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(54) **LAPAROSCOPIC SURGICAL INSTRUMENT**

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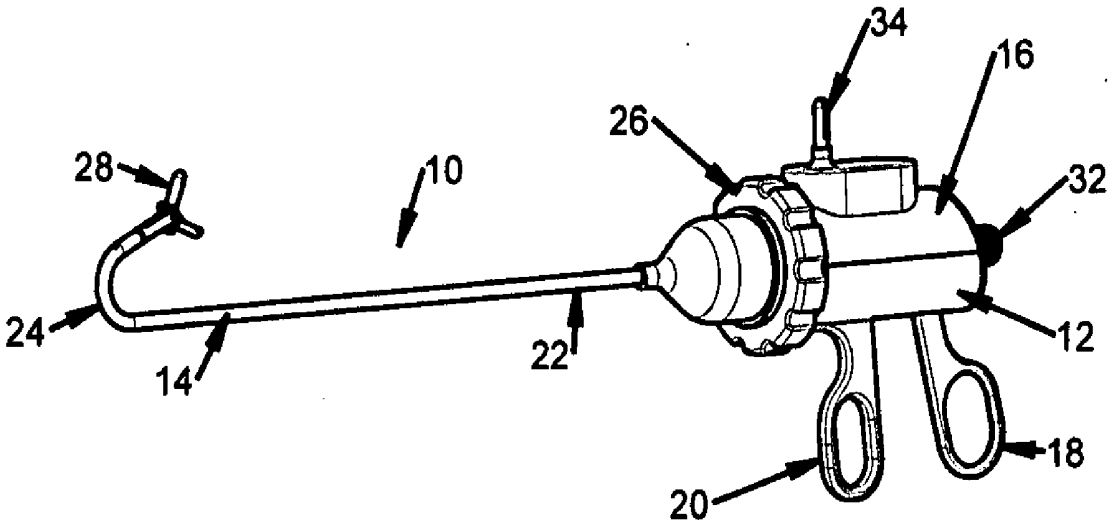
(57) **ABSTRACT**

An articulating surgical instrument for laparoscopic, endoscopic, and natural orifice translumenal endoscopic surgical procedures consisting of a separable combination of a reusable operational handpiece section and a separable reusable or disposable articulation section. The handpiece section which remains external to the patient incorporates various control and command devices and assemblies, while the articulation section is composed of various linkages, rods, and cables which transmit positioning and operating commands from the handpiece to end effectors positioned at the distal tip of the articulation section within the patient. Improved positioning and operating configurations for the end effectors suitable for the invention as well as the general class of these instruments are also disclosed.



