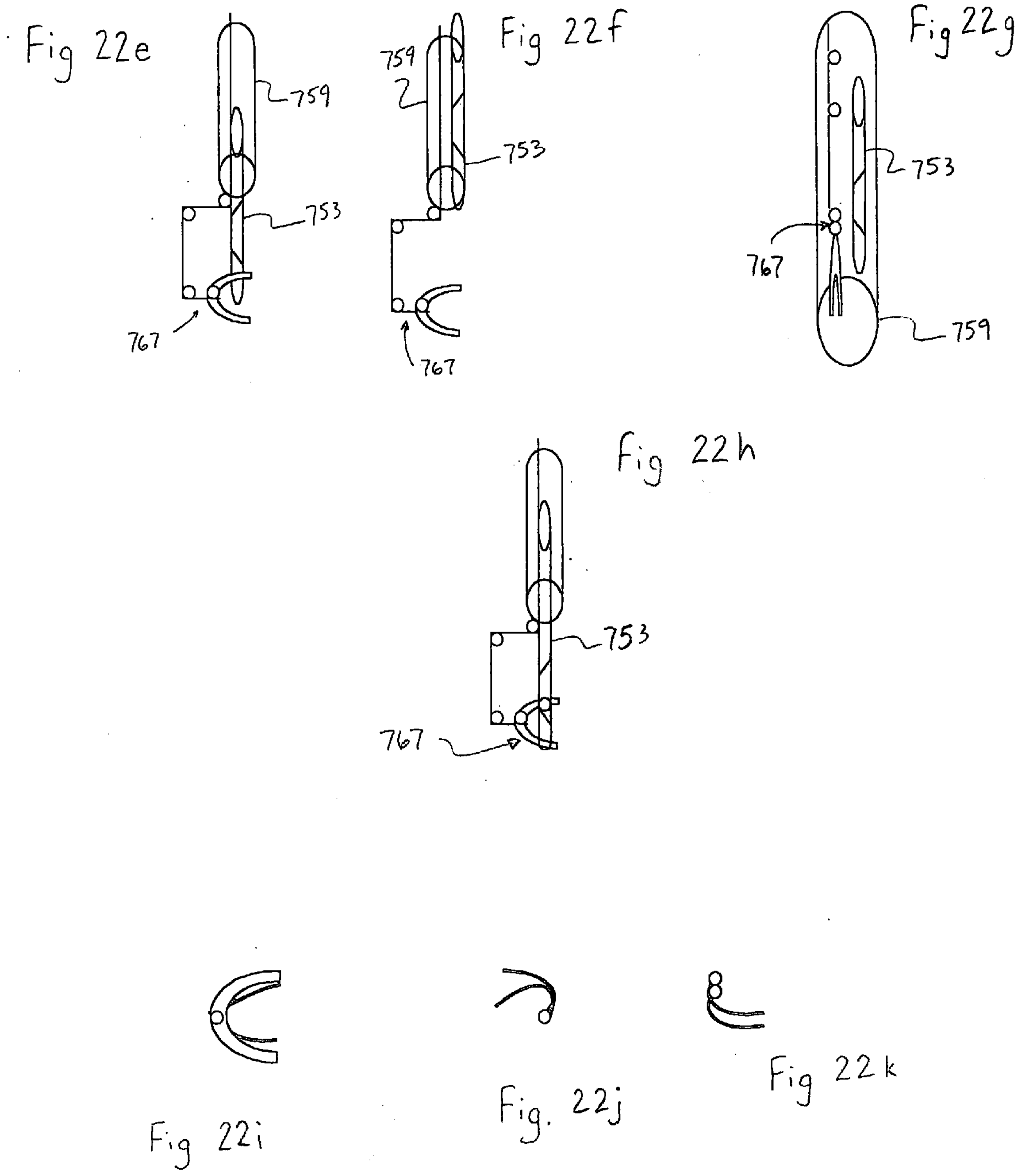


Fig 22e
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Fig 22f
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Fig 22g
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Fig 22h
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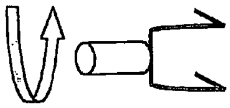
Fig 22i
Fig. 22j
Fig 22k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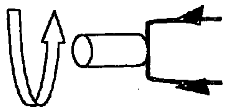


Fig 22m

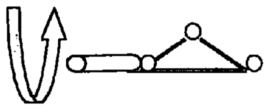


Fig. 22n

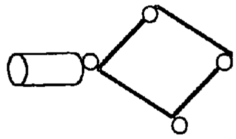
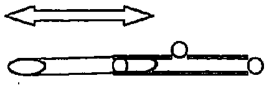


Fig 22p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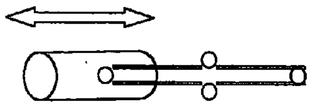


Fig. 22q

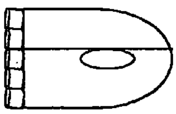


Fig. 22r

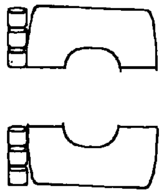
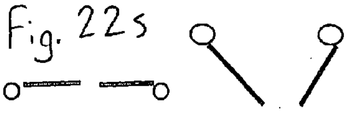


Fig. 22t

Fig. 22s


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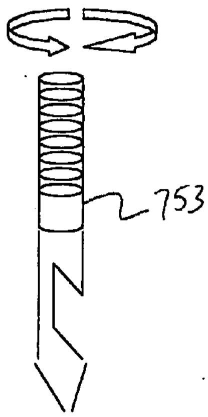


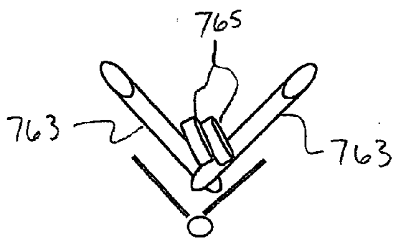
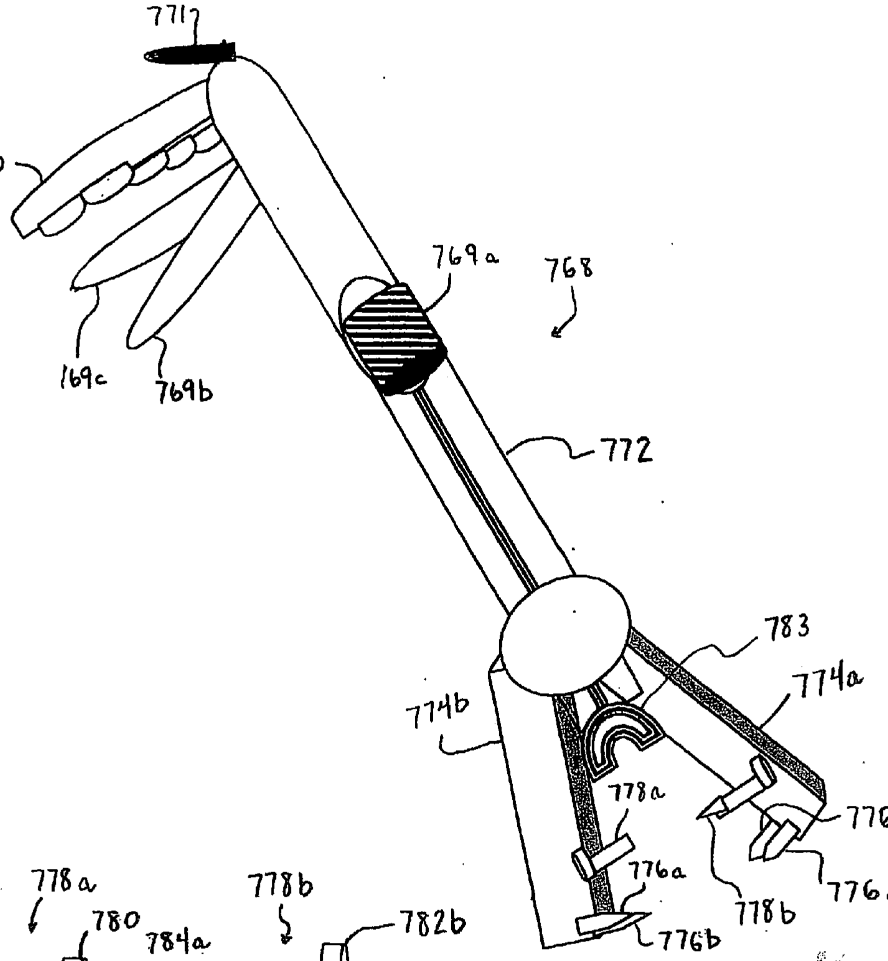


Fig. 22v

Fig. 23a



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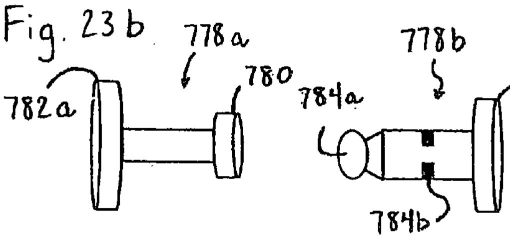


Fig. 23c

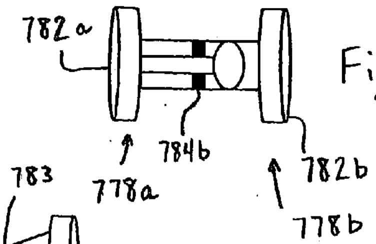
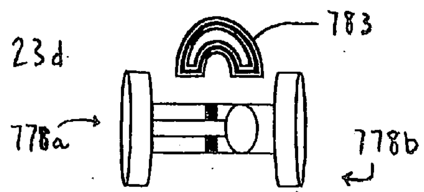


Fig. 23d



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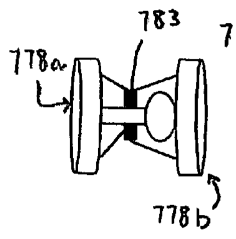


Fig. 23f

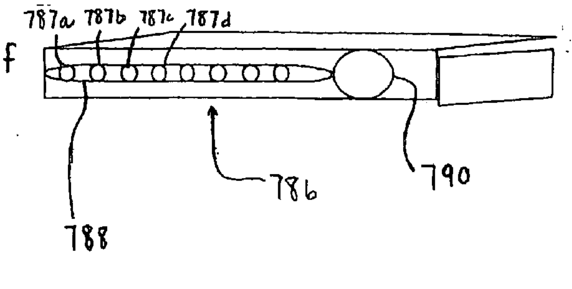


Fig. 23g

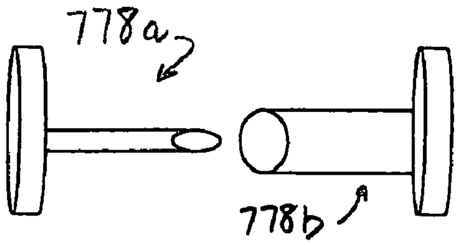


Fig. 23h

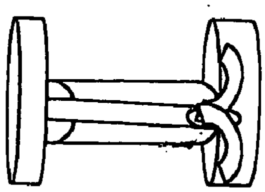


Fig. 23i

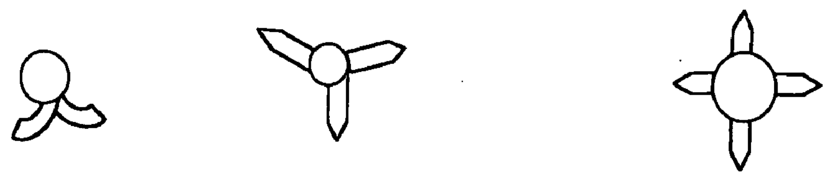
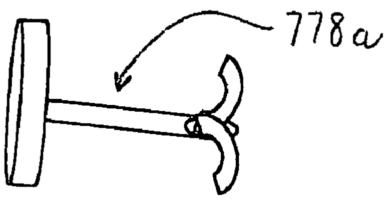


Fig. 23j



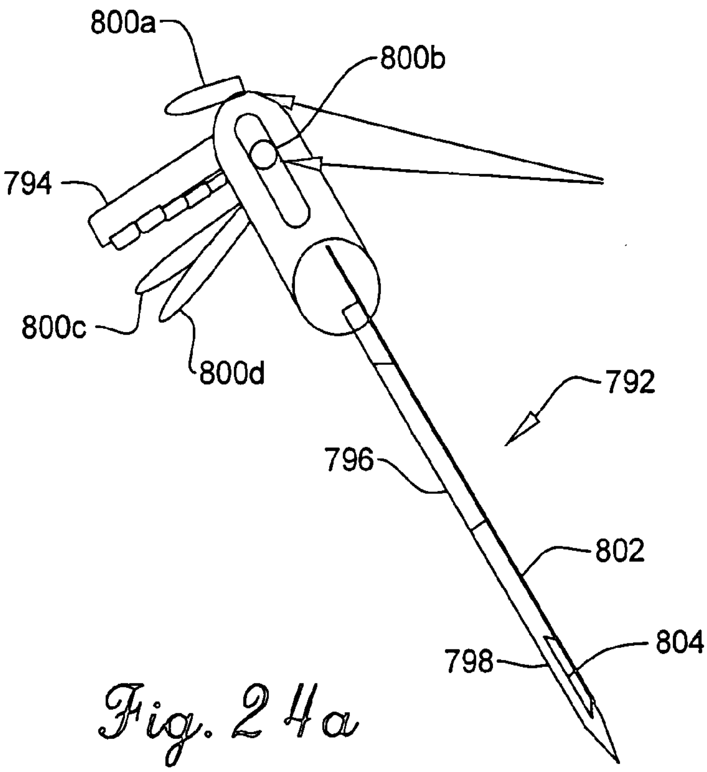


Fig. 24a

Fig. 24b

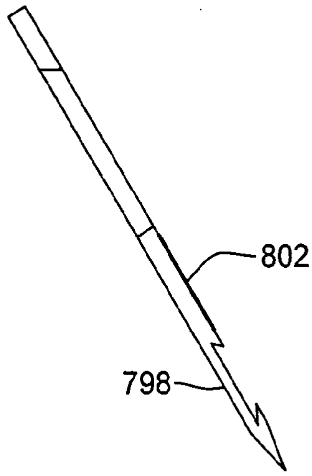
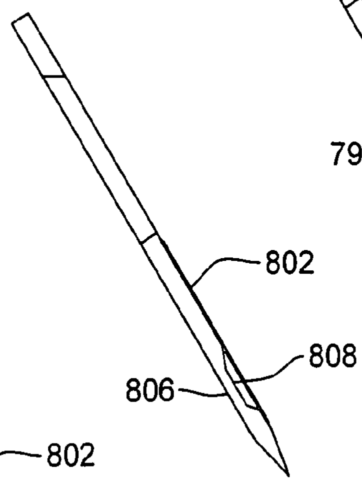


Fig. 24c



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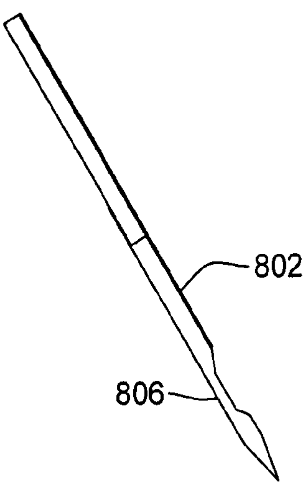

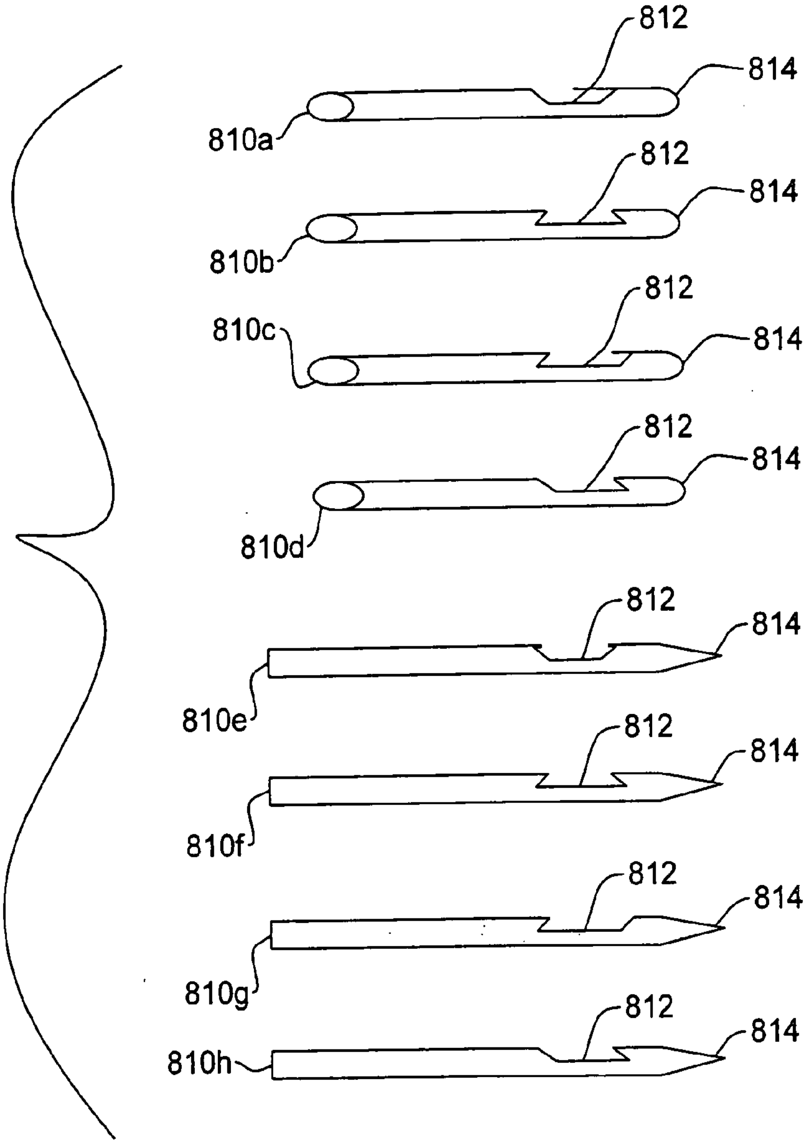
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Fig. 24e

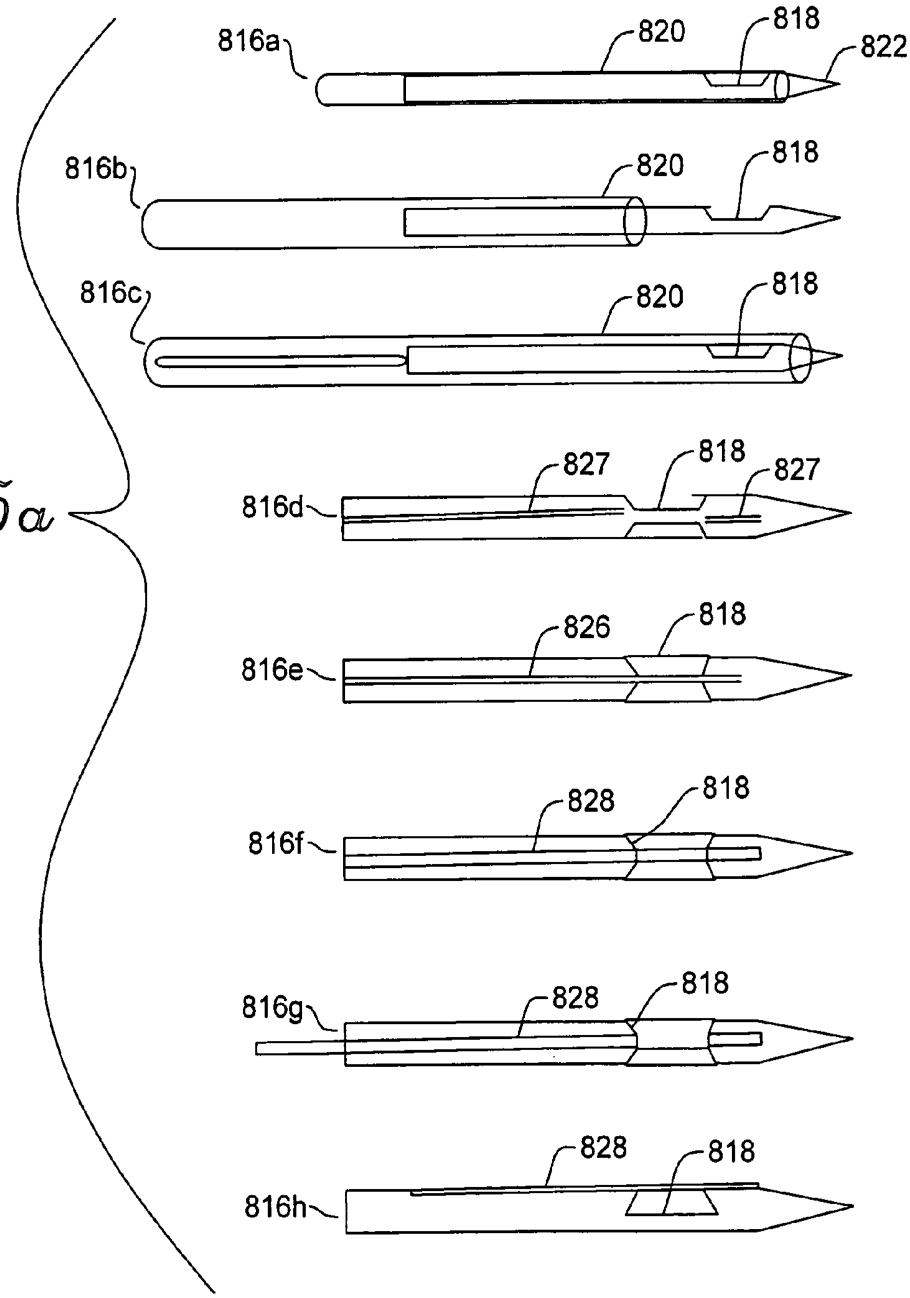
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Fig. 25a

