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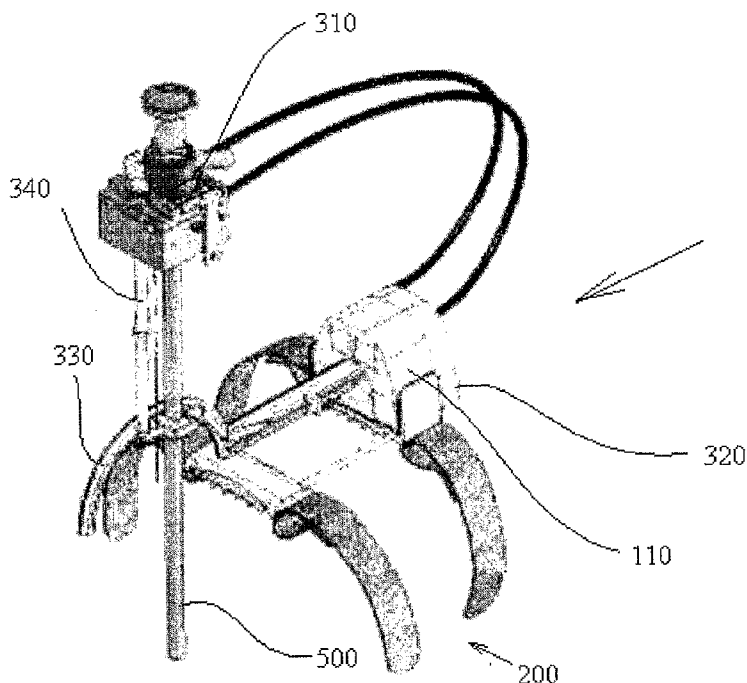
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(54) Title: ENDOSCOPIC POSITIONING SYSTEM



(57) Abstract: The present invention discloses cost effective endoscope positioning system (EPS), comprising of an at least four freedom degree mechanism (FDFM) which actuates the distal portion of an endoscope by maneuvering the proximal portion of the endoscope. The FDFM comprises at least a first, second, third and forth means for providing degrees of freedom: a means of first degree of freedom is a rotation sub-mechanism; a means of second degree of freedom is a tilting sub-mechanism; a means of third degree of freedom is an arch sub-mechanism; and a means of forth degree of freedom is a zoom mechanism. The invention also presents a method of manipulating an endoscope in at least four degrees of freedom by the EPS. This method comprises steps selected from a group consisting of providing at least four freedom degree mechanism (FDFM); and actuating the distal portion of the endoscope by maneuvering the proximal portion of said endoscope. A method of performing an endoscopic surgery is also disclosed.

ENDOSCOPIC POSITIONING SYSTEM

FIELD OF THE INVENTION

This invention relates to a structure for supporting a surgical instrument, such as an endoscope, and more particularly to a structure which provides for repositioning of the instrument during surgery without stressing an incision through which the instrument extends.

BACKGROUND OF THE INVENTION

Laparoscopic surgery is a procedure in which surgical instruments and a viewing scope, referred to generally as an endoscope and more specifically as a laparoscope, are inserted through small puncture wounds or incisions into the abdominal cavity of a patient. A small video camera is attached to the laparoscope and connected to a television monitor for viewing the procedure.

The instruments and the laparoscope are inserted through cannulae which are first inserted through the incisions. Cannulae are hollow tubes with gas valves. The cannulae are left in the puncture wounds throughout the procedure. This allows the instruments and scope to be removed and reinserted as necessary.

To aid in visualizing the intra-abdominal structures, gas is inserted through one of the cannulae to raise the abdominal wall. Seals are required at the exit points of the scope and instruments to prevent the gas from escaping.

The viewing laparoscope is inserted through a cannula which is usually inserted through an incision made in the umbilicus. The scope is then directed toward the pelvis for pelvic surgery or toward the liver for gallbladder surgery.

Throughout the procedure it is necessary for the surgeon, assistant surgeon, or a scrub nurse to hold the scope and direct it at the target of the surgery. It is constantly being repositioned to obtain the best view. This process ties up one hand of the surgeon or assistant surgeon, if either holds the scope. The scrub nurses also have other tasks to perform, and holding the scope interferes with performing these tasks. It is also difficult for the surgeon to direct others to

position the scope for the best view. When the scope is not held by the surgeon, it is often misdirected.

The support of a laparoscope has been provided through the use of robotic retractors. Retractors hold instruments in fixed positions, such as for holding an incision open to allow a surgeon access to the underlying body parts. The retractors are fixedly clamped to a mechanical skeleton. This skeleton has also been used to hold a laparoscope in a fixed position. When it is desired to move the scope, the clamp must be readjusted, and usually the skeleton linkages must also be adjusted to accommodate a change in the angle of insertion of the laparoscope.

US Patent 5571072 9 ('729) discloses a cannula and an associated endoscope secured to an operating table by a mechanical linkage assembly having linear and angular connections. These connections are adjustable for supporting an endoscope extending through an incision. According to '729, two angular connections are friction joints that allow manual repositioning of the scope by pivoting about respective orthogonal axes that intersect at a point along the scope that is coincident with the location of the incision.

US Patent 7048745 ('745) teaches surgical tool robotic manipulator. As taught by '745 embedded computer means can perform a number of functions when the tool is loaded on the tool manipulator: (1) providing a signal verifying that the tool is compatible with that particular robotic system; (2) identifying the tool-type to the robotic system so that the robotic system can reconfigure the programming; or (3) indicating tool-specific information, including measured calibration offsets indicating misalignment of the tool drive system, tool life data, or the like.

Patent Application WO2006111966 ('966) to the inventor, which is incorporated as a reference, discloses a computerized system enabling operative precise positioning laparoscopic surgical tools. The system comprises a manipulator providing displacement in four degree of freedom. The system consists of two main components: the first part has an arc shape in which the endoscope can be driven back and forth and at the same time can be moved from side to side; the second part is characterized by zoom and rotation properties.

Laparoscopic orthopedic surgeries differ from abdominal laparoscopic surgeries in their dynamic nature: it is common in orthopedic surgeries to move the limbs of the patient from side to side to bend the knee or the shoulder, or to stretch the patient's joints. Traditional endoscope holders are

fixed to the operation table and do not let the endoscope follow the limb movement and therefore are not used in these kinds of procedures. Today, endoscopic orthopedic procedures are performed by the surgeon holding the endoscope in one hand and using a tool in the other hand. When the surgeon needs to use two tools at the same time, he requires an assistant to hold and aim the endoscope for him. Hence, a system providing rigid fixation of the laparoscope relative to the human limb and laparoscope precise moving, especially a system with four or more degrees of freedom is still a long-felt need.

SUMMARY OF THE INVENTION

It is one object of the present invention to disclose an endoscope positioning system (EPS) essentially consisting of an at least four freedom degree mechanism (FDFM) which actuates the distal portion of an endoscope 500 by maneuvering the proximal portion of the endoscope. The FDFM comprises at least a first, second, third and forth means for providing degrees of freedom: a means of first degree of freedom is a rotation sub-mechanism 310; a means of second degree of freedom is a tilting sub-mechanism 320; a means of third degree of freedom is an arch sub-mechanism 330; and a means of forth degree of freedom is a zoom mechanism 340.

It is in the scope of the invention wherein at least one of the aforesaid first, second, third and forth means for providing degrees of freedom is activated by a mechanical or electrical motoring means.

It is also in the scope of the invention wherein the EPS, as defined in any of the above, additionally comprises an adapter, having attaching means to temporarily attach to the body of the patient. Moreover, it is in the scope of the invention wherein an adapter (see adapted 200 for example) has attaching means to temporarily attach to the body of the patient, and especially adapted for operating an endoscope in at least four degrees of freedom within the body of a patient is disclosed.

It is also in the scope of the invention wherein the attaching means is selected from a group consisting of strips, gripping means (e.g., means 201), magnets, screws, hooks, zips, fasteners, clips, flaps, claspers, springs, grips, hooks-and-loops (especially VelcroTM-type fasteners), hooks, hooks and eyes, straps, strings, wires, cables, tabs, links, poppers, nails, buttons, brackets,

buckles or any combination thereof.

It is also in the scope of the invention wherein a motoring means, suitable for activating at least one of the first, second, third and forth means for providing degrees of freedom, is adapted to maneuver in a relative manner to the aforesaid adapter.

It is also in the scope of the invention wherein the aforesaid motoring means comprises a plurality of N motors, N is an integer number equal or higher 2, at least two motors are adapted to simultaneously actuate the at least a first, second, third and forth means for providing degrees of freedom.

It is also in the scope of the invention wherein the motoring means and the at least a first, second, third and forth means for providing degrees of freedom are interconnected by a means of a transmission mechanism, e.g., a transmission box 180 and a muff 170.

It is also in the scope of the invention wherein the motoring means and the at least a first, second, third and forth means for providing degrees of freedom are reversibly interconnected, especially by a means of a quick release mechanism.

It is also in the scope of the invention wherein an arch sub-mechanism comprises a nut, connected to a first link, hinges, a plurality of coupling links that are located in semicircular guides; a muff is connected with the hinge to the distal end of the last link in a chain, in such a manner that endoscope passes through the inner part of the muff; the sub-mechanism is operatable in such a manner that when the screw rotates, the nut moves along the screw and affects the first link in the chain; other links are thus forced to move along a semi circular track and move the muff; being fixated in the muff, the endoscope moves along the arch.

