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(54) **ERGONOMIC HANDPIECE FOR LAPAROSCOPIC AND OPEN SURGERY**

ERGONOMISCHES HANDSTÜCK FÜR DIE LAPROSKOPISCHE UND OFFENE CHIRURGIE

PIÈCE À MAIN ERGONOMIQUE POUR CHIRURGIE LAPAROSCOPIQUE ET OUVERTE

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Description

[0001] The present invention relates to a surgical tool, and to a mechanism for its operation. More particularly, but not exclusively, it relates to such a tool having improved ease of manual control.

[0002] Over the past 20 years, much effort has been applied to the development of specialised surgical instruments which allow complex procedures to be performed with predictable outcome. (For example, see US Patents Nos. US6,887,252; US6,056,735; US6,063,050 and US6,468,286). Many of these devices are designed to manipulate and dissect biological tissues. These devices may be manually operated or alternatively may incorporate a powered element designed to deliver an enhanced tissue cutting performance with significant haemostasis: see for example US Patents Nos. US5,938,633; US5,322,055 and US6,352,532. Both ultrasound and RF electrical currents are commonly used to energise such instruments. The above instruments also embody ergonomic features associated with basic hand instruments providing core surgical needs. Document US2002/019646 discloses an ultrasonic curved blade according to the preamble of claim 1. A review of modern clinical trends related to the field of general surgery indicates an expectation on the part of specialists in minimal invasive surgery that any instruments offered in future will incorporate significantly enhanced handpiece designs, in order to enable the surgeon successfully to undertake long, intricate procedures without experiencing fatigue, which could compromise the surgical outcome.

[0003] There have been past attempts to provide relevant functionalities addressing the requirements for controlling the cutting plane orientation, combined with accurate tissue targeting. These have been limited by inadequate mechanism designs, which impose physical constraints on the surgeons' ability to operate freely. For example, mechanisms have been proposed in which the cutting plane of the surgical tool is rotated by pushing with the surgeon's fingertip. Accurate control is difficult, and even the most dextrous surgeons find that they can rotate the cutting plane in one sense but not rotate it back in the other sense.

[0004] It is hence an object of the present invention to provide a surgical tool and a mechanism for a surgical tool having enhanced ergonomic features which obviate the above problems and contribute to the above surgical requirements.

[0005] In a first aspect of the invention, special attention is paid to means of controlling the orientation of a cutting/coagulating plane of a surgical tool with respect to the manually held instrument handle

[0006] According to a first aspect of the present invention, there is provided a surgical tool adapted to be activated by ultrasonic vibrations comprising an elongate waveguide means to transmit ultrasound, said waveguide means being provided adjacent its distal end with effector means defining a plane of operation of the tool on body tissues; a transducer connected to a proximal end of the elongate waveguide means; manipulable handpiece means disposed adjacent a proximal end of the waveguide means; and a rotation mechanism adapted controllably to rotate the waveguide means and the effector means together about a longitudinal axis of the waveguide means so as to align said plane of operation defined by the effector means in a desired orientation; wherein the rotation mechanism comprises at least first and second elements co-operably moveable relative to one another; characterised in that said first and second elements of the rotation mechanism comprise a longitudinally-displaceable first driving element operatively engaged through helically-symmetrical engagement means with a rotatable second driven element.

[0007] The rotation mechanism may comprise a geared transmission mechanism.

[0008] Preferably, the rotation mechanism comprises a magnetic drive mechanism.

[0009] Preferably, the rotation mechanism comprises a powered rotation mechanism operatively connected to hand-operable activation means.

[0010] Said hand-operable activation means may be operable by a finger of a hand holding the handpiece means.

[0011] Said hand-operable activation means may be operable by finger-tip pressure.

[0012] Said hand-operable activation means may be operable by finger-tip contact.

[0013] Advantageously, the rotation mechanism comprises a first and second said hand-operable activation means, operation of each of which produces rotation in opposite senses.

[0014] The surgical tool advantageously also comprises a source of ultrasonic vibrations comprising said transducer.