Fig. 25b

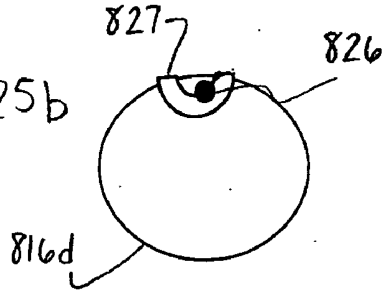


Fig. 25c

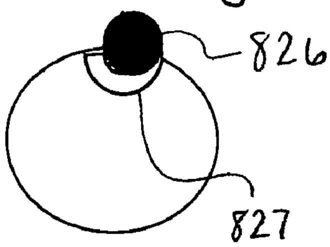
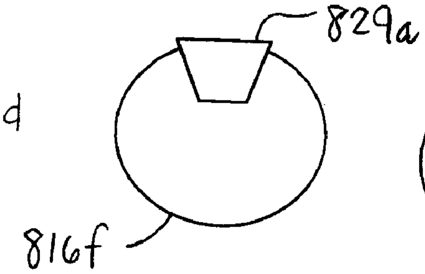


Fig 25d



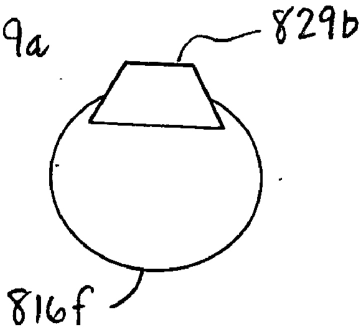


Fig 25e

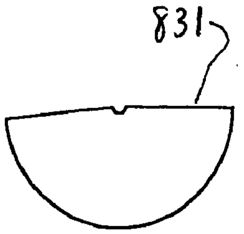


Fig 25f

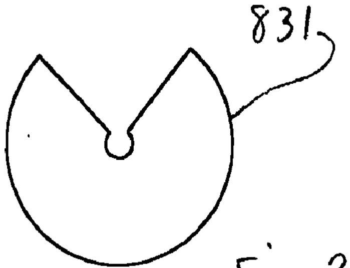


Fig 25g

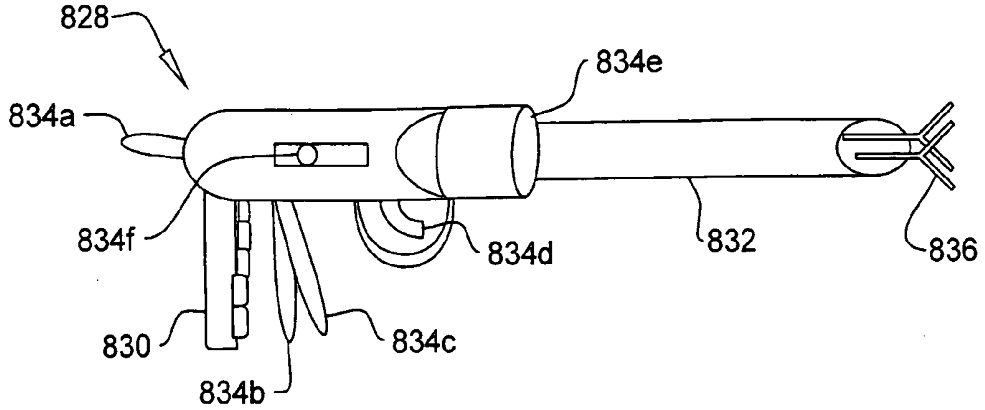
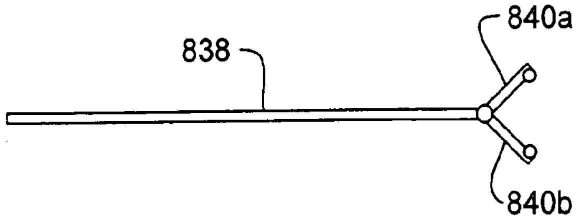


Fig. 26

Fig. 27a



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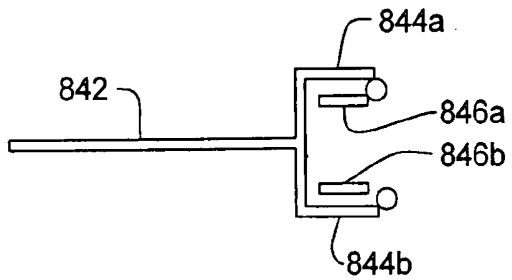


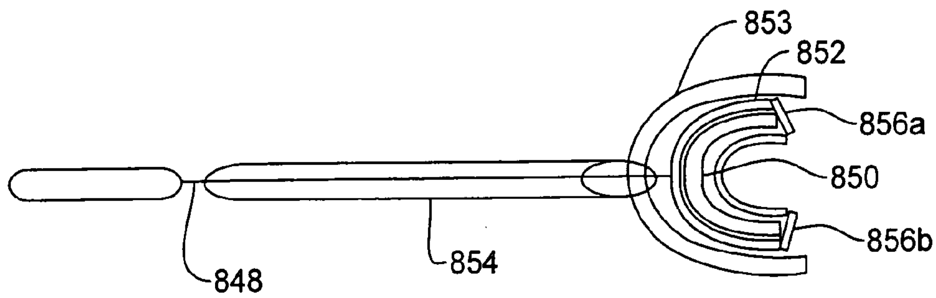
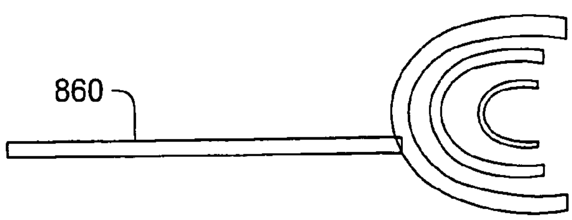


Fig. 27c

Fig. 27d



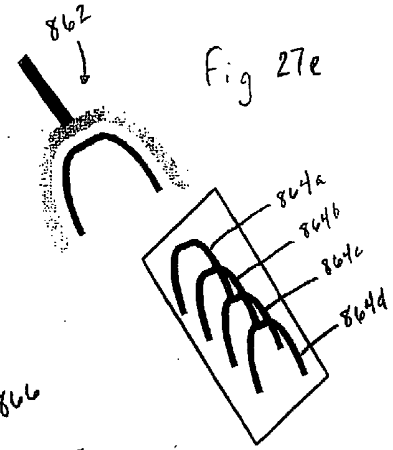
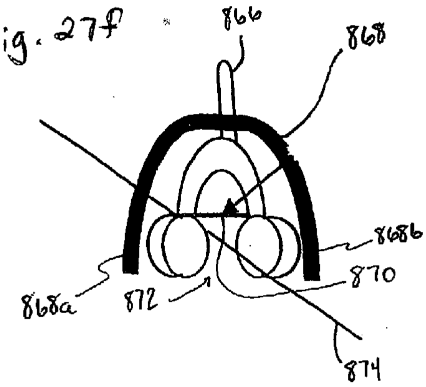


Fig 27e

Fig. 27f



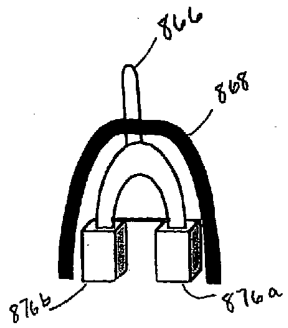


fig. 27g

Fig. 28a

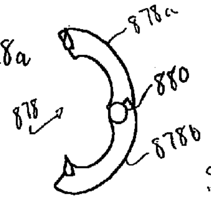


fig. 28b

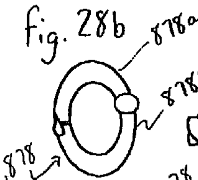


Fig. 28c

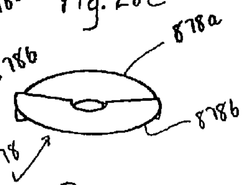


Fig. 29a

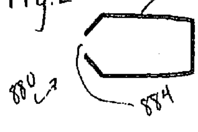


Fig. 29b

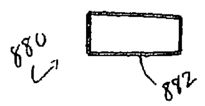


Fig. 29c

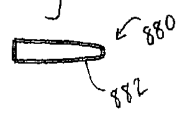


Fig 30a

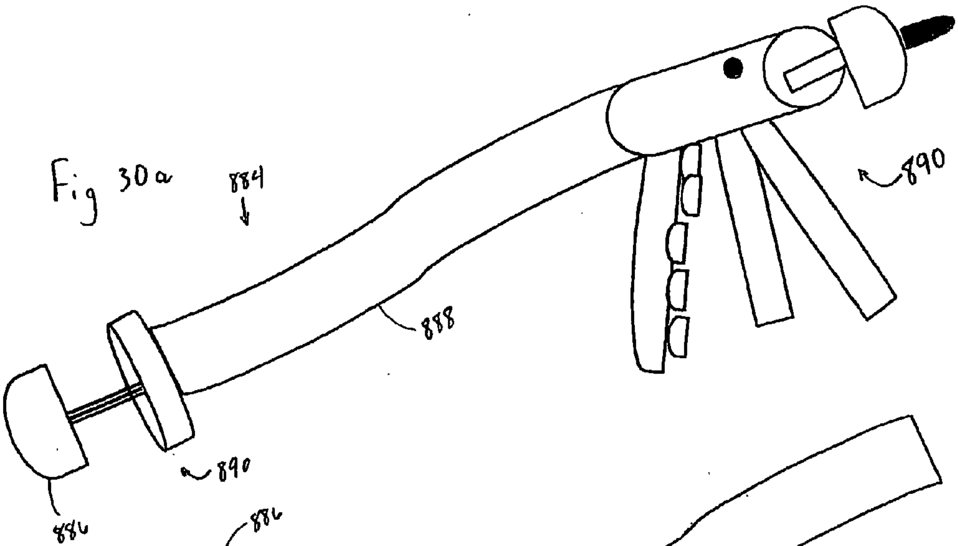


Fig 30b

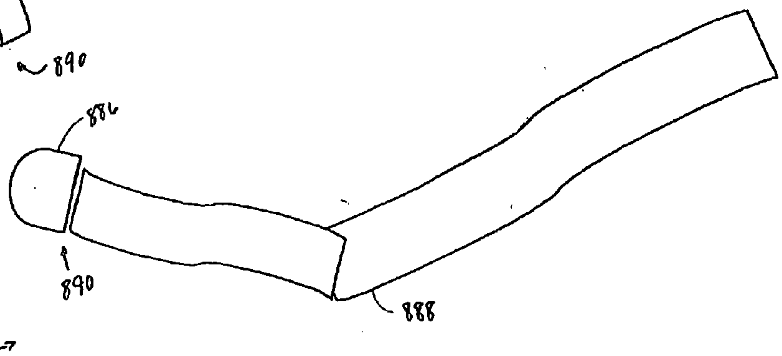


Fig 31a

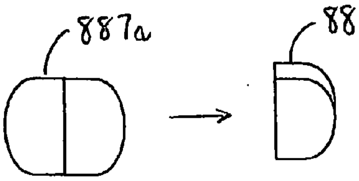


Fig 31b

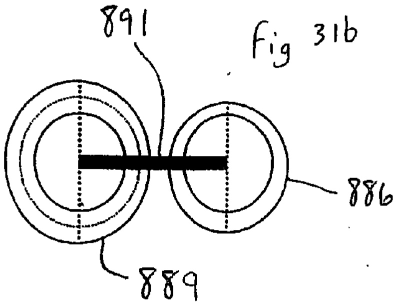
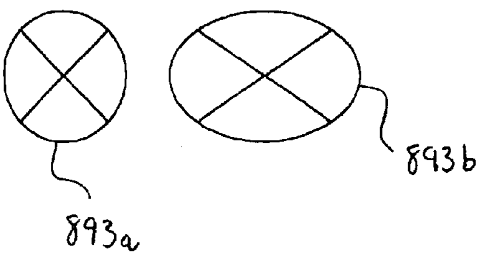


Fig 31c



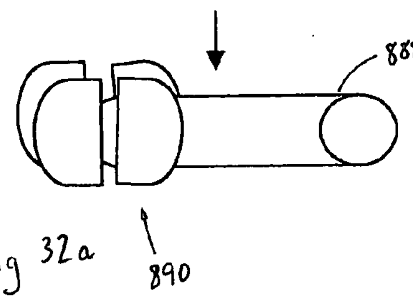


Fig 32a

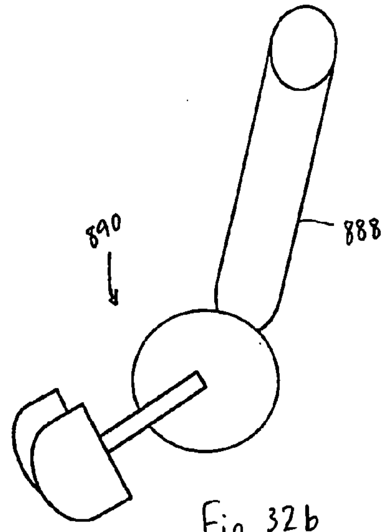


Fig 32b

Fig 33

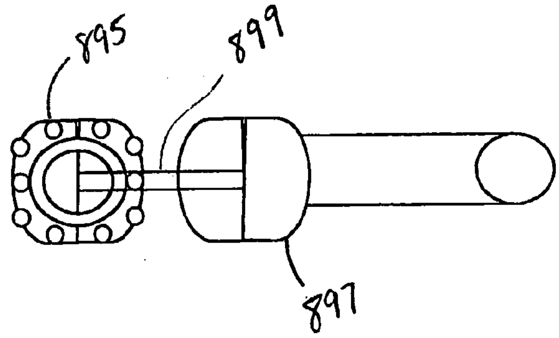
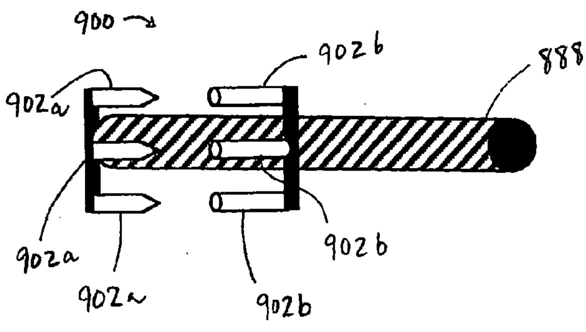