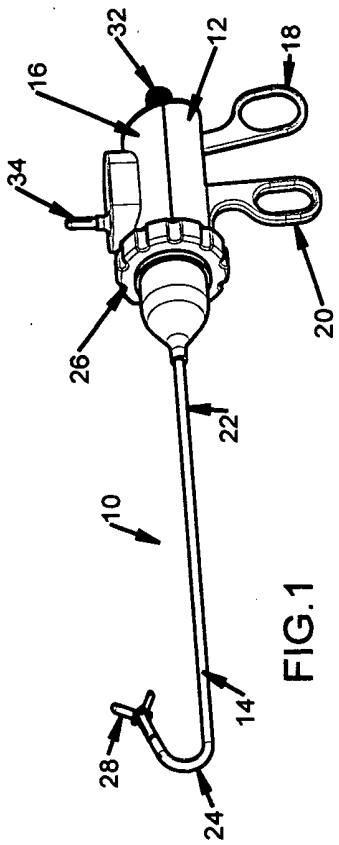


FIG.1

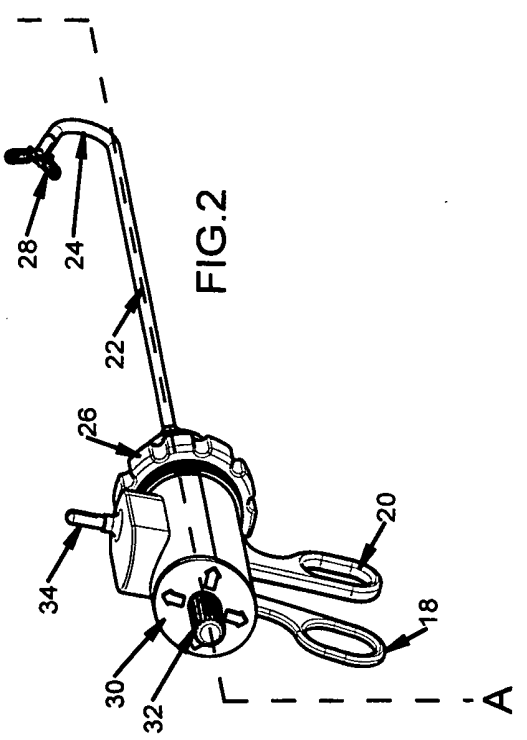


FIG.2

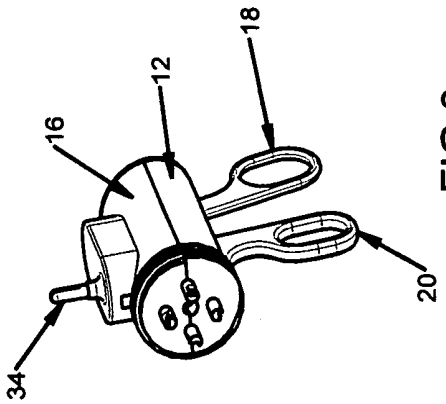


FIG.3

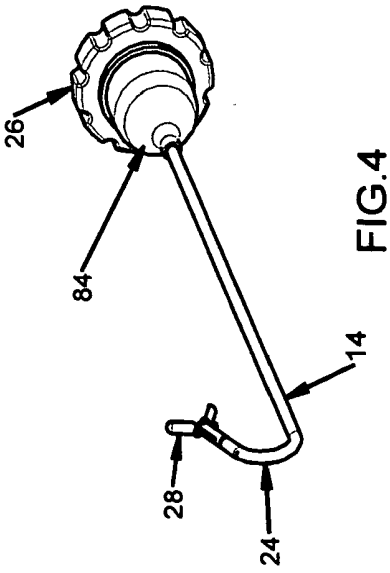


FIG.4