[0015] Said source of ultrasonic vibrations may comprise a source of any one of torsional mode ultrasonic vibrations, longitudinal mode ultrasonic vibrations, flexural mode ultrasonic vibrations, and a combination of any two or more of said modes of ultrasonic vibrations.

[0016] The source of ultrasonic vibrations may comprise an amplifying horn to which the waveguide means is mounted, and which may optionally also act as a conversion horn to produce a desired vibrational mode.

[0017] The handpiece means of the tool may contain ultrasound generator means operatively linked to a proximal end of the waveguide means.

[0018] The elongate member may additionally comprise an elongate optical transmission element, the effector means thereof comprising a directional viewing element, such as that of a laparoscope.

[0019] Preferably, the surgical tool comprises an operating mechanism for the effector means extending operatively between the handpiece means and the effector means.

[0020] Said effector means may comprise a mechanism controlled by the operating means to move within said plane of operation.

[0021] Said mechanism may comprise clamp means adapted to grasp an element of tissue.

[0022] Said clamp means may comprise a jaw member moveable by the operating means.

[0023] Said clamp means may be adapted to hold an element of tissue to the effector means so that the effector means may act thereon.

[0024] The effector means may transmit energy from the elongate waveguide means into tissue adjacent thereto.

[0025] Preferably, the operating means comprises sleeve means extending coaxially around the elongate waveguide means.

[0026] Advantageously, said sleeve means is rotatably displaceable relative to the elongate waveguide means.

[0027] Alternatively or additionally, the sleeve means may be longitudinally displaceable relative to the elongate waveguide means.

[0028] In a first embodiment, the rotation mechanism comprises a longitudinally displaceable first connecting element engaged with a helical second connecting element on a rotatable body.

[0029] Advantageously, the first connecting element is mounted to the handpiece means and the rotatable body comprises the elongate waveguide means.

[0030] The first connecting element may comprise pin means, optionally ball means, held within helical slot means, said helical slot means comprising said second connecting element.

[0031] In a second embodiment, the rotation mechanism acts on an energy generation means or an energy conversion means of the surgical tool, to which said elongate energy transmission member is mounted.

[0032] Preferably, part of the energy generation or conversion means also comprises part of the rotation means.

[0033] In a third embodiment, the helically-symmetrical engagement means comprises a body protruding from a first of the driving and driven elements and received within helically-extending groove means of a second of the driving and driven elements.

[0034] Alternatively, the helically-symmetrical engagement means may comprise helically-extending rib means protruding from a first of the driving and driven elements and received within slot means of a second of the driving and driven elements.

[0035] The protruding body preferably comprises ball means, optionally held freely rotatably to said first of the driving and driven elements.

[0036] Advantageously, the protruding body is mounted to the driving element and the helically-extending groove means is located on the driven element.

[0037] Preferably, the surgical tool comprises a linear drive means adapted controllably to displace the driving element.

[0038] Said linear drive means may comprise a linear electromagnetic motor means.

[0039] Said linear electromagnetic motor means may comprise electromagnet means fixedly mounted to the handpiece means of the surgical tool and permanent magnet means so mounted to the driving element that activation of the electromagnet means urges the driving element to move longitudinally of the tool.

[0040] The driven element is preferably fixedly mounted to energy generation means of the surgical tool, optionally to an energy conversion means thereof.

[0041] The driven element preferably comprises an integral portion of one of the energy generation means and its energy conversion means.

[0042] The driven element is advantageously joined to one of the energy generation means and its energy conversion means adjacent a nodal plane of ultrasonic vibrations therein.

[0043] Preferably, the surgical tool of any of the above embodiments is provided with means to detect a rotational position of the elongate waveguide means and the effector means.

[0044] Advantageously, said means to detect a rotational position comprises a potentiometer arrangement, whereby a rotational position is converted to an electrical signal.

[0045] Preferably, the surgical tool comprises means to govern the rotational movement of the elongate waveguide means and the effector means.

[0046] The means to govern the rotational movement of the elongate waveguide means and the effector means may comprise the means to detect a rotational position thereof.