Fig 34



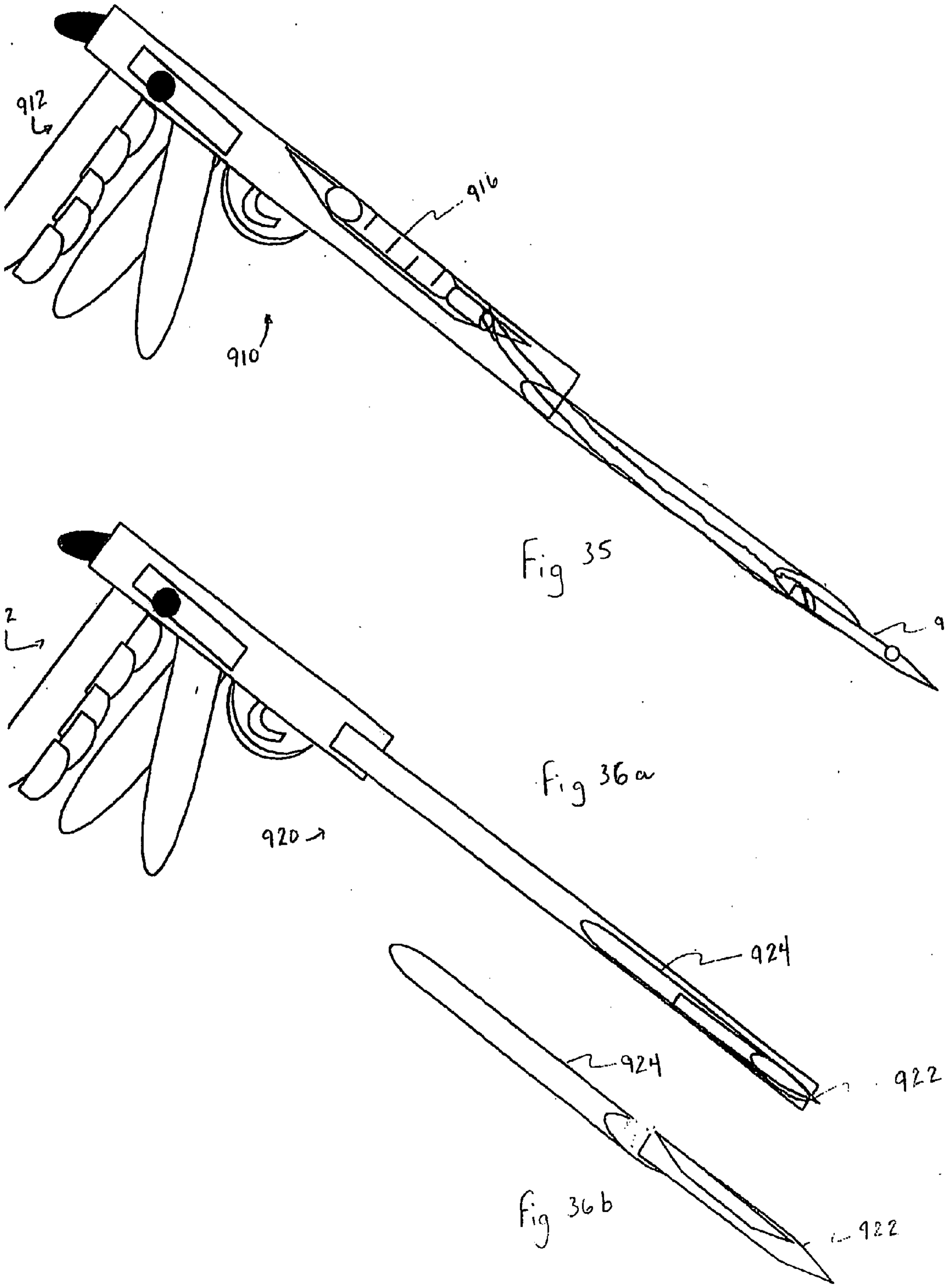


Fig 35

Fig 36a

Fig 36b

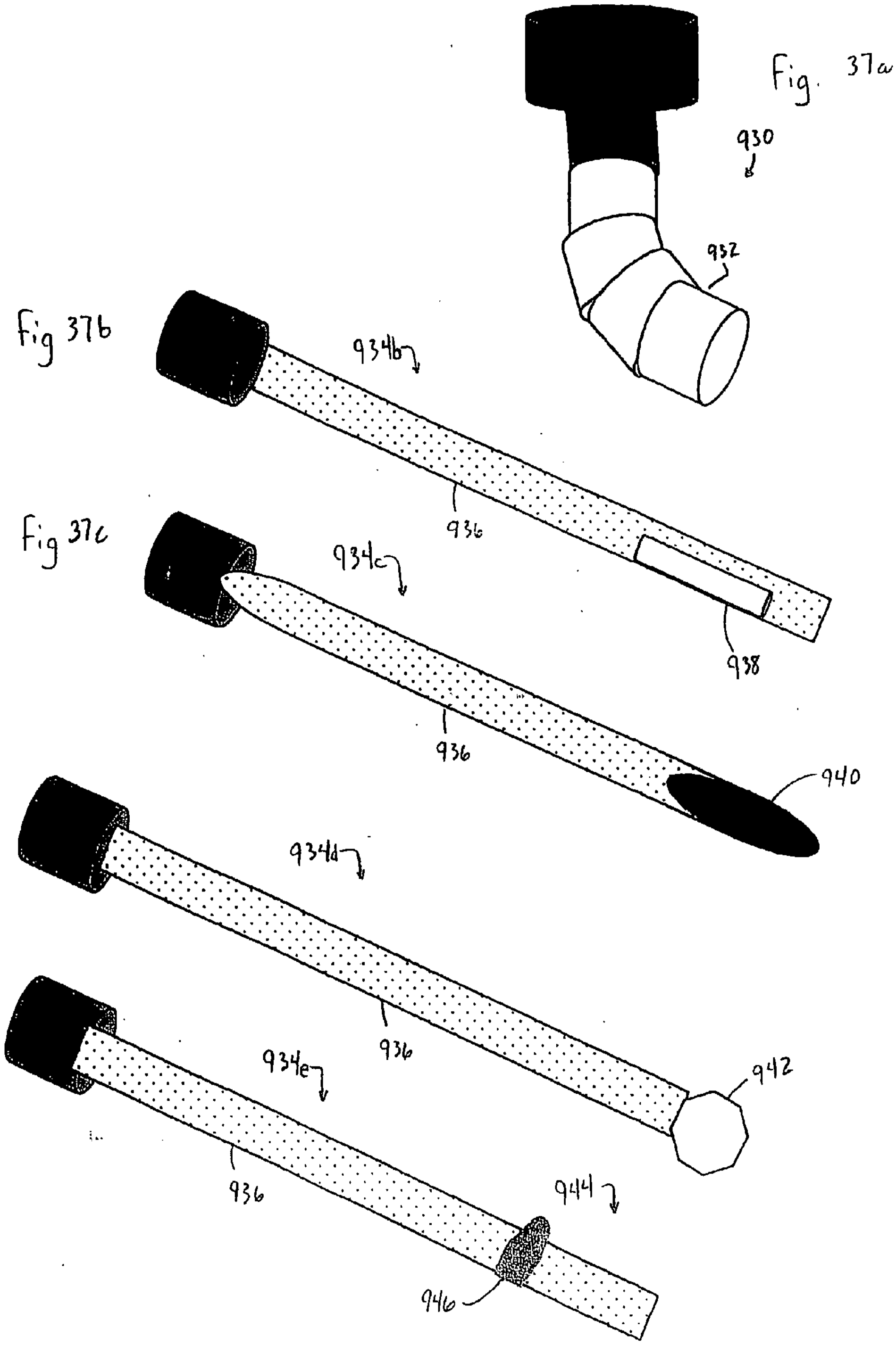


Fig. 37a

Fig 37b

Fig 37c

Fig 37d

Fig 37e

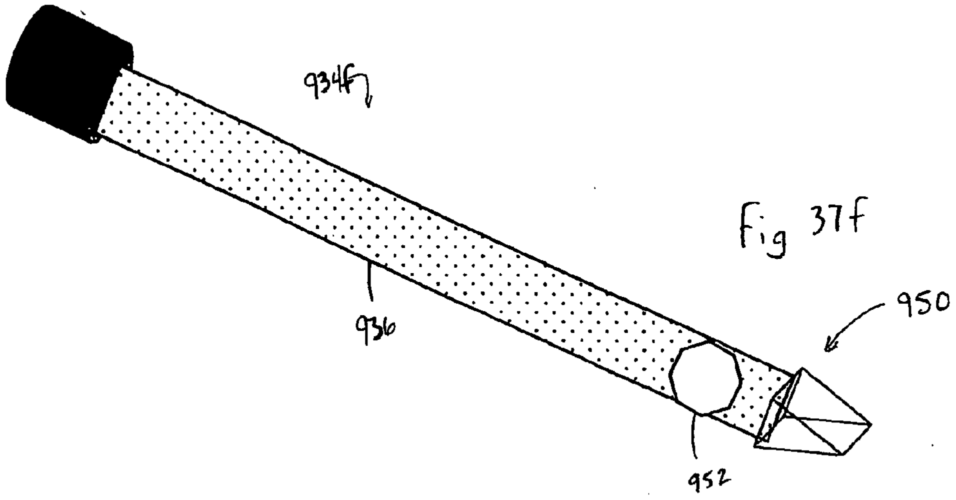


Fig 37f

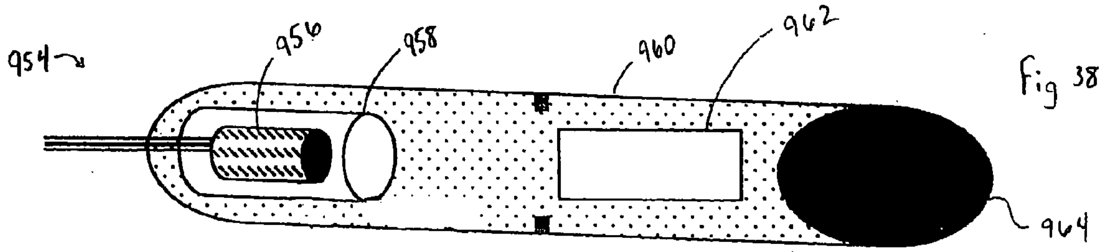


Fig 38

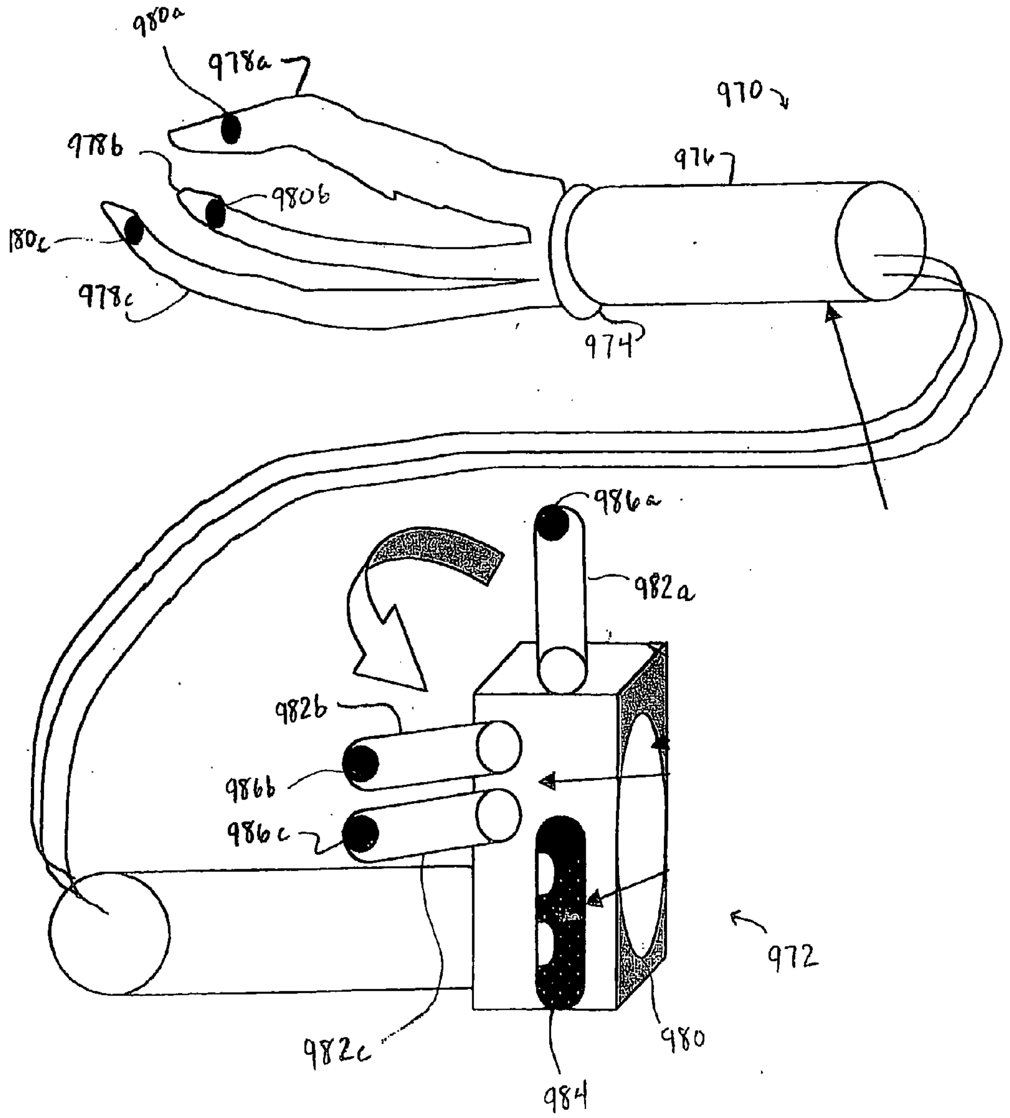


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Fig. 39

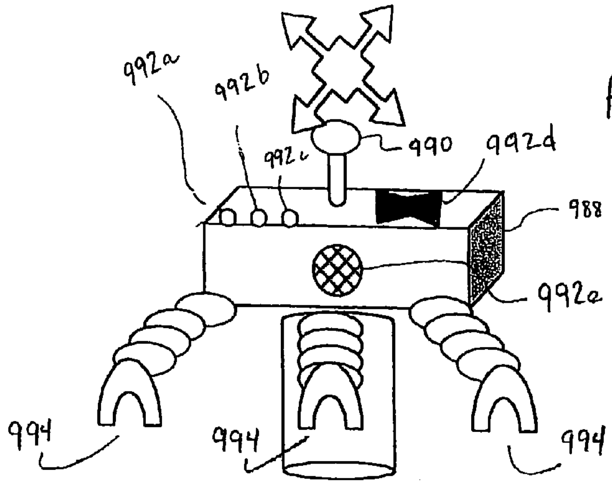
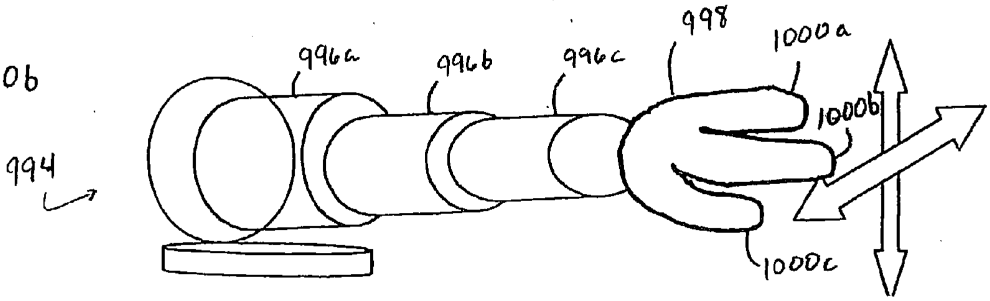


Fig. 40a

Fig. 40b



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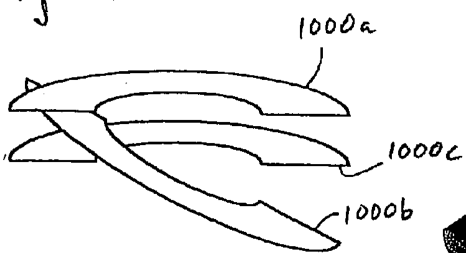

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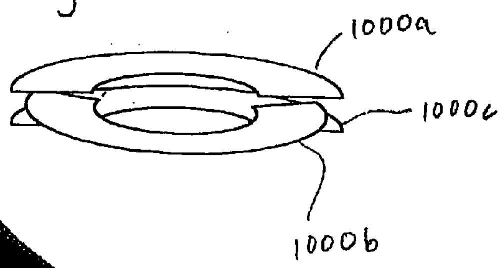

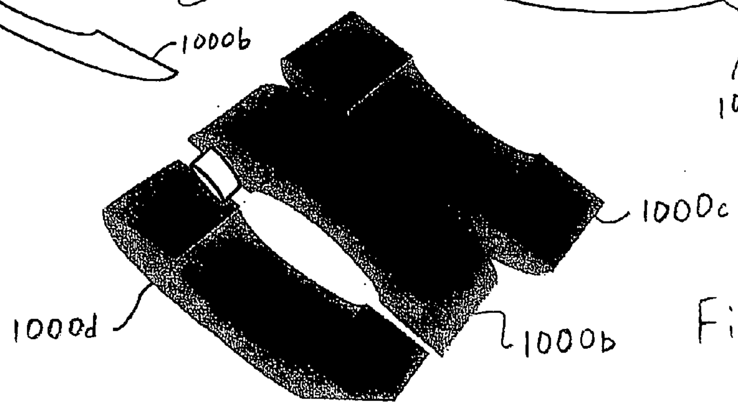

Fig. 40e

Fig 41

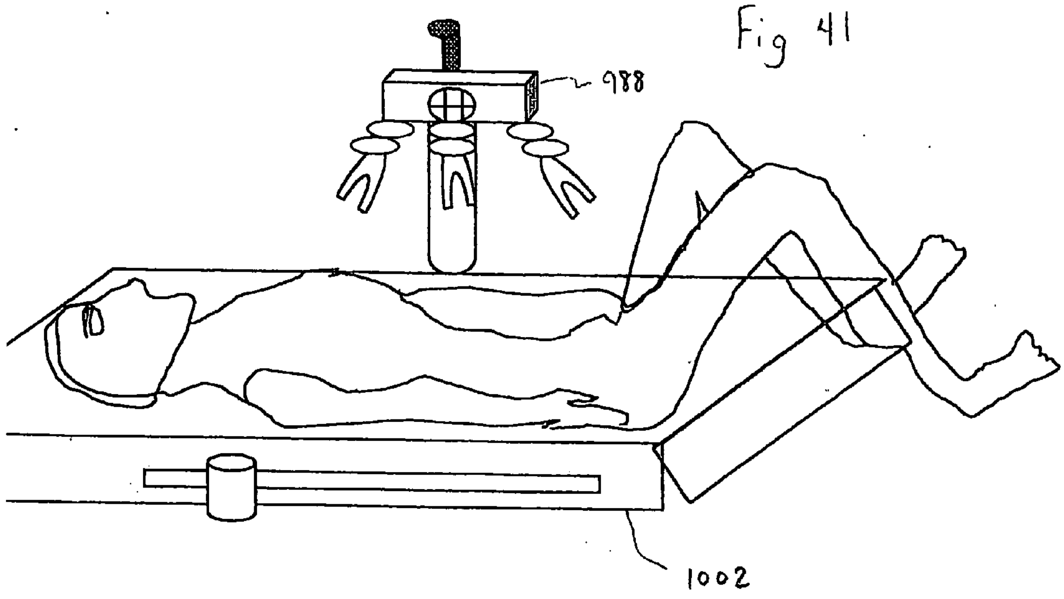
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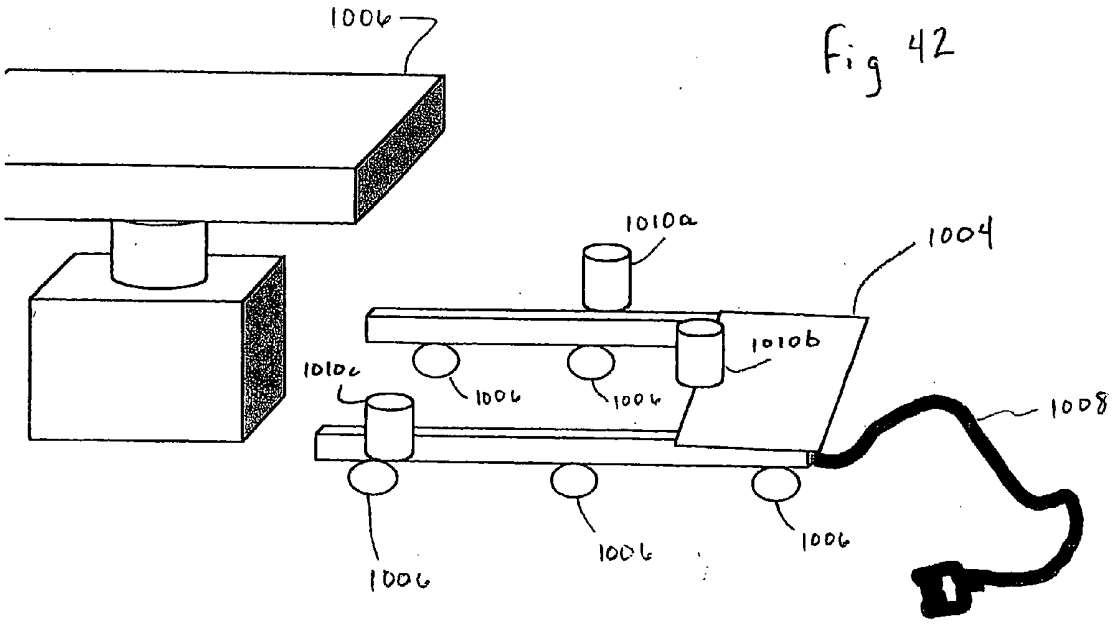
Fig 42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MEDICAL DEVICES FOR MINIMALLY INVASIVE SURGERIES AND OTHER INTERNAL PROCEDURES

FIELD OF THE INVENTION

[0001] In certain embodiments, the present invention relates to medical devices for internal use in a patient's body and, in particular, devices related to minimally invasive surgeries and other medical procedures.

BACKGROUND OF THE INVENTION

[0002] Various tools and procedures are known for use in minimally-invasive surgery. These tools and procedures are favored over "open" surgical techniques as the minimally-invasive techniques reduce patient discomfort and facilitate rapid healing and recovery. "Open" surgical techniques typically require the use of large incisions to gain entry to the interior of the body. "Open" surgeries also typically require a longer post-operative hospital stay and cause increased post-operative pain. The large incisions of "open" surgeries may leave large and sometimes unsightly scars.

[0003] Minimally-invasive surgical procedures, on the other hand, may often be conducted on an outpatient basis. Minimally invasive surgeries are often performed with relatively small surgical incisions or ports which, in contrast with the large incisions of "open surgery" have a decreased risk of infection. Minimally invasive surgery is also desirable for the benefit of generally avoiding much of the internal damage resulting from the larger incisions of "open" surgeries, such as the cutting of abdominal muscle and other tissue required to gain access to the abdominal body cavity in an "open" surgery. Because it is not as disruptive as "open surgery", minimally invasive surgery may be used as a diagnostic tool, enabling a physician to visually inspect, and even sample, certain tissues.

[0004] The presently available devices for minimally invasive surgical procedures all have certain inherent disadvantages, including, without limitation, difficulty and/or discomfort in use of the devices, limited features, and sensory and sensitivity loss between the operator and the material being examined or manipulated. The presently available devices are also somewhat difficult to use due to the limited vision provided by the cameras that are available for a surgeon to see his or her work.

[0005] These disadvantages combine to sometimes render minimally invasive surgical procedures more difficult than is desirable. The difficulty of the procedures, the lack of tactile perception, and the limited working area may increase the likelihood of accidental damage to the organs, vessels, and other tissues surrounding the surgical area.

[0006] A need exists for minimally invasive surgical devices that provide a surgeon with a wider variety of options than is presently available. Further, it is desirable to provide minimally invasive surgical devices that do not include the disadvantages of the presently-available devices.

SUMMARY OF THE INVENTION

[0007] One object of the present invention is to provide new devices useful for minimally invasive surgeries and other procedures which are performed within a patient's body that allow a surgeon to minimize unnecessary damage to the organs, vessels, and other tissues surrounding the surgical area.

[0008] A further object of the invention is to provide devices which facilitate an expanded field of vision during minimally invasive surgeries and other internal procedures.

[0009] Another object of the invention is to provide devices which facilitate easier handling and manipulation of instruments for minimally invasive surgeries and other internal procedures.

[0010] Another object of the invention is to provide devices for minimally invasive surgeries and other internal procedures which facilitate increased tactile and/or visual perception for the surgeon.

[0011] Yet another object of the invention is to provide devices for minimally invasive surgeries and other internal procedures which expand the range of options available to a surgeon.

[0012] According to one embodiment of the invention, an optical device is provided for minimally invasive medical procedures that facilitates stereoimagery through the use of multiple image acquisition devices. The optical device includes a plurality of linear image acquisition devices, and at least two of the linear image acquisition devices are adapted to receive an image from within a patient's body. The optical device also includes a linear housing laterally surrounding the linear image acquisition devices so that the linear image acquisition devices extend toward one end of the housing. The housing is such that at least a portion of it may be inserted within a patient's body and the housing is also adapted for cleaning. At least one input adjustment device is disposed upon at least one end of the plurality of linear image acquisition devices and the input adjustment device may include a lens and/or a reflective surface.

[0013] According to another embodiment of the invention, a medical device is provided with a hand piece, an instrument portion including a tool, and one or more control elements. The control elements are useful to operate or manipulate features of the device. One of the control elements may be a trigger. The hand piece may be configured for a right hand of a user, or a left hand of a user, or for use by either hand of a user.

[0014] According to another embodiment of the invention, a device for minimally invasive medical procedures is provided. The device includes a scissor-type hand piece with a first elongated portion and a second elongated portion. The first elongated portion is adapted for manipulation by a user's thumb and the second elongated portion is adapted for manipulation by one or more of a user's first, second, third, and fourth fingers. A temperature control element may also be provided to generate a signal upon manipulation of the control element. A tool is also provided, and is responsive to the signal generated by the temperature control element. In response to the signal of the temperature control element, at least a portion of the tool heats up, so as to be useful to cauterize tissue. Optionally, the tool may be detachable from the device.

[0015] According to another embodiment of the invention, a tool for use in minimally invasive medical procedures is provided. The tool includes an elongated first element, an elongated second element, and an elongated third element. The first and second element are opposed to the third element. The first element is configured to mimic the functionality of a first finger of a user, and the second element is configured to mimic the functionality of a second finger of a user. The third element is configured to mimic the functionality of a third finger of a user. Each of the first element, second element, and third element are configured to transmit a pressure sensation from that element to a user's finger.