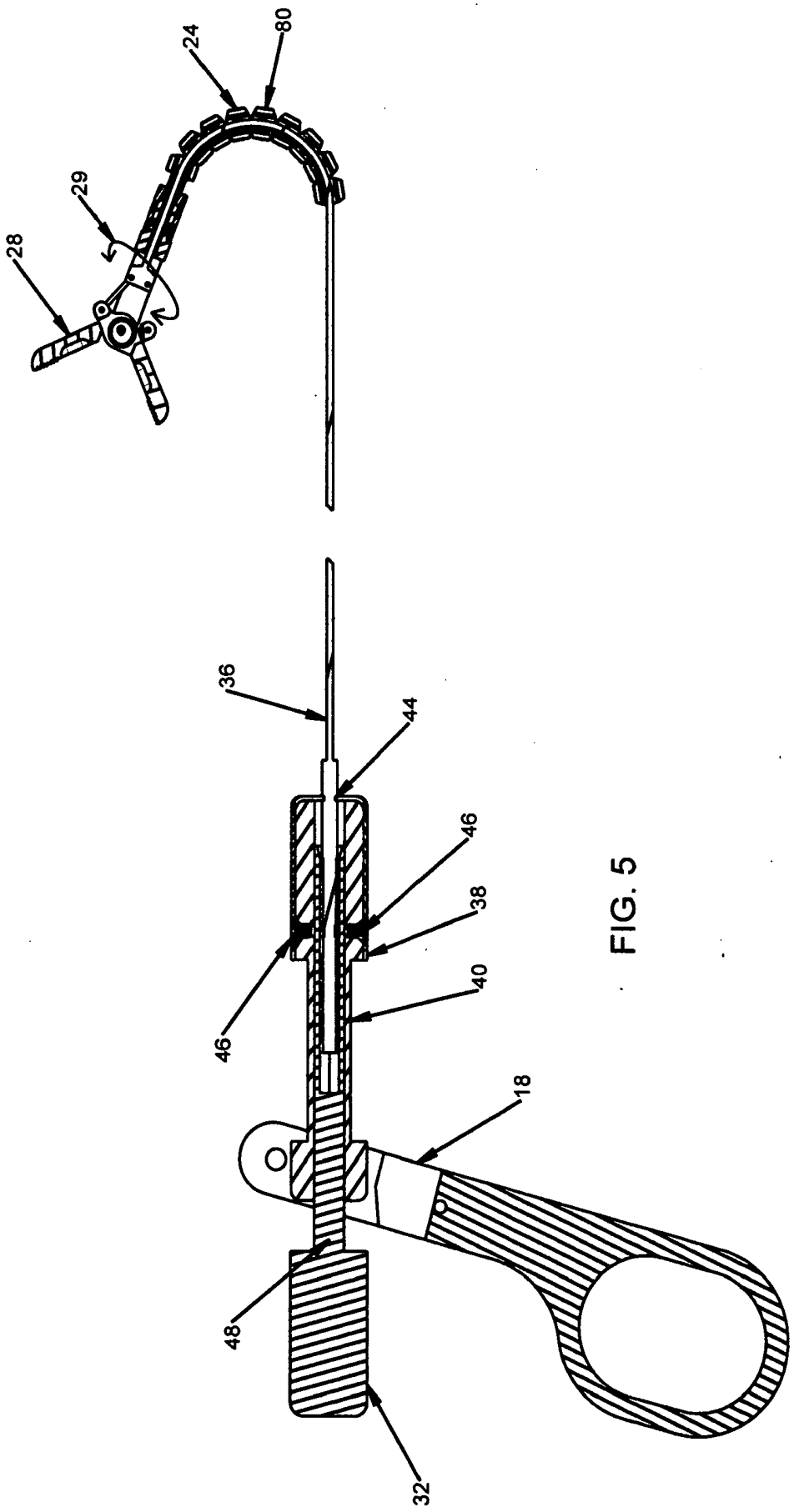


FIG. 5

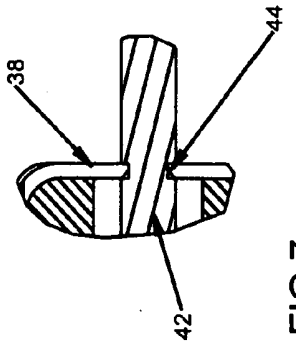


FIG.7

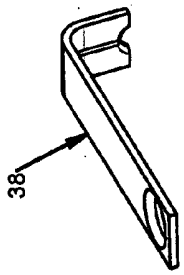


FIG.8

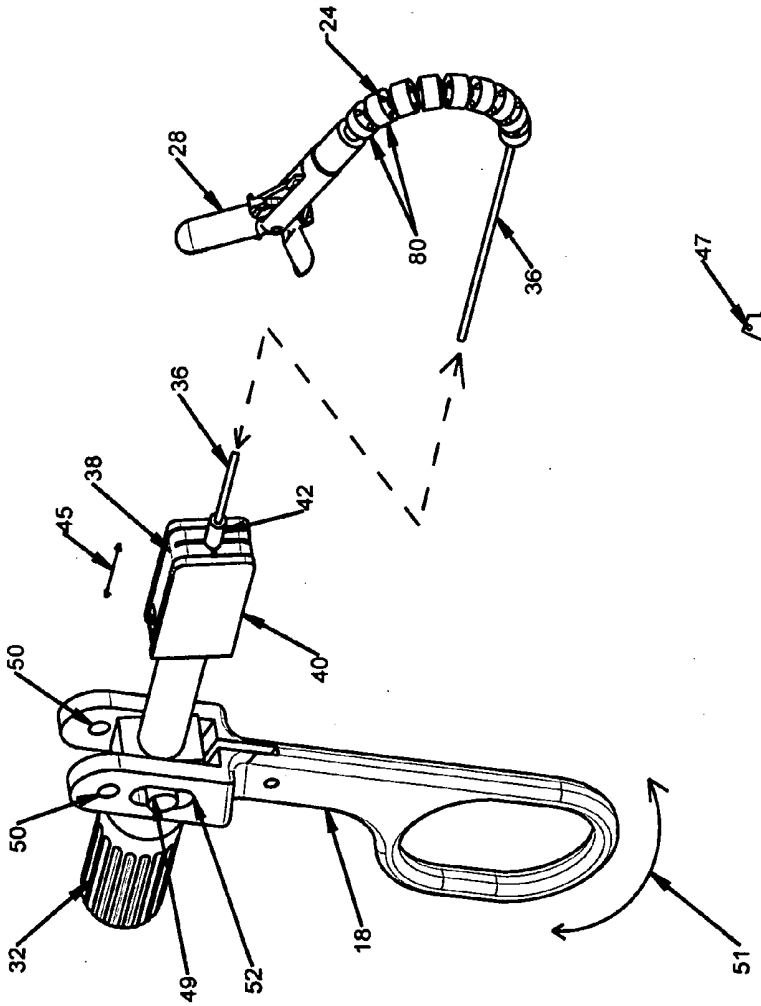
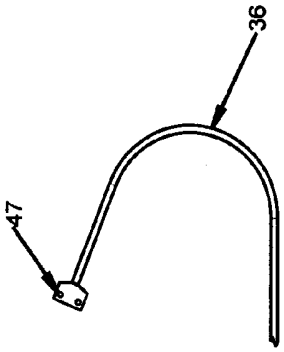