[0047] Said means to govern rotational movement may be adapted to select a rotational velocity of the elongate waveguide means and the effector means, based on a current rotational position thereof and a target rotational position input by a user, optionally on a continuous basis.

[0048] Said means to govern rotational movement may regulate a supply of power to the rotation mechanism in order to produce a selected rotational velocity, optionally by means of a pulse width modulated signal.

[0049] According to a second aspect of the present invention, there is provided a handpiece for a surgical tool comprising manipulable handpiece means mountable to a proximal end of an elongate member having adjacent its distal end effector means defining a plane of operation, and a rotation mechanism adapted controllably to rotate such an elongate member and effector means together about a longitudinal axis of the elongate member so as to align said plane of operation of the effector means in a desired orientation.

[0050] Embodiments of the present invention will now be more particularly described by way of example and with reference to the accompanying drawings, in which:

Figure 1a shows, schematically, an exploded perspective view of components of a first handpiece of an ultrasonically-activatable surgical tool outside the scope of the present invention, including cross sections of juxtaposed elements of its acoustic system;

Figure 1b is a cross-sectional plan view of the handpiece of Figure 1a, showing said acoustic elements;

Figure 1c is a cross-sectional side elevation of the handpiece of Figure 1a, showing said acoustic elements;

Figure 1d shows vibrational displacement characteristics of the acoustic elements shown in Figures 1b and 1c;

Figure 2 is a side elevation of the handpiece shown in Figure 1a;

Figure 3a shows, schematically, an exploded perspective view of components of a second handpiece of an ultrasonically-activatable surgical tool outside the scope of the present invention, including cross sections of juxtaposed elements of its acoustic system;

Figure 3b is a cross-sectional side elevation of the handpiece of Figure 3a, showing said acoustic elements;

Figure 4a shows, schematically, an exploded perspective view of components of a first handpiece of an ultrasonically-activatable surgical tool embodying the present invention, including cross sections of juxtaposed elements of its acoustic system;

Figure 4b is a cross-sectional side elevation of the handpiece of Figure 4a, showing said acoustic elements;

Figure 5 is a schematic cross-sectional side elevation of a second handpiece of an ultrasonically-activatable surgical tool embodying the present invention;

Figure 6 is shows, schematically, an exploded perspective view of components of a third handpiece of an ultrasonically-activatable surgical tool embodying the present invention;

Figure 7 is a cross-sectional side elevation of the assembled handpiece components of Figure 6;

Figure 8 is a cross-sectional side elevation of an operating mechanism of a fourth, preferred handpiece of an ultrasonically-activatable surgical tool embodying the present invention;

Figure 9 is an exploded perspective view from a first direction of the operating mechanism shown in Figure 8;

Figure 10 is an exploded perspective view from a second direction of the operating mechanism shown in Figure 8; and

Figures 11a to 11d are schematic flow charts of portions of a control method for the operating mechanism shown in Figure 8.

[0051] Referring now to the Figures and to Figure 1a in particular, an acoustic system for an ultrasonically-actuable surgical tool comprises a transducer 12, a waveguide 3 operatively connected thereto, and a distal end effector 3e. An isolating sleeve 6 is mounted to the acoustic system within a handpiece casing 1 (for which, see Figure 2). The acoustic system is mounted within casing components 12a and 12b. Coupling sleeve 14 and its extension components 14a and 14b is attached to an inner tube 15b of a contra rotatable tube-set 15 extending coaxially around the waveguide 3. The tube-set 15 comprises said inner tube 15b, an outer tube 15a and an outer tube collar 15c; a helical slot 15d extends around the outer tube collar 15c.