[0016] According to another embodiment of the invention, an automated device for minimally invasive medical procedures, is provided. The device includes a robotic console, a plurality of control features, and one or more robotic limbs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] **FIG. 1***a* shows a cross-sectional view of an optical device in accordance with one embodiment of the invention;

[0018] **FIG. 1***b* shows a cross-sectional view of an optical device in accordance with another embodiment of the invention;

[0019] **FIG. 2***a* depicts a portion of an optical device in accordance with an embodiment of the present invention;

[0020] **FIG. 2***b* depicts a portion of an optical device in accordance with another embodiment of the present invention;

[0021] **FIG. 2***c* depicts a portion of an optical device in accordance with another embodiment of the present invention;

[0022] **FIG. 3** shows a block diagram of a system according to an embodiment of the invention;

[0023] **FIG. 4***a* shows a lateral view of certain components of an optical device in accordance with an embodiment of the invention;

[0024] **FIG. 4***b* shows a cross-sectional view of an optical device in accordance with one embodiment of the invention;

[0025] **FIG. 4***c* shows a top view of an optical device in accordance with one embodiment of the invention;

[0026] **FIGS. 4***d*, **4***e*, **4***f*, **4***g*, **4***h*, **4***i*, **4***j* and **4***k* show a lateral views of a portion of an optical device in accordance with an embodiment of the invention;

[0027] **FIG. 5***a* shows a lateral view of certain components of a medical device in accordance with an embodiment of the invention;

[0028] **FIG. 5***b* shows a lateral view of certain components of a medical device in accordance with an embodiment of the invention;

[0029] **FIG. 5***c* shows a schematic diagram of certain components of a medical device in accordance with an embodiment of the invention;

[0030] **FIG. 6** shows a lateral view of certain components of a medical device in accordance with an embodiment of the invention;

[0031] **FIG. 7***a* shows a lateral view of a medical device in accordance with an embodiment of the invention;

[0032] **FIG. 7***b* shows a lateral view of the medical device of **FIG. 7***a* in a different position;

[0033] **FIG. 8** shows a lateral view of a medical device in accordance with an embodiment of the invention;

[0034] **FIG. 9** shows a lateral view of a medical device in accordance with an embodiment of the invention;

[0035] **FIGS. 10***a*, **10***b*, **10***c*, **10***d*, and **10***e* show various lateral views of components for use as part of medical devices in accordance with certain embodiments of the invention;

[0036] **FIGS. 11***a*, **11***b*, **11***c*, and **11***d* show lateral views of components for use as part of a medical device in accordance with certain embodiments of the invention;

[0037] **FIGS. 12***a*, **12***b* and **12***c* show lateral views of tools for use as part of a medical device in accordance with certain embodiments of the invention;

[0038] **FIG. 13***a* shows a lateral view of an ultrasonic device in accordance with one embodiment of the invention;

[0039] **FIG. 13***b* shows a screen image for use with the ultrasonic device of **FIG. 13***a*, in accordance with one embodiment of the invention;

[0040] **FIG. 13***c* shows two ultrasonic probes for use with an embodiment of the invention;

[0041] **FIG. 14***a* shows an laser in accordance with an embodiment of the invention;

[0042] **FIG. 14***b* shows a screen image for use with the laser device of **FIG. 14***a*, in accordance with an embodiment of the invention;

[0043] **FIG. 15***a* shows a lateral view of a medical device in accordance with an embodiment of the invention;

[0044] **FIG. 15***b* shows a lateral view of another medical device in accordance with an embodiment of the invention;

[0045] **FIG. 16** depicts a variety of components for use with certain medical devices of the present invention;

[0046] **FIG. 17** shows a variety of different cautery devices for use in accordance with certain embodiments of the invention;

[0047] **FIGS. 18***a* and **18***b* depict a device for use in accordance with certain embodiments of the invention;

[0048] **FIGS. 19***a*, **19***b* and **19***c* depict another device for use in accordance with certain embodiments of the invention;

[0049] **FIGS. 20***a* and **20***b* depict arrangements for stapling tissue in accordance with certain embodiments of the invention;

[0050] **FIG. 21***a* depicts a suturing device in accordance with an embodiment of the invention;

[0051] **FIG. 21***b* depicts a portion of the suturing device of **FIG. 21***a;*

[0052] **FIGS. 21***c* and **21***d* depict a lateral view of a suturing device in accordance with an embodiment of the invention;

[0053] **FIGS. 21***e*, **21***f* and **21***g* depict views of a portion of another suturing device in accordance with an embodiment of the invention;

[0054] **FIG. 21***h* depicts a lateral view of a suturing device in accordance with an embodiment of the invention;

[0055] **FIGS. 21***i* and **21***j* depict views of a portion of the suturing device of **FIG. 21***h;*

[0056] **FIGS. 21***k* and **21***l* depict cross-sectional views of a portion of the suturing device of **FIG. 21***h;*

[0057] **FIGS. 21***m*, **21***n*, **21***o*, **21***p*, **21***q*, **21***r*, and **21***s* depict lateral views of various portions of devices in accordance with certain embodiments of the invention;

[0058] **FIG. 22***a* depicts a bobbit-style suture holder device for use in accordance with certain embodiments of the invention;

[0059] **FIG. 22***b* depicts a base for use in accordance with a suturing device such as that depicted in **FIG. 21***a*, and a bobbit assembly such as that depicted in **FIG. 22***a;*

[0060] **FIG. 22***c* depicts an arrangement similar to that shown in **FIG. 22***a*, with an external bobbit assembly;

[0061] **FIG. 22***d* depicts a suture catcher for use in accordance with certain embodiments of the invention;

[0062] **FIGS. 22***e*, **22***f*, **22***g*, **22***h*, **22***i*, **22***j*, **22***k*, **221**, **22***m*, **22***n*, **22***p*, **22***o*, **22***q*, **22***r*, **22***t*, **22***s*, **22***u* and **22***v* depict views of portions of a suturing device in accordance with an embodiment of the invention;

[0063] **FIG. 23***a* depicts a rivet driver in accordance with another embodiment of the invention;

[0064] **FIG. 23***b* depicts the components of a fastener in accordance with an embodiment of the invention;

[0065] **FIG. 23***c* depicts another view of the components of a fastener, such as that shown in **FIG. 23***b;*

[0066] **FIG. 23***d* depicts another view of the components of a fastener, such as that shown in **FIG. 23***b;*

[0067] **FIG. 23***e* depicts another view of the components of a fastener, such as that shown in **FIG. 23***b;*

[0068] **FIG. 23***f* depicts a cartridge for a group of fasteners such as the fastener shown in **FIG. 23***b;*

[0069] **FIGS. 23***g*, **23***h*, **23***i*, and **23***j* depict views of various portions of fastening devices in accordance with certain embodiments of the invention;

[0070] **FIG. 24***a* depicts a needle driver for use in accordance with certain embodiments of the invention;

[0071] **FIG. 24***b* depicts a needle similar to that shown in **FIG. 24***a*, with the bevel lock in an open position;

[0072] **FIG. 24***c* depicts a needle similar to that shown in **FIG. 24***a*, however the needle of **FIG. 24***c* has an inverted bevel;

[0073] **FIG. 24***d* depicts the needle of **FIG. 24***c*, with the bevel lock in an open position;

[0074] **FIG. 24***e* depicts various needles for use in accordance with certain embodiments of the invention;

[0075] **FIG. 25***a* depicts various needles for use in accordance with certain embodiments of the invention;

[0076] **FIGS. 25***b*, **25***c*, **25***d*, **25***e*, **25***f* and **25***g* depicts cross-sectional views of certain needles for use in accordance with certain embodiments of the invention;

[0077] **FIG. 26** depicts a pistol-style ligation device in accordance with certain embodiments of the invention;

[0078] **FIG. 27***a* depicts one embodiment of a grasping rod for use in accordance with one embodiment of the invention;

[0079] **FIG. 27***b* depicts another embodiment of a manipulation or grasping rod for use in accordance with an embodiment of the invention;

[0080] **FIG. 27***c* depicts a manipulation or grasping rod for use in accordance with an embodiment of the invention;

[0081] **FIG. 27***d* depicts an adhesive ligation staple rod for use in accordance with an embodiment of the invention;

[0082] **FIG. 27***e* depicts an adhesive stapler loading device in accordance with an embodiment of the invention;

[0083] **FIG. 27***f* depicts an injector which injects an adhesive substance into a compressor mold in accordance with one embodiment of the invention;

[0084] **FIG. 27***g* depicts an injector similar to that shown in **FIG. 27***f;*

[0085] **FIG. 28***a* depicts a fastener for use in accordance with an embodiment of the invention;

[0086] **FIG. 28***b* depicts the fastener of **FIG. 28***a* in a closed position;

[0087] **FIG. 28***c* depicts a view of a fastener similar to that shown in **FIG. 28***a*, in a different position;

[0088] **FIG. 29***a* depicts a fastener similar to that depicted in **FIG. 28***a* for use in accordance with an embodiment of the invention;

[0089] **FIG. 29***b* depicts the fastener of **FIG. 29***a* in a closed position;

[0090] **FIG. 29***c* depicts the fastener **FIG. 29***a* in another closed position;

[0091] **FIG. 30***a* depicts a circular stapler device in accordance with an embodiment of the invention;

[0092] **FIG. 30***b* shows the circular stapler device of **FIG. 30***a* in another position;

[0093] **FIGS. 31***a*, **31***b*, and **31***c* depict portions of a circular stapler similar to the circular stapler shown in **FIGS. 30***a* and **30***b*.

[0094] **FIGS. 32***a* and **32***b* depict views of a circular staple head;

[0095] **FIG. 33** depicts a portion of a circular stapler in accordance with an embodiment of the invention;

[0096] **FIG. 34** depicts a side view of a portion of a circular stapler in accordance with an embodiment of the invention;

[0097] **FIG. 35** depicts a side view of a surgical device in accordance with an embodiment of the invention;

[0098] **FIG. 36***a* depicts a side view of a surgical device similar to that shown in **FIG. 35**;

[0099] FIG. 36*b* depicts a side view of a portion of the surgical device of FIG. 36*a;*

[0100] FIG. 37*a* depicts a portion of a medical device in accordance with an embodiment of the invention;

[0101] FIGS. 37*b*, 37*c*, 37*d*, 37*e*, and 37*f* depict views of different embodiments of a components for use with a medical device similar to that shown in FIG. 37*a;*

[0102] FIG. 38 shows a side view of a portion of a medical device for use in accordance with an embodiment of the invention;

[0103] FIG. 39 shows a side view of a medical device in accordance with another embodiment of the invention;

[0104] FIG. 40*a* depicts a view of a medical device in accordance with another embodiment of the invention;

[0105] FIG. 40*b* depicts a view of a portion of a medical device for use in accordance with a device similar to that shown in FIG. 40*a;*

[0106] FIGS. 40*c* and 40*d* depict a view of a portion of a medical device for use in accordance with a device similar to that shown in FIG. 40*b;*

[0107] FIG. 40*e* depicts a view of a device for use in accordance with a medical device similar to that shown in FIG. 40*b;*

[0108] FIG. 41 depicts a view of a device similar to that shown in FIG. 40*a*, in accordance with an embodiment of the invention;

[0109] FIG. 42 depicts a view of a device for use in accordance a medical device similar to that shown in FIG. 41, in accordance with another embodiment of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0110] The present invention may be understood by reference to the following detailed description of particular embodiments of the invention. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting.

[0111] In one embodiment, the present invention provides an optical device for minimally invasive surgery that allows the user to view multiple images in a variety of arrangements or formats. The device achieves this by using multiple image acquisition devices. Each image acquisition device obtains an image and transmits it to a display device capable of displaying the images in multiple formats. In one embodiment, the device allows a user to switch between binocular and trinocular image presentation.

[0112] In one embodiment, an optical device is provided with two image acquisition devices. FIG. 1*a* presents a cross-sectional view of such an optical device 2. A housing 4 laterally surrounds two linear image acquisition devices 6*a* and 6*b*. The housing 4 extends linearly along the image acquisition devices 30*a* and 6*b*. At least a portion of the housing 4 is configured so that it may be inserted within a patient's body. Similarly, at least a portion of the housing 4 may be adapted for cleaning and sterilization so that the optical device 2 may be cleaned, sterilized, and reused.

[0113] The linear image acquisition devices 6*a* and 6*b* may be configured in accordance with any suitable means for image acquisition. For instance, the image acquisition devices 6*a* and 6*b* may be fiber optic cables or cameras which digitally capture an image and transmit it electronically. In the case of the later embodiment, the cameras are positioned at one end of the linear housing 4 with wiring or some other suitable means for transmission of an electronic signal extending through the linear housing 4.

[0114] Image information may be transmitted with wireless transmitters: (electronic or optical). Electronic data is preferably set to a specific wavelength and frequency to keep it secure and avoid interference with other equipment, for instance nearby medical equipment such as electromagnetic imaging equipment. A short range optic "wireless" transmission may also be used, especially where wireless electronic transmission is or could be problematic.

[0115] FIG. 1*b* shows a cross-sectional view of another embodiment of an optical device wherein three image acquisition devices 6*a*, 6*b*, and 6*c* are protected by a housing 4, which laterally surrounds the linear image acquisition devices 6*a*, 6*b* and 6*c*. This embodiment allows the optical device to collect three images for presentation to the user. In another embodiment (not shown) one or more light sources may be provided to provide lighting for the image acquisition devices 6*a*, 6*b*, and 6*c*. Alternatively, any of the image acquisition devices, for instance 6*b*, may be replaced with a light source to provide illumination for image acquisition devices 6*a* and 6*c*.

[0116] FIG. 2*a* depicts a view of a portion of an optical device such as that shown in FIG. 1*a*. In the portion of the optical device shown in FIG. 2*a*, two image acquisition devices 6*a* and 6*b* are provided. Each image acquisition device 6*a* and 6*b* is provided with an image adjustment device 8*a* and 8*b*. The image adjustment device 8*a* and 8*b* may be any device suitable for manipulating an image, such as a prism, a lens, a reflecting mirror, or a combination of the foregoing.

[0117] FIG. 2*b* depicts a view of a portion of an optical device similar to that depicted in FIG. 2*a*. The portion of the optical device shown in FIG. 2*b* includes two image acquisition devices 6*a* and 6*b*. The image adjustment devices 8*a* and 8*b* are similar, to those shown in FIG. 2*a*, however in FIG. 2*b*, the image adjustment devices 8*a* and 8*b* are oriented differently so as to provide a different field of view for each of the image adjustment devices 8*a* and 8*b*.

[0118] FIG. 2*c* depicts another view of a portion of an optical device similar to that depicted in FIGS. 2*a* and 2*b*, however in FIG. 2*c*, a single image adjustment device 10 is provided. This single image adjustment device 10 may be oriented so as to provide two images. One of each of the images is provided to a separate image acquisition device (not shown).

[0119] FIG. 3 depicts a system diagram of one embodiment of an imaging system 18 in accordance with the present invention. In this embodiment, a optical device 20 consists of a plurality of linear image acquisition devices 22*a*, 22*b*, and 22*c* and at least one input adjustment device 24. A controller 26 is provided for receiving and responding to instructions to control the imaging system 18. In particular, the controller 26 may be in communication with the input adjustment device **24** and the display system **28**. The controller **26** may control any number of a variety of features related to image acquisition, for instance, focusing the image or rotating a mirror disposed on the image acquisition devices so as to rotate or change the view displayed by the imaging system **18**. Additionally, or alternatively, the controller **26** may operate to control the display system **28**. In such an embodiment, the controller **26** may control a variety of different features associated with a display device, for instance, the tint, color, brightness, sharpness, contrast or any of a variety of other features known to be adjustable in image acquisition devices. Further, the controller **26** may direct what display format the images acquired by the optical device **20** are displayed in. For instance, where two image acquisition devices (not shown) are used, the image may be displayed in either a single image or a left/right image format as two images beside each other. Where three image acquisition devices **22***a-c* are utilized, the third image may be presented as a screen insert. In yet another alternative where multiple image acquisition devices are used, images from any one or combination of the image acquisition devices may be selected for presentation on the display system **28**.

[0120] The display system **28** may be either a traditional television style display device with a monitor and a screen, a goggle style display device with an eyeglass-type frame that presents a separate image to each eye of the user, or a combination of one or more of these. In the latter case, the images may vary between the eyes so that the left eye receives a left image provided one linear image acquisition device and the right eye receives a right image obtained by a different linear image acquisition device. Alternatively, a third image may be presented in one or both of the left eye and right eye image as an insert or, where desired by the user, as a complete replacement for either the left or right eye. Any of these options may be selected by the user through the operation of the controller **26**. Where the display system **28** includes an eyeglass-frame type display device, it may optionally be configured so that the display screen of one or both eyes may be slipped up or down so as to be moved in front of entirely clear of one or both eyes of the user. In one embodiment, multiple display devices are provided.

[0121] In one embodiment, the controller **26** operates through voice activation so that the user need only verbally audibilize commands directing the controller **26** to perform some function or change in the operation of the imaging system **18**. Alternatively, or in combination with voice operation, the controller **26** may provide features for manual manipulation by the user, including various control elements such as buttons, switches, dials, or any other control element which allow a user to control one or more functions of the imaging system **18**.

[0122] **FIG. 4***a* depicts two linear image acquisition devices **6***a* and **6***b*, each of them with an input adjustment device **36***b* and **36***b* disposed at the end of the linear image acquisition device **6***a* and **6***b*. Each input adjustment device **36***a* and **36***b* provides a mechanism to manipulate the image it acquires through the image acquisition device **6***a* or **6***b*. The input adjustment device **36***a* and **36***b* may be either a mirror or a lens or a combination of one or more of both of them to amplify and/or focus the image. In one embodiment, lenses are provided which enable magnification of the image in a range from 0 to 40 times magnification. This magnification capability can be applied to all lenses or to a single lens. In the case of a binocular optical device which includes two image acquisition devices **6***a* and **6***b* or where only two of a plurality of image acquisition devices are selected for operation, the magnification may be applied to a single lens. This lens may provide magnification adjustable between zero and up to 40 times. This may be useful to provide multiple views of the same subject or collection of subjects. In another embodiment, the input adjustment devices **36***a* and **36***b* may be configured to provide digital manipulation of the image to amplify, magnify or focus as desired by the user. This digital manipulation may be provided in combination with, or as a substitute for, one or more mirrors and/or lenses for manipulation of an image.

[0123] **FIG. 4***b* depicts various views that may be obtained where three image acquisition devices are provided. In **FIG. 4***b*, the right view field **42***a* is depicted R, and the left view field **42***b* is depicted L, while the rear or posterior view field **42***c* is depicted P. A lens **44***a*, **44***b*, or **44***c* is associated with each of the respective view fields, **42***a*, **42***b*, or **42***c*. From **FIG. 4***b* it can be appreciated how a user would be provided an advantage over systems which include only two view fields, by way of an additional viewing field with the posterior view **42***c*. One can also appreciate how the left view field **42***b* and the right view field **42***a* may combine to give a complete, or seamless view field. In one embodiment, the left view field **42***b* and the right view field **42***a* combine to give a field from approximately 0 to 180° while the posterior **42***c* view field may be used to give a view field from approximately 190 to 350°. Alternatively, the various fields **42***a*, **42***b*, and **42***c* may be configured so that one or more of them overlap, or so that each of them is entirely separate.

[0124] **FIG. 4***c* provides another depiction of the various views **42***a*, **42***b*, and **42***c* that may be obtained in accordance with certain embodiments of the invention. As can be seen in **FIG. 4***c*, the optical device (not shown) may be arranged so that the various views **42***a*, **42***b* and **42***c* are essentially contiguous with one another. Alternatively, two or more of the views **42***a*, **42***b*, and **42***c* may overlap, or the views **42***a*, **42***b*, and **42***c* may be entirely separate from one another.

[0125] **FIG. 4***d* shows a lateral internal view of an optical device **50** in accordance with an embodiment of the invention. The optical device **50** is provided with at least one image transmission apparatus such as optic cable **52**, which is preferably flexible. The optical cable **52** may optionally be provided with an image capture mechanism **54**, such as a camera or lens. One or more light sources **56***a* and **56***b* may also be provided to illuminate the area under examination or surgery. Reflective surfaces, such as mirrors **58***a* and **58***b*, may also be provided as necessary or desirable. The mirrors **58***a* and **58***b* may be used to redirect the light from the light sources **56***a* and **56***b* or to redirect an image into the image transmission apparatus such as optic cable **52**. A lens **60** may be provided to further modify and adjust one or both of the light from the light sources **56***a* and **56***b* or the image being directed to the image transmission apparatus such as optic cable **52**. Further, a protective lens **62** may be provided on or near the outside of the optical device **50**.

[0126] Thus, one can appreciate that multiple lenses may be used to increase the viewing field of the device. These multiple lenses may be or may include a spheroid lens cover or a spheroid lens. The spheroid lens cover **64***a* and spheroid lens **64***b* are shown in **FIGS. 4***e* and **4***f*, respectively. Each of these may serve as a wider optical lens which will amplify and/or expand the viewing field **66** of the internal lens **68**. In particular, the spheroid lens cover **64***a* and/or spheroid lens **64***b* may be used to expand the visual field **66**, for instance, to 180°, effectively expanding the visual field **66** into a trapezoidal shape with a greater width at the edge further away from the internal lens **68**. The internal lens **68** may be used to magnify or otherwise modulate the viewing field **66**.