It is also in the scope of the invention wherein a transmission mechanism transmits rotational motion from a motor to a screw; a nut moves along the screw and acts upon a link; the nut is connected to a chain of links by means of a fast quick release mechanism; the link chain is connected to the muff which moves the endoscope along a predetermined arch.

It is also in the scope of the invention wherein a tilting sub-mechanism is comprised of a transmitting means which transmits rotational motion from a motor to an arch, tilting the arc at any angle of interest.

It is also in the scope of the invention wherein the tilting sub-mechanism is characterized in that the reciprocal movement of a muff along an arch, and tilting of the arch are completely independent movements.

It is also in the scope of the invention wherein a zoom mechanism comprises a flexible shaft which couples a motor located in a motor box to an axle of a worm gear; a drum mechanically connected to a worm gear which is adapted to wind wire up so that the distance between a drum and a muff becomes shorter. The mechanism is constructed in such a manner that when the motor stops moving, the spring keeps tension of wire up, and in a manner that the structure of the worm gear prevents the spring from unsanctioned displacement of the transmission box; during zoom down movement, the motor rotates in an opposite direction, an unwrapped wire permits a spring to extend, and as a result, said zoom box transmission rises.

It is also in the scope of the invention wherein the rotation mechanism comprises a flexible shaft which couples a motor to another motor, located in motor box to axle of a worm gear, which rotates a cog wheel; the cog wheel has a centered passage for a proximal portion of the endoscope.

It is also in the scope of the invention wherein a quick locking sub-mechanism, which is especially adapted to enable an optional vertical displacement, comprises a lever, furnished with two perpendicular slots. The lever rotates around an axis. The locking sub-mechanism is characterized by a locked position and an unlocked position. In the locked position, the hinge of a link is trapped by the slot. In the unlocked position, said lever enables maneuvering a link into its said slot. An appropriate position of the lever is maintained by e.g., two openings, fixated by a screw.

It is also in the scope of the invention wherein the EPS additionally comprises a coupling/decoupling sub-mechanism which comprises a screw that couples/decouples another screw to a transmission mechanism. Clockwise rotation of the screw pushes the second screw backward and the separation of the first screw from the transmission is provided. Counterclockwise rotation of the second screw results in engagement of the first screw with transmission.

It is also in the scope of the invention wherein the EPS additionally comprises a quick fixing

sub-mechanism, adapted to connect and disconnect endoscope and transmission box from an arch, so that endoscope cleaning is provided. The quick fixing sub-mechanism comprising a muff, adapted to rotate on cylinder, which serves here as a hinge. Cylinder abuts against balls and prevents the muff from separating from the cylinder. The disconnection of the muff from the cylinder is attained by counterclockwise rotation of a screw. The muff is adapted to be pulled out from the cylinder, hence releasing balls. The muff is mounted on cylinder such that the endoscope is connected. The screw is rotatable clockwise; balls are pushed out from the cylinder, preventing the muff from disconnecting.

Still another object of the invention is to disclose a method of manipulating an endoscope in at least four degrees of freedom by the EPS, e.g., an EPS as defined in any of the above. The method comprises steps selected from a group consisting inter alia steps of

- (i) providing at least four freedom degree mechanism (FDFM); and
- (ii) actuating the distal portion of the endoscope by maneuvering the proximal portion of said endoscope.

The step of providing the FDFM further comprises steps of obtaining means of first degree of freedom (a rotation sub-mechanism 310); means of second degree of freedom (tilting sub-mechanism 320); means of third degree of freedom (arch sub-mechanism 330); and, means of forth degree of freedom (zoom mechanism 340).

It is in the scope of the invention wherein the method additionally comprising step of activating at least one of the first, second, third and forth means for providing degrees of freedom by e.g., a mechanical or electrical motoring means.

It is in the scope of the invention wherein the method additionally comprises a step of temporarily attaching an adapter, having one or more attaching means, directly or indirectly, to the body of the treated patient.

It is in the scope of the invention wherein the method additionally comprises a step of actuating the at least a first, second, third and forth means for providing degrees of freedom by means of motoring means, e.g., one or more motors actuated simultaneously or individually.

It is in the scope of the invention wherein the method additionally comprises step of transmitting

the movement of the at least a first, second, third and forth means for providing degrees of freedom and the motoring means by a means of a transmission mechanism, e.g., a transmission box and a muff.

A last object of the invention is to disclose a method for performing an endoscopic surgery. The method comprises steps as follows:

- (i) attaching an endoscope 500 to an EPS (300);
- (ii) providing the EPS with an FDFM (100);
- (iii) actuating the distal portion of said endoscope by maneuvering the proximal portion of the endoscope by means of said FDFM;

wherein the step of providing the FDFM further comprises steps of obtaining means of first degree of freedom (a rotation sub-mechanism 310); means of second degree of freedom (tilting sub-mechanism 320); means of third degree of freedom (arch sub-mechanism 330); and, means of forth degree of freedom (zoom mechanism 340).

BRIEF DESCRIPTION OF THE FIGURES

The objects and advantages of various embodiments of the invention will become apparent from the following description when read in conjunction with the accompanying drawings, wherein:

Fig. 1 is an isometric view of a four degree mechanism with an adapter;

Fig. 2 is a schematic view representing four degree displacement;

Figs. 3a-3c are schematic views showing optional working arrangements for shoulder (3a) and knee (3b and 3c) surgery;

Fig. 4 is a schematic view showing optional displacement provided by a sliding adapter;

Fig. 5 is a schematic overview of a displacement mechanism;

Fig. 6 is a schematic diagram of a sub-mechanism of arch reciprocal displacement;

Fig. 7 is a detailed view of a sub-mechanism of arch reciprocal displacement;

Fig. 8 is a detailed view of a tilting sub- mechanism;

Fig. 9 is a detailed view of a zoom sub-mechanism;

Fig. 10 is a detailed view of a rotation sub-mechanism;

Fig. 11a is an isometric view of a locking sub-mechanism;

Fig. 11b is an isometric view of a locking sub-mechanism in the locked position;

Fig. 11c is an isometric view of a locking sub-mechanism in the unlocked position;

Fig. 12a is a detailed view of a coupling/decoupling sub-mechanism;

Fig. 12b is an enlarged view of a screw of the coupling/decoupling sub-mechanism;

Fig 13a is a schematic view representing an endoscope fixing sub-mechanism on the arch guides;
and,

Fig 13b is a schematic view representing an endoscope gripping unit alone.

DETAILED DESCRIPTION OF THE EMBODIMENTS

The following description is provided, alongside all chapters of the present invention, so as to enable any person skilled in the art to make use of said invention and sets forth the best modes contemplated by the inventor of carrying out this invention. Various modifications, however, will remain apparent to those skilled in the art, since the generic principles of the present invention have been defined specifically to provide (i) an endoscope positioning system (EPS) essentially consisting at least four freedom degree mechanism (FDFM); (ii) a method of manipulating an endoscope in at least four degrees of freedom by the EPS; and (iii) method for applying endoscopic surgery.

The terms "**endoscope**" and "**laparoscope**" refer interchangeably hereinafter to a fiber optical device that consists of a flexible tube. Glass or plastic filaments allow the internal refraction of light for viewing. This medical device is used in laparoscope, endoscope, laparoscopic and endoscopic surgeries. It is also in the scope of the invention wherein the term also refers also to means for looking inside bodies, especially inside the human body and mammalian body for medical reasons using an instrument; and especially to means for minimally invasive diagnostic

medical procedure, such as rigid or flexible endoscopes, fiberscopes, means for robotic surgery, trocars, surgical working tools and diagnosing means etc.

The terms "**endoscopic surgery**" and "**laparoscopic surgery**" interchangeably refer hereinafter to modern surgical technique in which operations into the body of a patient, e.g., in the abdomen, are performed through small incisions (usually 0.5 to 1.5 cm) as compared to larger incisions needed in traditional surgical procedures, or via natural cavities of the body. Laparoscopic surgery includes e.g., operations within the abdominal, pelvic or joint cavities. Endoscopy surgery involves, inter alia, operations in the gastrointestinal tract, e.g., in the oesophagus, stomach and duodenum (esophagogastroduodenoscopy), small intestine, colon (colonoscopy, proctosigmoidoscopy), bile duct, endoscopic retrograde cholangiopancreatography (ERCP), duodenoscope-assisted cholangiopancreatography, intraoperative cholangioscopy, the respiratory tract, the nose (rhinoscopy), the lower respiratory tract (bronchoscopy), the urinary tract (cystoscopy), the female reproductive system, the cervix (colposcopy), the uterus (hysteroscopy), the Fallopian tubes (falloscopy), normally closed body cavities (through a small incision), the abdominal or pelvic cavity (laparoscopy), the interior of a joint (arthroscopy) organs of the chest (thoracoscopy and mediastinoscopy), during pregnancy, the amnion (amnioscopy), the fetus (fetoscopy), plastic surgery, panendoscopy (or triple endoscopy), combining laryngoscopy, esophagoscopy, and, bronchoscopy; and various non-medical uses for endoscopy. It is also in the scope of the invention wherein the term also refers also to any manipulation of laparoscopes and endoscopes as defined above into the body of a patient.

The invention concerns an endoscope positioning system suited for all kinds of laparoscopic surgeries. It is best suited for orthopedic surgeries as defined below. Laparoscopic orthopedic surgeries differ from abdominal laparoscopic surgeries in their dynamic nature: it is common in orthopedic surgeries to move the limbs of the patient from side to side to bend the knee or the shoulder, or to stretch the patient's joints. Traditional endoscope holders are fixed to the operation table and do not let the endoscope follow the limb movement and therefore are not used in these kinds of procedures. Today, endoscopic orthopedic procedures are performed by the surgeon holding the endoscope in one hand and using a tool in the other hand. When the surgeon needs to use two tools at the same time, he requires an assistant to hold and aim the endoscope for him. The present invention provides a quick and optimal endoscope setup,

automatic and precise positioning of the endoscope, which allows the surgeon to use both his arms for simultaneously operating two tools at the same time, without interfering with the flow of the operation process.