FIG.9



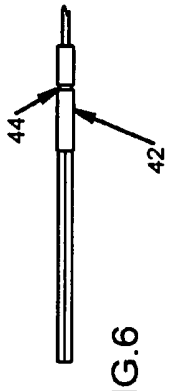


FIG.6

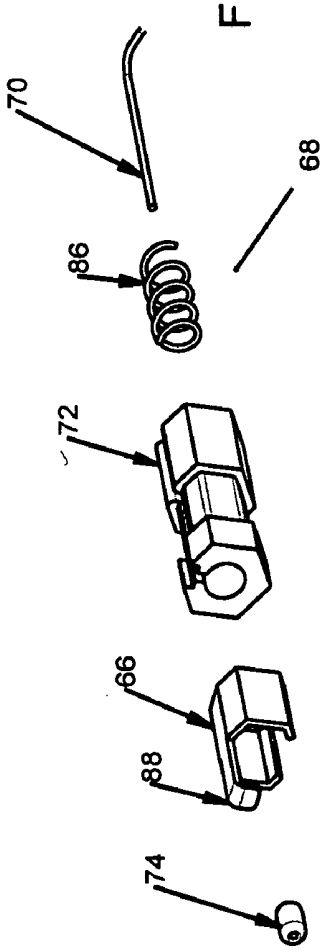


FIG.11

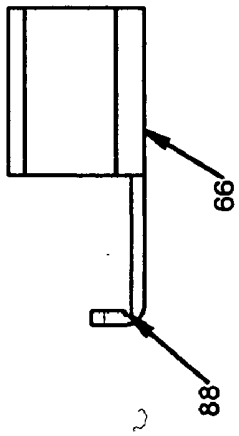


FIG.12

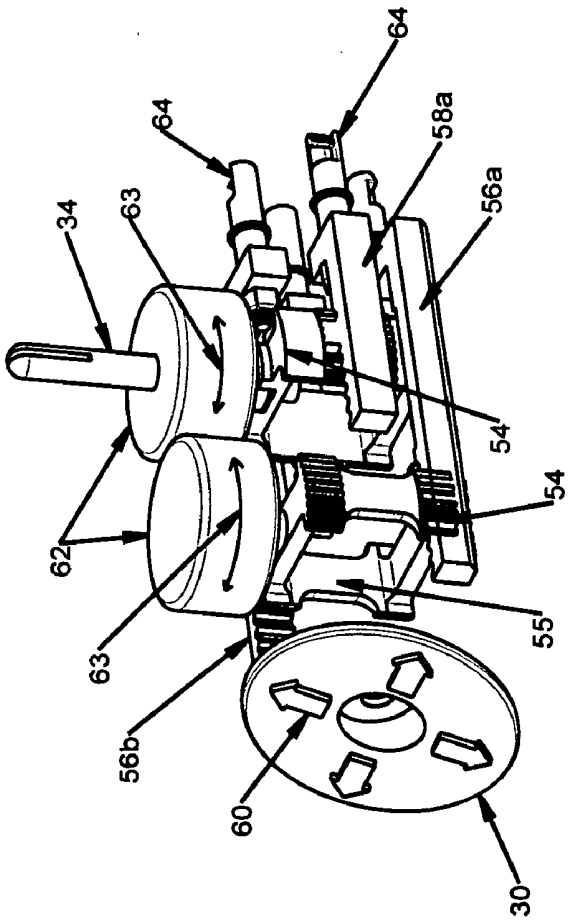


FIG.10

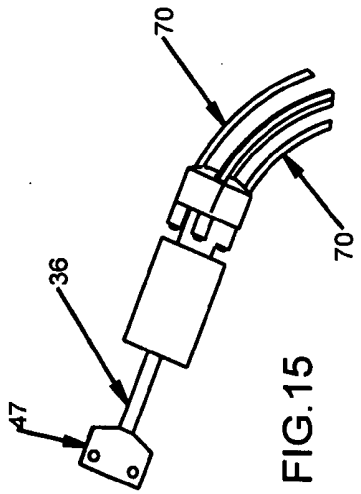


FIG.15

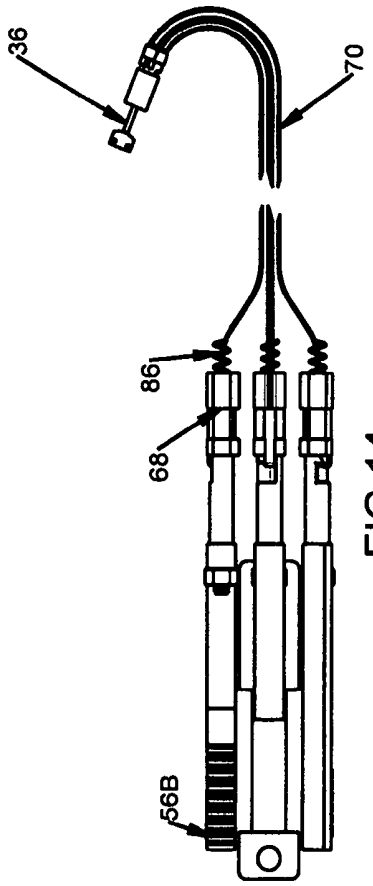


FIG.14

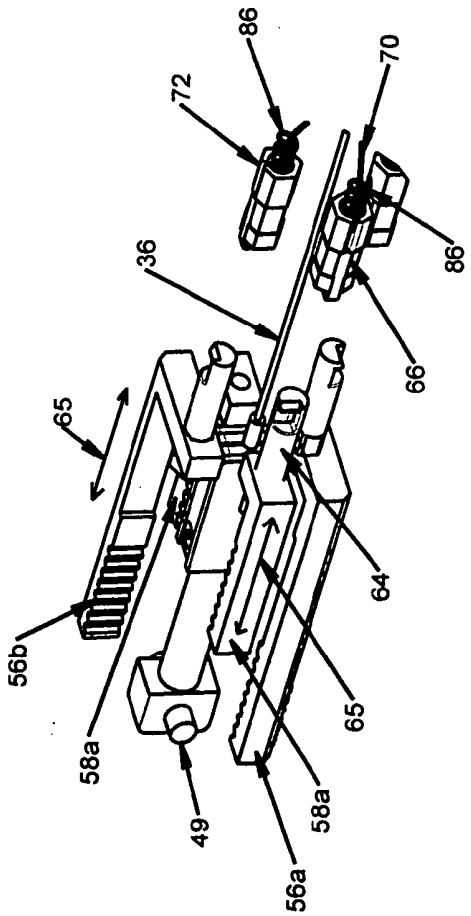


FIG.13

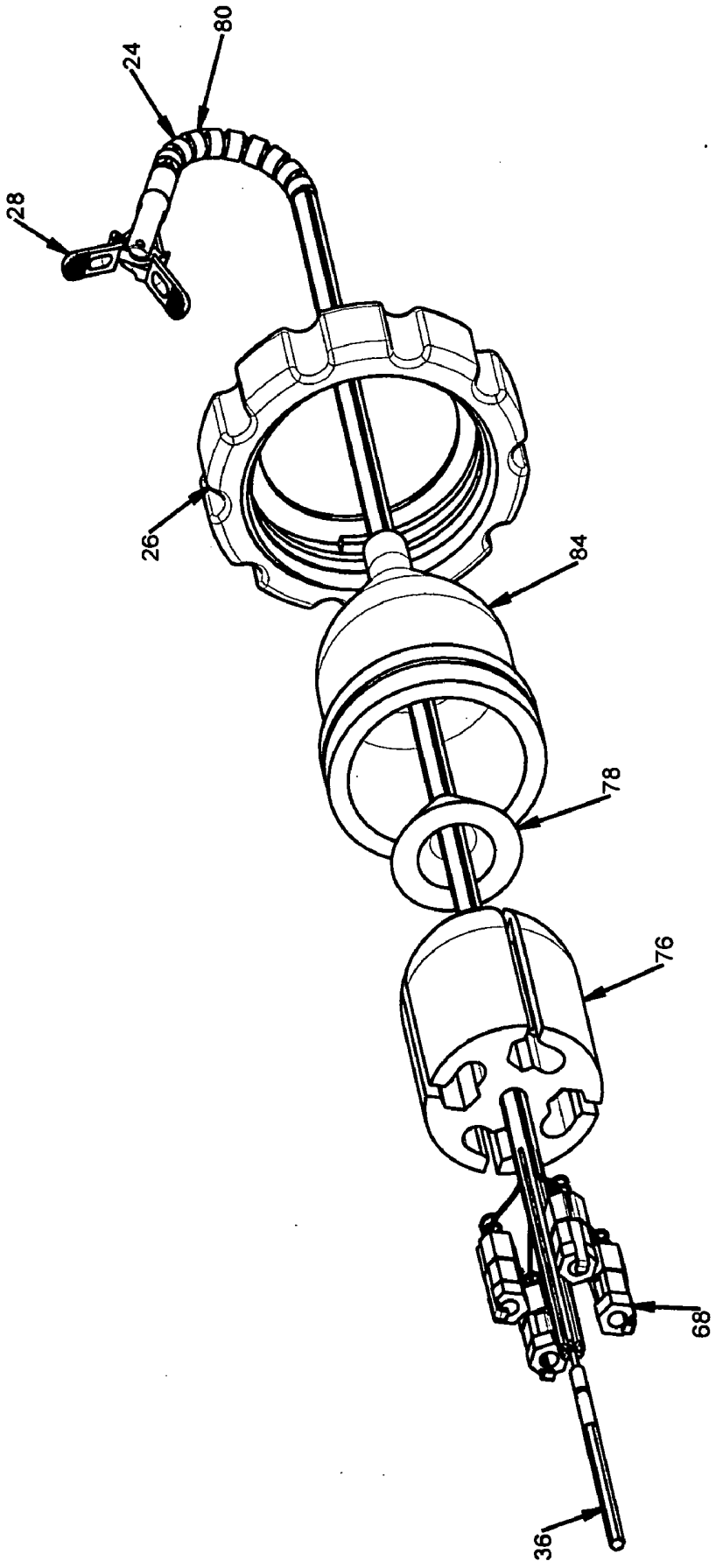
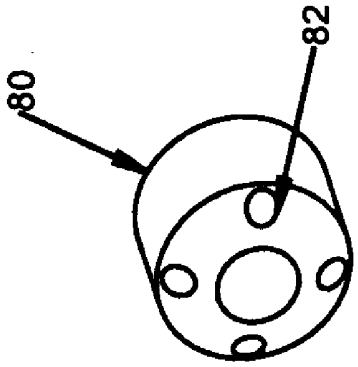