[0127] Further, the spheroid lens cover **64***a* and/or spheroid lens **64***b* may be stacked as shown in **FIGS. 4***g*, **4***h* and **4***i*, along with stacked internal lenses **68***a* and **68***b*. As shown in **FIG. 4***h*, the internal lenses **68***a* and **68***b* are positioned at an angle relative to each other and two spheroid lens covers **64***a* are provided. **FIG. 4***i* depicts another arrangement, wherein the internal lenses **68***a* and **68***b* are positioned laterally so that the viewing fields **66** overlap.

[0128] **FIGS. 4***j* and **4***k* depict spheroid lens **64***b* arrangements similar to those shown in **FIG. 4***i*, with the exception that the embodiments shown in **FIGS. 4***j* and **4***k* use a single internal lens **68***a* with multiple spheroid lenses **64***b*. As one skilled in the art would appreciate, a variety of arrangements are feasible. In **FIG. 4***j*, the spheroid lenses **64***b* are stacked to arrive at generally adjacent viewing fields **66**. **FIG. 4***k* shows the spheroid lenses **64***b* stacked so that the result in overlapping viewing fields **66**.

[0129] The stacking concept described above may be applied to any variety of optic faces as desirable or necessary. Additionally, the spheroid lenses and lens covers described above may be provided with further protective lens covers which are shaped so as to provide no optical modulation or distortion. Rather, these protective lens covers serve to protect the optics from their external environment.

[0130] In another aspect of the invention, a medical device is provided which allows a surgeon to manipulate one or more tools inside a patient, while inserting little more than the tool portion of the device within the patient. **FIG. 5***a* depicts a medical device **80** in accordance with such an embodiment of the invention; In this embodiment, a hand piece **82** is provided that accepts either a right hand, or a left hand of a user. In certain embodiments, the hand piece **82** is configured to accept a gloved hand. The hand piece **82** may also be configured bilaterally, to universally accept either hand of a user. In certain embodiments, the hand piece **82** may be sized so as to accept a particular hand size, for instance, a size 6-8 hand as measured for surgeon's gloves. The hand piece **82** may include separate portions for a user's fingers **84***a-e*. One or more of these portions for a user's fingers **84***a-e* may optionally be combined, so that a user's fingers rest within a mitten-like area (not shown).

[0131] In one embodiment, one or more pressure sensors **86***a-d* are provided. Each pressure sensor **86***a-d* detects the amount of pressure being applied by the relevant finger. This information is passed along to a mechanism (not shown) associated with the instrument portion (not shown) which operates a tool (not shown). The mechanism is responsive to the amount of pressure being applied by a particular finger and adjusts the operation of the tool accordingly. In this way, when a user exerts more force upon a pressure sensor **86***a-d*, a greater force is implemented by the tool. In such an embodiment, the tool may be such that one aspect of the tool is fixed. For instance, where the tool is forceps, one prong of the forceps may be fixed, and the other mobile. Alternatively, or in combination with this pressure system, the tool and mechanism may be configured to transmit to the user any resistance to the pressure being applied by that user. For instance, if the tool is a forceps, once the forceps reach a point at which they can no longer close any further due to the complete compression of the tissue or other material being grasped, the lever **88** being used to operate the forceps would similarly not close any further. In this way, the user experience is as though the user were working directly with the material being manipulated, rather than through the various mechanical or electronic linkages provided by the medical device **80**.

[0132] The medical device includes an instrument portion **100** (shown in **FIG. 5***b*), and one or more devices or control elements to allow a user to manipulate a tool (not shown). The tool is associated with the instrument portion **100** or some other feature of the medical device **80**. In one embodiment, a trigger (not shown) and a lever **88** are provided to manipulate the tool. In an embodiment with a trigger, the trigger may be manipulated by squeezing a finger of a user by to cause some operation of the tool. For instance, squeezing the trigger may cause a tool to rotate. The lever **88** may be operated by squeezing one or more fingers, thereby also manipulating the tool. In alternate embodiments, the operations of the lever **88** and the trigger may be reversed or may be otherwise provided by buttons or switches or some other control element or combination of control elements.

[0133] In **FIG. 5***b*, the instrument portion **100** is shown. The instrument portion **100** houses and includes mechanisms for manipulation and operation of a tool **102**. A trigger (not shown) may operate to cause the tool **102** to rotate in the direction of arrow B, from position I to position II. In one embodiment, the tool **102** rotates to one of several preset positions, for instance, the tool **102** may be at an angle of 0, 45, or 90 degrees in relation to the instrument portion **100**. When set at an angle of 0 degrees, the tool **102** is in a straight line in relation to the instrument portion **100**. In another embodiment, the tool **102** may be set at anywhere between an angle of from 0 degrees to about 90 degrees in relation to the instrument portion **100**.

[0134] Referring to **FIGS. 5***a* and **5***b*, the interaction of the various components of the device may be more fully appreciated. A transcutaneous shaft **104** engages an internal shaft **106**. The internal shaft **106** is optionally removably attached to the transcutaneous shaft **104** and linearly extends away from the transcutaneous shaft **104**. The internal shaft **106** is attached to the tool **102**. The tool **102** may optionally be detachable from the internal shaft **106**. A knob **108** may be provided and is operable to cause the internal shaft **106**, and any attached tool **102**, to rotate, for instance in the direction of arrow A. Alternatively, the knob **108** may be provided further up the transcutaneous shaft **104**, or the function of the knob **108** may be provided by some other control element provided with the hand piece **82**.

[0135] In the embodiment of **FIG. 5***b*, the tool **102** is depicted as forceps. In accordance with the present invention, the tool **102** may be a wide variety of other useful devices, especially where such devices are useful in medical procedures. For instance the tool **102** may be forceps, flat scissors, curved scissors, right angle scissors, DeBakey-type forceps, right angle forceps, blunt forceps, curved clamps, angular clamps, an ultrasound probe, a laser, a cautery device, a staplers, a knife, a suturing device, a rivet driver, a ligation device, an aspiration device, an injection device, a biopsy device, a radiotherapy device; or a radioactive emitter loading device. The tool is preferably one of three types. The first type of tool is configured for a single use on a patient and is then discarded. A second tool type is replaceable and preferably sterilizable. In such a device the entire instrument may be cleaned and sterilized for repeated use or the tool itself may be removed for cleaning and sterilization. In a third tool type, a variety of different tools may be interchangeably used with a single device, and may be detached and reattached to the device as required by a user.

[0136] **FIG. 5***c* depicts an schematic showing an arrangement of pressure sensors that may be used in accordance with certain embodiments of the invention. In the arrangement of **FIG. 5***c*, pressure sensors **116***a-d* are provided for the thumb and first three fingers, respectively. As described above, the mechanism which operates the tool is responsive to the amount of pressure being applied by a particular finger and adjusts the operation of the tool accordingly. The mechanism which operates the tool may be either mechanical or electrical in nature, or may be a combination of both.

[0137] Pressure sensors **118***a* and **118***b* may also be provided for the tool of a medical device, in accordance with certain embodiments of the invention. In one embodiment, the tool is a pair of forceps, one of which is fixed and the other mobile. The pressure sensors **118***a* and **118***b* may be used in such an arrangement to detect the pressure being placed upon the forceps. The pressure sensors **118***a* and **188***b* are configured so that the pressure they sense is transmitted back to the user, through a mechanical or electrical mechanism, as previously described. Alternatively, the mechanism used to transmit the pressure signal generated by the pressure sensors **118***a* and **118***b* is both mechanical and electrical in nature.

[0138] Referring to **FIG. 6**, another embodiment of a medical device **130** is depicted. This device **130** includes a cauterization button **132**. The cauterization button **132** is associated with a mechanism in the tool (not shown) which causes at least a portion of the tool to heat up so as to permit a user to cauterize tissue. In one embodiment activation of the cauterization button **132** closes an electrical circuit (not shown) so that a voltage is delivered to the tool which is then ready to provide electro-cautery to tissue. Once the cauterization button **132** is deactivated, the electricity is no longer delivered to the tool and the tool cools off. The medical device **130** is generally insulated from the electric circuit so that an electrical charge is not unintentionally transmitted to other parts of the medical device **130** or to the user. Optionally, the function of the cauterization button **132** may be provided by a different control element or feature.

[0139] Where the hand piece **134** includes separate finger portions **136***a-d*, the hand piece **134** may be configured so that a user's hand fits entirely or partially with the hand piece **134**. In such an embodiment, the hand piece **134** includes an interior portion (not shown) configured to accept a user's hand, and preferably to accept a gloved hand. The interior portion is accessed through an opening **138** in the hand piece **134** of sufficient size to allow a user's hand, or part of a hand, to enter the interior portion of the hand piece **134**. The trigger **140** and trigger guard **142** are positioned for easy access by the user's index finger. A grip, or palm rest **144** may also be provided within the interior space of the hand piece **134**. The grip or palm rest **144** facilitates easy manipulation of the medical device **130**, and helps to provide the user a firm grasp of the device **130**, and prevent slippage. A rotation knob **146** for the internal shaft **148** is also depicted in this view.

[0140] **FIG. 7***a* depicts a medical device **160** in accordance with another embodiment of the invention. A scissor-type hand piece **162** is provided with a first elongated portion **164***a* and a second elongated portion **164***b*. Together, the first elongated portion **164***a* and the second elongated portion **164***b* are moveable towards each other, much like the operation of the handle of a pair of scissors. Movement of these elongated portions **164***a* and **164***b* in the path of arrow C operates the tool **166**. A cauterization button **168** is provided and operates in a manner similar to that previously described. Another button **170** rotates the tool **166** at an angle relative to the device **160**. This button **170** operates in a manner similar to that previously described with respect to the trigger of other embodiments of the invention. This embodiment is depicted with an alternative single shaft **172**, which is rotatable in relation to the hand piece **162**, for instance in the path of arrow D. A rotation knob **174** is provided to facilitate a user's rotating the shaft **172**. As with the other embodiments, the control elements are not limited to the particular arrangement shown.

[0141] **FIG. 7***b* shows a lateral view of the medical device **160** of **FIG. 7***a* in a different position. In **FIG. 7***b*, the scissor-type hand piece **162** is in a closed position. In particular, the first elongated portion **164***a* and the second elongated portion **164***b* are moved toward each other.

[0142] **FIG. 8** depicts a pistol-handled medical device **186** in accordance with another embodiment of the invention. In this device **186** a pistol style handle **188** is provided which fits into the palm of a user's hand. In other respects, the medical device **186** is similar to those previously depicted. A cauterization button **190** is provided, as is a lever **192** for operation of the tool **194**. A trigger guard **196** is also provided, as is a trigger **198** for rotation of the tool **194** in relation to the device **186**. This embodiment is depicted with a single transcutaneous shaft **200** and a detachable tool **194** affixed to the end of the single shaft **200**. A rotation knob **202** is also provided to facilitate rotation of the single shaft **200** and the tool **194** thereon.

[0143] **FIG. 9** depicts another medical device **214** with a palm/wrist circumferential band **216** and sleds **218***a-d* for the thumb and middle, ring, and little fingers. The band **216** is useful to secure the device **214** to a user's hand and to prevent slippage. In other respects, the medical device **214** is similar to that depicted in **FIG. 8**. A handle (not shown) may be provided for a user to grip with the hand much like the pistol style handle of the embodiment shown in **FIG. 8**. A cauterization button **220** is provided, as is a lever **222** for operation of the tool (not shown). A trigger guard **224** is also provided, as is a trigger **226** for rotation of the tool in relation to the device **214**. This embodiment is depicted with a single transcutaneous shaft **228**, and a rotation knob **230** is also provided to facilitate rotation of the shaft **228** and the tool thereon.

[0144] The sleds **218***a-d* may be provided with pressure sensors **232***a-d* in the medical device **214** of **FIG. 9**. These pressure sensors **232***a-d* operate in substantially the same manner as that previously described in **FIGS. 5***a* and **5***c*, providing sensory input between the user and the device with regard to the tissue density being encountered by the tool (e.g., soft tissue, firm tissue or bone) or the pressure being applied by the user upon the device **214**. The sleds may be constructed so as to achieve functionality similar to that achieved with the glove-handle of **FIG. 5***a*.

[0145] Referring to **FIGS. 10***a*, **10***b*, **10***c*, **10***d* and **10***e* a variety of scissors-type tools for use with certain embodiments of the present invention are provided. **FIG. 10***a* shows a flat scissors tool **244** with a first cutting element **245***a* and a second cutting element **245***b*. This scissors tool **244** may be provided in a variety of sizes, for instance as a small version of Mayo-type scissors. The scissors tool **244** may be rotated, for instance in the direction of arrow E. After such a rotation the scissors tool **244** may be in the position shown in **FIG. 10***b*. **FIG. 10***c* shows a right-angled scissors tool **246** with a first cutting element **248***a* and a second cutting element **248***b*. This scissors tool **246** may be provided in a variety of sizes and may function similar to Potts-style scissors. Further, this scissors tool **246** may be rotated, for instance in the direction of arrow F. **FIG. 10***d* shows a curved scissors tool **250** with a first cutting element **252***a* and a second cutting element **252***b*. Each of the first cutting element **252***a* and second cutting element **252***b* are provided with a curved shape. This scissors tool **250** may also be provided in a variety of sizes and may function similar to dissection scissors, such as Metzenbaum-type scissors. **FIG. 10***e* shows a cauterizing scissors tool **254** with a first cutting element **256***a* and a second cutting element **256***b*. Additionally, each cutting element **256***a* and **256***b* includes a heating element **258***a* and **258***b*. Any of the foregoing scissors tools may be configured with heating elements for cauterizing tissue. Further, many of the other tools contemplated for use with the various medical devices of the invention may be provided with heating elements for cauterizing tissue. Each of the scissors tools **244**, **246**, **250**, and **254** may be rotated. This rotation may include both rotation about the axis of the shaft to which the tools are mounted and about an axis at an angle to that shaft, as described with respect to the previous tool embodiments.

[0146] Referring to **FIGS. 11***a*, **11***b*, and **11***c*, a variety of forceps tools for use with certain embodiments of the present invention are provided. **FIG. 11***a* shows a DeBakey style forceps tool **270** with a first grasping arm **472***a* and a second grasping arm **472***b*. This forceps tool **270** may be configured so that it is suitable for vascular work, and other fine tissue handling. For delicate work, the forceps tool **270** may be configured to deliver only limited amounts of force, and need not be configured to deliver a crushing level of force. In one embodiment, the forceps tool **270** is provided with pressure sensors **274***a* and **274***b* which are useful to transmit a pressure sensation from the forceps tool **270** back to the user, as previously described, especially with reference to **FIGS. 5***a* and **5***c*. **FIG. 11***b* shows the forceps tool **270** of **FIG. 11***a* in a closed position.

[0147] **FIG. 11***c* depicts a right-angled forceps tool **276** with a first grasping arm **278***a* and a second grasping arm **278***b*. Preferably this forceps tool **276** is constructed from a material with characteristics that are or are similar to metal or metallic materials, especially with regard to the material's density, strength, and flexibility. The tips of the forceps tool **276** may be configured in a variety of shapes, including fine, sharp tips, larger smooth blunt tips, or large blunt curved or right-angled tips.

[0148] **FIG. 11***d* shows a blunt forceps tool **280** with a first grasping arm **282***a* and a second grasping arm **282***b*. This forceps tool **280** may be configured similarly to blunt tip clamps often used in open procedures, such as a Babcock-style clamp. Each of the forceps tools **270**, **276**, and **280** may be rotated as described above, both about the axis of the shaft to which they are mounted and about an axis at an angle to that shaft, as described with respect to the previous tool embodiments.

[0149] Preferably, the forceps tools **270**, **276**, and **280** may be configured to mimic the action, and provide the sensation and operation of a common "open handed" forceps tool. The forceps tools **270**, **276**, and **280** may be provided with spring action which must be overcome in order to close or approximate the forceps tool **270**, **276**, and **280**. This spring action may provide a user with feedback useful to determine the mechanical pressure needed to close the forceps tool **270**, **276**, and **280**. The forceps tools **270**, **276**, and **280** may otherwise be provided with pressure sensors such as those depicted in **FIG. 11***a* as part of an electrical or mechanical pressure sensor-based feedback mechanism, as described previously. Further, the forceps tools **270**, **276**, and **280** may include a combination of pressure sensors based feedback mechanisms and purely mechanical feedback mechanisms. An example of such a purely mechanical feedback mechanism would be the resultant feedback provided by a mechanical linkage as the tool reaches the limit of its range of motion. Where the control is mechanically linked to the tool, movement of the control is limited as the movement of the tool is limited.

[0150] Referring to **FIGS. 12***a* and **12***b*, clamp tools for use with certain embodiments of the present invention are provided. **FIG. 12***a* shows a Cooley style clamp tool **300** with a first clamping arm **302***a* and a second clamping arm **302***b*. **FIG. 12***b* shows a Satinski style clamp tool **304** with a first clamping arm **306***a* and a second clamping arm **306***b*. This clamp tool **304** includes at least one angle in the clamping arms **306***a* and **306***b*, which in some embodiments is from about 75 to 85 degrees. Each of the clamp tools **300** and **304** may be rotated as described above, both about the axis of the shaft to which they are mounted and about an axis at an angle to that shaft, as described with respect to the previous tool embodiments. **FIG. 12***c* depicts clamp tool **304** of **FIG. 12***b*, in a different position, after the clamp tool was rotated.

[0151] While the clamp tools **300** and **304** may be configured similarly to the style of clamps used in open surgery, they are specially adapted for minimally invasive surgery. In certain embodiments the clamp tools **300** and **304** are adapted to collapse into a small size so as to fit through a trocar port, or other surgical incision, and then to expand upon deployment within a patient's body. A mechanical mechanism or combination of mechanisms may be provided to close or approximate the tips of the clamp tools **300** and **304**. The mechanical mechanism or mechanisms transmit the force of pressure applied by the user and preferably are adapted to provide the user feedback on the amount of resistance delivered to the clamp tools **300** and **304**. The clamp tools **300** and **304** may be configured so that they may be locked at a particular degree of closure or approximation.

[0152] Referring to **FIG. 13***a*, an ultrasonic medical device **320** is provided. The ultrasonic medical device **320** is useful to image various tissues and structures of a patient. The device **320** can image solid, hollow, or blood or fluid filled structures. The device **320** can also measure the flow rate of vascular structures and can be used to provide graphic diagrams of tissue based on the selection of a user. For instance, a user may elect to view hepatic, lung, bone, bowel, spleen, vessel, ovary, uterine, or a variety of other types of tissue. The device **320** may be configured with a probe tip **322** that is smaller than that currently available for use with ultrasonic devices. Further, the device **320** is adapted for manipulation with a single hand so that it is easy to position and use.

[0153] The ultrasonic medical device **320** may be used in combination with an optical medical device, or other minimally invasive medical device as described herein. When use with an optical medical device the images produced by the devices may be combined in a single display for the convenience of the user. **FIG. 13***b* depicts a screen image with a combination of an visual image **330**, such as that obtained by a camera, and an inset ultrasonic image **332**. The ultrasonic image **332** may replace the visual image **330** entirely and the ultrasonic image **332** may include a diagrammatic depiction of the subject being imaged. For instance, the ultrasonic image **332** may include an outline of vessels with the pulse and/or flow rate determined and displayed along with the ultrasonic image **332**. The volume or size of fluid filled and other structures may also be calculated and depicted along with the ultrasonic image **332**.

[0154] **FIG. 13***c* depicts two ultrasonic probe types for use in accordance with certain embodiments of the invention. One is a curvilinear probe **334** which images a cone shaped area **336** that progressively increases with increasing distance from probe **470**. A second type is a spherical probe **338** which images a rounded area **340** that generally extends in a 180 degree arc away from the spherical probe **338**. A third type of probe suitable for use with certain embodiments of the invention is a flat probe (not shown) which is useful for imaging vascular structures. In one embodiment, an ultrasonic device is provided that has may be used with multiple detachable probes, such that any of a variety of ultrasonic probes may be used.

[0155] **FIG. 14***a* depicts a laser **350** in accordance with another embodiment of the invention. The laser **350** may be any suitable type of laser, and in one embodiment is an argon laser. The laser **350** is specially adapted for minimally invasive surgery to apply laser energy to a target selected by the user. The laser **350** is equipped with a tip **352** that is mobile, so that the user may maneuver it. In this way, the laser **350** may be positioned for delivery of laser energy in the vision field provided by a second medical device. The tip **352** may be attached to a flexible wand **354** which further facilitates convenient manipulation and direction of the laser energy. The laser **350** may be multi-directional such that laser energy is directed into one of several discreet areas surrounding the tip **352**.

[0156] **FIG. 14***b* depicts a display screen **364** showing a control panel useful for controlling a laser, such as that depicted in **FIG. 14***a*. The control panel is associated with a controlling computer (not shown) and allows a user to select from various laser intensity levels and effective distances from the laser tip. The control panel also provides a user the ability to select the direction of emission of the laser energy in relation to the laser tip. The control panel may be touch sensitive, or it may be provided with a separate keyboard and/or pointing device, such as a mouse (not shown) for the user to input instructions to the controlling computer.