The term "**Degrees of freedom**" (DOF) refers hereinafter to a set of independent displacements that specify completely the displaced position of the endoscope or laparoscope as defined above. In three dimension space, there are six DOF, three DOF of linear displacement and three rotational DOFs, namely, moving up and down, moving left and right, moving forward and backward, tilting up and down, turning left and right, tilting side to side. The present invention refers to a system essentially comprising means for at least four DOF selected from any of those defined above.

The terms "**distal portion**" and "**proximal portion**" refer hereinafter to the side of the endoscope within the body of the patient, and outside the body of the patient, respectively.

Reference is now made to **Fig. 1**, illustrating a typical endoscope positioning system 300 comprising four freedom degree mechanism (FDFM) (100) that moves the endoscope 500, the body adapter 200 enabling an optimal placement of the mechanism. The mechanism 100 comprises a rotation sub-mechanism 310, a tilting sub-mechanism 320, an arch sub-mechanism 330, and a zoom mechanism 340. The sub-mechanisms 310, 320, 330, and 340 are activated by a motor box 110.

Reference is now made to **Fig. 2** showing the mechanism 300 enabling displacement of the endoscope 500 with FDFM. FDFM 300 is used for linearly and angularly positioning the endoscope 500 relative to a joint incision.

Reference is now made to **Fig. 3**, illustrating optional arrangements of the endoscope positioning system 100 on human limbs. The adaptor grippers 201 embrace a human arm 400 (Fig. 3a) and a human leg 410 (Fig. 3b and 3c). By using the adapter stripes or grips (201) the adapter is fixed firmly to the patient's body allowing the mechanism to move the endoscope to the desired position.

Reference is now made to **Fig. 4**, presenting the motor box 110 which is adapted to move relative to the adapter 200. This option allows the surgeon to attach the first gripper 201 firmly to the patient limb, and then to position the mechanism 300 in the optimal arrangement relative to a

joint incision (not shown) and finally fixate mechanism 300 by the second gripper 201.

Reference is now made to **Fig. 5**, disclosing a motor box 110 that contains the four motors. The transmission 115 transmits motion from the motors located in the motor box 110 to a tilting sub-mechanism 320 and an arch sub-mechanism 330. Driving the zoom and rotation sub-mechanisms is performed by means of flexible shafts 199. The endoscope 500 passes through a transmission box 180 and a muff 170. The endoscope is locked to transmission box 180 by quick release mechanism 181.

Reference is now made to **Fig. 6** illustrating the arch sub-mechanism 330. A nut 151 is connected to a first link 152a. Hinges 153 coupling links 152b, 152c are located in semicircular guides 154. The number of the links 152b, 152c et cetera illustrated does not limited the described embodiment. The muff 170 is connected with the hinge 153 to the distal end of the last link in a chain. The endoscope 500 passes through the inner part of the muff 170. When the screw 155 rotates, the nut moves along the screw and affects the first link 152a in the chain. The other links are forced to move along the semi circular track 154 moving the muff 170. Due to being fixed to the muff 170, the endoscope 500 moves along the arch 150.

Reference is now made to **Fig. 7**, illustrating the transmission. 115a transmits rotational motion from a motor 157a to the screw 155. The nut 151 moves along the screw 155 and acts upon the link 152a. The nut is connected to a chain of links 152 by means of a fast release mechanism 310 (not shown). The link chain 152 is connected to the muff 170 that moves the endoscope 500 along the arch.

Reference is now made to **Fig. 8** showing the main components of the tilting sub-mechanism 320. The transmission 116 transmits rotational motion from a motor 157b to the arch 150 tilting the arc 150 at an angle of interest. Reciprocal movement of the muff 170 along the arch 150 and tilting the arch 150 are completely independent.

Reference is now made to **Fig. 9** presenting the zoom mechanism 340. A flexible shaft 199a couples a motor 157c located in the motor box 110 (not shown) to an axle 184 of a worm gear 181. A drum 182 mechanically connected to the worm gear 181 winds the wire 183 up, so that the distance between the drum 183 and the muff 170 becomes shorter. When the motor stops moving, the spring keeps tension of the wire 183 up. The structure of the worm gear prevents the

spring 185 from unsanctioned displacement of the transmission box 180. During zoom down movement the motor 157c rotates in the opposite direction. The unwrapped wire 183 lets the spring 183 extend. As a result the zoom box transmission rises.

Reference is now made to **Fig. 10** showing the rotation mechanism 310. A flexible shaft 199b couples a motor 157d to motor 157d located in motor box 110 to an axle 202 of a worm gear 186 which rotating a cog wheel 187. The aforesaid cog wheel 187 has a centered passage for a proximal portion of the endoscope 500. A locking sub-mechanism (not shown) is adapted to fixate and release the endoscope 500.

Reference is now made to **Fig. 11a, 11b, and 11c**, presenting a quick locking sub-mechanism 350 enabling optional vertical displacement. The sub-mechanism 350 consists of a lever 190 furnished with two perpendicular slots 196 and 197. The lever 190 rotates around an axis 191 (**Fig. 11a**). In a locked position, the hinge 153 of link 152a is trapped by the slot 196 (**Fig. 11b**). In an unlocked position the lever enables inserting the link 152a into the slot 197 (**Fig. 11c**). An appropriate position of the lever 190 is kept by openings 194 and 195. The openings 194 and 195 are fixated by the screw 155.

Reference is now made to **Fig. 12a and 12b** showing a coupling/decoupling sub-mechanism 360. The mechanism 360 consists of a screw 196 that couples/decouples the screw 155 to the transmission 115a. Clockwise rotation of the screw 197 pushes the screw 155 backward leading to separation of the screw 155 from the transmission 115a. Conversely, counterclockwise rotation of the screw 197 results in engagement of the screw 155 with transmission 115a.

Reference is now made to **Fig. 13a and 13b**, disclosing a quick fixing sub-mechanism 370 enables connection and disconnection of the endoscope 500 and the transmission box 180 from arch 151. This is a very important option for switching modes or for cleaning the endoscope 500. A muff 170 is adapted to rotate on a cylinder 162 that serves as a hinge. The cylinder 162 abuts against balls 163 and do not let the muff 170 separate from cylinder 162. Disconnection of the muff 170 from the cylinder 162 is attained by rotating the screw 161 in counterclockwise way. The muff 170 is pulled out from cylinder 162 releasing the balls 163. In order to connect the endoscope 500 (not shown), to the muff 170 is mounted on cylinder 162. The screw 161 is rotated clockwise. The balls 163 are pushed out the cylinder 162 preventing the muff 170 from

disconnecting.

As stated above, the endoscope positioning system 300 is installed on the human limb. Precise positioning provided by the four freedom degree mechanism 100 enables alignment of the position of the endoscope 500 before insertion into a human joint and displacement of a distal end of the endoscope 500 inside the human joint. Rigid fixation of the endoscope 500 relative to the human limb provides freedom of surgeon's hands from the endoscope 500 during a surgical operation, which is a long-felt need.

CLAIMS

1. An endoscope positioning system (EPS, 300) essentially consisting of an at least four freedom degree mechanism (FDFM) (100), which actuates the distal portion of an endoscope 500 by maneuvering the proximal portion of said endoscope; wherein said FDFM comprises at least a first, second, third and forth means for providing degrees of freedom:
 - a. said means of first degree of freedom is a rotation sub-mechanism 310;
 - b. said means of second degree of freedom is a tilting sub-mechanism 320;
 - c. said means of third degree of freedom is an arch sub-mechanism 330; and,
 - d. said means of forth degree of freedom is a zoom mechanism 340.
2. The EPS according to claim 1, wherein at least one of said first, second, third and forth means for providing degrees of freedom is activated by a mechanical or electrical motoring means 110.
3. The EPS according to claim 1, additionally comprising an adapter (200), having attaching means to temporarily attach to the body of the patient.
4. The EPS according to claim 3, wherein said attaching means are selected from a group consisting of strips, gripping means (201), magnets, screws, hooks, zips, fasteners, clips, flaps, claspers, springs, grips, hooks-and-loops (especially VelcroTM-type fasteners), hooks, hooks and eyes, straps, strings, wires, cables, tabs, links, poppers, nails, buttons, brackets, buckles or any combination thereof.
5. The EPS according to claim 3, wherein a motoring means 110, suitable for activating at least one of said first, second, third and forth means for providing degrees of freedom, is adapted to maneuver in a relative manner to the adapter 200.
6. The EPS according to claim 3, wherein said motoring means 110 comprises a plurality of motors, at least two motors are adapted to simultaneously actuate said at least a first, second, third and forth means for providing degrees of freedom.
7. The EPS according to claim 3, wherein said motoring means 110 and said at least a first, second, third and forth means for providing degrees of freedom are interconnected by a

means of a transmission mechanism, e.g., a transmission box 180 and a muff 170.