[0052] The outer tube collar 15c is either integral with, or mouldably attached to, said outer tube 15a, so as to cause pivoting movement of a distally-mounted hinged jaw 15e in the direction of arrows C and C^1 when the outer tube collar 15c is reciprocally rotated in the direction indicated by arrows D and D^1. (A variety of mechanisms to convert rotational movement of the outer tube 15a to pivoting movement of the jaw 15e are known from the above references and elsewhere) The outer tube collar 15c is urged to rotate by a slide ring 16 provided with a drive pin 16a which engages with said helical groove 15d of the outer tube collar 15c through an axial slot 14c in extension component 14b. This slide ring 16 is in turn moved longitudinally in the direction of arrows A and A^1 by manual movement of a trigger 17 pivotally mounted about axis 17a and engaged at its inner tip with a circumferential groove 16b extending around the slide ring 16. Manual movement of the trigger 17 thus causes corresponding rotation of jaw 15e according to arrows C and C^1. The plane defined by the end-effector 3e and the travel of the jaw 15e comprises a cutting plane of the tool.

[0053] The rotation of the acoustic system and attached isolating elements, 6, 14, 14a, and 14b, relative to the handpiece casing 1, about the longitudinal axis of said acoustic system, may be achieved by several exemplary means.

[0054] An advantageous embodiment, outside the scope of the present invention, is shown schematically in Figures 1a to 1c. The acoustic system, comprising the transducer 12, the waveguide 3, and its end effector 3e, together with the jaw 15e adjacent to the end effector 3e and pivotable into engagement therewith, has the integrally or clamped compressively coupled isolating sleeve 6 positioned between an ultrasonic horn 10 and a proximal section 3b of the waveguide 3, at an annular interface 3a. The isolating sleeve 6 has a vibrational displacement node 6d (see Figure Id) located at a distance from interface 3a corresponding to one quarter of a wavelength of ultrasonic vibrations therein.

[0055] A circumferential flange 6a is integral with the isolating sleeve 6 and co-incidental with nodal plane 6d, said flange 6a containing a plurality of "hard" permanent magnets 6c inserted radially and at regular circumferential intervals around the flange 6a. Said magnets may be made of NdFeB or other suitable magnet material.

[0056] As shown in Figure 1a, a "soft" magnetic stator core 18 comprises a plurality of electromagnet elements 18a, disposed coaxially around the flange 6a, with a radial gap 18b between them. The stator core 18 is firmly held stationary within the handpiece casing 1. An even number of permanent magnets 6c inserted into the flange

6a is matched by an equal number of electromagnetic elements 18a in the fixed stator ring 18. Electromagnet windings are coiled around each electromagnet element 18a, and may controllably be supplied with direct current through the housing 12a, 12b of the transducer 12, coupled via a cable 30 to a generator or other DC source 31 (see Figure 1c).

[0057] Said electromagnet windings are connected in radially opposed pairs so as to provide alternating magnetic polarity between adjacent windings when current is passed therethrough, causing a magnetic interaction with the permanent magnets 6c in the nodal flange 6a. Pulsed activation of selected electromagnet winding coils is produced by control circuitry in the electrical generator 31. This activation is supplied in response to pressure on one or other of two switches 26a and 26b of a switch unit 26 conveniently mounted to an exterior of the handpiece 1 for fingertip access (see Figure 2). Respective switches 26a, 26b reverse the direction of rotation of the acoustic system and functionally associated components.

[0058] In a preferred variation of this embodiment, the relative positions of the permanent magnets 6c, and of the stator core 18 and its electromagnetic elements 18a are reversed. Thus a ring of permanent magnets 6c would be mounted to the (static) handpiece 1 casing 12a, encircling a ring of electromagnet elements 18a arranged around the flange 6a on the (rotatable) isolating sleeve 6. When the windings around each electromagnet element 18a are energised, this arrangement works in the same way as that described above. A benefit of this preferred arrangement is that the handpiece 1 casing 12a, 12b is usually disposable (since it cannot be sterilised by autoclaving), and so it is preferable to mount the simple, cheap permanent magnets 6c to this component of the tool, and to mount the more complex electromagnet elements 18a to the autoclavable acoustic system.

[0059] The principle described above in respect of the embodiment shown in Figures 1a to 1c may be implemented as described by deploying a circumferential array of permanent magnets 6c around electromagnet elements 18a. Alternatively, a configuration based on that disclosed in US Patent No. US4,841,189 may be employed. The configuration of US4,841,189 comprises annular pole pieces having interleaved individually formed poles and permanent magnet rotor, but in the present invention may be transposed so that the electromagnet structures (hitherto described as the stator winding) is arranged to rotate within an array of permanent magnets mounted around its periphery.