[0157] In another embodiment, the present invention provides tools for tissue cautery. **FIG. 15***a* depicts a view of one embodiment of a forceps-type cautery device **380**. A scissors-style handle is provided with a first elongated portion **382***a* and a second elongated portion **382***b* similar to that shown in **FIGS. 7***a* and **7***b*. A variety of controlling elements **384***a-c* such as knobs, buttons, or switches are provided to control the tool **386**. A first controlling element **384***a* may be used to activate or deactivate cautery. A second control element **384***b* may be used to orient the tool **386**, for instance rotating the tool **386** at an angle relative to the shaft **388** to which the tool **386** is mounted. A third control element **384***c* may be used to cause the tool **386** to retract or advance relative to the cautery device **380**. The tool **386** shown in the embodiment in **FIG. 15***a* is a forceps tool **386**, however a variety of other tools might also be used.

[0158] **FIG. 15***b* depicts another cautery device **390**. This cautery device **390** is similar to that depicted in **FIG. 15***a*, however a wand-type handle **392** is provided. This handle **392** allows the device **390** to be used by either hand singularly. The tool **394** in this embodiment is a cylindrical cautery tool. A variety of controlling elements **396***a-c* may also be provided. A separate cautery controller **398** may also be provided and is connected to the cautery device **390** by a cord **400**. The cautery controller **398** may include a variety of controller elements **402***a* and **402***b* which allow a user to adjust the intensity of the energy delivered to cauterize tissue or to turn the cautery function on or off, or to control some other aspect of the cautery device **390**. Although only described with reference to cautery device **390**, the cautery controller **398** may be used with a wide variety of cautery devices.

[0159] **FIG. 16** shows a variety of different cautery tool tip types. These cautery tool tip types include the following: a flat tool **412** which is a dull square blade; a forceps tool **414** similar to the forceps cautery tool used in open surgery; a spherical ball tool **416** which provides a greater surface area for cauterizing more tissue; a rounded tool **418** which is blunt and may be provided as a relatively small tool; and a needle tool **420** for cutting or performing fine dissections. These cautery tools are configured so that they be used for probing, touching, and moving tissue without damage until the cautery function is activated by the user.

[0160] **FIG. 17** depicts a stapler **440** in accordance with an embodiment of the invention. The stapler **440** is constructed to staple tissue and/or cut between the staple lines. The stapler **440** allows a user to simply staple tissue, or staple and then cut the stapled tissue. Alternatively, a user may decide to staple tissue and then cut the tissue using a cautery scissor or cautery wand to divide the tissue between the staple lines. The stapler **440** provides superior staple lines and is appropriately sized to be of particular use in minimally invasive surgical techniques. The stapler **440** includes a knife (not shown) that may cut in either a cold (ambient temperature) setting or a hot (e.g., a cautery temperature) setting. The stapler **440** may be configured for single handed operation.

[0161] In the stapler **440**, a handle **442** is provided that, in one embodiment, may be gripped by either the right or left hand of the user. A double lever system with a close lever **444** and a staple lever **446** is also provided. The close lever **444** operates to close the stapler about the tissue to be stapled. The staple lever **446** operates to actually staple the tissue together. A cut controlling element, for instance a button or switch **448**, engages the cutting function of the stapler **440** and a position controlling element **450** allows a user to rotate the position of the stapler tool **452** in relation to the stapler shaft **454**. The staple function and the cutting function of the stapler **440** may be manually or automatically driven. When the staple function is automatic, it may be either gas or electric or any other suitable method of automatically driving staples.

[0162] In one embodiment, the stapler tool **452** may be positioned at an adjustable angle from 0 to 90 degrees in relation to the stapler shaft **454**. In an alternate embodiment, the stapler tool **452** may be positioned at a preset angle of either 0, 45, or 90 degrees in relation to the stapler shaft **454**.

[0163] The stapler tool **452** may also include a lock function which operates to ensure that the tissue to be stapled and/or cut is not squeezed out before being stapled. If the tissue is squeezed out as the stapler is closed, a complication may arise resulting in bleeding or leakage from the staple line. **FIG. 18***a* depicts an embodiment where a lock **460** functions to substantially hold and secure the tissue in place before stapling and/or cutting. In **FIG. 18***a*, the lock **460** is shown in an open position. **FIG. 18***b* depicts the same embodiment as FIG. **18***a*, with the lock **460** in a closed position. In the closed position, the lock **460** is dropped on the two anvils **462***a* and **462***b* to hold the tissue in place. The anvils **462***a* and **462***b* are mounted in a V-configuration in relation to each other and one end of each of anvils **462***a* and **462***b* moves toward the other in order to staple tissue together. The use of the lock significantly increases the integrity and security of the staple line.

[0164] **FIGS. 19***a*, **19***b* and **19***c* depict an alternate embodiment of a portion of a stapler device **470**. In this embodiment, the anvils **472***a* and **472***b* are mounted in a parallel arrangement to each other and the entire anvil **472***a* or **472***b* moves toward the other anvil **472***a* or **472***b* in order to staple tissue together. **FIG. 19***a* depicts a stapler **470** with the anvils **472***a* and **472***b* in an open position. The lock mechanism **474** is also in an open position. The lock mechanism of **FIGS. 19***a*, **19***b*, and **19***c* operates similarly to that of **FIGS. 18***a* and **18***b*, wherein the lock mechanism prevents tissue from being squeezed out of position when the anvils **472***a* and **472***b* are closed, but before the tissue is stapled. **FIG. 19***b* depicts the anvils **472***a* and **472***b* in an open position, with the lock mechanism **474** closed. In the position shown in **FIG. 19***b*, the tissue is held in position by the lock mechanism **474**, however the anvils **472***a* and **472***b* are not yet closed together to effect driving a staple through the tissue. **FIG. 19***c* depicts an embodiment of a stapler **470** with parallel anvils **472***a* and **472***b* in a closed position. In **FIG. 19***c*, anvils **472***a* and **472***b* are positioned almost immediately next to one another.

[0165] Optionally, the stapler **470** may staple and cut the tissue. In one embodiment the cut is performed with an unheated razor blade (not shown). Alternatively, the cut may be performed with a heated razor blade so that the tissue is cauterized as it is cut. Simultaneously cauterizing and cutting the tissue discourages excess bleeding from the cut tissue. Electrical energy may be applied to the blade or a separate cautery element (not shown) in order to sufficiently heat the tissue for cauterization.

[0166] **FIGS. 20***a* and **20***b* depict arrangements for stapling tissue in accordance with certain embodiments of the invention. A double row of staple lines **490***a* and **490***b* is applied to one side of the cut **492** while a second double row of staple lines **494***a* and **494***b* is applied to the other side of the cut **492**. The cut **492** is separate from the edges of the nearer staple lines **490***b* and **494***b*.

[0167] **FIG. 20***b* depicts an additional option, where the tissue is compressed along a tissue compression lines **496***a* and **496***b* on the outermost side of the staple lines **490***a* and **494***a*. With this option, the tissue is compressed prior to stapling or cutting so as to reduce blood flow to the region before stapling or cutting. This has the added effect of increasing the success of the stapling to control and restrict blood flow in all vessels (arteries, veins, and capillaries). Further, the compression may help to keep the tissue immobile for the stapling procedure, thereby assuring the stapling procedure creates a strong and secure fastener for the tissue or tissues being joined or closed.

[0168] **FIG. 21***a* depicts a suturing device **740** in accordance with an embodiment of the invention. A firing gun **742** is provided with a needle **744** which is adapted to push suture material through tissue and withdraw it. The firing gun **742** includes a trigger **746** which, with each pull, causes the firing gun **742** to push the needle **744** and attached suture material through the tissue and then withdraw it. Alternatively, each pull of the trigger **746** may cause only a portion of the needle's movement, for instance the pushing of the needle **744** through the tissue. Then a separate pull of the trigger **746** would cause the needle **744** to be withdrawn from the tissue. A shaft **748** may be used to secure the firing gun **742** to a base **750** with a bobbit **752**. An internal bobbit **752** is depicted, although an external bobbit (not shown) may also be used.

[0169] **FIG. 21***b* depicts a portion of the suturing device of **FIG. 21***a* as it operates. In operation the suture material **754** is grasped by the needle **744** upon passage to the bobbit assembly **752** and is then pulled through the tissue **756**. The needle **744** moves in the direction of arrow G. The needle **744** advances and after advancement, comes to a stop. With another trigger pull, the needle **744** withdraws. A portion of the suture material **754** is then on the other side of the tissue **756** (opposite the bobbit assembly **752**) and is left in this position by the needle **744**. The needle **744** is then moved laterally along the tissue **756** and may descend through the tissue **756** to retrieve another portion of suture material **754**.

[0170] **FIGS. 21***c* and **21***d* depict a needle driver device **500**. The needle driver device **500** is constructed to accept a straight needle and/or a curved needle. It includes two driver arms **502**_a_ and **502**_b_ which are pivotally attached, for instance by a hinge. A retractable guard **504** may also be provided. A separate hinge **506** may also be provided for one or more of the needle holders **508**_a_ and **508**_b_.

[0171] **FIGS. 21**_e_, **21**_f_ and **21**_g_ show a garrot style needle holder **520**. **FIG. 21**_e_ shows the garrot style needle holder **520** empty. A holder base **522** is provided, as is a garrot **524**. In **FIG. 21**_e_, the garrot is in a loose position, while in **FIG. 21**_f_, the garrot **524** is tight around the needle **526**. **FIG. 21**_g_ shows an end view of the garrot style needle holder **520**. The garrot in this embodiment is depicted as two components, a noose spring **526** and a noose **528**. Preferably the noose **528** is constructed from a generally flexible material such as wire or nylon.

[0172] **FIGS. 21**_m_-**21**_s_ depict yet another variety of a needle driver: an anvil-style needle holder **540**. In **FIG. 21**_m_, a portion of an anvil-style needle holder **540** is shown. In this embodiment, a first jaw **542** is shown as an elongated jaw. A second jaw **544** is shown with a pivotal hinge **546** provided in the middle. The hinge **546** permits a portion of the second jaw **544** to move relative to the first jaw **542**. Each of the jaws **542** and **544** is provided with a pivotally attached anvil **548**. **FIG. 21**_n_ shows a complete anvil-style needle holder **540**. The two jaws **542** and **544** of **FIG. 21**_m_ are shown, along with two rings **550** for grasping and manipulating the device. An anvil switch **552** is provided for each anvil **548**, and is used to actuate the respective anvil **548**. **FIG. 21**_o_ shows a side view of a portion of an anvil-style needle holder with the jaws apart and the anvils **548** open. **FIG. 21**_p_ shows a side view of a portion of an anvil-style needle holder with the jaws apart and one anvil **548**_a_ closed and one anvil open **548**_b_. **FIG. 21**_q_ shows a side view of a portion of an anvil-style needle holder with the jaws closed and one anvil **548**_b_ closed and one anvil **548**_a_ open. **FIG. 21**_r_ shows a side view of a portion of an anvil-style needle holder with an anvil switch **552**. **FIG. 21**_s_ shows a system of pulleys and hin

[0173] A variety of needle sizes are suitable for use with certain embodiments of the present invention including: 6-0, 5-0, 4-0, 3-0, 2-0, 0-0, 1, and 2. Similarly, the needle **744** may be any of a variety of suitable types, including blunt, sharp, standard bevel, or inverted bevel. Suitable suture materials include dexon, polyglactic **910** (sold by Ethicon, Inc. under the tradename VICRYL), polydioxanone (sold by Ethicon, Inc. under the tradenames PDS and PDS II), nylon, stainless steel, or a monofilament material such as that sold by Ethicon, Inc., under the tradename Proline.

[0174] **FIG. 21**_c_ depicts another arrangement for a suturing device **743**. In this generally gun-shaped suturing device **743**, a bobbit box cartridge **745** may be placed or loaded into the suturing device **743**. Preferably the bobbit box cartridge **745** is constructed to snap into place. Various control elements are provided on the suturing device **743**. In the particular arrangement shown, a button **747** is provided to cause a suture catcher **749** to advance. A handle lever **751** is provided to cause the needle **753** to advance. A trigger **755** is used to actuate the closing or opening of a bevel **757** on the needle **753**. Preferably the needle **753** and suture catcher rod **749** are provided through the barrel **759** of the suturing device **743**. This snap-in construction for the bobbit box cartridge **745** facilitates changing suture material and reuse of the suturing device **743** in a patient for multiple suture materials, for instance in different tissues.

[0175] **FIGS. 21**_d_ and **21**_e_ depict arrangements for the bobbit box cartridge **745**. In the arrangement shown in **FIG. 21**_d_, the bobbit suture **761** is a double strand which works in conjunction with the needle **753**. The arrangement shown in **FIG. 21**_e_ shows the bobbit suture **761** as a single strand which again, works in conjunction with the needle **753**. Generally, the bobbit is optional and is preferably constructed to conserve space and minimize entanglement.

[0176] **FIGS. 21**_f_ and **21**_g_ show cross-sectional views of the barrel 759. In **FIG. 21**_f_, the bobbit box cartridge **745** is shown installed in the barrel 759. The suture catcher rod 749 and needle **753** are also shown in **FIGS. 21**_f_ and **21**_g_. **FIG. 21**_g_ depicts a cross-sectional view of the barrel **759** taken further down the barrel **759**, away from the handle of the device (not shown) as compared to **FIG. 21**_f_. A guide slot **763** is shown in **FIG. 21**_g_ and provides an area for the suture material (not shown) to pass.

[0177] **FIG. 22**_a_ depicts a bobbit-style suture holder device **758**. The suture holder device **758** includes two bobbits **760**_a_ and **760**_b_ which hold the suture material **754**. The suture material **754** can be drawn between the bobbits **760**_a_ and **760**_b_ from left to right or right to left. The bobbits **760**_a_ and **760**_b_ are interconnected by a hollow tube **762** containing suture material (not visible) and are also interconnected by external suture material **754**, which is free to be caught by the needle.

[0178] **FIG. 22**_b_ depicts a base **750** secured to the shaft **748**. In this embodiment, the shaft **748** includes a needle guide **764**. The bobbits **760**_a_ and **760**_b_ of **FIG. 22**_b_ may be snapped into place in the base **750** thereby facilitating easy switching among different suture materials and suture sizes.

[0179] **FIG. 22**_c_ depicts an arrangement similar to that of **FIG. 22**_a_, but with an external bobbit assembly **766**. The external bobbit assembly **766** is optional and may be placed near the end of the needle guide **764**.

[0180] **FIGS. 22**_d_-**22**_v_ depict various embodiments of a suture catcher for use in accordance with certain embodiments of the invention. The suture catcher functions to hold the suture after the needle advances to the full extent (i.e. after it passes through tissue, or is reloading). The needle opens the bevel to release a suture it holds, or it can open the bevel to receive and then close to take the suture held by the suture catcher. In the embodiment shown in **FIGS. 22**_e-h_ and **22**_v_, the suture catcher is on a rod which may be triply-hinged and springed-loaded. When advanced, the rod forms a "C" shape to reach around the tissue, to meet the needle on the opposite side. When the needle is advanced by the user, at full advance it will rotate as shown in **FIG. 22**_u_ and the bevel is then opened (for instance by pulling the trigger) and the suture catcher can then grasp the suture from the needle. Preferably, the needle penetrates the catcher in the final 0.5 to 0.2 cm of the full needle advance distance. Preferably, the catcher is similar to tissue, in that the needle easily penetrates and pushes the suture catcher open. This avoids any significant friction or force which might tear or rip the suture. The catches at the end of the suture catcher may be "U" shaped, see **FIGS. 22**_i-k_, or "U" shaped with barbs, see **FIGS. 22**_l-m_, or in the form of a closed loop or "0" shape, see **FIGS. 22**_n_-**22**_t_. In one embodiment of the closed loop shape, the catcher is hinged to fold closed, see **FIGS. 22***n*-**22***q*. Preferably the suture catcher is constructed so that when the needle retracts or is not present, the catcher spring hinge design closes the catcher. When the catcher shaft is retracted into the barrel of the device, the hinged joints are leveled to form a straight shaft. When the catcher is advanced the spring hinged elbow joints may form the open "C", "U", or "O" shape. In operation, for instance, the suture catcher of **FIGS. 22***n* and **22***p* may be advanced out of the barrel with the advancing of the needle. With the needle bevel open and the needle withdrawn, the suture catcher may close on the suture, and in this way hold it.

[0181] With particular reference to the Figures showing the suture catcher embodiments, **FIG. 22***e* shows the suture catcher **767** with the needle **753** advanced. **FIG. 22***f* shows the embodiment of **FIG. 22***e* with the suture catcher **767** advanced. **FIG. 22***g* shows a similar embodiment in the closed position, with the suture catcher **767** and the needle **753** inside the barrel **759**. **FIG. 22***h* shows a similar embodiment, with the needle **753** advanced to release a suture to the suture catcher **767**. **FIGS. 22***i*-*k* show different positions of one embodiment of the suture catcher **767** as it goes from an open position, **FIG. 22***i*, to a partially open position **FIG. 22***j*, to a closed position, **FIG. 22***k*. **FIGS. 22***n* and **22***o* show a triangle-shaped suture catcher in an open and closed position, respectively. **FIGS. 22***p* and **22***q* show a quadrangle suture catcher in an open and closed position, respectively. **FIGS. 22***r* and **22***t* show a flat "hole" suture catcher in a closed and open position, respectively, and **FIG. 22***s* shows side views of the flat "hole" catcher. **FIG. 22***u* shows the circular movement action of the needle **753** which may be used to release a suture from an open bevel, and to reload a suture and close the bevel. Finally, **FIG. 22***v* shows a close-up view of a hinge for a suture catcher, with a catcher shaft **763** and multiple springs **765**.

[0182] **FIG. 23***a* depicts a rivet driver **768** in accordance with another embodiment of the invention. The rivet driver **768** is configured to drive and crimp a fastener across tissue. The rivet driver **768** may be used to fasten or close dense tissue such as fascia, or the diaphragmatic crus during esophageal hernia repairs. The rivet driver **768** may include a rotation knob **769***a* and certain control levers **769***b* and **769***c* to provide a user control over the disposition and operation of the rivet driver **768**. The rivet driver **768** also includes a handle **770** attached to an elongated shaft **772**. One of the control levers **769***b* may control, for instance, the closing of elongated members **774***a* and **774***b* which make up the rivet tool.

[0183] Each elongated member **774***a* and **774***b* may include one or more claws or barbs **776***a-d*. The barbs **776***a-d* are useful to help keep the tissue together or to keep the tissue in position prior to the rivet fastener or nail traversing the tissue. The barbs **776***a-d* may have sharp thin teeth (not shown). In one embodiment, the barbs **776***a-d* are very short, which allows easy withdrawal from tissue and avoids damage to the tissue grasped by the barbs **776***a-d*.

[0184] In one embodiment, the rivet driver **768** pushes the fastener, which is made up of two rivet portions **778***a* and **778***b* together so that the rivet portions **778***a* and **778***b* will not disengage once released by the rivet driver **768**. A rivet portion **778***a* or **778***b* fits in each elongated member **774***a* and **774***b*. In certain embodiments (not shown) multiple rivet portions (not shown) may be stored in a channel or a cartridge assembly which automatically loads a new rivet portion upon releasing a used rivet portion. Alternatively, a nail be used instead of rivet portions **778***a* and **778***b*. A crimper button or lever **771** may be provided to allow a user to separately control the crimping of a rivet, with a crimper **783**, as described below.

[0185] **FIG. 23***b* depicts rivet portions **778***a* and **778***b* which may be constructed from non-absorbable material including stainless steel, nylon, or plastic, or an absorbable material such as polyglactic **910** (sold by Ethicon, Inc. under the tradename VICRYL), polydioxanone (sold by Ethicon, Inc. under the tradenames PDS and PDS II), chromic material, a polymer material such as polyethylene, or any other suitable material. Each rivet portion **778***a* and **778***b* is configured to be complimentary to and engage its complimentary rivet portion **778***a* or **778***b*. The rivet portion **778***a* on the left includes a narrow portion with a tip **780** which penetrates tissue. The tip **780** may be blunt, or bulbous, or sharpened. A flat, disc-shaped head **782***a* is also provided and helps to anchor the rivet portion **778***a* to the tissue the rivet portion **778***a* is driven through.

[0186] The partner rivet portion **778***b* has a similar diameter, but is slightly larger, in order to accommodate the complimentary rivet portion **778***a*. One end of the partner rivet portion **778***b* is open to provide access to a hollow tube **784***a*. Hollow tube **784***a* includes an internal indentation, notch or ring **784***b* which the tip **780** of the rivet portion **778***a* will engage once the rivet portions **778***a* and **778***b* are pushed together. This indentation **784***b* helps to prevent disengagement once the rivet portions **778***a* and **778***b* are pushed together. One end of rivet portion **778***b* may also be provided with a flat, disc-shaped head **782***b*.

[0187] **FIG. 23***c* depicts a pair of rivet portions **778***a* and **778***b* which have been partially pushed together. In the configuration depicted in **FIG. 23***c*, the rivet portions **778***a* and **778***b* are engaged and from this position, they may normally be more fully pushed together so as to form secured fastener. The position of the heads **782***a* and **782***b* of the rivet portions **778***a* and **778***b* is visible in this drawing as being useful to provide an anchor in the tissue the rivet portions **778***a* and **778***b* are driven through.