FIG. 16

FIG.17



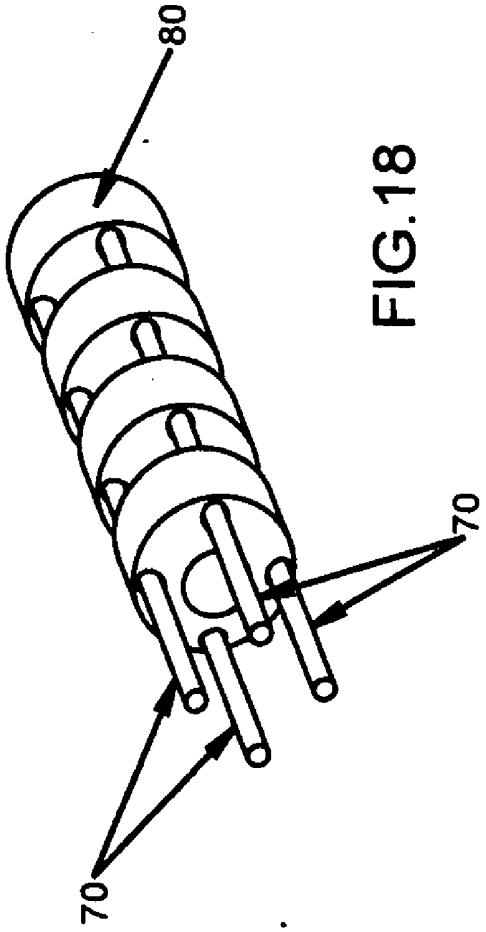


FIG.18

LAPAROSCOPIC SURGICAL INSTRUMENT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on the disclosure of Provisional Application Ser. No. 61/271,765 filed Jul. 27, 2009 which is hereby incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The invention resides in the field of surgical apparatus and more particularly relates to instruments for performing laparoscopic, endoscopic, and natural orifice translumenal endoscopic surgery.

[0004] 2. Description of the Prior Art

[0005] Devices of the type to which the invention is directed are well known in the prior art. Generally classed as laparoscopic or endoscopic surgical instruments, their purpose is to perform surgical procedures within the body through relatively small incisions which allow the insertion of small surgical tools or end effectors mounted on elongated shafts which are manipulated or articulated to position the surgical tool and then are further operated to achieve the desired surgical procedure. The articulation, positioning and activation of the tools are all controlled by a corresponding handpiece located outside the body.

[0006] Illumination and viewing of the internal surgical site is accomplished by, for example, an additional device of the same general type employing a light source and miniature-imaging device such as a TV camera.

[0007] In contrast to the prior art, the present invention provides improved devices and assemblies for operating an end effecter, rotating the end effecter about the longitudinal axis of the articulation portion of the instrument, as well as for a control and operation system for articulating or bending the tip of the articulation portion and an attached end effecter.

[0008] The handpiece and articulation sections may also be separable in order to prolong the life of one or the other components of the instrument, to use multiple articulation sections with different end effecters with a single handpiece, and to provide for the prevention of reuse of a particular articulation portion or section.

[0009] Examples of prior art instruments which are illustrative of and relate to the invention are shown in U.S. Pat. Nos. 5,454,827, Aust et al., a distal tip articulation mechanism; 5,578,052, Koros et al., a separable handpiece and articulation section; and 5,860,995, Berkelaar, an end effecter articulation assembly.

SUMMARY OF THE INVENTION

[0010] The invention may be summarized as a laparoscopic surgical instrument composed of an operational handpiece and an elongated articulation section having a flexible bending portion. These two components may be permanently connected, or separate and connectable. The mechanism joining the two components may optionally include an arrangement for preventing reuse of the articulation section by, for example, destroying or altering a portion of the connecting linkage to preclude the possibility of reconnection.

[0011] The handpiece contains the control mechanisms for positioning and operating a surgical tool or end effector disposed at the tip of the articulation section. These controls may include a knob or lever for rotating a flexible link or rod connected to the end effecter for rotating the end effecter, means to laterally move the same or an additional link to activate the end effector, such as a scissors, and hand or motor operated means to simultaneously pull and release appropriate cable or wire connections to the bending portion to alter or articulate its position or orientation to any point within a spherical space along the longitudinal axis of the instrument.

