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(71) Applicants (for all designated States except US): **INDIAN INSTITUTE OF SCIENCE** [IN/IN]; Bangalore 560 012, Karnataka (IN). **BANGALORE ENDOSCOPIC SURGERY TRAINING INSTITUTE & RESEARCH CENTRE** [IN/IN]; B.E.S.T. Institute and Research Centre, # 9, Patalamma Temple Street, Basavanagudi, Bangalore 560 004, Karnataka (IN).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **GHOSAL, Ashitava** [IN/IN]; Department Of Mechanical Engineering, Indian Institute Of Science, Bangalore 560 012, Karnataka (IN). **GOEL, Piyush** [IN/IN]; Department Of Mechanical Engineering, Indian Institute Of Science, Bangalore 560 012 (IN). **KUMBHARE, Harihar Suresh** [IN/IN]; Department Of Mechanical Engineering, Indian Institute Of Science, Bangalore 560 012 (IN). **RAMESH, Makkam** [IN/IN]; Bangalore Endoscopic Surgery Training Institute & Research Centre, #9, Patalamma Temple Street, Bangalore 560 004 (IN).

(74) Agents: **VARADACHARI, Lakshmikumaran** et al.; Lakshmi Kumaran & Sridharan, 505-508, 5th Floor, Brigade Plaza(North Block), No. 71/1, Subedar Chatram Road, Anand Rao Circle Bangalore 560 009 (IN).

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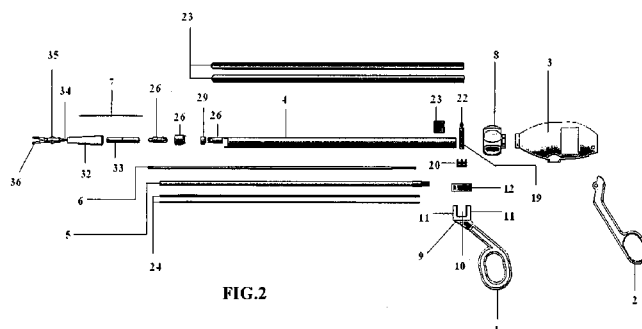
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(54) Title: LAPAROSCOPIC APPARATUS



(57) Abstract: The present invention provides a laparoscopic apparatus having an elongated barrel connected to a handle case with a fixed handle and a movable handle. A rotatable conduit is connected to a rotatable wheel with a movable rod disposed inside the elongated barrel, which is operable by the rotatable wheel. An end-effector with wrist-like movement is connected to an articulation assembly of the fixed handle in conjunction with a universal joint. The laparoscopic apparatus of the present invention with the end-effector assembly provides a wrist-like lateral movement. The laparoscopic surgical apparatus of the present invention has an improved articulation and an extra degree of freedom, while retaining its existing surgical functions.

LAPAROSCOPIC APPARATUS

Technical Field

The present invention relates to a surgical device and in particular to a laparoscopic apparatus.

Background of the Invention

Recent development in the field of robotics has opened a new frontier for innovation and development of surgical tools for use in minimally invasive surgery (MIS). An instrument of this type is used in particular in surgical procedures that use minimally invasive operating techniques. In a minimally invasive operation, a number of small incisions are made, and instruments and the like can be inserted through these incisions to perform operation like grasping, suturing, cutting, tying knots, etc. Minimally invasive surgery technique has the advantages of smaller incision, less pain, faster recovery period, and less exposure of other internal organs.

In addition to the known benefits of the MIS operating technique, a number of drawbacks were also encountered. For example, existing MIS instruments deny the surgeon the flexibility of tool placement found in open surgery. Most of the laparoscopic tool have rigid shafts and are constrained to approach the workspace from the direction of the small incision. Additionally, the length and construction of many laparoscopic instruments reduce the surgeon's ability to feel forces exerted by tissues and organs on laparoscopic instruments. The lack of dexterity and sensitivity provided by laparoscopic tools is a major impediment to the expansion of MIS.

In stapler type of surgical instruments, rotating trigger mechanisms are used to move graspers or jaws of the instruments for their positioning. However, in such instruments no locking devices are present to lock the rotating trigger mechanism at any specified position before actuating the graspers or jaws.

In some surgical tools, there are two working members or fingers, which pivot about a common pivot axis, such as the graspers or forceps. The fingers are actuated to exert a gripping force on tissues or organs. An actuation drive arrangement, such as a pulley and cable system or a push-pull rod, is used to actuate end-effectors. Because the size of the tools is kept small, force is not enough to hold the organs/tissues. For instance, in a pulley and cable system, the force transmission is often increased by increasing the

size of the pulley. In the MIS, a significant increase in the size of the pulley used in an end-effector is not desirable.

In trigger controlled laparoscopic surgical tools, bend and rotation of a shaft mimics human wrist-like movement. A "pen click" switch controls opening and closing of the graspers. The mechanism allows simultaneous bending and rotation of an end of the shaft and graspers. However, the bend of the shaft leaves an opening in the tool, making sterilization nearly impossible. This mechanism also has multiple ball bearings in the trigger and the shaft, which cannot be easily sterilized due to the grease needed for smooth movement of the ball bearings.

In a joystick control design, a thumb operated joystick is used for smooth movement of serrated graspers. Movement of the joystick is translated to a ball and socket joint due to simultaneous bend and rotation of a shaft. A trigger mechanism control opens and closes the serrated grasper. However, the problem with this tool is the lack of tactile feedback, which surgeons desire during operation.

Summary of the invention

The present invention provides a laparoscopic surgical apparatus having an elongated barrel connected to a handle case with a fixed handle and a movable handle. A rotatable conduit is provided, which is connected to a rotatable wheel with a movable rod is disposed inside the elongated barrel. The apparatus further comprises a laterally movable end-effector with an operating element on one side and the rotatable conduit connected to the other side. Further, the apparatus comprises a holder with a holder ring connected to the fixed handle and a movable vertical support member with guide actuators movably connected to movable guide members. At least a pair of the movable guide members is axially disposed in an intervening space between the elongated barrel and the rotatable conduit and is connected to the guide actuators and the end-effector. Also, a universal joint is connected to the rotatable conduit on one side and to the end-effector on the other side. Further, a movable and flexible element is connected to the movable rod and the operating element to provide an articulation support to surgical functions of the apparatus. The laparoscopic apparatus, during the course of a laparoscopic surgery, enables the user not only to hold and cut the selected subject but

also simultaneously enables the lateral wrist-like movement along with rotary movement of the movable end-effector.

The above summary of the present invention is not intended to describe each illustrated embodiment of the present invention. The other aspects and embodiments of the invention will become apparent upon the review of the following drawings and detailed description.

Brief Description of the diagrams

Fig. 1 is a schematic view of a laparoscopic apparatus showing an end effector with an operating element, according to an in accordance with one embodiment of the subject matter.

Fig. 2 is an exploded view of the laparoscopic apparatus of Fig.1, showing the arrangement of various parts, according to an embodiment.

Fig. 3 is an exploded view of a fixed handle and some of the parts associated with an actuating mechanism of the laparoscopic apparatus, according to an embodiment.

Fig. 4 is a cross-sectional view of a handle case and the actuating mechanism of Fig.3 according to an embodiment.

Fig. 5 is a top perspective open view of a rotatable wheel, guide actuators, movable guide members, and a holder ring of the laparoscopic apparatus, according to an embodiment.

Fig. 6 is a top cross-sectional view of the rotatable wheel, the movable guide members, the guide actuators, a rotatable conduit, and an elongated barrel of the laparoscopic apparatus.