8. The EPS according to claim 3, wherein said motoring means 110 and said at least a first, second, third and forth means for providing degrees of freedom are reversibly interconnected, especially by means of a quick release mechanism 181.
9. The EPS according to claim 1, wherein said arch sub-mechanism 330 comprises a nut 151, connected to a first link 152a, hinges 153, a plurality of coupling links, especially links 152b, 152c, that are located in semicircular guides 154; muff 170 is connected with said hinge 153 to the distal end of the last link in a chain, in such a manner that endoscope 500 passes through the inner part of said muff 170; said sub-mechanism is operatable in such a manner that when screw 155 rotates, said nut moves along said screw and affects the first link 152a in said chain; other links are thus forced to move along a semi circular track 154 and move said muff 170; being fixated in said muff 170, the endoscope 500 moves along said arch 150.
10. The EPS according to claim 7, wherein a transmission mechanism 115a transmits rotational motion from motor 157a to screw 155; nut 151 moves along said screw 155 and acts upon link 152a; said nut is connected to a chain of links 152 by means of a fast quick release mechanism 310, said link chain 152 is connected to muff 170 which moves the endoscope 500 along a predetermined arch.
11. The EPS according to claim 1, wherein said tilting sub-mechanism 320 comprises a transmission 116 which transmits rotational motion from motor 157b to arch 150, tilting said arc 150 at an angle of interest.
12. The EPS according to claim 1, wherein said tilting sub-mechanism 320 is characterized in that the reciprocal movement of muff 170 along arch 150, and tilting of arch 150 are completely independent movements.
13. The EPS according to claim 1, wherein said zoom mechanism 340 comprises a flexible shaft 199a which couples a motor 157c located in motor box 110 to axle 184 of worm gear 181; drum 182 mechanically connected to worm gear 181 which adapted to wind wire 183 up so that the distance between drum 183 and muff 170 becomes shorter; mechanism 340 is constructed in such a manner that when the motor stops moving, the spring keeps tension

of wire 183 up, and in such a manner that the structure of the worm gear prevents spring 185 from unsanctioned displacement of transmission box 180; during zoom down movement, motor 157c rotates in an opposite direction, unwrapped wire 183 lets spring 183 extend, and as a result, said zoom box transmission rises.

14. The EPS according to claim 1, wherein said rotation mechanism 310 comprises a flexible shaft 199b which couples a motor 157d to motor 157d, located in motor box 110 to axle 202 of a worm gear 186, which rotates cog wheel 187; said cog wheel 187 has a centered passage for a proximal portion of said endoscope 500.
15. The EPS according to claim 8, wherein said quick locking sub-mechanism 350, adapted to enable an optional vertical displacement, comprises lever 190, furnished with two perpendicular slots 196 and 197, said lever 190 rotates around axis 191; said locking sub-mechanism 350 is characterized by a locked position and an unlocked position; in said locked position, hinge 153 of link 152a is trapped by the slot 196; in said unlocked position, said lever enables maneuvering said link 152a into said slot 197; an appropriate position of said lever 190 is maintained by openings 194 and 195, fixated by screw 155.
16. The EPS according to claim 1, additionally comprising a coupling/decoupling sub-mechanism 360 comprising screw 196 which couples/decouples screw 155 to transmission 115a; clockwise rotation of screw 197 pushes said screw 155 backward and separation of said screw 155 from the transmission 115a is provided; counterclockwise rotation of said screw 197 results in engagement of screw 155 with transmission 115a.
17. The EPS according to claim 1, additionally comprising a quick fixing sub-mechanism 370 adapted to connect and disconnect endoscope 500 and transmission box 180 from arch 151, so that endoscope 500 cleaning is provided; said quick fixing sub-mechanism 370 comprising muff 170, adapted to rotate on cylinder 162, which serves here as a hinge; cylinder 162 abuts against balls 163 and prevent muff 170 from separating from cylinder 162; disconnection of muff 170 from cylinder 162 is attained by counterclockwise rotation of screw 161; muff 170 is adapted to be pulled out from cylinder 162, hence releasing balls 163; muff 170 is mounted on cylinder 162 such that endoscope 500 is connected; screw 161 is rotatable clockwise, balls 163 are pushed out from cylinder 162, preventing muff

170 from disconnecting.

18. A method of manipulating an endoscope in at least four degrees of freedom by an endoscope positioning system (EPS, 300); comprising steps of providing an at least four freedom degree mechanism (FDFM, 100); and actuating the distal portion of said endoscope 500 by maneuvering the proximal portion of said endoscope; wherein said step of providing said FDFM further comprises steps of obtaining means of first degree of freedom (a rotation sub-mechanism 310); means of second degree of freedom (tilting sub-mechanism 320); means of third degree of freedom (arch sub-mechanism 330); and, means of forth degree of freedom (zoom mechanism 340).
19. The method according to claim 18, comprising activating at least one of said first, second, third and forth means for providing degrees of freedom by a mechanical or electrical motoring means 110.
20. The method according to claim 18, comprising a step of temporarily attaching an adapter (200), having attaching means, to the body of the treated patient.
21. The method according to claim 18, comprising a step of actuating said at least a first, second, third and forth means for providing degrees of freedom motoring means 110 by one or more motors.
22. The method according to claim 21, comprising a step of transmitting the movement of said at least a first, second, third and forth means for providing degrees of freedom and said motoring means 110 by a means of a transmission mechanism, e.g., a transmission box 180 and a muff 170.
23. A method for performing endoscopic surgery, comprising steps of attaching an endoscope to an endoscope positioning system (EPS, 300); providing said EPS with a four freedom degree mechanism (FDFM, 100); actuating the distal portion of said endoscope 500 by maneuvering the proximal portion of said endoscope by means of said FDFM; wherein said step of providing said FDFM further comprises steps of obtaining means of first degree of freedom (a rotation sub-mechanism 310); means of second degree of freedom (tilting sub-mechanism 320); means of third degree of freedom (arch sub-mechanism 330); and, means of forth degree of freedom (zoom mechanism 340).

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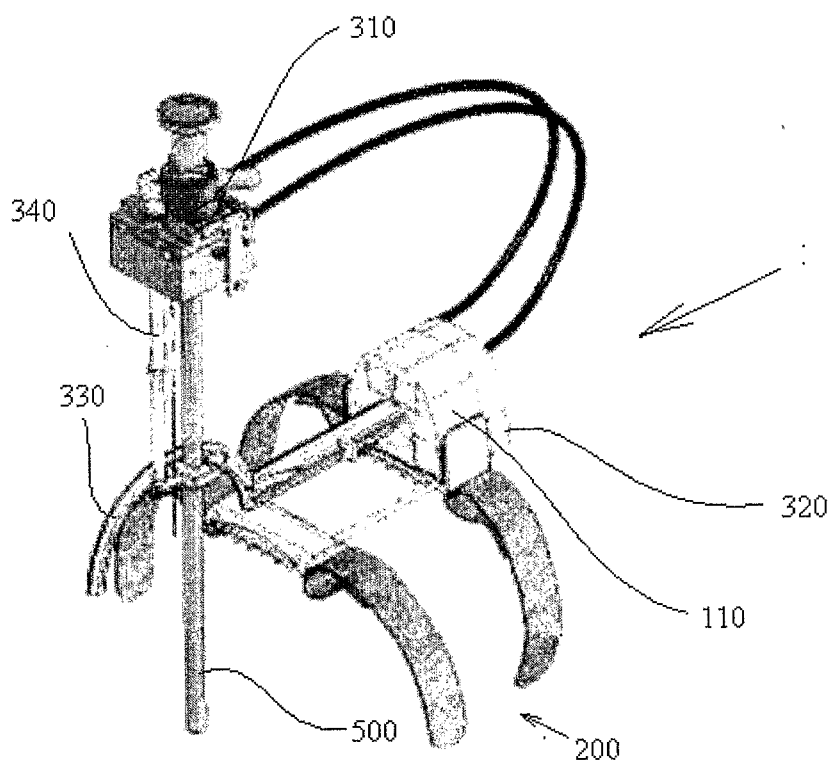


Fig. 1

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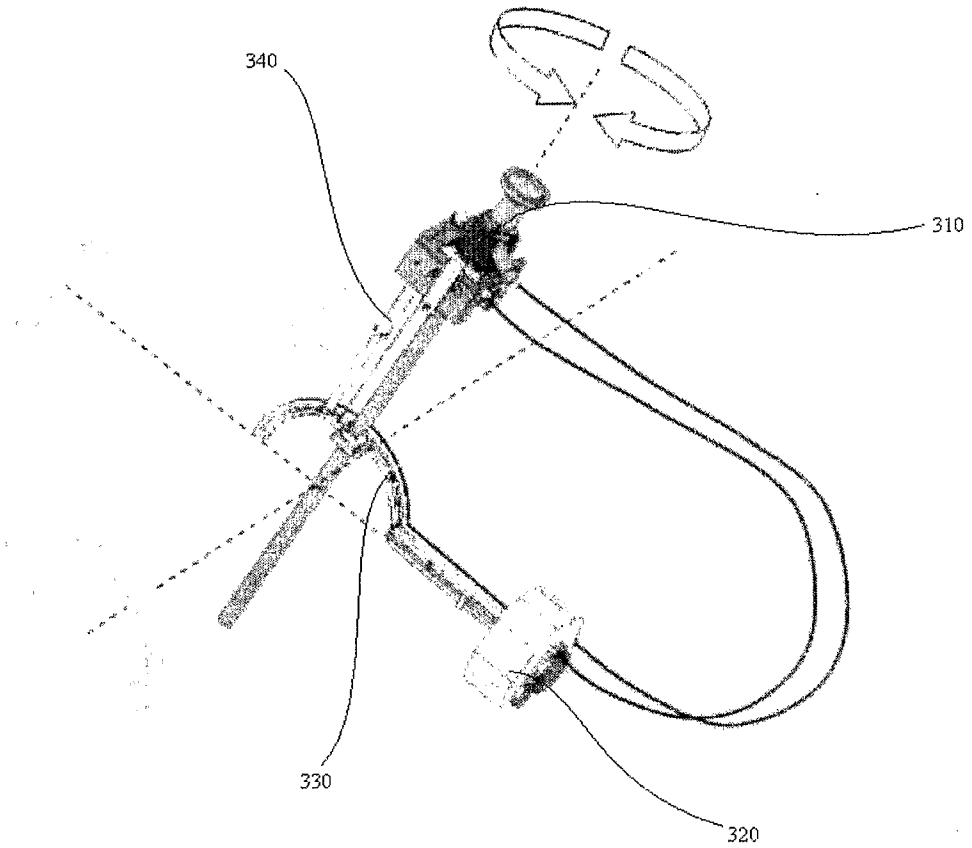