[0188] **FIG. 23***d* depicts rivet portions **778***a* and **778***b* in a closed position. Additionally, a crimper **783** is provided for use with rivet portions **778***a* and **778***b*. The crimper **783** compresses the middle portion of the fastener formed by the rivet portions **778***a* and **778***b*, between the two heads **782***a* and **782***b* of the rivet portions **778***a* and **778***b*. The crimper **783** helps to assure the rivet portions **778***a* and **778***b* join solidly to form a secure fastener.

[0189] **FIG. 23***e* depicts the rivet portions **778***a* and **778***b* in a closed position after application of the crimper **783** to secure the rivet portions **778***a* and **778***b* together. In this embodiment, the compression of the rivet portions **778***a* and **778***b* by the crimper **783** is clearly visible.

[0190] **FIG. 23***f* depicts a rivet holder or cartridge **786** which may be fitted into a rivet driver such as rivet driver **768** shown in **FIG. 23***a*. The rivet holder **786** may include a channel **788** with a riveting zone from which the rivets may be applied. The channel **788** holds the rivet portions **787***a-d* until they are ready for use. The channel **786** may also include an opening **790** which allows the rivet portions **787***a-d* to be released as they are used, one at a time. The rivet holder **786** may be configured to hold multiple rivets. In one embodiment, the rivet holder **786** is configured to hold up to 10 rivet portions **787***a-d*.

[**0191**] **FIG. 23***g* depicts a two rivet portions **778***a* and **778***b*, which are similar to those described above, however in this embodiment internal fastener rivet portion **778***a* splits at an angle (preferably about ninety degrees) inside the receiving rivet portion **778***b*, when closed, as is shown in **FIG. 23***h*. The split, caused by the mechanical compressive force of the device pushing the fasteners together is not reversible through mild to moderate traction force. Thus, the rivet portions **778***a* and **778***b* are held together in this fashion. **FIG. 23***i* depicts various ways the rivet portion **778***a* might be constructed to split, for instance into halves, thirds or quarters. In another alternative, rivet portion **778***a* may be used alone, without a complementary rivet portion **778***b*, as shown in **FIG. 23***j*. In this embodiment, the part of the rivet portion **778***a* that splits is used to secure tissue.

[**0192**] Table 1 below shows suitable rivet sizes for use in accordance with certain embodiments of the invention. These sizes refer to an assembled and compressed rivet.

TABLE 1

RIVET SIZES

Gauge	Head Diameter (cm)	Length (cm)
4	0.5–1	0.5–2
6	0.5–1	0.5–2
8	0.5–1	0.5–2
10	0.5–1	0.5–1.5
12	0.5–1	0.5–1.5
16	0.5–1	0.5–1.5
18	0.25–0.5	0.5–1
20	0.25–0.5	0.5–1

[**0193**] Additionally, rivets portions **778***a* and **778***b* may be provided in the following dimensions: a shaft length of 0.5 cm with a total length when closed of 0.7 cm. The diameter of the rivet head may be 0.4-0.8 cm and the thickness 0.1 cm. The tip head may be 0.3-0.5 cm with a hollow tube diameter of 0.1 cm and an inner ring diameter of 0.08 cm and an exterior diameter of 0.1 cm.

[**0194**] **FIG. 24***a* depicts a needle driver **792** with a handle **794** and an elongated shaft **796** with a needle **798** mounted thereto. Numerous control elements **800***a-d* are provided to control operation of the needle driver **792**. A bevel lock **802** may also be provided to close the bevel **804** on the needle **798**. The bevel lock **802** may be operated by one or more of the control elements **800***a-d*, for instance a lever **800***a* and a button **800***b* may be used to open or close the bevel lock **802** over the bevel **804**. Levers **800***c* and **800***d* may be used to advance the needle **798**.

[**0195**] **FIG. 24***b* depicts the needle **798** of **FIG. 24***a*, with the bevel lock **802** in an open position.

[**0196**] **FIG. 24***c* depicts a needle **806** similar to that shown in **FIG. 24***a*, however the needle **806** of **FIG. 24***c* has an inverted bevel **808**. In **FIG. 24***c*, the bevel lock **802** is shown in a closed position.

[**0197**] **FIG. 24***d* depicts the needle **806** of **FIG. 24***c*, with the bevel lock **802** in an open position.

[**0198**] **FIG. 24***e* depicts various needles **810***a-h* for use in accordance with certain embodiments of the invention, particularly the needle driver of **FIG. 24***a* and the suturing device of **FIG. 21***a*. Needles **810***a*-**810***d* all include a blunt tip, while needles **810***e-h* include a sharp tip, which may be either a smooth circular or a cutting type of tip. The needles **810***a*-**810***h* also vary in some instances in the bevel type **812** of the particular needle **810***a*-**810***h*. Needles **810***a* and **810***e* have a traditional open bevel **812**. This allows suture material (not shown) to slide in or out of the needle's grasp. Needles **810***b* and **810***f* have an inverted bevel **812**. This arrangement is similar to that of the open variety, however the edges of the bevel **812** are turned inward, giving the needles **810***b* and **810***f* a different grasp of suture material. Needles **810***c* and **810***g* have a pusher style bevel **812**. In this arrangement the suture material is generally held in place while the needles **810***c* and **810***g* push through a tissue, and the suture material is left behind as the needles **810***c* and **810***g* exit the tissue. Needles **810***d* and **810***h* have a puller-style bevel **812**. These needles **810***d* and **810***h* are similar the needles **810***c* and **810***g*, however they work in the opposite directions. Thus, needles **810***d* and **810***h* pull suture material through tissue as they exit the tissue and leave the suture material behind as the needles enter and push through tissue. Preferably the needles are constructed from stainless steel, however they may also be constructed from other suitable materials.

[**0199**] Where a needle is intended for use with the suturing device of **FIG. 21***a*, the pusher-style and puller-style needles are particularly useful. When the suturing device uses an internal bobbit, the puller style needles **810***d* and **810***h* are useful. When the suturing device uses an external bobbit, the pusher style needles **810***c* and **810***g* are useful.

[**0200**] In certain embodiments, the needles **810***a*-**810***h* are provided in the following dimensions: a needle gauge of 6, 8, 10, 12, 14, 16, 18, 19, 20, 22, 24, 28, 30, 32; a bevel length of from 0.25 cm to 1 cm; and an overall needle length of from 2 cm to 15 cm, with the portion of the needle intended to be internal to the device being from 1 cm to 10 cm and the portion of the needle external to the device ranging from 1 cm to 5 cm. Needles of other dimensions may also be used in accordance with the invention.

[**0201**] **FIG. 25***a* depicts needles **816***a-h* for use with certain embodiments of the invention. These needles **816***a-h* include locking features for their bezels. Needle **816***a* includes a sheath **820** which is a hollow tube that slides laterally along the needle **816***a* to cover and close the bezel **818**. In one embodiment, the sheath does not cover the tip **822** of the needle **816***a*. The sheath **820** may also slide along the needle to an open position, as is depicted with needle **816***b*. A needle **816***c* may also be provided with a pusher or mounting rod **824**. In this embodiment, various needles are exchangeable and may be mounted to the pusher **824** as desired by the user. Alternatively, the needle and the pusher **824** may be fused together.

[**0202**] A needle **816***e* may also be provided with a bevel lock mechanism incorporating a wire **826**. The wire **826** may slide from an open position to a closed position over the bevel **818**. As can be seen in with respect to needle **816***e*, the wire serves to partially close access to the bevel **818**, thereby preventing any suture material from entering or leaving the bevel **818**, as the case may be. A wire guide channel **827** may be provided in which the wire **826** may at least partially rest.

[0203] A needle **816***f* may alternatively be provided with a bevel lock mechanism based on a slidable plate **828**. Needle **816***f* is shown with a slidable plate **828** in a closed position. Needle **816***g* is shown with a slidable plate **828** in an open position, away from the bevel **818**. Needle **816***h* is depicted from a lateral view and is shown with a slidable plate **828** in a closed position over the bevel **818**.

[0204] **FIGS. 25***b* and **25***c* depict a cross-sectional view of a needle **816***d* which uses a wire-type bevel lock. In **FIG. 25***b*, the cross-section is taken above the bevel. A wire guide channel **827** is shown which may be used to provide a guide space for the wire **826**. **FIG. 25***c* shows a cross-sectional view similar to that shown for **FIG. 25***b*, however in **FIG. 25***c*, the wire **826** sits partially above the wire guide channel **827** profile.

[0205] **FIGS. 25***d* and **25***e* depict a cross-sectional view of the needle **816***f* with a slidable plate-type bevel lock. As may be appreciated from the drawings, different types of slidable plates **829***a* and **829***b* may be used to lock the bevel on the needle **816***f*. These needles are preferably provided with a channel in which the slidable plate **829***a* and **829***b* may slide. **FIGS. 25***d* and **25***e* show this channel at the intersection of the slidable plate **829***a* or **829***b* and the needle **816***f*.

[0206] **FIGS. 25***f* and **25***g* depict a cross sectional view of the bevel portion of the needle **831**. In **FIGS. 25***f* and **25***g*, the cross section is taken at the bevel, and the remaining raised portion of the needle **831** is not shown, thus the view is only a cross section of the bevel portion of the needle **831**. The bevel portion may a variety of sizes, as is useful for the particular application. By way of example, **FIG. 25***f* depicts a bevel portion with approximately 50% of the needle **831** cut away, **FIG. 25***g* depicts a bevel portion with approximately 20% of the needle **831** cut away.

[0207] Thus, it may be appreciated that the needle may be fixed relative to the device, and the needle bevel is opened or closed by a mobile lock such as the sheath, plate or wire lock described above. Alternatively, the needle may be mobile and the needle bevel lock mechanism, such as the sheath, plate or wire described above, may be in a fixed position relative to the device. The needle bevel is constructed so that it may hold a suture or be empty or release a suture.

[0208] **FIG. 26** depicts a pistol-style ligation device **828**. The device **828** includes a handle **830** associated with an extended shaft **832**. Certain control elements **834***a-f* are provided to allow a user control over the operation of the device **828**. In one embodiment, the device **828** has at least one of four distinct features. First, the device **828** may grasp two sutures to be joined as is commonly done with an open instrument. Second, the user may position the device **828** and choose the desired tension of the sutures and the actual site of the binding of the suture material. Third, the equivalent of a knot may be formed by fusion of the suture material either thermally or through adhesive fusion. Finally, the device **828** may provide the option of cutting off the sutures above the fusion or adhesive knot. Alternatively, the cutting may be performed by a separate scissor device (not shown).

[0209] One of two types of adhesive ligatures are preferably used in accordance with certain embodiments of the present invention such as that depicted in **FIG. 26**. One type involves the injection of liquid adhesive into a ligature forming mold (not shown) which may be heat sensitive. Upon application of heat, the liquid adhesive hardens to form a permanent to semi-permanent ligature, depending upon the material being used. The adhesion may be accomplished with a variety of suitable agents, including mixtures of multiple agents. Alternatively, mixtures of reactive agents may be formed which undergo a chemical reaction, either in the presence of heat energy or not, resulting in a permanent or semi-permanent solid with the sutures bound together therein. Ligatures may also be formed using an adhesive that hardens upon contact with some third substance, which third substance may act as catalyst. In one embodiment, the adhesive hardens upon contact with a mold frame. Suitable adhesives include plastic, polymeric silicon (available from Dow Chemicals under the tradename SILASTIC), polypropylene, polyglycolic, polyvicryl, GORTEX, cellulose, a chromic material, polyethylene, ceramic, glass, and stainless steel. In another embodiment, sutures are bound using a staple configuration

[0210] Control element **834***d* is a trigger that activates a scissor or blade to cut the suture material above the fusion site. In one embodiment, the suture material is cut 0.05 cm-1.0 cm above the fusion site. Preferably, control element **834***d* causes the blade or microscissor or regular scissor to advance to a position just above the suture so that the excess suture material may be cut away. Preferably the blade or scissors is advanced and then automatically retracted as a result of the single trigger pull.

[0211] The ligation device **828** may also include one or more rods **836** which are useful for manipulating the sutures. For instance, the rods **836** may be used to push or grasp or pull the sutures so that they may be ligated together. These rods **836** enable the ligation device **828** to be used to securely grasp the suture material the user desires to ligate, tie, or fuse together. The rods **836** may be integrated with the extended shaft **832**. In one embodiment (not shown) there are three rods **836** provided with the ligation device **828**. One rod is for grasping two sutures, one rod is for fusing or adhesive ligation stapling, and the third rod may be used for cutting the suture after ligation. Alternatively, a combination of a lesser number of the aforementioned rods may be provided.

[0212] **FIG. 27***a* depicts one embodiment of a grasping rod **838** for use in accordance with one embodiment of the invention. The grasping rod **838** includes two elongated grasping elements **840***a* and **840***b*, each of which are configured to close about a suture or other material and grasp it for manipulation by a user. In this embodiment, an adhesive substance is loaded in to a ligation device such as ligation device **828** depicted in **FIG. 26**. The adhesive substance may be provided in a particular shape or configuration, for instance in the configuration of a staple. The adhesive substance is applied or compressed on to the suture material which needs to be bound and the adhesive substance fuses together with the suture material. The adhesive substance may be fused by the activation of a fusion switch. The fusion switch activates a temperature controller which heats a heating element to cause fusion of a temperature sensitive adhesive.

[0213] **FIG. 27***b* depicts a stapler **842** for use in accordance with an embodiment of the invention. This stapler **842** may be used to staple two sutures together instead of using a knot to tying them together. The stapler includes elongated grasping elements **844***a* and **844***b*, similar to that depicted in **FIG. 27***a*. Each of the elongated grasping elements **844***a* and **844***b* is also provided with a thermal element **846***a* and **846***b* which may be used to induce melting of suture material together. In one embodiment, the thermal element is switched on by the touching of the thermal elements **846***a* and **846***b* together which closes an electrical circuit. This may then either melt the suture material or initiate a heat sensitive reaction with some other binding compound (as described below). Preferably this heat need only be applied for a few seconds, after which the thermal element **846***a* and **846***b* may be released Alternatively, the thermal elements **846***a* and **846***b* may be replaced with binding compound. The binding compound may take on any suitable form. In one arrangement, the binding compound is a non-metallic material which is pressed onto the sutures to be joined and the non-metallic material adheres to the sutures, creating a bond which is the functional equivalent of a knot tying the sutures together. The bond may be formed as a result of chemical reactivity between different binding compounds being brought together, or it may be spontaneous, as in the case of cyanoacrylate based glues, or a heat sensitive material such as chromic, plastic, nylon. The material may or may not be absorbable. Thus, the grasping rod **842** may be used to grab the sutures that are to be fastened together and then secure them through a thermal fusion action by use of the thermal elements or with binding compound.

[0214] **FIG. 27***c* depicts a manipulation rod **848** for use in accordance with an embodiment of the invention. This rod **848** is configured to grasp the sutures together, and then apply an injectable adhesive which binds the sutures together. A variety of suitable configurations may be used in order to apply the adhesive to the sutures. In the embodiment depicted in **FIG. 27***c*, the adhesive **850** is encased within an injectable mold **852**. In use, the mold **852** is compressed by lateral movement of the rod housing **854**, or alternatively movement of the rod **848** within the rod housing **854**, which compresses the mold **852**, forcing the adhesive **850** out each end of the adhesive housing **856***a* and **856***b* so that the adhesive **850** is applied to the sutures. Alternatively, the mold **852** may be opened to grasp the sutures to be bound together. At the desired position, the adhesive is injected and the sutures become bound. Preferably, the glue or adhesive bonds almost instantly so that after application of the glue or adhesive to the already-present sutures, they may be released from the grasp of the device and they are bound together. Further, a container **853** may be provided to hold and dispense the glue or adhesive for the stapler. The container **853** may be replaceable and tube-shaped and preferably dispenses the glue or adhesive as a result of pressure applied to the outer surfaces thereof.

[0215] **FIG. 27***d* depicts an adhesive ligation staple rod **860** similar to that shown in **FIG. 27***c*, but without the injector components. This staple rod **860** can be used to secure sutures together with an adhesive staple. In use, the staple rod **860** can be pushed into an open position followed by closure around the sutures which are to be secured together. An adhesive may then be applied and the sutures thereby secured together.

[0216] **FIG. 27***e* depicts an adhesive stapler loading device **862**. The adhesive stapler loading device **862** is configured to accept multiple staples **864***a*-**864***d* of different types. In on embodiment, two types of staples are provided, either hot or cold staples. The cold staples are compressed around the sutures to be fastened together, and no thermal energy is required to secure the ligation. The hot, or thermal staples, are configured to be compressed around the suture and thermal energy is applied to precipitate a chemical reaction to secure a bond between the sutures being fastened together. Preferably, the staples are nonmetallic, for instance they may be configured from nylon, polypropylene, polyethylene, or another plastic or other suitable material which may be used to bind the sutures together with either or both of compressive force and heat.

[0217] **FIG. 27***f* depicts an injector **866** which injects an adhesive substance into a compressor mold **868**. The compressor mold **868** may be either spherical, or rectangular, or box shaped. A suture guard **870** is provided to capture the suture material in an adhesive compression chamber **872** within the compressor mold **868**. Once the suture material **874** is captured within the compression mold **868**, two sides of the compression mold **868***a* and **868***b* are approximated, or closed together, and the adhesive is injected. In this way, the suture material is glued or bound together.

[0218] **FIG. 27***g* depicts an injector **866** similar to that shown in **FIG. 27***f*. The injector **866** of **FIG. 27***g* includes a compressor mold **868**. However, this compressor mold **868** includes rectangular or box shaped compression features **876***a* and **876***b*. The compression features **876** and **876***b* may be provided in any of a variety of shapes or configurations. For instance, the circular spheres depicted in **FIG. 27***f* or elliptical shapes or the rectangular shape shown in **FIG. 27***g*. The spherical delivery of the adhesive results, from the device shown in **FIG. 27***f*, results in a generally spherical shape of adhesive. The cube shaped delivery of the adhesive results, from the device shown in **FIG. 27***g*, in a generally cube-shape of adhesive.

[0219] **FIG. 28***a* depicts a tie clasp **878** which may be used to secure or bind sutures. The tie clasp **878** is configured from two semicircular shaped elements **878***a* and **878***b* which are pivotally attached to rotate about axis **880**.

[0220] **FIG. 28***b* depicts the tie clasp **878** of **FIG. 28***a* in a closed position. In the position shown in **FIG. 28***b*, semicircular elements **878***a* and **878***b* are closed so as to form a single circular, elliptical, or oval-shaped unit.

[0221] **FIG. 28***c* depicts another drawing of the tie clasp **878** of **FIG. 28***a*. In **FIG. 28***c* the tie clasp **878** is closed tightly. As can be seen in the drawing, the semicircular elements **878***a* and **878***b* are closed so as to tightly bind any suture material that might be on the interior of the closed shape formed by the two circular elements **878***a* and **878***b*.

[0222] **FIG. 29***a* depicts a clip **880** similar to that depicted in **FIG. 28***a*. However, the clip **880** of **FIG. 29***a* more closely resembles a staple than a device with two elongated semicircular rounded elements which pivot about an axis. The clip **880** of **FIG. 29***a* may be constructed from a single length of wire, flat metal, or other suitable material **882**. This single length of material **882** may be bent into what is generally a "U" shape with an opening **884** at one end.

[0223] **FIG. 29***b* depicts the clip **880** of **FIG. 29***a* in a closed position. The single length of material **882** is pressed together so that the opening **884** (depicted in **FIG. 29***a*) is closed. Preferably the single length of material **882** is closed about one or more sutures so as to bind them together.

[0224] **FIG. 29***c* depicts the clip **880** of **FIG. 29***a* in another closed position. In **FIG. 29***c* the clip **880** is closed tightly so that the single length of material **882** forms a loop with an interior area which is smaller than that depicted in **FIG. 29***b*. This may be useful in order to bind one or more sutures together tightly.

[0225] Referring to **FIGS. 28***a***-28***c* and **29***a***-29***c* certain clasps **878** and **880** are shown which may be used with certain embodiments of the present invention. These clasps **878** and **880** are configured to have an opening which may accept the one or more sutures to be bound. The clasps **878** and **880** are then closed about the sutures so as to bind them together. The clasps **878** and **880** may be closed in either loose or tight positions depending on the wishes of the user and upon the tissue response. Alternatively, the clasps **878** and **880** may be useful for binding multiple tissues or closing off openings in tissue, as in the case of closing a severed bowel, vessel, or other tubular-shaped tissue, or tissue with an opening.

[0226] **FIG. 30***a* depicts a circular stapler device **884** in accordance with an embodiment of the invention. The circular stapler device **884** is configured to staple pieces of bowel (stomach, colon, intestine, esophagus, or other tubular tissue) together. The circular stapler device **884** is useful to anastomose, or interjoin multiple tissues, such as tubular vessels. The circular stapler device **884** may be configured in a specific inner anastomosis diameter with a minimum of from a minimum of about 1 cm to about 3 cm. The circular stapler device **884** is configured to collapse into a smaller diameter when necessary to enter a laparoscopic port, or the bowel, prior to closure for stapling. The circular stapler **884** includes an anvil **886** which is attached to an elongated portion **888** and is operated by a handle configuration **890**. The handle configuration **890** is similar to that provided with respect to other embodiments of the invention (as previously described). The stapler head **890** is configured so that it may be angled in relation to the elongated shaft **888** as desired by the user. Angling the circular staple head **890** provides significantly improved positioning in a constricted space, as is commonly encountered during minimally invasive medical procedures.