Fig. 7 is a view of an end effector assembly of the laparoscopic apparatus, connected to the movable guide members, a universal joint and an operating element, according to an embodiment.

Fig. 8 and 9 depict a view of a universal joint of the laparoscopic apparatus of the present subject matter.

Fig. 10 depicts the connectivity of the movable rod and the movable and flexible element used in the articulation of the laparoscopic apparatus, along with a cross-sectional view and a perspective view of the movable operating element.

Fig. 11 depicts the movable element, in the form of a gripper, of the laparoscopic apparatus.

Fig. 12 and **13** depict cross sectional views of the end effector assembly of the laparoscopic apparatus in an articulated position.

Detailed Description of the invention

A laparoscopic apparatus, according to an aspect of the present subject matter, is described by referring to the accompanied figures. Initially, referring to the Figures as illustrated in **Figs 1** through **2**, the laparoscopic apparatus includes a fixed handle **1**, a movable handle **2**, and a pistol-shaped handle case **3** connected to a proximal end of an elongated barrel **4**. The fixed and movable handles **1** and **2** are connected to the handle case **3**, as shown in **Fig 1**. Both the fixed and the movable handles **1** and **2** provide a grip to a user and enables the user to actuate other parts of the laparoscopic apparatus, for instance, during the course of laparoscopic surgery, as hereinafter described. The expression “proximal” as used above in the description indicates that portion of the laparoscopic apparatus which is normally close to a user while holding the laparoscopic apparatus. Similarly the expression “distal” indicates that portion of the laparoscopic apparatus which is farther away from the user.

Further, a rotatable conduit **5** with proximal and distal ends is disposed inside the elongated barrel **4** and extends axially from the movable handle **2** through the length of the elongated barrel **4**. The proximal end of the rotatable conduit **5** is connected to a rotatable wheel **8**. The rotatable conduit **5** is rotated by the user by means of the rotatable wheel **8**.

A movable rod **6** with a ball-shaped proximal end is connected to the movable handle **2**. Triggering movement of the movable handle **2** is translated into an axial movement of the movable rod **6**. In one implementation, the movable rod **6** can also be arranged in conjunction with a tensioning device, like a spring, to provide a free play of the movable rod **6**.

Now by referring to **Fig 3-6**, the constructional arrangement of components to attain the wrist-like lateral movement of the laparoscopic apparatus is described. In one implementation, as shown in **Fig. 3**, an actuating assembly **1a** that facilitates actuating motion of movable parts of the laparoscopic apparatus is described. The actuating

assembly **1a** includes the fixed handle **1** has a gripping portion and a holder **9** connected to the handle case **3**. The holder **9** is provided with wall portions **11**, which are designed to form peripheral slots **10**. The wall portions **11** and the slots **10** are arranged in a manner to form an alternate arrangement of the wall portions **11** and the slots **10**, on the periphery of the holder **9**.

A holder ring **12** with a stopper element **16** is rotatably mounted on the outer periphery of the wall portions **11** of the holder **9** of the fixed handle **1**. The holder ring **12** is disposed to move both in clockwise and counter clock-wise directions. The movement of the holder ring **12** is effected by the user. The stopper element **16** is provided that acts as a stopper to the movement of the holder ring **12**. The stopper element **16** defines an extent of movement to the holder ring **12** in both clockwise and counter clock-wise directions. The holder ring **12**, according to an embodiment, is a circular ring or a wheel. Any other compatible arrangements that can effect the desired circular movements can also be used as the holder ring **12**.

A base ring **13** and an arm ring **14** with an intervening space **15** are disposed inside the holder ring **12**. An inner surface of the arm ring **14** is covered with protrusions **18**. A movable vertical support member **19**, which is a stud-like structure, having longitudinal grooves **17** on its lateral surface and a base **20**, is permeably fitted through the inner protrusions **18** of the arm ring **14**. The connectivity of the movable vertical support member **19** with the holder ring **12** ensures the transmission of circular movement of the holder ring **12**, which is effected by the user, to the movable vertical support member **19**.

The fixed handle **1** is connected to the handle case **3** by means of projections **21** provided on the base **20** of the movable vertical support member **19**.

Further, a pair of guide actuators **22**, which are in the form of lateral projections, are mounted on the movable vertical support member **19**. In one implementation, the projections have winged configuration; however, other suitable configurations can also be used for the guide actuators **22**.

In another implementation, the holder ring **12**, the base ring **13**, the arm ring **14**, the movable vertical support member **19**, and the guide actuators **22** can be made from any metal or alloy or any wear resistant polymers.

A space **25** is arranged inside the elongated barrel **4** and rotatable conduit **5**. The space **25** extends through the length of the elongated barrel **4**.

The laparoscopic apparatus further includes at least one pair of immovable guide member supporters **24**, which is axially disposed inside the space **25** between the elongated barrel **4** and the rotatable conduit **5**. In one embodiment, the immovable guide member supporters **24** are disposed on top and bottom inner surfaces of the elongated barrel **4**. The guide member supporters **24** are elongated slides or strips extending from the rotatable wheel **8** to the distal end of the elongated barrel **4**.

Movable guide members **23**, in the form of elongated slides or strips having proximal and distal ends, are movably and axially disposed in the space **25** between the elongated barrel **4** and the rotatable conduit **5**. The proximal ends of the movable guide members **23** are abutted to the guide actuators **22**. Accordingly, whenever the guide actuators **22** are actuated, the corresponding motion is transmitted to the movable guide members **23** so that the movable guide members **23** move axially through the elongated barrel **4**.

Therefore, the movable guide members **23** are disposed to possess a relative axial movement, inside the space **25**, of the elongated barrel **4** and the rotatable conduit **5**, on being actuated by the rotary motion of the movable guide members **23**.

Now by referring to **Figs 7-11**, the constructional features of a universal joint **26** and its integration with the other parts of the laparoscopic apparatus are described.

The universal joint **26** includes a pair of rotatable universal joint arms **27** connected to the rotatable conduit **5** on one side and to a movable universal joint arm link **29** having a passage **30**, on the other side. Consequently, the universal joint arms **27** and the movable universal joint arm link **29** are disposed to rotate in conjunction with the rotation of the rotatable conduit **5** upon the rotation of the holder ring **12**. Further, a pair of movable universal joint arms **28** is connected to the movable universal joint arm link **29**. The connectivity of the rotatable universal joint arms **27**, the movable universal joint arm link **29**, and the movable universal joint arms **28** form the universal joint **26** to provide a flexible and movable connecting link between the elongated barrel **4** having the movable guide members **23**, the rotatable conduit **5**, and the movable rod **6** on one side and a movable end-effector **32** on the other side, as hereinafter described.

The movable end-effector **32** includes an end-effector housing **32a**. The end-effector housing **32a** includes a cylinder **28a** having a passage **28b**, which is connected to the movable universal joint arms **28**. A movable piston **33** is connected to the cylinder **28a** in a spatial arrangement by means of a flexible and movable element **7**, as hereinafter described. A movable piston rod **34**, which is also enclosed in the end-effector housing **32a**, is connected to the movable piston **33**. Further, a movable arm supporting member **36** is connected to the end-effector housing **32a**. Also, a movable piston rod **34** is connected to the movable piston **33** to receive the axial motion from the movable piston **33**. The movable piston rod **34** is arranged in a manner to extend from the end-effector housing **32a** to the movable arm supporting member **36**. Movable arms **35** are movably connected at a converging point **35a** of the movable arms **35**. The movable arms **35** are pivoted to the movable arm supporting member **36**, which is connected to the end-effector housing **32a**. The converging point **35a** acts like a pivot for the movable arms **35**. Further, a pair of movable operating element **37** is linked to the movable arms **35**. The movable operating element **37** is held by the movable arm supporting member **36** with a riveting arrangement as shown in **Fig 10**. In one implementation of the present embodiment, the movable operating element **37** is implemented as a pair of scissors. However, in another embodiment, depicted in **Fig. 11**, the movable operating element **37** may be implemented as a gripper **38**.