[0012] Electronic controls for achieving the articulation of the bending portion through the use of motor driven gear assemblies are also disclosed.

[0013] The articulation section, in general, an elongated hollow shaft with a flexible bending portion, contains the above mentioned wires, links, and/or rods as well as suitable protective sheaths or coverings. The shaft, providing the main support structure for the end effecter, may be comprised in part of a series of segments or links which will move in relation to one another to produce the articulation.

[0014] These and other features and advantages of the invention will be more fully understood from the following description of the preferred embodiment in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** is a perspective frontal (distal) view of the preferred embodiment of the invention;

[0016] FIG. **2** is a perspective rear (proximal) view of the preferred embodiment of the invention;

[0017] FIG. **3** is a perspective frontal view of a separated portion of the embodiment of FIG. **1**;

[0018] FIG. **4** is a perspective frontal view of an additional separated portion of the embodiment of FIG. **1**;

[0019] FIG. **5** is a cross-sectional view of a portion of FIG. **2** along line A-A;

[0020] FIG. **6** is a side view of a component of FIG. **1**;

[0021] FIG. **7** is a partial cross-sectional view of the component of FIG. **6**;

[0022] FIG. **8** is a perspective view of a component of FIG. **5**;

[0023] FIG. **9** is a perspective view of the component of FIG. **5**;

[0024] FIG. **10** is a perspective detailed view of an internal assembly of a component of FIG. **3**;

[0025] FIG. **11** is an exploded perspective view of a component of FIG. **4**;

[0026] FIG. **12** is a side view of a component of FIG. **11**;

[0027] FIG. **13** is a perspective view of a portion of the assembly of FIG. **10**;

[0028] FIG. **14** is a side view of a portion of the assembly of FIG. **10**;

[0029] FIG. **15** is a side view of a portion of the assembly of FIG. **14**;

[0030] FIG. **16** is a detailed perspective view of the component of FIG. **4**;

[0031] FIG. **17** is a perspective view of a component of FIG. **9**; and

[0032] FIG. **18** is an additional perspective view of a portion of FIG. **9**

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0033] FIG. **1** is a perspective frontal view of the preferred embodiment of the laparoscopic instrument **10** of the invention for performing multiscopic surgery that is capable of

holding, grasping, cutting, hooking, manipulating, burning, and coagulating tissue along a non linear trajectory. This instrument is a combination of an operational handpiece **12** and an articulation section **14**. A variety of different articulation sections and their associated end effectors are used to perform different surgical tasks.

[0034] Handpiece **12** has an outer case **16** surrounding and supporting control mechanisms to be described in detail below, a trigger handle **18**, and an opposing finger grip **20**. Articulation section **14** consists of an elongated hollow shaft **22**, a flexible bending portion **24**, and joining nut **26** for attaching handpiece **12** and articulation section **14**. An end effecter or surgical tool is attached or mounted on tip **24**.

[0035] FIG. **2** is a rearward or proximal view of the instrument of FIG. **1** further showing an articulation control backplate **30** mounted on case **16** for controlling the position or orientation of bending portion **24**. A rotary thumb actuator **32** for rotating end effecter **28** is also mounted on case **16** in conjunction with backplate **30**. An electrical connection post **34** for enabling cauterization procedures is further positioned atop case **16**.

[0036] FIGS. **3** and **4** illustrate handpiece **12** and articulation section **14** separated from one another. FIGS. **1-4** above present an overview of the general configuration of the invention, the components and operation of which will now be described in accordance with FIGS. **5-18** in more particular detail as follows.

[0037] FIG. **5** shows, in cross-sectional format, the components and control assembly which provide for the axis rotation of articulation section **14**, more specifically, a selected end effecter **28** disposed at the distal tip of bending portion **24** as indicated by motion arrow **29**. This is accomplished by the rotation of pushrod **36** disposed in shaft **22** as controlled or moved by thumb actuator **32** mounted on handpiece **12**.

[0038] Pushrod **36** is cylindrical with a non-round shaped tip that is pushed through the center of the teeth **38** that are mounted on lock assembly **40** disposed in handpiece **12**. Pushrod **36** is aligned with the center of teeth **38** of the lock assembly and extends through the center of the assembly. Pushrod **36** continues further until it engages and is positioned inside rotary thumb actuator **32** where it mechanically mates against a non-round inside wall. Pushrod **36** does not bottom out against the proximal end of actuator **32**. Instead, it is allowed clearance to slide back and forth axially inside actuator **32**. The total linear distance in which pushrod **36** can slide is determined by the travel needs of bending portion **24** as it bends from a straight line to its maximum deflected position. Also compensated for is the travel distance of end effecter **28** as it opens and closes as or if required. Both events are able to occur simultaneously. Rotary thumb actuator **32** is fixed to the control backplate **30**. Actuator **32** rotates radially about the center axis but is fixed in position axially to backplate **30** and does not move forward or backward.

[0039] As shown in FIGS. **6** and **7**, the proximal end **42** of pushrod **36**, which fits within handpiece **12** and is of a larger diameter than the much longer distal portion, has a cylindrical notch **44**. The backside of notch **44** engages the front side of teeth **38** mounted on lock assembly **40** by locator screws **46**. Teeth **38** provide a clamping force against pushrod segment **42** within notch **44** thereby keeping the entire pushrod fixed within lock assembly **40**.

[0040] Therefore, when rotary thumb actuator **32** is turned in either radial direction, end effecter **28** mounted on pushrod endplate **47** will turn in compliance with the rotation of the actuator. Actuator **32** thereby drives the rotation of end effecter using by way of pushrod **36**.