Fig. 2

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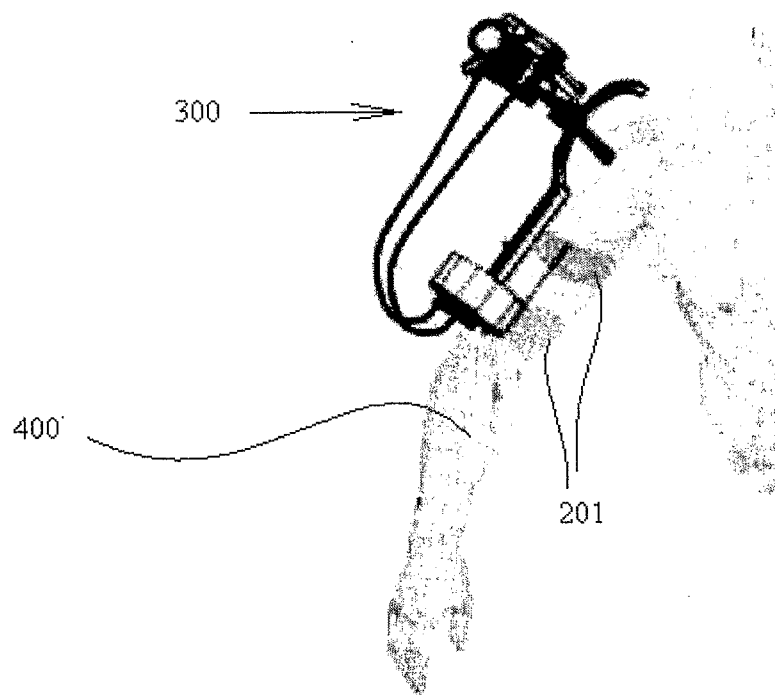


Fig. 3a

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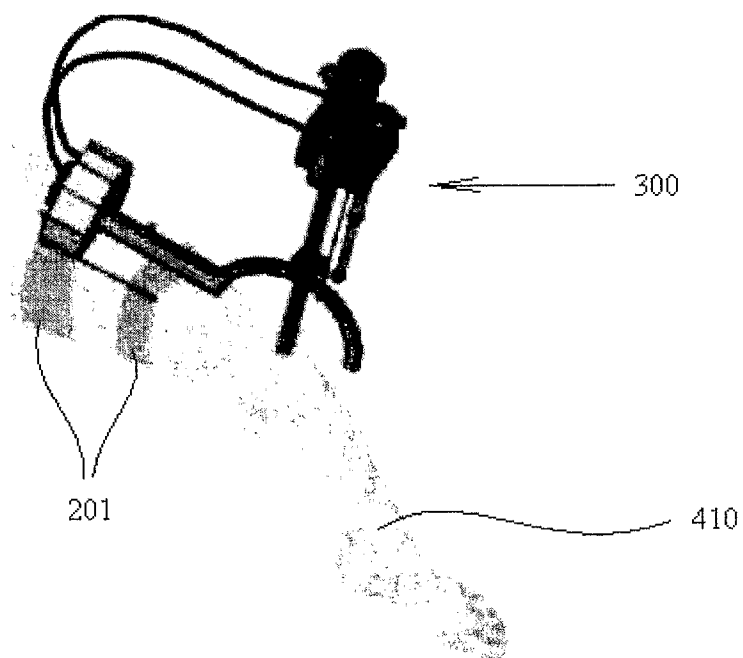


Fig. 3b

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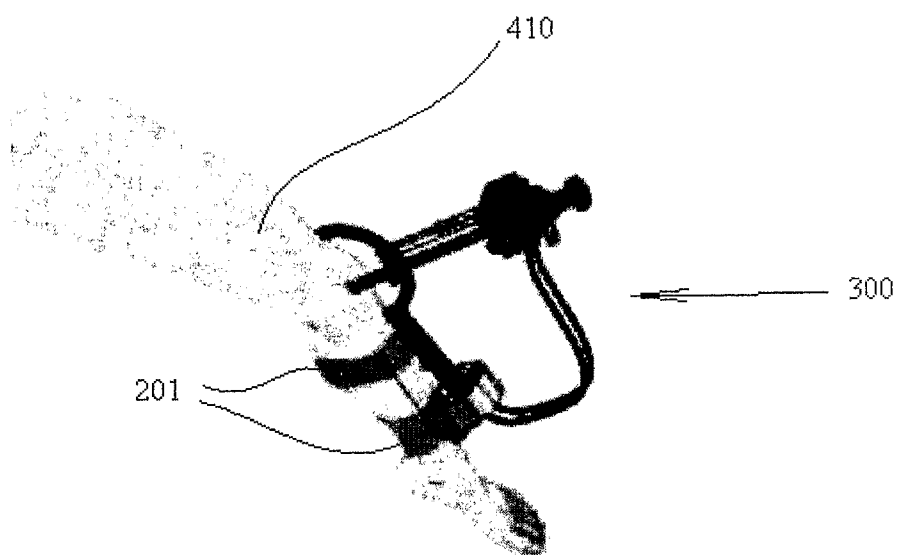


Fig. 3c

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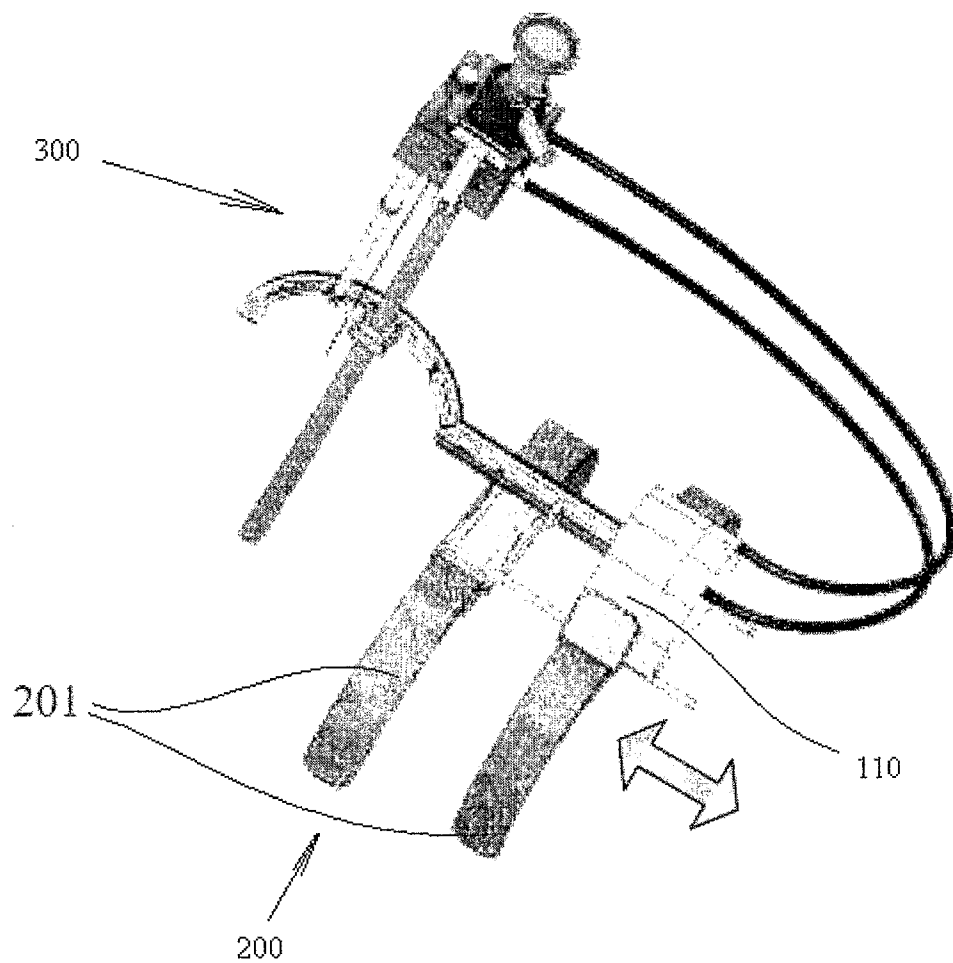