The movable and flexible element **7**, which can be a flexible wire or a cable, is coupled to the distal end of the movable rod **6** on one side and to the movable piston **33** on the other side, as shown in **Fig 10**. The movable and flexible element **7** has a ball-shaped end **6b**, which is press-fitted into a coupler **6a** having a corresponding cavity. An identical coupling arrangement is also implemented on the other end of the movable and flexible element **7** when it is connected to the movable piston **33**. Further, the proximal end of the movable rod **6** is connected to the movable handle **2** as shown in **Fig 4**. The movable and flexible element **7** originating from the distal end of the movable rod **6** is permitted to pass through the universal joint arm link passage **30** of the universal joint **26**. The movable and flexible element **7**, which is connected to the movable piston **33**, is further connected to movable piston rod **34**, which in turn is connected to the movable arms **35** and the corresponding movable operating element **37**.

Accordingly, by referring again to **Fig 10**, when the user operates the laparoscopic apparatus for a surgery, the movable handle **2** is triggered and the resultant axial motion is transmitted through the movable rod **6**. The axial movement of the movable rod **6** is further transmitted to the movable and flexible element **7**, which in turn activates the movable piston **33** by pulling the movable piston **33** towards the proximal end of laparoscopic apparatus. Consequently, the movable piston rod **34**, which is connected to the movable piston **33**, pulls the movable arms **35** so that movable arms **35** move closer to each other, resulting in closing of the movable operating element **37**. Thereafter, whenever the movable piston rod **34** is released or moved towards the distal end, due to release of the movable handle **2**, the movable arms **35** respond by moving away from each other, thus resulting in opening of the movable operating element **37**. The co-operative movements of opening and closing of the movable arms **35** facilitate operations of the movable operating element **37**, in the form of either gripping or cutting the desired tissue/organ during the course of the laparoscopic surgery.

An end-effector actuating space **31** is arranged between the elongated barrel **4** and the movable end-effector **32**. The universal joint **26** is disposed in the end-effector actuating space **31**. Further, the end-effector actuating space **31** allows the movable universal joint arms **28** to move axially and actuate the movable end-effector **32** by pushing the movable end-effector **32** to the desired lateral wrist-like movement.

The lateral wrist-like movement of the movable end-effector **32** is now described by referring Figs. **12** and **13**. In one implementation, the articulation of the holder ring **12** actuates the movable guide members **23**. The clock-wise and the counter clock-wise rotations of the holder ring **12** actuates the axial movement of the corresponding movable guide members **23**. The axial movement of the movable guide members **23** extends into the end-effector actuating space **31** and pushes the movable end-effector **32**, in a pre-determined direction, corresponding to the clock-wise and the counter clock-wise rotary movement of the holder ring **12**, thereby causing the lateral wrist-like movement of the movable end-effector **32**.

The laparoscopic apparatus of the present invention possesses a workable range of angle of articulation of the movable end-effector **32** along with a rotation of 360° about the axis of the elongated barrel **4**.

The laparoscopic apparatus, during the course of a laparoscopic surgery, enables the user not only to hold and cut the selected subject but also simultaneously enables the lateral wrist-like movement along with rotary movement of the end-effector 32.

The laparoscopic apparatus has a decoupling arrangement in the form of separation of various functions of the laparoscopic apparatus *viz.*, lateral wrist like motion of the movable end-effector 32, cutting and gripping arrangement of the movable operating element 37, and rotary motion of the movable operating element 37, which are effected by the combined operation of movable end-effector 32 and the universal joint 26 and the handle assemblies as shown in corresponding representative Figs. 7-13.

Therefore, the laparoscopic apparatus of the present invention provides an improved articulation with an extra degree of freedom, while retaining its existing surgical functions. The end effector of the laparoscopic apparatus is provided with a wrist-like lateral movement to provide desired extra degree of freedom.

The laparoscopic apparatus of the present invention is provided with independent actions for lateral wrist-like motion, cutting and gripping arrangement and rotary motion.

The movable end-effector can be easily detachable from the body of the laparoscopic apparatus. The laparoscopic apparatus has an extra degree of freedom that enhances the dexterity of a user in a minimally invasive surgery.

While there have been described what are presently believed to be the preferred embodiments of the invention, those skilled in the art will realize that various changes and modifications may be made to the invention without departing from the spirit of the invention, and it is intended to claim all such changes and modifications as fall within the scope of the invention.

We Claim:

1. A laparoscopic device comprising; a movable handle 2, a handle case 3, an elongated barrel 4, connected to said handle case 3, a rotatable conduit 5 disposed inside said elongated barrel 4 and connected to a rotatable wheel 8 of said handle case 3, a movable rod 6 disposed inside said rotatable conduit 5 connected to said movable handle 2, characterized in that a fixed handle 1 with an actuating assembly 1a, connected to said handle case 3, a space 25 disposed between said elongated barrel 4 and said rotatable conduit 5, at least a pair of immovable guide member supporters 24 axially disposed in said space 25, at least a pair of movable guide members 23 with proximal and distal ends, axially disposed inside said space 25, and wherein said proximal ends connected to said actuating assembly 1a, a universal joint 26 functionally connected to said rotatable conduit 5, a movable end-effector 32 functionally connected to said universal joint 26 and to said distal end of movable guide members 23, an end-effector actuating space 31 disposed between said elongated barrel 4 and said movable end-effector 32 and wherein said universal joint 26 disposed in said end-effector actuating space 31, and a movable and flexible element 7 connected to said movable rod 6 and to said movable end-effector 32, wherein said movable and flexible element 7 is permitted to pass through said universal joint 26.
2. The laparoscopic device as claimed in claim 1, wherein said actuating assembly comprises; a holder 9 with slots 10 and wall portions 11, a movable holder ring 12 mounted on said wall portions 11 of said holder 9, and a movable vertical support member 19 with guide actuators 22 connected to said holder ring 12.
3. The laparoscopic device as claimed in claim 2, wherein said movable holder ring 12 comprises; a base ring 13, an arm ring 14 with intervening space 15, and a stopper element 16 rotatably mounted on said wall portions 11 of said holder 9 and disposed between said holder ring 12 and said base ring 13.
4. The laparoscopic device as claimed in claim 1, wherein said universal joint 26 comprises; a pair of rotatable universal joint arms 27 connected to said rotatable conduit 5, movable universal joint arms 28 connected to said movable end-effector 32, and a movable universal joint arm link 29 with a passage 30 disposed

to connect said rotatable universal joint arms **27** and said movable universal joint arms **28**.

5. The laparoscopic device as claimed in claim 1, wherein said movable end-effector **32** comprises; an end-effector housing **32a**, a cylinder **28a** with a passage **28b** connected to said movable universal joint arms **28**, a movable piston **33** disposed in said end-effector housing **32a** connected to said cylinder **28a**, a movable piston rod **34** and movable arms **35**, wherein said movable arms **35** pivoted to a movable arm supporting member **36**, and a movable operating element **37** operably connected to said movable arms **35**.
6. The laparoscopic device as claimed in claim 5, wherein said movable operating element **37** is scissors or a gripper **38**.
7. The laparoscopic device as claimed in claim 1, wherein said movable and flexible element **7** is a wire or cable.