[0060] Furthermore, any of the above structures may be mounted at different locations within a surgical instrument, in order to effect the required rotation, as will be described below and shown in Figure 5. In this second embodiment of the present invention, a distal portion of the drive assembly of the handpiece of the tool comprises fixed stator windings 40, mounted to a manually-graspable handle 5 of the tool, while magnetic rotor elements 41 are attached to a distally-extending handpiece member 2 (which may comprise the waveguide 3 or an equivalent energy transmission member) and a proximally-extending transducer 12 through a connecting mechanism 45. The member 2, the magnetic rotor elements 41, the connecting mechanism 45 and the transducer 12 may thus be rotated about a longitudinal axis in the sense of arrow 42, relative to the handle 5 and a remainder of the casing 1 of the handpiece. Alternatively, electromagnetic elements 50 may be incorporated into the casing 12a, 12b of the transducer 12, and are capable of generating a rotational torque by magnetic interaction with a permanent magnet array 49 fixed within the casing 1 of the handpiece, which is held by the handle 5 by a surgeon or other user.

[0061] This particular electromagnetic mechanism may be applied to any such tool or instrument requiring an electrical coupling to a power source/controller (such as generator 31 in Figure 1c). This would include electrosurgical devices in which the ultrasonic components described herein would be substituted with electrodes carrying controlled electrical currents to an end-effector at the distal operative tip of the tool for tissue treatment. Such devices would be outside the scope of the present invention, however.

[0062] An alternative means of rotation of the cutting plane of the tool may be effected by the second embodiment outside the scope of the present invention, illustrated in Figures 3a and 3b. The aforementioned isolating sleeve 6, with its same nodal plane 6d, is provided with a raised circumferential flange having a profile comprising a gear ring 6g. A tangentially-mounted electric motor 11, fixed to handpiece casing 1 has a gearbox 11b operatively connected thereto, provided with an output worm gear 11a, which is operatively engaged with said gear ring 6g. The motor 11 is activated by switches 26a and 26b on the exterior of the handpiece casing 1 and conveniently positioned for digital access.

[0063] In the tools illustrated, which contain 'L-shaped' transducers 12 adapted to produce torsional mode ultrasonic vibrations, rotation of the cutting plane would be limited to + 90° about a neutral plane. If an alternative axisymmetric transducer 12 were used, both the above approach and that described in the context of Figures 1a to 1c would be capable of 360° rotation of the cutting plane.

[0064] A first embodiment of the present invention, comprising an arrangement for rotating the cutting plane, is shown in Figures 4a and 4b. The acoustic isolating sleeve 6 is provided with a helically-extending slot 6h, within which is held a hardened ball 6k (see Figure 4a). The ball 6k is compelled to move in a direction parallel to the longitudinal axis of the waveguide 3 by slideable knob 9b, which is constrained to travel within a longitudinal slot 9a in an outer sleeve 9. Slideable knob 9b is provided with a protruding socket 9c, which receives part of the ball 6k and which also passes through a longitudinal slot 7c in an inner slide sleeve 7. Longitudinal movement of the knob 9b, in the direction of arrows E and E[1], thus causes a corresponding rotational displacement of said acoustic isolator 6, and hence the transducer 12 and waveguide 3 connected thereto, as indicated by arrows D and D[1]. The inner slide sleeve 7 is operatively connected at its distal end to tube holder 14, and at its proximal end to the transducer casing 12a, in order to achieve effective positional movement of all the components which control the orientation of the cutting plane.

[0065] A third embodiment of the present invention of an arrangement for rotating the cutting plane is shown in Figures 6 and 7. This arrangement is believed to be particularly effective, both in the magnetically-driven variant described in detail below and in a pneumatically-driven variant, which is described in outline only.