Fig. 4

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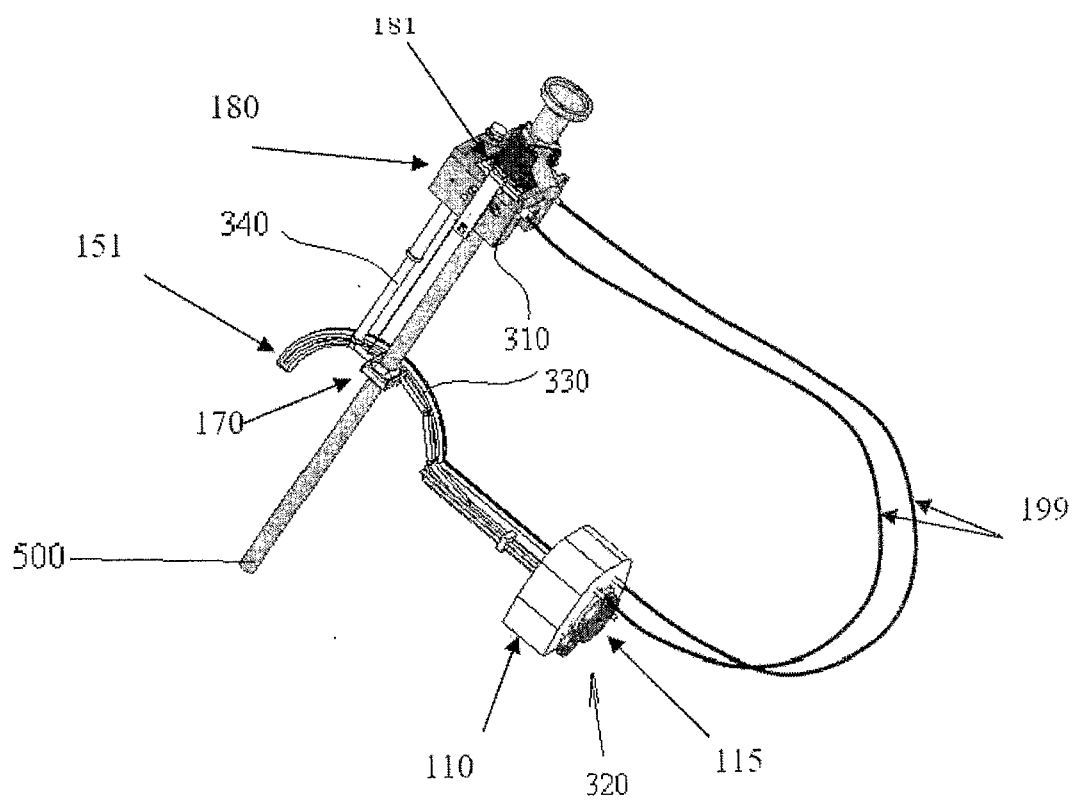


Fig. 5

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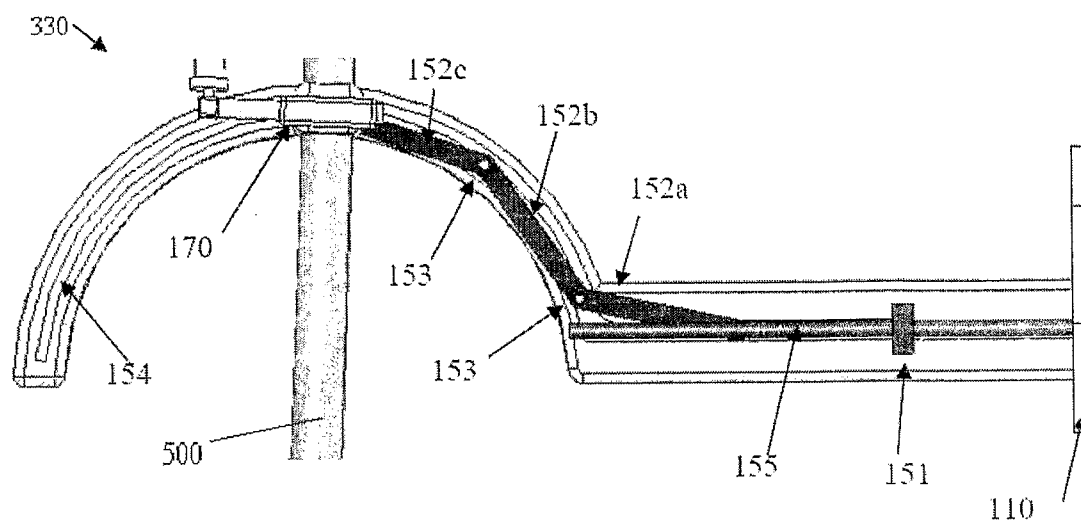


Fig. 6

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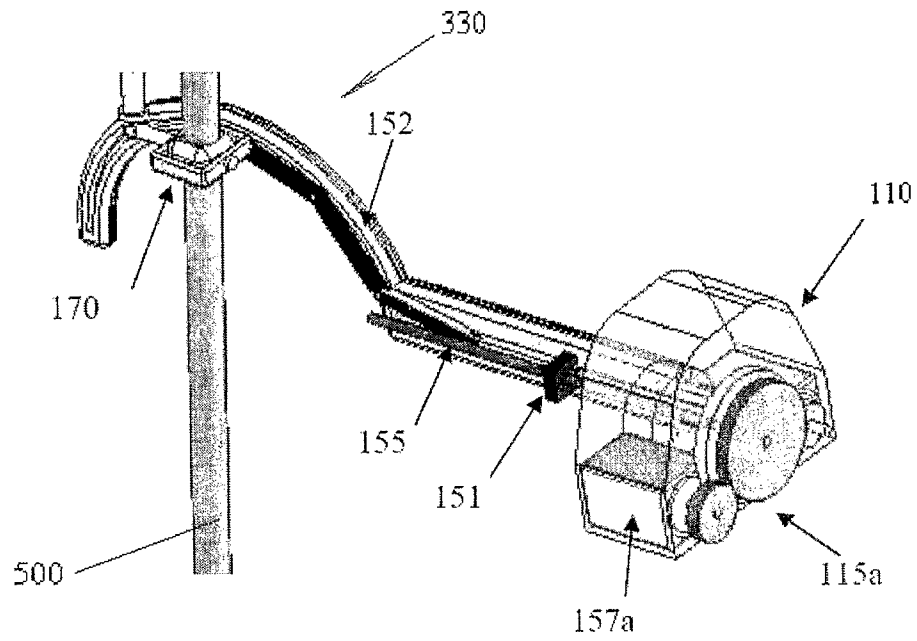


Fig. 7

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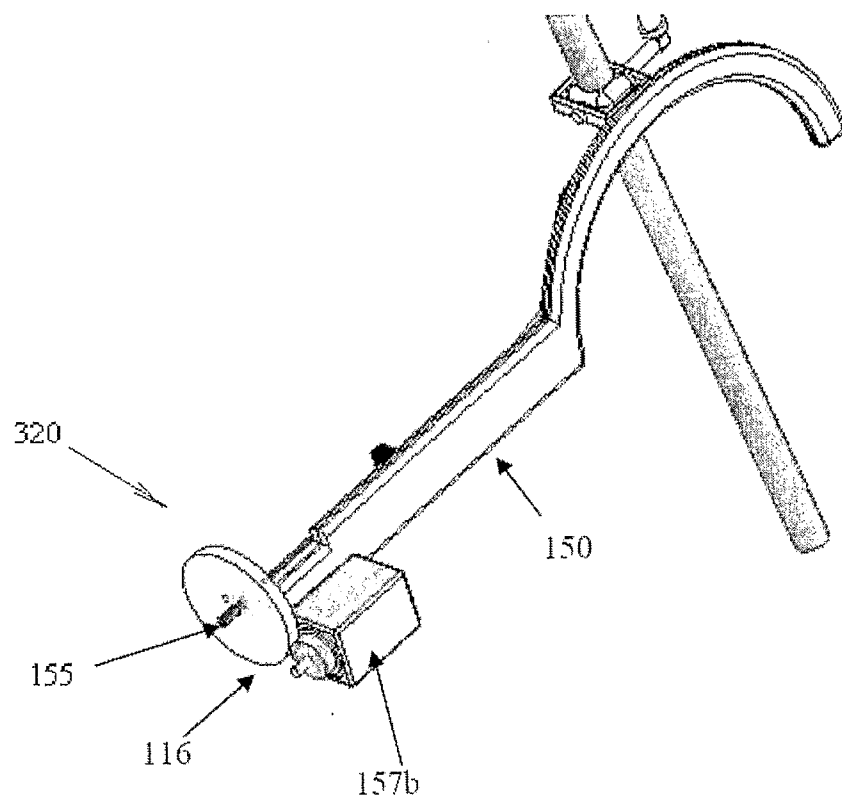