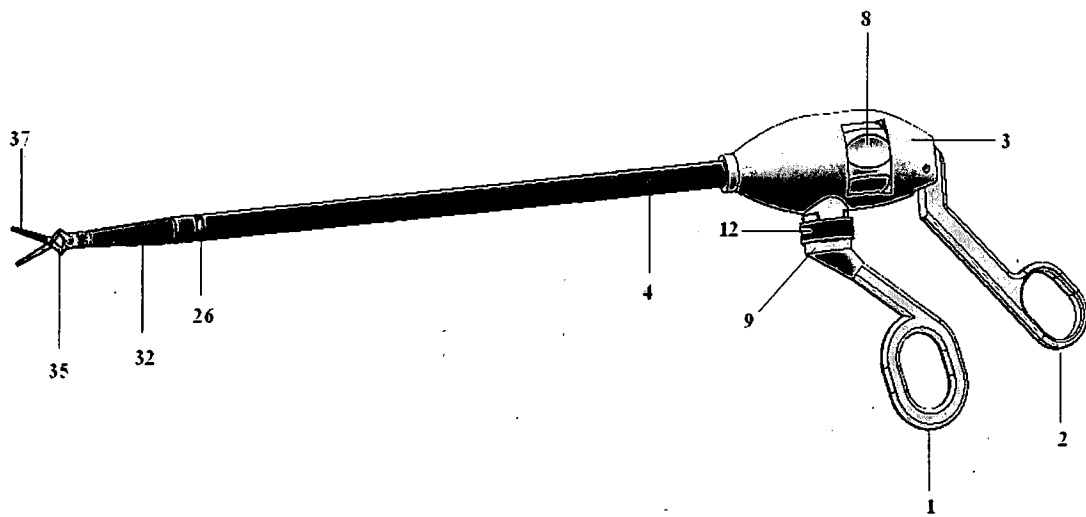


FIG.1

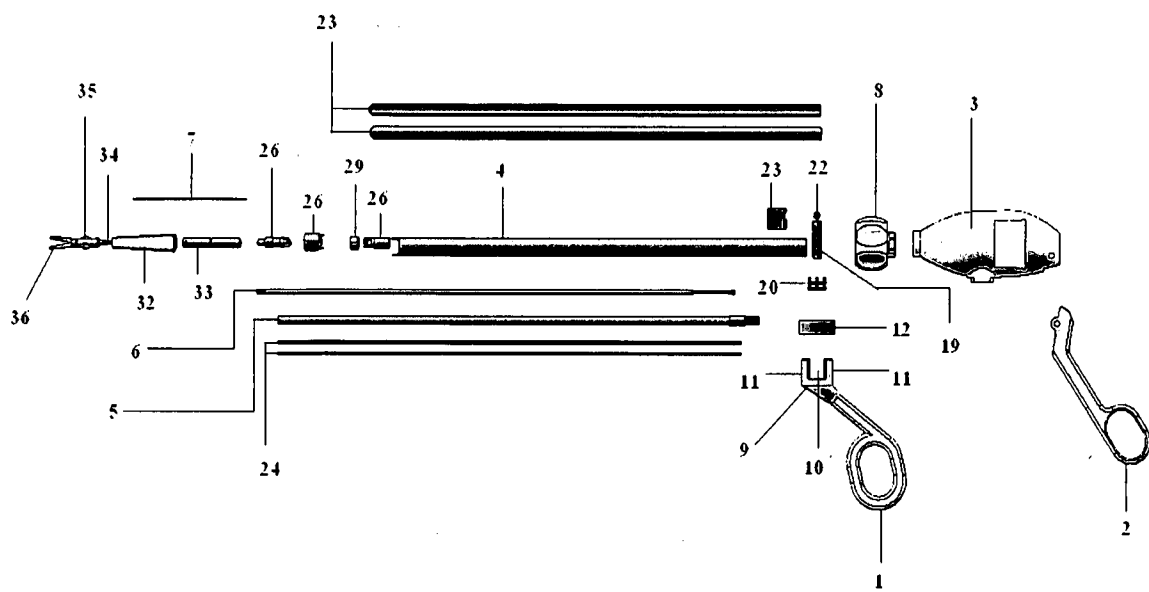


FIG.2

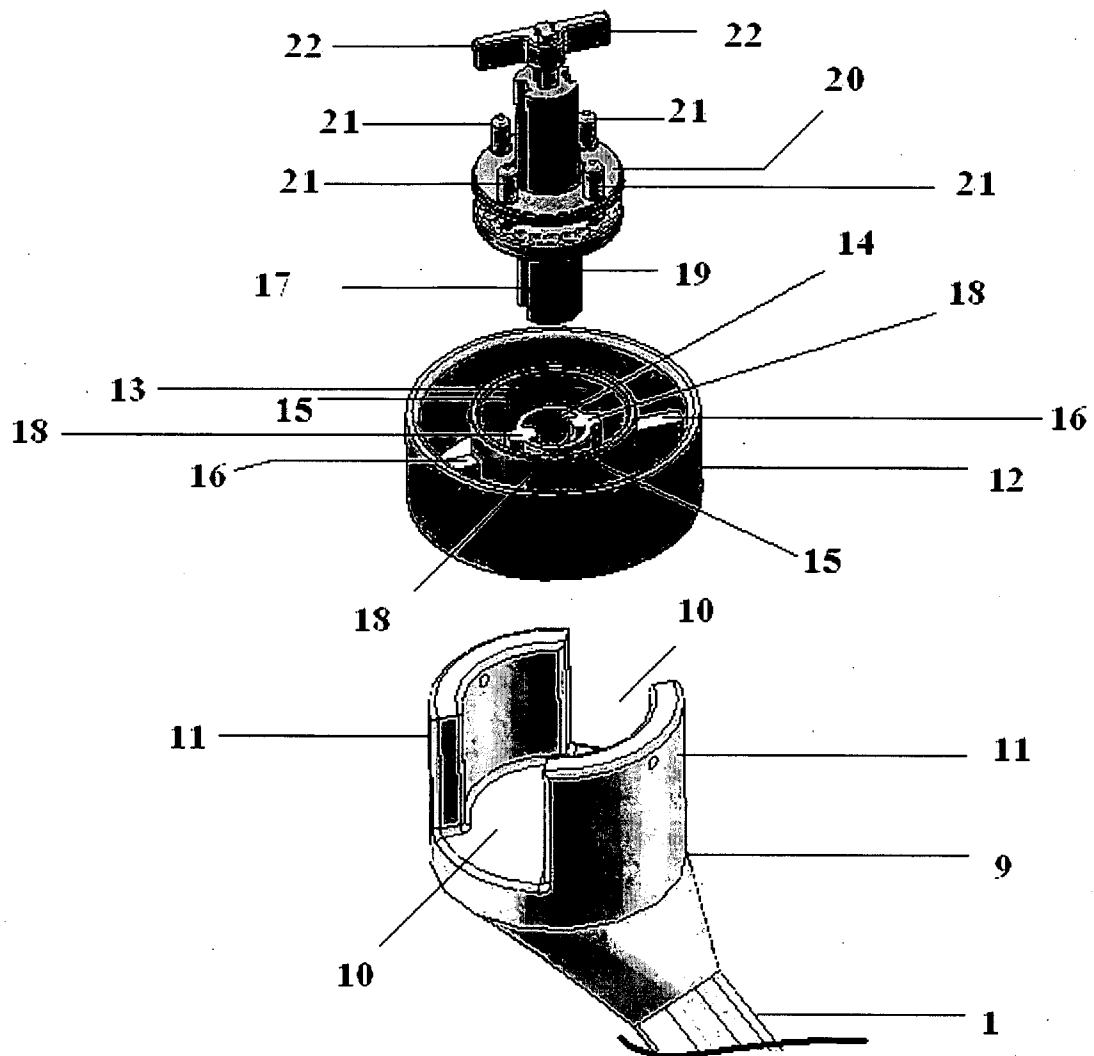


FIG.3

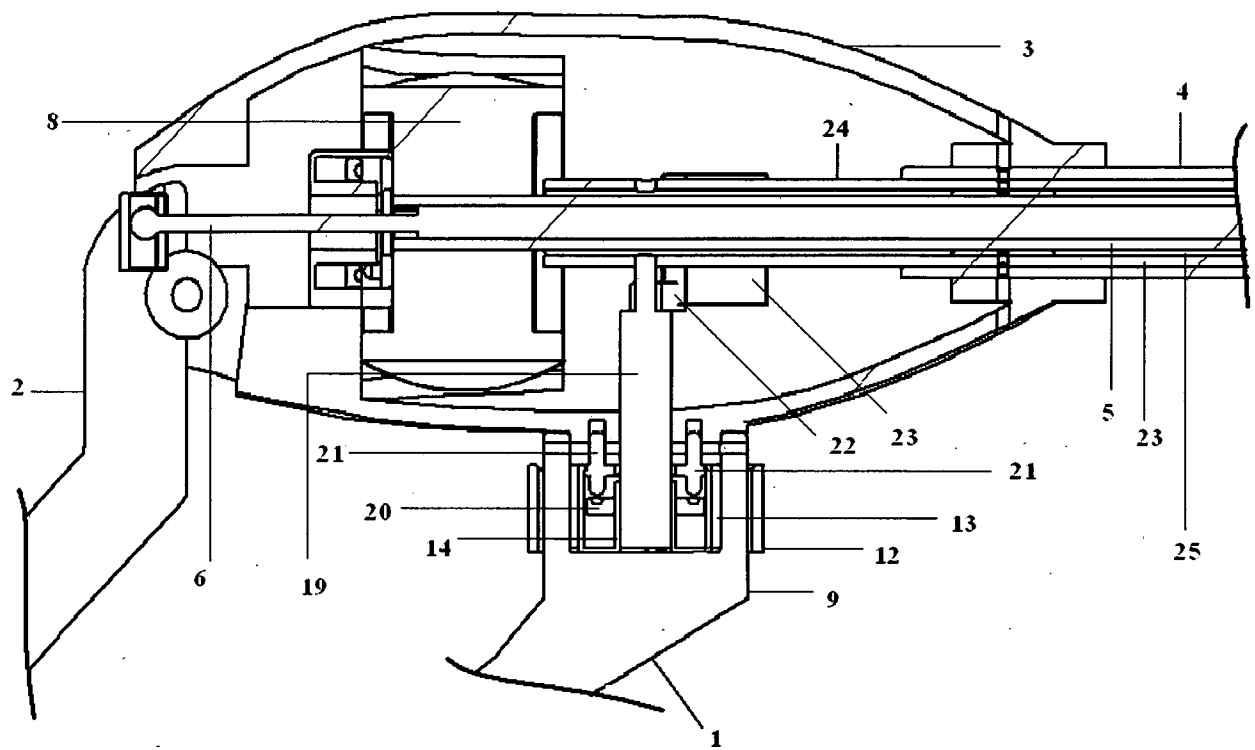


FIG.4

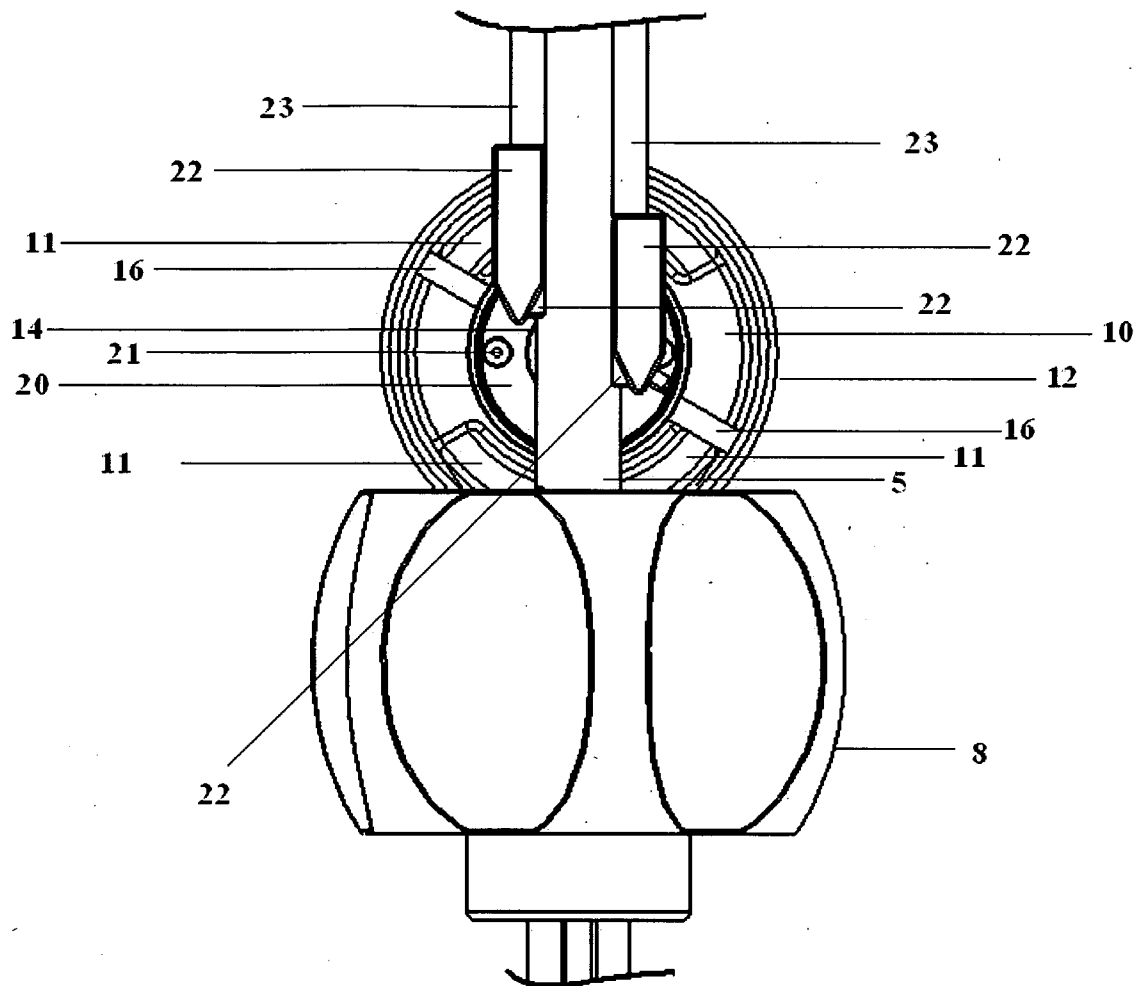


FIG.5

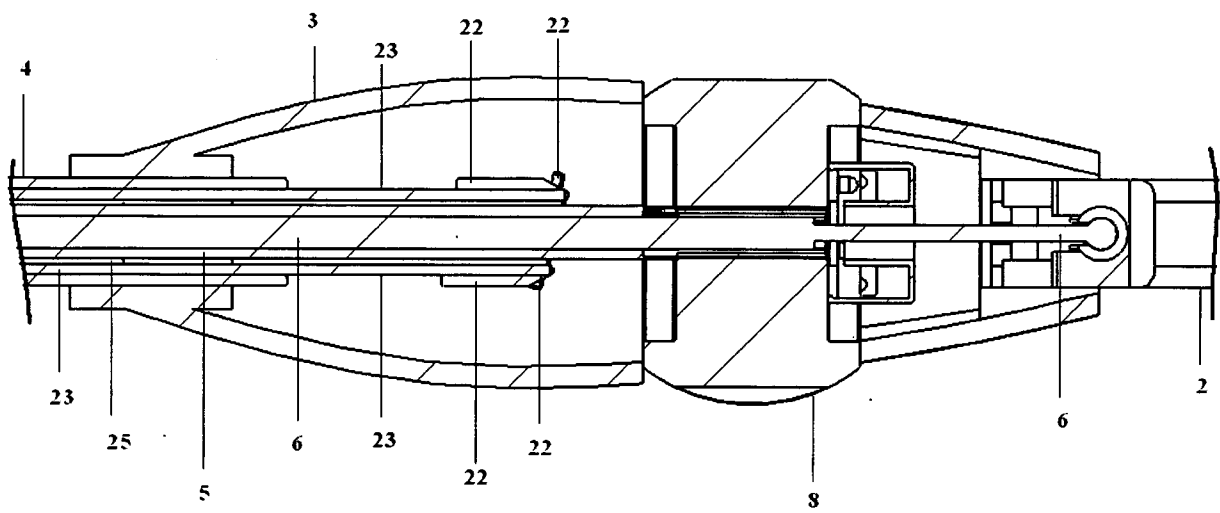


FIG.6

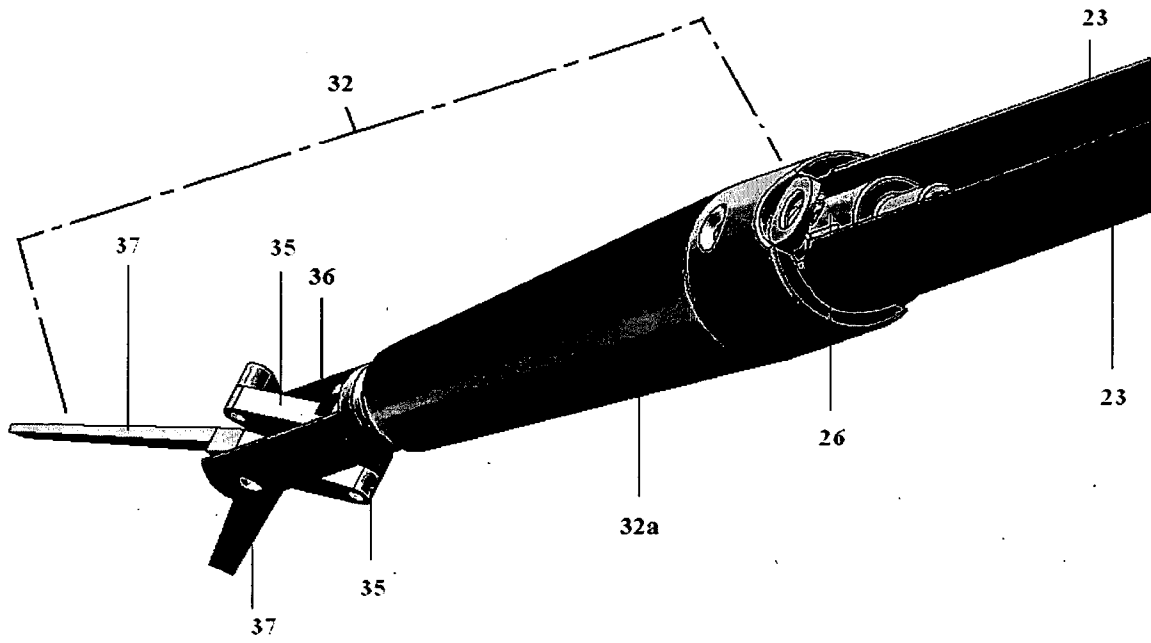


FIG.7

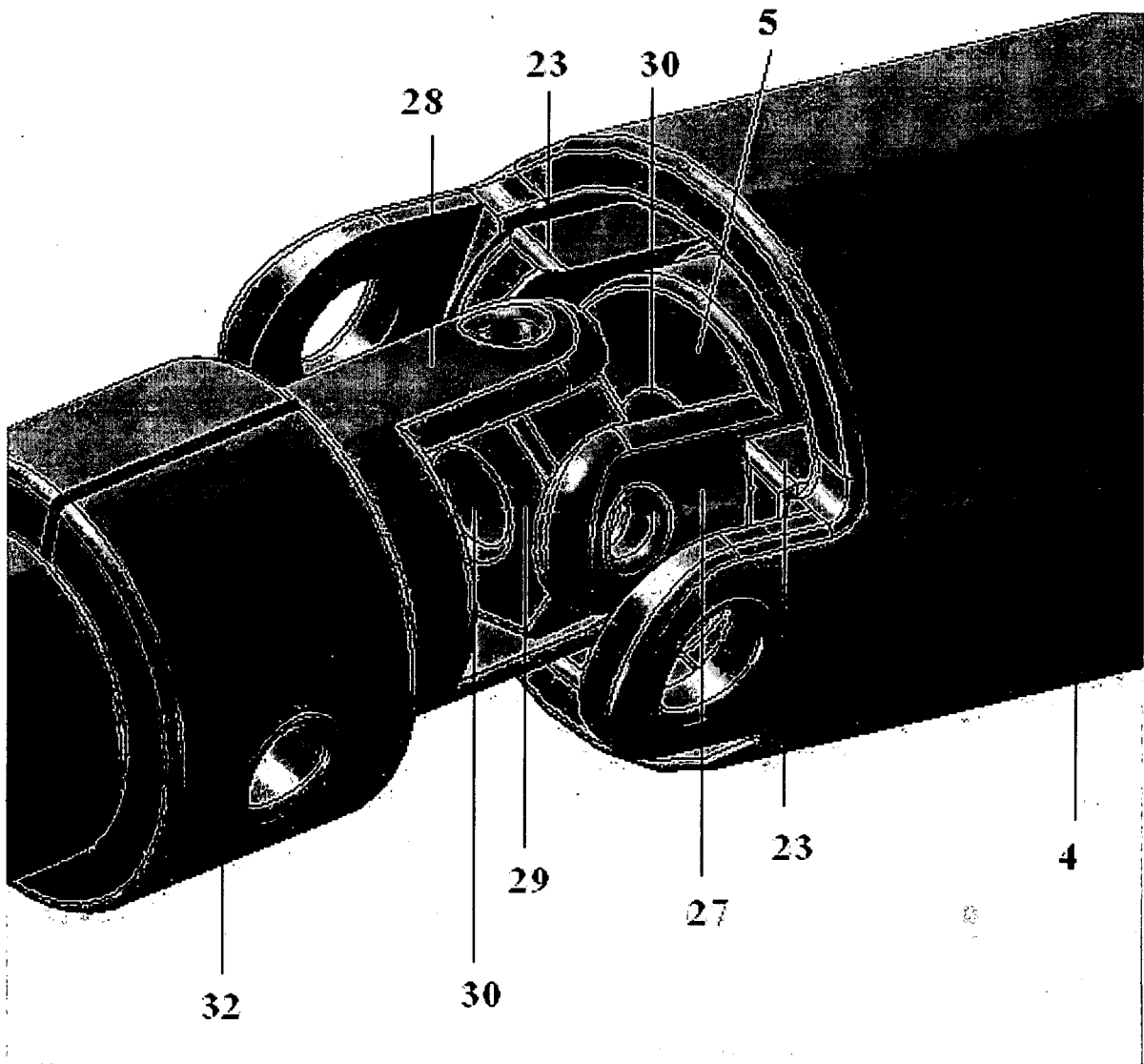


FIG.8

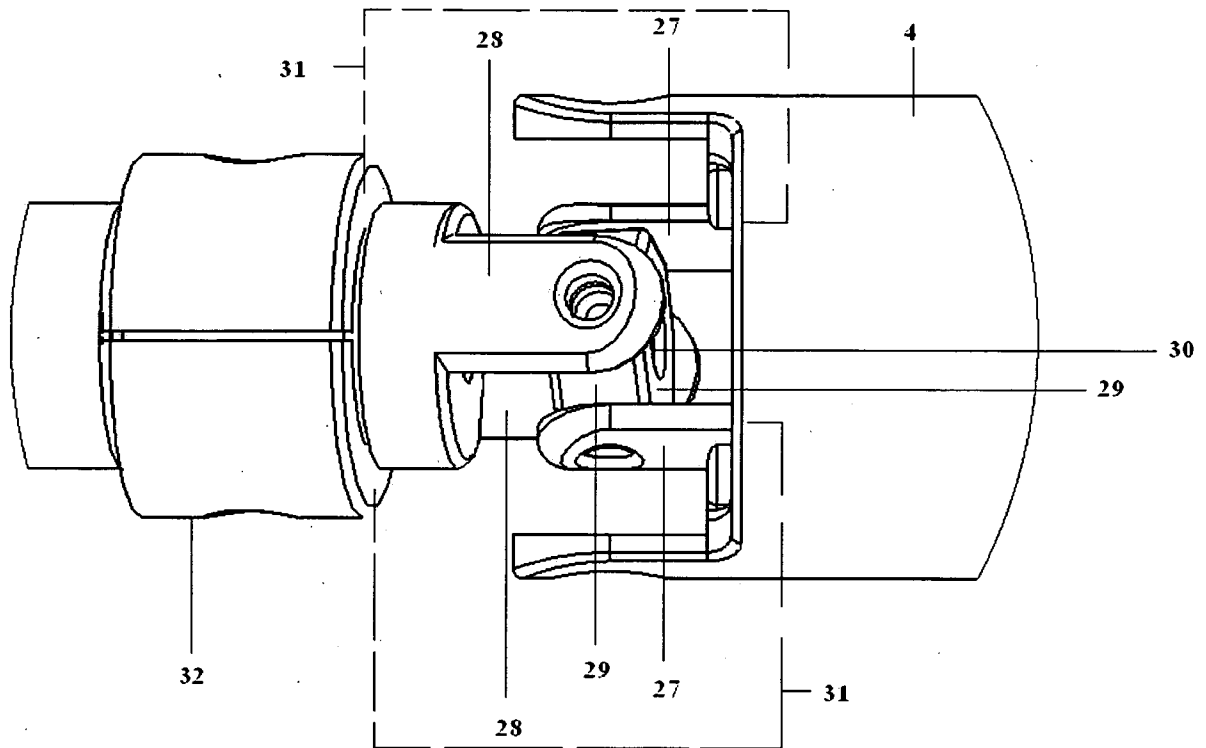


FIG.9

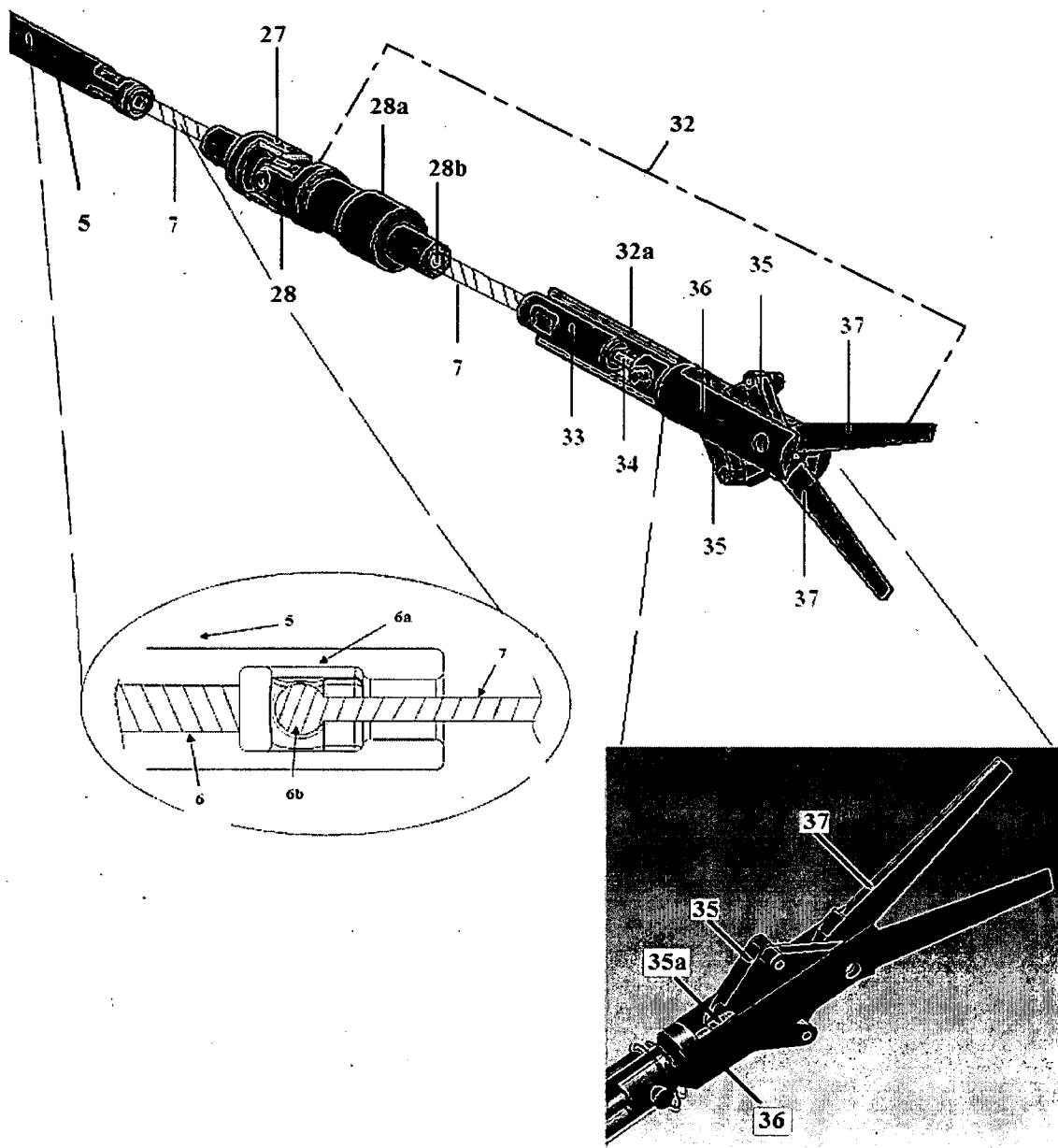


FIG.10

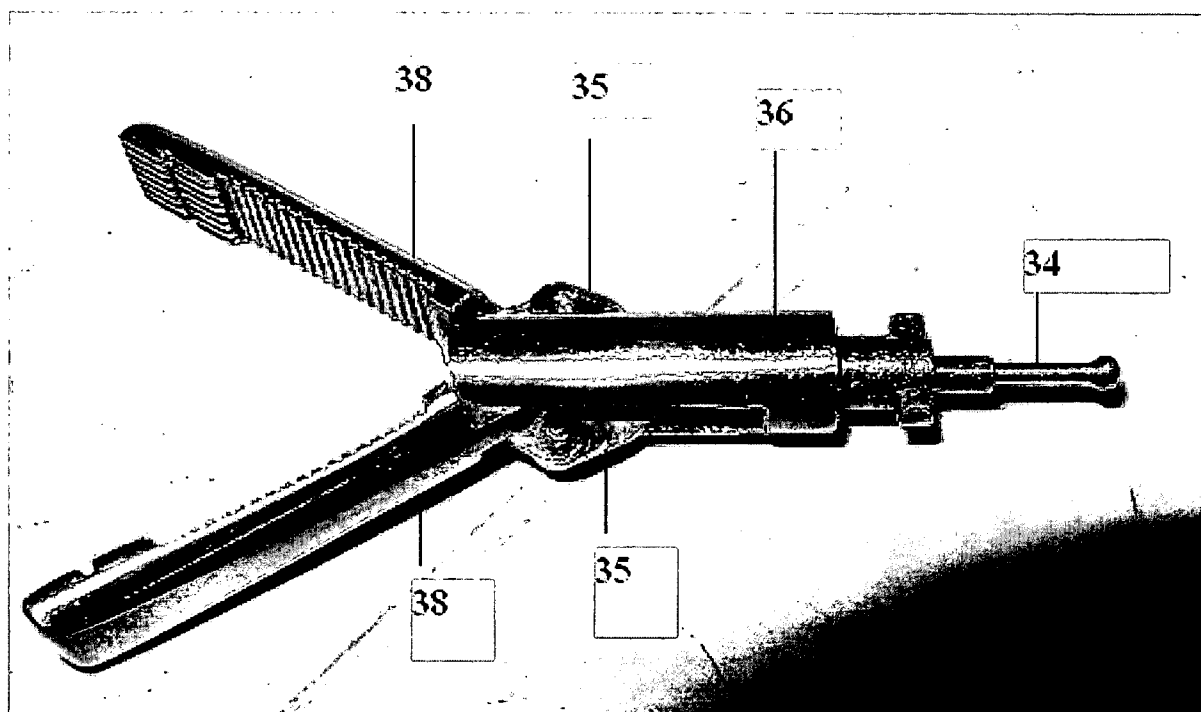