[0066] The arrangement of Figures 6 and 7 employs a linear magnetic drive, the longitudinally movable component of which is coupled to a cylindrical sleeve comprising part of the acoustic horn of the ultrasound generation/conversion system. A ball, pin or the like is held by the movable component of the linear magnetic drive and travels within a helical groove extending around an outer surface of the cylindrical sleeve, such that longitudinal motion of the linear magnetic drive causes rotational motion of the cylindrical sleeve and the acoustic horn of which it forms part. A conventional elongate waveguide is mounted to the acoustic horn, such that the entire acoustically-vibratable assembly rotates about its longitudinal axis, rotating the cutting plane of the end effector located at a distal end of the waveguide.

[0067] Looking at this embodiment in more detail, with reference to Figures 6 and 7, a transducer stack 12c is eccentrically mounted to an ultrasound conversion/ amplification horn ("ultrasonic horn") 10. An elongate waveguide 3 is mounted coaxially extending from the ultrasonic horn 10 and has adjacent its remote distal end an end effector 3e. The end effector 3e may comprise a cutting edge defining a surgical plane, or may comprise part of a jaw mechanism as shown in Figure 1, cooperating with a pivotable jaw 15e. The end effector 3e and jaw 15e would then define the surgical plane between them. The waveguide 3 and ultrasonic horn 10 between them define a longitudinal axis 71 of the surgical tool.

[0068] A hollow cylindrical sleeve element 60 extends distally from the horn 10, coaxially enclosing a proximal end 3b of the waveguide 3 and the annular interface 3a between the horn 10 and the waveguide 3, across which ultrasonic vibrations are transmitted to the waveguide 3.

[0069] An annular flange 10a extends outwardly from the horn 10 adjacent the junction of the horn 10 and a proximal end of the cylindrical sleeve element 60. The annular flange 10a and the junction of the sleeve element 60 are located at or closely adjacent to a nodal plane 10a of the ultrasonic vibrations in the horn 10, and so the annular flange 10a and the sleeve element 60 are isolated from said vibrations. Ideally, the annular flange 10a and the sleeve element 60 are formed integrally with the horn 10.

[0070] One or more helical grooves 67 extend around an outer face of the cylindrical sleeve element 60. These helical grooves 67 extend almost from end to end of the cylindrical sleeve element 60, but are closed at each end.

[0071] A hollow cylindrical drive member 63 coaxially encircles the cylindrical sleeve element 60, and is free to slide longitudinally along the outer surface of the cylindrical sleeve element 60. The drive member 63 holds one or more low-friction balls 63c in respective recesses on its internal cylindrical surface 63d, such that the or each ball 63c is also received engagingly in a respective helical groove 67 on the outer cylindrical surface of the cylindrical sleeve element 60 of the horn 10. The ball or balls 63c thus operatively connect the drive member 63 and the cylindrical sleeve element 60.

[0072] The cylindrical drive member 63 is provided with two or more annular permanent magnet rings 63a coaxially encircling its outer surface, the permanent magnet rings 63a being spaced apart by soft magnetic rings 63b.

[0073] The permanent magnet rings 63a preferably comprise a magnetic composition containing neodymium, or a similar rare earth composition.

[0074] The cylindrical drive member 63 is in turn coaxially encircled by a phased array of electromagnetic coils 65; an even number of said coils 65 is preferred. When the phased array of coils 65 is energised by passage of electrical current therethrough, the array 65 interacts with the permanent and soft magnet rings 63a, 63b on the drive member 63 to form a linear magnetic drive. The drive member 63 can thus be controllably driven back and forth, longitudinally of the array 65 and of the sleeve element 10, as shown by arrows 69.

[0075] This longitudinal motion of the drive member 63 causes the sleeve element 10 to move, being engaged by means of the balls 63c travelling in the helical grooves 67. The sleeve element 10 thus rotates about the longitudinal axis 71 of the tool. As a result, the entire ultrasonic horn 10, together with the transducer stack 12c and the waveguide 3, is driven to rotate about the longitudinal axis 71. This in turn rotates the surgical plane of the end effector 3e located at the distal end of the waveguide 3.