Fig. 8

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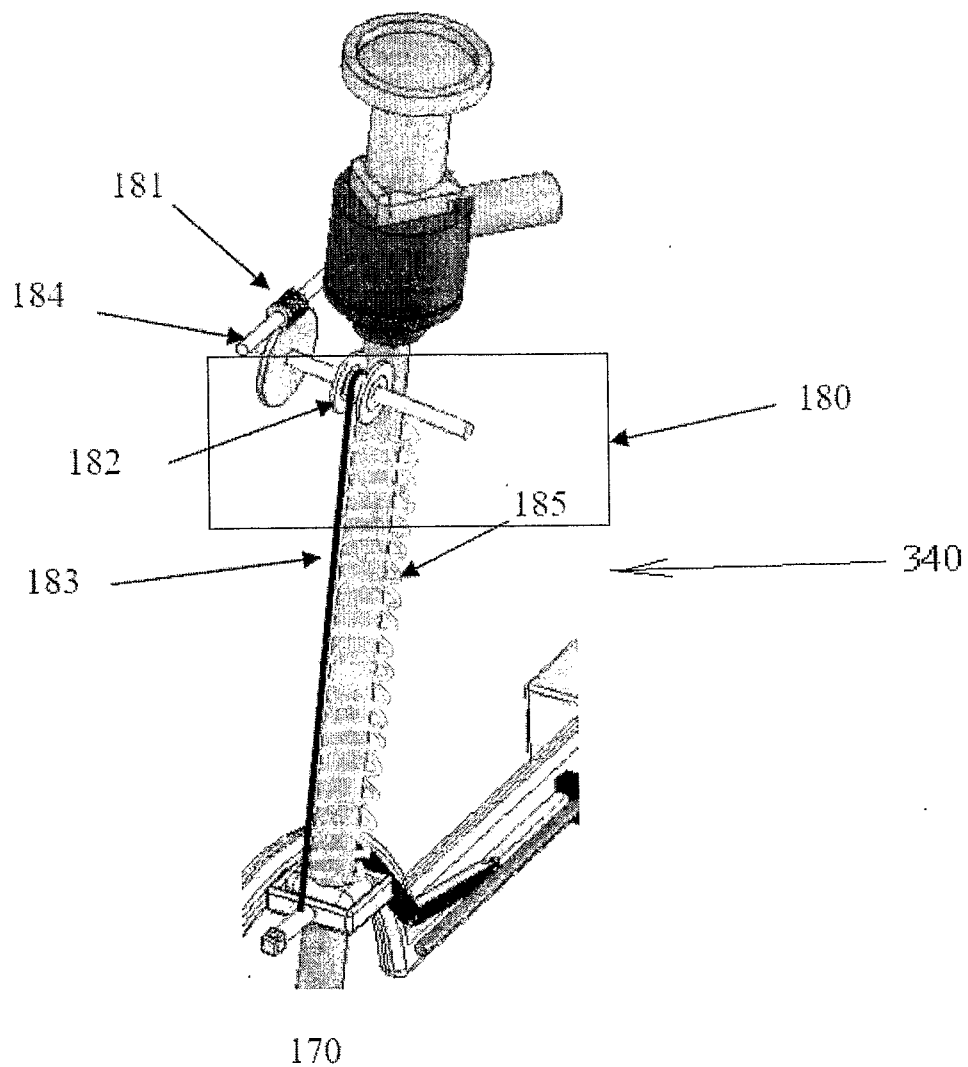


Fig. 9

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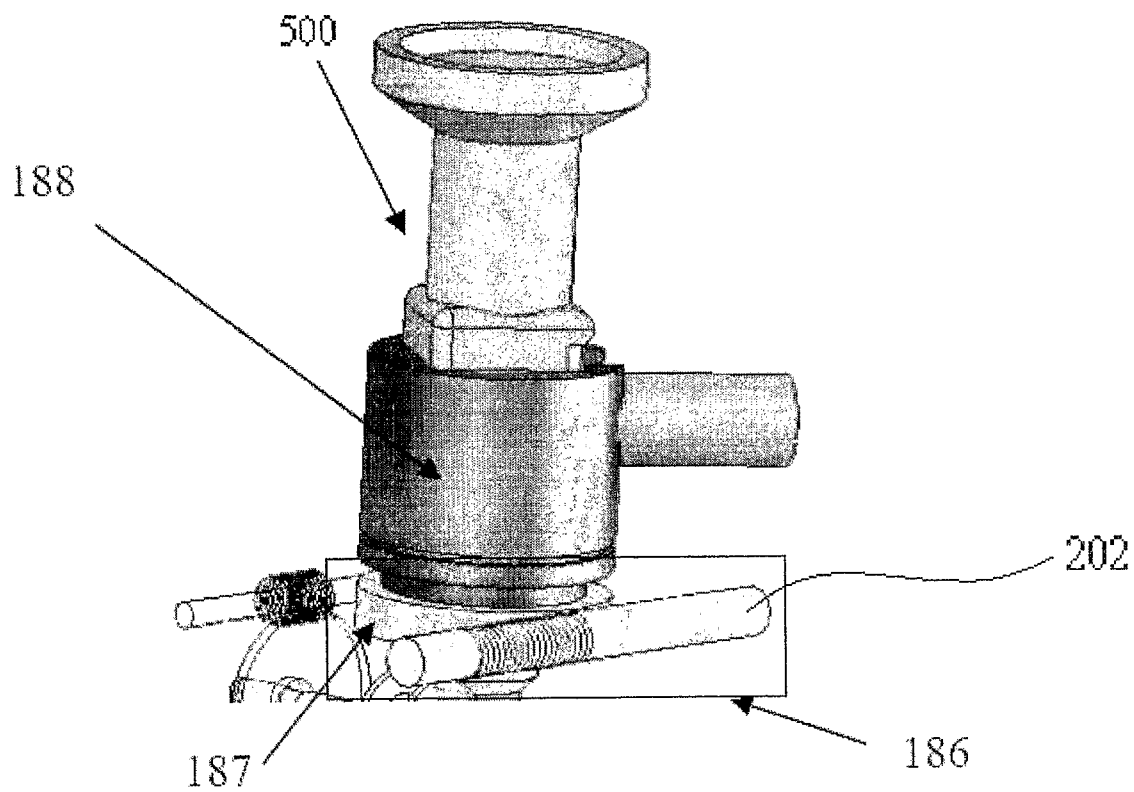


Fig. 10

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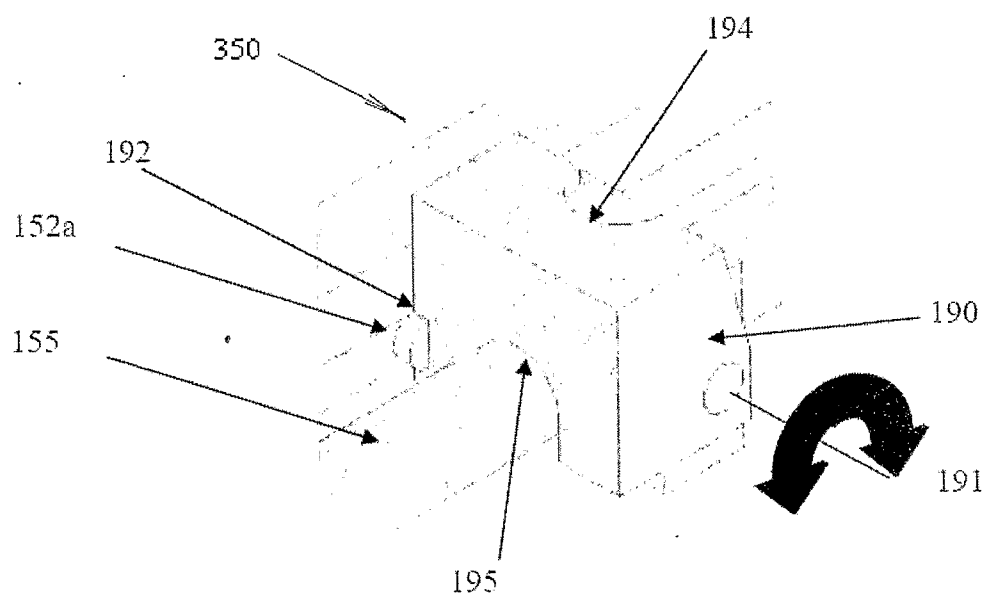


Fig. 11a

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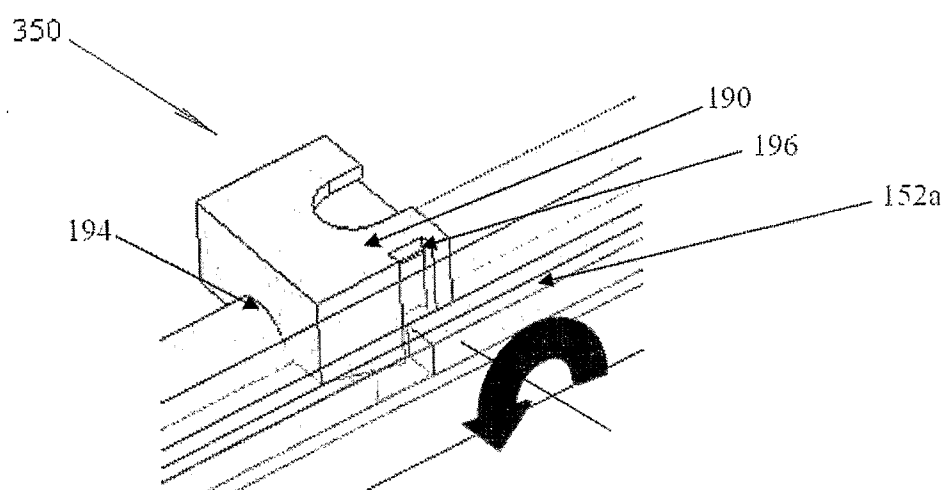