FIG.11

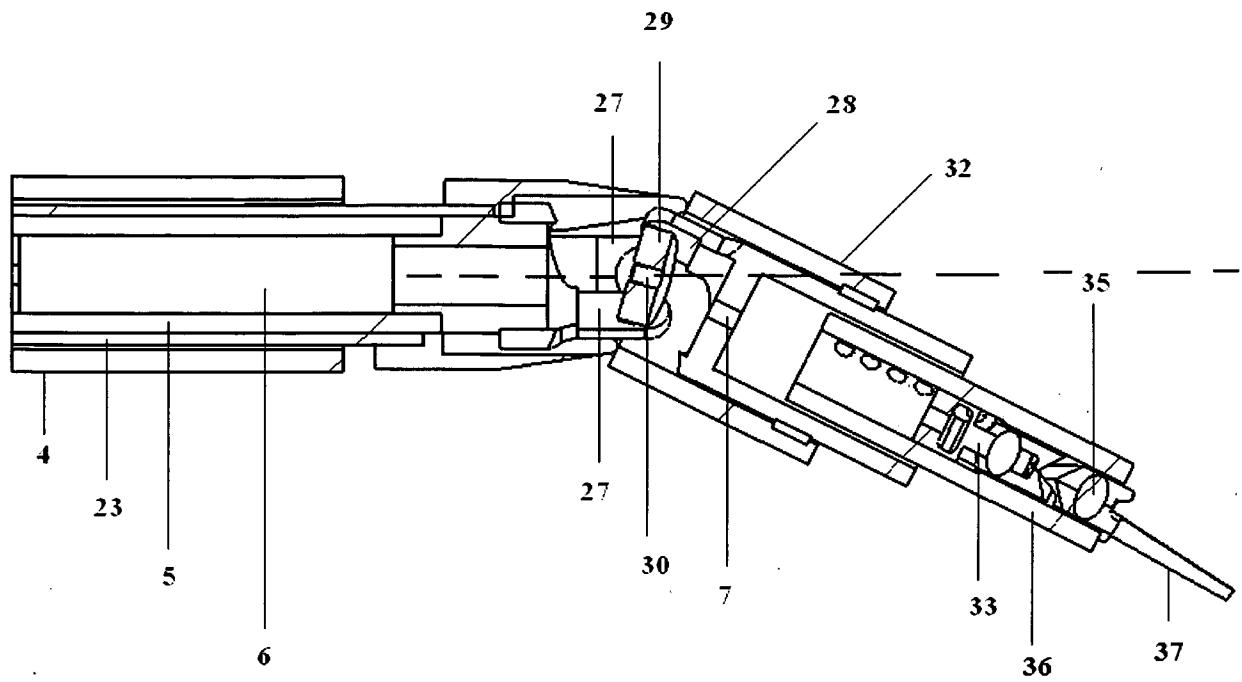


FIG.12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2010/000559

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

A61B 17/295 (2006.01)**A61B 17/94** (2006.01)**A61B 19/00** (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Patent Lens, Google Patents & EPODOC: EPOQUE & WPI: IPC & ECLA: A61B17/- and A61B19/- and Keywords: Laparoscopic, Surgical, Handle, Elongate, Shaft, Grip, Cut, Jaw, Movable, Rotary, Rotation, Pivotal, Circular, Wire, Cable