[0041] As described above, flexible metal teeth **38**, as shown in perspective in FIG. **8**, are secured to lock assembly **40** with two locator screws **46**, one for each tooth. Lock assembly **40** travels forward and in reverse and is controlled by the trigger handle **18** closing against finger grip **20**. The front side of each tooth pushes against the backside of the cylindrical notch and drives the pushrod forward. End effecter **28** then closes. When the trigger handle **18** is pulled in the opposite direction away from the finger grip **20**, lock assembly **40** travels in reverse, the opposite side of notch **44** is pushed, and end effecter opens **28**.

[0042] As shown in FIG. **7**, the backsides of the teeth are also beveled to allow the disengagement of the pushrod when handpiece **12** and articulation section **14** are separated. The cylindrical nature of notch **44** allows pushrod **36** to be rotated radially while simultaneously fixing it into position axially.

[0043] As further illustrated by FIG. **9**, lock assembly **40** is shuttled forward and in reverse, proximally and distally, as indicated by arrow **45**, by the action, arrow **51**, of trigger handle **18**. Lock assembly **40** also travels axially over the distal portion of rotary actuator **32**, using the rotary actuator as a guide. Lock assembly **40** is also connected to trigger **18** by means of two outboard pins **49** (one not shown) that may be a molded feature of assembly **40**. Trigger **18** is further connected to handpiece **12** on swing pivots **50**. The swing pivot is a molded feature of the handpiece **12**. Engagement slots **52** in trigger handle **18** receive the outboard pins **49**. When the trigger handle **18** is moved, outboard pins **49** impart the driving force to move lock assembly **40**. Engagement slots **52** allow the required clearance necessary for the arc travel of trigger handle **18** without binding against assembly **40**. The user places their thumb into the ring of trigger handle **18** and their fingers into the ring of finger grip **20**. Closing the hand provides the force to shuttle the lock assembly **40** back and forth thereby manipulating end effecter **28**.

[0044] The positioning of an end effecter at a desired orientation at a surgical site within the body can be provided by articulation and in this instrument is achieved by the use of four cables extending from the handpiece to the distal end of the bending portion where they are attached in an orthogonal array such that by withdrawing one cable toward the proximal end and simultaneously releasing it's corresponding opposite cable disposed directly across from the cable being withdrawn, the end effecter will move up or down, left or right, and toward or away from the surgeon depending upon which cable pair is selected for manipulation. This may be carried out manually by, for example, thumbwheel devices or preferably as described below by a motorized system using driving motors, appropriate gear systems and a hand operated control to select the desired angle and amount of articulation.

[0045] Referring to FIG. **10**, there are two sets of two rotatable motion motor gears **54** mounted on motor gear frame **55** which drive two sets of associated linear motion gear rack pairs **56***a* and **56***b* and **58***a* and **58***b* all of which are mounted inside handpiece **12**. When used in combination they cause articulation up and down and also articulation left and right. The resultant motion of articulation is not limited to up, down, left or right. The hand operated control, as indicated by control backplate directional arrows **60**, allows for any angle between these positions. In this instrument the two motors convert rotary motion to linear motion using the gear drive that causes the end effecters to travel in a circular trajectory.

[0046] Two reversible motors **62**, one each for manipulating each pair of opposing articulating cables, are wired to backplate **30** and installed in handpiece **12**. Backplate **30** is mounted onto the back of handpiece **12** and is marked with the backplate directional arrows **60** that indicate direction of articulation. Each opposing arrow operates a switch that in turn activates one or the other of the motors in the appropriate direction as indicated by arrows **63**. Backplate **30** is also wired to a remote motor power supply (not shown) that may be controlled by foot pedals set on the floor of an operating room and within easy reach of the surgeon.

[0047] When pressure is applied to any arrow **60** on backplate **30**, the corresponding motor gear turns in the corresponding direction. The appropriate gear rack will move either forward or in reverse, arrows **65**, FIG. **13**, depending upon which arrow is pressed. As a gear rack moves forward, it's opposite corresponding gear rack moves in the opposite direction, the motor gear teeth meshing with the gear rack teeth. When not energized, the motors are used as a positive locking mechanism for the entire assembly, that is, at rest, the gear racks cannot move.

[0048] As shown in FIGS. **13** and **14**, the distal ends of the gear racks are connected to connector pins **64**. Connector pins **64** are shaped in a specific way that allows them to easily release away from opposing mating connector clips **66**, FIG. **12**, which are located in articulator section **14** shown in FIG. **16**

[0049] Articulator section **14** connects to handpiece **12** to form the complete multiscopic surgical instrument. Articulator section includes two sets of opposing cable assemblies and a selected end effecter of choice. Each cable assembly **68**, FIG. **11**, is further comprised of a cable **70** assembled to a connector housing **72** by means of a crimp connector **74** which in turn is snapped onto a connector clip **66**. Cable guides **76** and **78** are shown in FIG. **16**. The two cable sets are paired and are arranged for articulation of bending portion **24** up and down and left and right. When a directional arrow **60** on control backplate **30** is pushed thereby activating one of the appropriate motors **62**, a gear rack pulls on its mating cable assembly while the opposite mating cable assembly is released by the opposite gear rack to travel in the opposite direction. FIG. **15** shows the attachment of opposing cables **70** to the distal end of bending section **24**.

[0050] Articulation section **14** may be composed of a linked together plurality of individual segments **80** each having two sets of orthogonal ports **82** serving as cable guides, a section of which is shown in FIGS. **17** and **18**.