Fig. 11b

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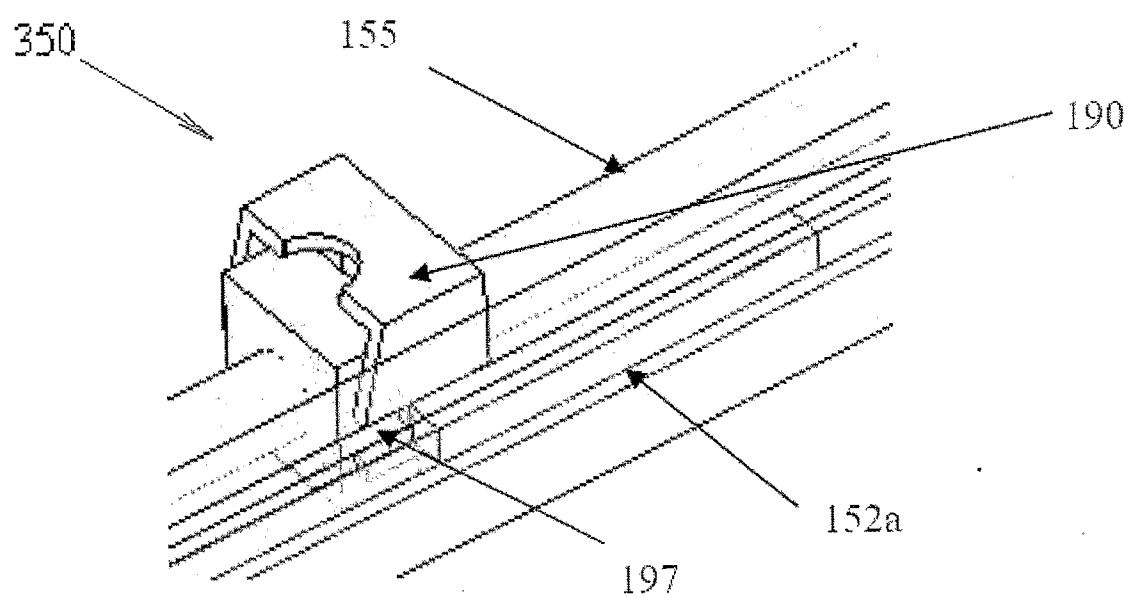


Fig. 11c

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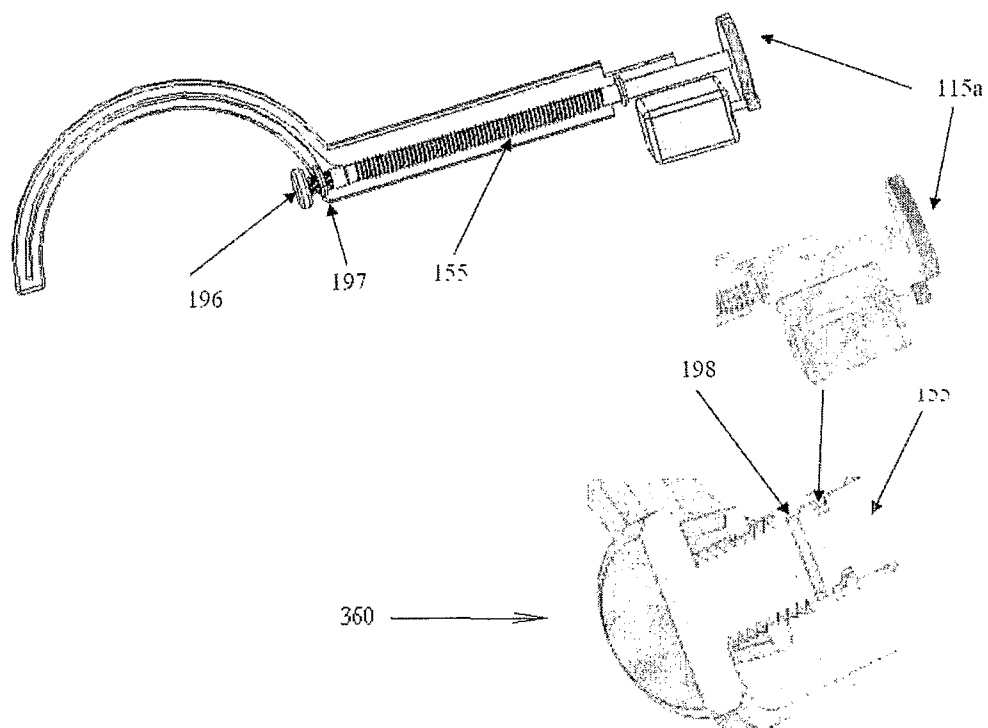


Fig. 12a

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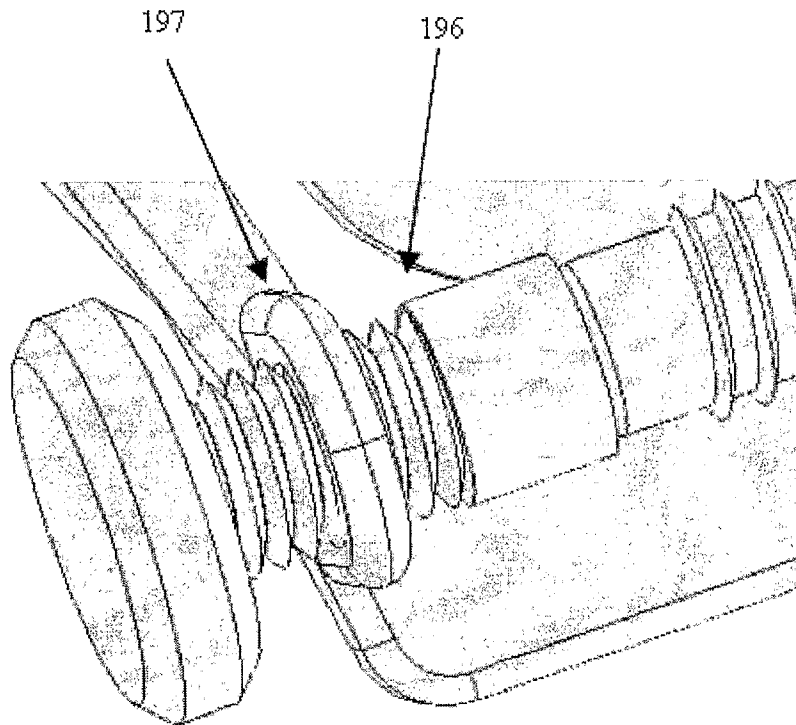


Fig. 13b

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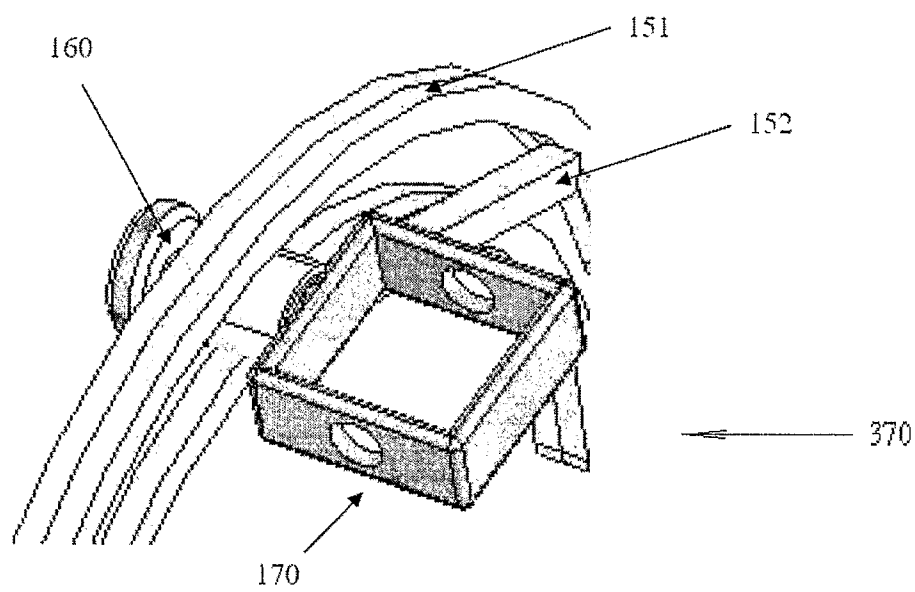


Fig. 13a

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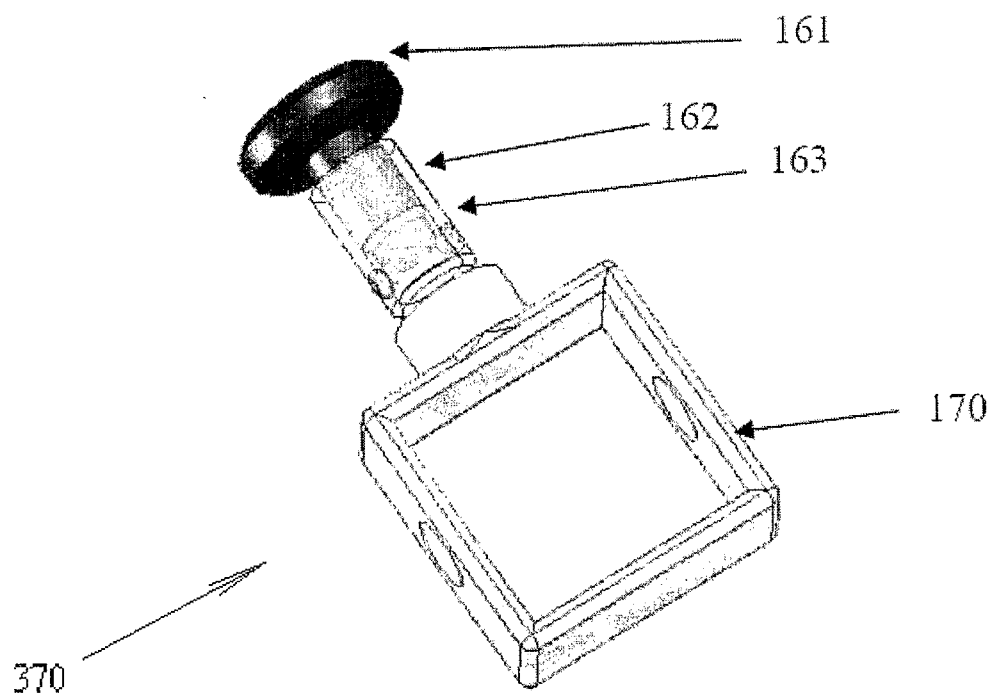


Fig. 13b