and like terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5350391 A (IACOVELLI) 27 September 1994 See Abstract, Col.2 – Lines 44-56, Col.8 – Lines 33-43, Figs.1-10	1-2 & 4-7
X	US 6685724 B1 (HALUCK) 03 February 2004 See Abstract, Col.6 – Lines 7-16, Col.4 – Lines 48-53, Col.5 – Lines 59-64	1-2 & 4
X	US 2007/0093790 A1 (DOWNEY et al.) 26 April 2007 See Abstract, Para [0008]-[0009] & [0033], Fig.4	1-2, 4 & 6
A	US 2009/0209979 A1 (YATES et al.) 20 August 2009 See Whole Document	

☐ Further documents are listed in the continuation of Box C☒ See patent family annex

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Date of the actual completion of the international search
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Name and mailing address of the ISA/AU
AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustalia.gov.au
Facsimile No. +61 2 6283 7999

Authorized officer
VARUN WADHWA
AUSTRALIAN PATENT OFFICE
(ISO 9001 Quality Certified Service)
Telephone No : +61 2 6225 6142

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/IN2010/000559

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report			Patent Family Member		
US	5350391	NONE			
US	6685724	AU 67961/00 WO 2001/013804	US 2004/0138701	US	7331978
US	2007/0093790	AU 2006305976 WO 2007/050969	CA 2626156	EP	1940281
US	2009/0209979	BR PI0901282 CN 101507627 EP 2090238 JP 2009189835	BR PI0903064 CN 101507628 EP 2090249 JP 2009189838	BR PI0903065 CN 101507635 EP 2090250 JP 2009213878	
Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.					
END OF ANNEX					