[0051] When connecting articulator section **14** to handpiece **12**, the first contact is made by pushrod **36** which extends beyond the base of the articulation section **14** bottom by a length that is long enough to snap the pushrod notch **44** against teeth **38** of the lock assembly **40**. As pushrod **36** enters the center of lock assembly **40**'s teeth set, the four connector clips **66** simultaneously snap and lock onto the four connector pins **64**. Pushrod **36** is longer than the extension of the connector clips **66** and enters handpiece **12** and the lock assembly before connector clips **66** are snapped into the four connector pins **64**.

[0052] Articulation section **14** includes a trocar adapter **84** which engages and locks against handpiece **12**. Compression springs **86** apply pressure against connector pins **64**. The spring force ensures simultaneous constant pressure against all four of the Connector Pins allowing for simultaneous connection of the four connector pins to the four connector clips and additionally provides for slack removal. Articulation section **14** is finally securely joined to handpiece **12** by Nut **26**.

[0053] To separate articulation section **14** and handpiece **12**, nut **26** is unscrewed. As the nut is being unscrewed, the back wall of the nut presses against the back wall of trocar adapter **84** causing the two components, articulator section **14** and handpiece **12** to separate. The clips **66** in the articulation section are pulled at the same time but are stopped by the length of the cable. The continued travel of articulation section **14** causes the right angle clip extension **88** on the clip **66** to go past its yield point and straighten out. In this straightened condition, the four clips **66** cannot be used a second time and thereby rendering articulation section **14** unusable for continued use.

[0054] The scope of the invention is hereby defined by the following claims.

What is claimed is:

1. A laparoscopic surgical instrument comprising in combination the components of:

A. an articulation section, said articulation section comprising in combination:
   i. an elongated shaft having a proximal end and a distal end and at least one passageway disposed along the entire length of said shaft;
   ii. a flexible bending portion disposed at said elongated shaft distal end having a proximal end and a distal end and at least one passageway disposed along the entire length of said bending portion;
   iii. at least one flexible control member having a proximal end and a distal end disposed in said passageways along the entire length of said shaft and said bending portion;

B. an end effecter mounting assembly attached to the distal end said control member; and

C. A handpiece connected to the proximal end of said articulation section, the proximal end of said shaft, and the proximal end of said flexible control member, said handpiece for moving and controlling said control member and said end effecter mounting assembly.

2. The surgical instrument of claim **1** further including an end effecter mounted on said end effecter mounting assembly

3. The surgical instrument of claim **2** wherein said end effecter is operated by said control member.

4. The surgical instrument of claim **3** wherein said end effecter is rotated by said control member.

5. The surgical instrument of claim **4** further including connecting means for connecting and disconnecting said handpiece and said articulation section whereby said instrument is separable into said articulation section and said handpiece.

6. The surgical instrument of claim **5** wherein said connecting means further includes means to prevent the reconnection of said articulation section and said handpiece upon disconnecting said articulation section and said handpiece.

7. A laparoscopic surgical instrument comprising in combination the components of:

A. an articulation section, said articulation section comprising in combination:
   i. an elongated shaft having a proximal end and a distal end and at least one passageway disposed along the entire length of said shaft;
   ii. a flexible bending portion disposed at said elongated shaft distal end having a proximal end and a distal end

and at least one passageway disposed along the entire length of said bending portion;

iii. at least one flexible control member having a proximal end and a distal end disposed in said passageways along the entire length of said shaft and said bending portion;

B. an end effecter mounting assembly attached to the distal end said control member;

C. means for articulating said bending portion about a complete circular pattern with respect to the axis of said shaft, said means comprising a plurality of cables attached to said bending portion distal end, said cables disposed in said passageways along the entire length of said shaft and said bending portion; and

D. a handpiece connected to the proximal end of said articulation section, the proximal end of said shaft, the proximal end of said flexible control member, and the proximal end of said cables, said handpiece for controlling and moving said control member and said end effecter mounting assembly, said handpiece for further controlling and moving said cables and said bending portion.

8. The surgical instrument of claim **7** wherein said cables comprise four in number, two pairs each attached orthogonally about said bending portion distal end.

9. The surgical instrument of claim **8** wherein each of said cable pairs are simultaneously pulled and released to accomplish said articulation.

10. The surgical instrument of claim **9** further including two reversible rotary electric motors and two sets of linear motion gear racks operated by said motors disposed in said handpiece and wherein said cable pairs are attached one each to one each of said sets of gear racks, and wherein said cable pairs are simultaneously pulled and released by the operation of said motors and said gear racks.

11. The surgical instrument of claim **10** wherein said reversible motors are controlled by electrical switches mounted on the back of said handpiece.

12. The surgical instrument of claim **7** further including an end effecter mounted on said end effecter mounting assembly.

13. The surgical instrument of claim **12** wherein said end effecter is operated by said control member.

14. The surgical instrument of claim **13** wherein said end effecter is rotated by said control member.

15. The surgical instrument of claim **14** further including connecting means for connecting and disconnecting said handpiece and said articulation section whereby said instrument is separable into said articulation section and said handpiece.

16. The surgical instrument of claim **15** wherein said connecting means further includes means to prevent the reconnection of said articulation section and said handpiece upon disconnecting said articulation section and said handpiece.

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摘要(译)

一种用于腹腔镜，内窥镜和自然孔口腔内窥镜外科手术的铰接式外科器械，包括可重复使用的操作手持部分和可分离的可重复使用或一次性铰接部分的可分离组合。保持在患者体外的手持件部分包括各种控制和指令装置和组件，而铰接部分由各种连杆，杆和电缆组成，这些连杆，杆和电缆将定位和操作指令从手持件传递到位于远端尖端的末端执行器。患者体内的关节部分。还公开了适用于本发明的末端执行器的改进的定位和操作配置以及这些仪器的一般类别。