[0227] **FIG. 30***b* shows the circular stapler device **884** of **FIG. 30***a*. However, the elongated shaft **888** is in an angled position. As described previously, when angled, the extended shaft **888** may facilitate better positioning of the stapler head **890**. Also visible in **FIG. 30***b* is the anvil **886** which has been positioned more closely to the extended shaft **888** than is shown in **FIG. 30***a*.

[0228] **FIG. 31***a* depicts an anvil **887***a* for a circular stapling device such as that shown in **FIG. 30***a*. The anvil **887***a* of **FIG. 31***a* is hinged so that it may fold into a smaller size. In its folded form the it resembles anvil **887***b*. **FIG. 31***b* depicts an anvil **886** and a base **889** connected by a rod **891**. **FIG. 31***c* shows an anvil **893***a* with a quartered "pie" construction which allows for a size reduction (anvil **893***b*). The anvils shown in **FIGS. 31***a***-31***c* represent methods of anvil construction that facilitate temporarily reducing the profile or size of the anvil so that it may be passed through skin or fascia through an entry port and for small enterotomy in gastric tissue, the small bowel or colon.

[0229] Referring to **FIGS. 32***a* and **32***b*, the circular staple head **890** is depicted along with the extended shaft **888**. In **FIG. 32***a* the circular staple head **890** is shown essentially as a linear extension of the extended shaft **888** such that the circular staple head **890** is in line with the extended shaft **888**. In **FIG. 32***b* the circular staple head **890** is shown at an angle of approximately 45° with respect to the extended shaft **888**. As discussed previously, this movement of the circular staple head **890** from a straight to an angled position at the desire of the user is useful in positioning and articulating the circular staple head **890** to anastomose tissues or other internal materials.

[0230] **FIG. 33** depicts an anchor face with a staple ring and anchor stud needles. The needles pass through the tissue and enter the hollow needle pockets prior to stapling. **FIG. 33** shows the stapler guide receptacle to close the staples after they penetrate the tissue being anastomosed. Both the anvil **895** and the base **897** are shown "flat faced", that is, in line with the connecting rod **899**, so as to facilitate passage of the device through a laparoscopic port.

[0231] **FIG. 34** depicts a side view of a portion of anchor **900** showing the anchor stud needles **902***a* and the hollow needle pockets **902***b*. The needles **902***a* pass through tissue and enter the hollow needle pockets **902***b* so as to ensure the tissue is grasped by the device and properly held in place. The needles **902***a* may also help to ensure proper position of the tissue for adequate stapling. The extended shaft **888** of the device is also shown in **FIG. 34**.

[0232] **FIG. 35** depicts an aspiration or injection device **910**. The aspiration or injection device **910** includes a handle portion **912** similar to that described with respect to other embodiments of the invention, see, for instance, **FIGS. 10***b*, **23***a*, **24***a*, and **26**, among others. The aspiration or injection device **910** may be provided with a needle **914** that may be manipulated, and/or operated by one or more of the numerous control devices provided with the handle **912**. The needle **914** may operate in connection with a syringe **916** which is preferably removable. In this way, material in the syringe **916** may be injected through the needle **914** into a patient. Alternatively, material from the patient may be withdrawn through the needle **914** and into the syringe **916**. In one embodiment the needle **914** is removable and may be replaced by any one of a variety of different tools, including needles of varying sizes and/or materials. In one embodiment, the needle may be manipulated by the trigger. For instance, the needle **914** may be advanced and/or retracted by operation of one or more trigger pulls.

[0233] **FIG. 36***a* depicts a biopsy device **920**. The biopsy device **920** is provided with a handle **912** configured like the handles of the previous embodiments, for instance, like the handle of **FIG. 35**. The biopsy device **920** is provided with a biopsy needle **922** which is arranged so that it may be advanced and/or withdrawn as required by a user. A protective sheath **924** is also provided. The protective sheath **924** serves to seal off the sample containing portion of the biopsy needle **992**. The biopsy device **920** is configured to safely obtain a biopsy sample with a needle and at the same time avoid the risks associated with obtaining biopsy samples via transcutaneous needles, which are known to leave a needle track that may be at least partially filled with biopsy material in the subcutaneous tissue or skin. In certain instances, this may result in cancer and/or infection or the subcutaneous tissue or skin.

[0234] In operation, the sheath **924** is retracted so that the needle **922** is outside of the biopsy device **920** and the needle **992** is inserted into the tissue to be sampled. At this point, the needle **922** is beyond the sheath **924** as is shown in **FIG. 36***b*. Subsequently, the sheath **924** is advanced to cover the needle **922** and effectively protect the biopsy material collected within the needle **922** from all other tissues. The entire biopsy device **920** may then be withdrawn from the patient, thereby safely removing the biopsy material.

[0235] **FIG. 37***a* depicts an external radiation machine **930** with a flexible connective elbow **932**. The external radiation device **930** is useful for internal delivery of radiation therapy, especially gamma radiation. **FIGS. 37***b*-**37***e* depict various radiation delivery scopes **934***b*-**934***e* for use in combination with the radiation machine **930** of **FIG. 37***a*. The radiation scopes **934***b*-**934***e* all include an elongated shaft **936** which is adapted for internal use on a patient. The radiation scopes **934***b*-**934***e* vary in the type of radiation that they deliver and the way that that radiation is delivered.

[0236] **FIG. 37***b* depicts a radiation scope **934***b* with an elongated shaft **936**, which includes a window **938** for the delivery of radiation. Preferably the radiation scope **934***b* of **FIG. 37***b* is configured to deliver gamma radiation.

[0237] The radiation scope **934***c* of **FIG. 37***c* includes an elongated shaft **936** with an open end **940**. The open end **940** is configured to deliver radiation from the radiation scope **934**. Preferably, the radiation scope **934***c* of **FIG. 37***c* is configured to deliver gamma radiation.

[0238] The radiation scope **934***d* of **FIG. 37***d* includes an elongated shaft **936** with an open end **942** which is configured to allows for the emission of radiation. The radiation scope **934***d* of **FIG. 37***c* is preferably configured for use with beta radiation.

[0239] The radiation scope **934***e* of **FIG. 37***e* includes an elongated shaft **936** and also includes an enhanced tip **944**, which allows for positioning. This is useful, for instance, when the radiation scope **934***e* is being employed for work on an inner-organ tumor. The radiation scope **934***e* may be used in conjunction with a separate imaging device which provides a visual field either through the use of visual image capture configuration or an ultrasonic image capture device. In the embodiment depicted in **FIG. 37***e*, an ultrasonic tip **946** is provided in conjunction with the radiation scope **934***e* so that a single device may be used to both deliver a radiation treatment to a patient and to image the area of treatment. This may make the use of the radiation scope **934** easier, and lessens the invasiveness of the procedure for the patient. Alternately, the ultrasonic tip **946** may be associated with the radiation device **934***e* in another way. For instance, the ultrasonic tip **946** may be placed inside or on one end of the elongated shaft **936** of the radiation device **934***e*.

[0240] **FIG. 37***f* depicts a radiation tool **934***f* in accordance with the invention. The radiation tool **934***f* includes an extended shaft **936** and a boring tip **950**. The boring tip **950** allows placement of the tool into a patient's organ by boring through the surrounding tissue. Once in position, the boring tip **950** retracts to expose radioactive material **952** which is positioned near one end of the radiation tool **934***f* so as to enable radiation therapy for the patient.

[0241] **FIG. 38** depicts an radiation delivery device **954** which is loaded with a radioactive emitter **956**. The radioactive emitter may be a gamma or a beta emitter. The total dose for use in a given therapy is determined by the user, typically a radio-oncologist, or a radiation scientist prior to loading of the radioactive emitter **956**. The radioactive emitter may be loaded within its own case **958**, which is located within the scope **960** itself. The case **958** for the radioactive emitter **956** may be a lead shield. Preferably the radiation scope **960** is placed in a proper position within the patient prior to beginning the radiation therapy and all personnel in the room are evacuated. Once radiation therapy is to begin, the shield or case **958** is opened or moved so as to expose the radioactive emitter **956**. The patient may be irradiated through either the window **962** or an end opening in the radiation scope **960**. Once therapy is complete, the shield **954** is replaced to avoid irradiation of health care personnel.

[0242] **FIG. 39** depicts a medical device **970** which includes a glove handle **972** similar to that depicted in **FIG. 6**. The glove handle is connected to a tool **974** which includes an elongated shaft **976**. At one end of the elongated shaft **976** are three elongated finger members **978***a*, **978***b* and **978***c*. Each of the finger members **978***a*, **978***b*, and **978***c* are configured to mimic the motion and responsiveness of human fingers. In particular, finger member **978***a* replicates a thumb. Finger member **978***b* replicates an index finger. Finger member **978***c* replicates a middle finger. Each of the finger members **978***a*, **978***b* and **978***c* are provided with a pressure sensor **980***a*, **980***b* and **980***c*. The pressure sensors **980***a*-**980***c* operate similarly to those previously described.

[0243] The glove handle **972** includes an opening **980** that allows a user to place his or her hand inside of the glove handle **972**. Separate pockets may be provided for one or more of the fingers. In particular, a thumb pocket **982***a*, an index pocket **982***b*, and a middle finger pocket **982***c* may be provided as part of the glove handle **972**. The fourth and fifth digits of a user's hand may be used to wrap around a grip rod **984** provided within the glove handle **972**. Pressure sensors may also be provided as part of the finger pockets **982***a*, **982***b* and **982***c*. Pressure sensors **9862**, **986***b* and **986***c* operate in a manner similar to that previously described. The glove handle **972** may be provided in either a left or a right-handed version for the respective hands of a user. Accordingly, the tool **974** is configured to mimic the hand configuration provided in the glove handle **972**.

[0244] The medical device **970** as shown in **FIG. 39** effectively extends the function of the right or left hand of a user from outside the patient to inside the patient. The finger members **978***a*, **978***b* and **978***c* are flexible and include pressure sensitive pads **980***a*, **980***b* and **980***c* to communicate, among other things, the tissue density and firmness of the grip by the tool **974**. In one embodiment, the tool **974** is passable through an port of approximately 2 cm in diameter. Once inside the patient the tool **974** may open so that the finger members **978***a*, **978***b* and **978***c* are of a size of up to about the size of three average adult human fingers. In one embodiment, the finger members **978***a*, **978***b*, and **978***c* are configured not only to grasp or release an object but also to move up and down or laterally right to left. Further, the finger members **978***a*, **978***b* and **978***c* may be configured to rotate either individually or as a unit and also to move forward and backward.

[0245] **FIG. 40***a* depicts another embodiment of the present invention. In the embodiment depicted in **40***a*, a robotic console **988** is provided along with a manual driving stick **990**. The manual driving stick **990** operates in conjunction with certain other control features **992***a-e*. The control features **992***a-e* may be used to control one or more robotic limbs **994** which are in communication with the robotic console **988**. In the embodiment depicted in **FIG. 40***a*, control features **992***a*, **992***b* and **992***c* may be used to pick which robotic limb **994** is currently being manipulated by the robotic console **988**. Control feature **992***d* allows a user to control the height of the robotic console **988** relative to a patient. Control feature **992***e* is a microphone which may be configured with suitable electronics (including any necessary software in addition to required hardware) to facilitate auditory control of the device.

[0246] **FIG. 40***b* depicts a robotic limb **994** for use in accordance with the robotic console **988**, such as that depicted in **FIG. 40***a*. The robotic limb **994** may be provided with one or more telescoping sections **996***a*, **996***b* and **996***c* which enable the retraction or extension of the robotic hand **998** attached to the robotic limb **994**. Robotic hand **998** may be configured in a similar fashion as robotic tool **974** described in **FIG. 39**. As described with respect to the tool **974** of **FIG. 39**, the robotic hand **998** may move in a variety of directions including up and down, laterally right to left or backwards and forwards with further refined movements, including rotation, of one or all of the finger members **1000***a*, **1000***b*, and **1000***c*.

[0247] **FIG. 40***c* depicts the finger members **1000***a*, **1000***b*, and **1000***c* of the robotic hand in an open position.

[0248] **FIG. 40***d* depicts the finger members **1000***a*, **1000***b* and **1000***c* of the robotic hand in a closed position. Referring to **FIGS. 40***c* and **40***d*, it may be appreciated how finger members **1000***a*, **1000***b* and **1000***c* may be moved between an open positions, such as that shown in **FIG. 40***c* and a closed position, such as that shown in **FIG. 40***d*, so as to grasp and/or release an object, material or tissue.

[0249] **FIG. 41** depicts the robotic console **988** as previously described. However, the robotic console **988** is used in conjunction with an operating table **1002**. In certain embodiments, the robotic consol **988** may be installed as part of the operating table **1002**.

[0250] **FIG. 42** shows a movable pedestal **1004** in accordance with one embodiment of the invention. The movable pedestal **1004** may be configured with one or more caster wheels **1006** attached thereto for ease of movement in and around the surgical area. A power cord **1008** may also be provided as part of the pedestal **1004**. The robotic console **988** may be position at multiple places on the movable pedestal **1004** as shown by mounting features **1010***a*, **1010***b*, and **1010***b*. The movable pedestal **1004** is configured so that multiple robotic consoles **988** may be installed thereupon. The preferable orientation for the multiple robotic consoles **988** is such that one robotic console is provided on either side of the patient and a third robotic console is provided between the legs of a positioned patient.

[0251] Alternatively, one or more robotic limbs **994**, as shown in **FIG. 40***b*, may be mounted to the movable pedestal **1004**. These separately mounted robotic limbs may be controlled by one or more robotic consoles **988**, such as that depicted in **FIG. 40***a*. The moveable pedestal **1004** is preferably configured so that it will fit around an operating table **1006**.

[0252] The foregoing description and examples have been set forth merely to illustrate the invention and are not intended to be limiting. Since modifications of the described embodiments incorporating the spirit and substance of the invention may occur to persons skilled in the art, the invention should be construed broadly to include all variations within the scope of the appended claims and equivalents thereof.

What is claimed is:

1. An optical device for minimally invasive medical procedures, comprising:

a plurality of linear image acquisition devices, wherein each of said linear image acquisition devices is adapted to acquire an image from within a patient's body;

a linear housing laterally surrounding said plurality of linear image acquisition devices such that the linear image acquisition devices extend toward an end of the housing, wherein at least a portion of said housing may be inserted within a patient's body and wherein said housing is adapted for cleaning and sterilization;

at least one input adjustment device disposed upon at least one end of the plurality of linear image acquisition devices such that said input adjustment device facilitates adjustment of one or more characteristics of said image; and

a display system, wherein said display system is configured to display the images acquired by the linear image acquisition devices in multiple formats.

2. The optical device of claim 1, wherein said display system is configured to display the images acquired by the linear image acquisition devices in a two-dimensional and a three-dimensional format.

3. The optical device of claim 1, wherein said input adjustment device provides a lens and a reflective surface and wherein said optical device further comprises a protective cover associated with the housing.

4. The optical device of claim 1, wherein said input adjustment device provides a digital manipulator.

5. The optical device of claim 1, further comprising at least one light source.

6. The optical device of claim 1, further comprising a controller for receiving and responding to instructions to control at least one of the display system and the input adjustment device.

7. The optical device of claim 1, wherein said display system provides a single image combining the images from the plurality of linear image acquisition devices.

8. The optical device of claim 1, wherein said display system provides a separate image for two or more of the plurality of linear image acquisition devices.

9. The optical device of claim 1, wherein said display system includes an eyeglasses frame having an image presentation mechanism, said image presentation mechanism presenting a left image to a wearer's left eye and a right image to a wearer's right eye.

10. The optical device of claim 9, wherein at least a portion of said image presentation mechanism may be rotated away from a wearer's eyes, to permit vision beyond the image presentation mechanism without removal of the eyeglasses frame.

11. The optical device of claim 1, wherein one linear image acquisition device provides a left image from a front side of the housing and a second linear image acquisition device provides a right image from a front side of the housing and a third linear image acquisition device is disposed to provide a posterior image from a back side of the housing and wherein said display system provides any of the left image, the right image, and the posterior image as selected by a user.

12. A device for minimally invasive medical procedures, said device comprising:

a hand piece configured for either a right gloved hand of a user, a left gloved hand of a user, or a right or a left gloved hand of a user;

an instrument portion attached to said hand piece, said instrument portion including a tool;

a trigger attached to said hand piece and associated with said instrument wherein said trigger may be manipulated by a finger of a user and said trigger is useful to manipulate said instrument; and

one or more control elements attached to said hand piece and associated with said instrument wherein said one or more control elements may be manipulated by one or more fingers of a user and are useful to manipulate said instrument.

13. The device of claim 12, wherein said hand piece comprises:

an interior portion configured to accept the user's gloved hand; and

an opening to allow access to said interior portion.

14. The device of claim 12, wherein said instrument portion further comprises:

a transcutaneous shaft configured to attach to said hand piece;

an internal shaft extending away from said, said internal shaft being rotatably attached to said transcutaneous shaft and having a knob with a mechanism that causes the internal shaft to rotate in response to manipulation of said knob, wherein said internal shaft is detachable and wherein said tool is detachable to said internal shaft.

a tool affixed to an end of the internal shaft, wherein said tool is detachably affixed to said internal shaft.

15. The device of claim 12, wherein said tool is selected from the group consisting of forceps, flat scissors, curved scissors, right angle scissors, DeBakey-type forceps, right angle forceps, blunt forceps, curved clamps, angular clamps, ultrasound probes, lasers, cautery devices, staplers, circular staplers, knives, suturing devices, rivet drivers, ligation devices, aspiration devices, injection devices, biopsy devices, radiotherapy devices; and radioactive emitter loading devices, wherein manipulation of one or more of said one or more control elements causes operation of said tool and wherein manipulation of said trigger causes said tool to rotate to a new position.

16. A device in accordance with claim 15, wherein said tool is a stapler configured to staple tissue together by providing two pairs of overlapping rows of staples, one pair on either side of a cut line and wherein said stapler provides two lines of tissue compression, one line of tissue compression being on the outer side of each of the pairs of overlapping rows of staples.

17. The device of claim 12 further comprising:

at least one sensory pad associated with one or more of said control elements, said sensory pad being configured to transmit a pressure signal from a user's finger; and

a mechanism to operate said tool, wherein the mechanism to operate said tool is responsive to said pressure signal.

18. The device of claim 12 further comprising:

a mechanism to operate said tool, wherein said mechanism to operate said tool is configured to transmit feedback to the user, said feedback relating to the operation of said tool.

19. The device of claim 12 further comprising:

a temperature button, wherein said temperature button is attached to said hand piece and is configured to generate a signal upon manipulation by a user, wherein said tool is responsive to said signal generated by said temperature button so as to cause at least a portion of said tool to heat up so as to be useful to cauterize tissue.

20. The device of claim 12, wherein said instrument portion is configured to detachably engage a variety of replaceable tools and wherein said device further comprises a replaceable tool.

21. The device of claim 12, further comprising a band which secures the device to the wrist, or palm, or both the wrist and palm of a user.

22. A device for minimally invasive medical procedures, said device comprising:

a scissor-type hand piece; said hand piece having a first elongated portion and a second elongated portion, said first elongated portion being adapted for manipulation by a user's thumb and said second elongated portion being adapted for manipulation by one or more of user's first, second, third, and fourth fingers;

a temperature control element attached to said hand piece and configured to generate a signal upon manipulation by a user's finger; and

an instrument portion attached to said hand piece wherein said instrument portion is responsive to manipulation of the first elongated portion and second elongated portion, wherein said instrument portion includes a tool, said tool being responsive to said signal generated by said temperature control element so as to cause at least a portion of said tool to heat up so as to be useful to cauterize tissue, said tool being detachable.

23. A tool for use with a device for minimally invasive medical procedures, said tool comprising:

an elongated first element, an elongated second element and an elongated third element; wherein said first element and said second element are opposed to said third element and said first element is configured to mimic the functionality of a first finger of a user, and said second element is configured to mimic the functionality of a second finger of a user, and said third element is configured to mimic the functionality of a thumb of a user, wherein at least one of said first element, second element, and third element includes a sensory pad configured to transmit a pressure sensation from said element to a user's finger.

24. An automated device for minimally invasive medical procedures, said device comprising:

a robotic console;

a plurality of control features; and

one or more robotic limbs.

25. The automated device of claim 24, said device further comprising:

a mobile pedestal, wherein said one or more robotic limbs are affixed to said mobile pedestal.

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专利名称(译)	用于微创手术和其他内部程序的医疗设备		
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摘要(译)

提供了微创手术装置和相关工具。这些装置包括图像采集装置和镊子，剪刀，夹具，超声探头，激光器，烧灼装置，缝合器，刀具，缝合装置，铆钉驱动器，结扎装置，抽吸装置，注射装置，活检装置，放射治疗装置;和放射性发射器加载装置。还提供了用于患者体内内部程序或便于这些程序的其他装置。