[0076] The array of electromagnetic coils 65 is held in a casing 70, which is fixedly mounted to a casing (not shown in Figures 6 and 7) of the handpiece. The casing 70 contacts the drive member 63 and the annular flange 10a of the horn 10 sufficiently closely to maintain the respective coaxial alignment of the various components, while allowing the drive member 63 to slide freely, longitudinally, and the annular flange 10a (and the horn 10, transducer stack 12c, sleeve element 67 and waveguide 3) to rotate freely within the handpiece.

[0077] This arrangement produces smooth, controlled and continuous rotational movement of the surgical plane of the end-effector, activated by any desired form of control element (although fingertip controls 26, as shown in Figure 2, should be particularly convenient to a user).

[0078] It is envisaged that the linear magnetic drive described above could be replaced by a pneumatic drive mechanism, the casing 70 representing an outer casing of a piston arrangement, and the drive member 63 the piston itself, driven to move longitudinally back and forth. The same arrangement of balls 63c in helical grooves 67 would be used to convert linear motion of the drive member 63 into rotational motion of the sleeve element 10a, horn 10 and so forth.

[0079] The generator 31, indicated schematically in Figure 1c, has a primary function of controlling power delivery to the acoustic system, comprising the transducer 12, the waveguide 3, and its end effector 3e. The generator 31 may also incorporate circuitry designed to control cutting plane rotation and to regulate the timing of plane rotation in relation to acoustic activation.

[0080] Figures 8 to 10 show a fourth, preferred embodiment of the present invention of an arrangement for rotating the cutting plane. This is similar in principle to that shown in Figures 6 and 7, but also comprises a mechanism for detecting the current rotational position of the cutting plane and for producing a controlled and smooth rotational motion between positions of the cutting plane.

[0081] As in the third embodiment of Figures 6 and 7, this fourth embodiment employs a linear magnetic drive in conjunction with a helically-grooved transmission arrangement to convert the longitudinal motion of the linear magnetic drive to rotational motion of the stack, transducer, acoustic horn, waveguide and end effector.

[0082] The fourth embodiment also comprises a mechanism for detecting a current rotational position of these elements which employs a potentiometer mechanism to produce an electrical signal having a magnitude directly related to the rotational position. This signal is used as the basis for a control sequence (described in more detail below in respect of Figures 11a to 11d) for the drive that produces rapid, accurate, smooth and controlled motion between selected rotational positions.

[0083] A transducer stack 12c is mounted eccentrically to an ultrasound conversion/amplification horn ("ultrasonic horn") 10. An elongate waveguide 3 is mounted to extend coaxially from the ultrasonic horn 10, through a central axis of the drive mechanism 88, and has an end effector 3e at its distal end. This end effector 3e may comprise a cutting edge defining an operative plane. It may also comprise part of a jaw mechanism as shown in Figure 1, cooperating with a pivotable jaw 15c, the operative plane being defined by the end effector 3e and the plane through which the jaw 15c is swept.

[0084] The drive mechanism 88 is centred around an elongate hollow cylindrical drive shaft 80, which is mounted at its proximal end to an annular flange 10a, extending radially outwardly from the ultrasonic horn 10 adjacent its junction with the waveguide 3. The annular flange 10a is located at or near a nodal plane in the ultrasonic vibrations set up in the horn 10 and waveguide 3, so as to isolate the drive mechanism from these vibrations.

[0085] Towards a distal end of the drive shaft 80, a set of three helical grooves 87 extend around its outer surface. The helical grooves 87 each have a part-circular cross-sectional profile to receive a respective one of three low-friction ceramic balls 84, which are thus free to travel along their respective helical grooves 87.

[0086] A hollow cylindrical permanent magnet 83 encircles the drive shaft. On its inner surface, a coaxial non-magnetic ring 86 (not shaded for clarity) holds the three ceramic balls 84 in respective part-spherical recesses, leaving the balls 84 free to rotate within each recess. The cylindrical permanent magnet 83 is free to travel longitudinally back and forth along the drive shaft 80 and waveguide 3, as shown by arrow 81.

[0087] The permanent magnet 83 has three straight grooves 82 extending longitudinally along its outer surface, spaced at 120° to each other around its circumference. These each receive a pair of additional low-friction ceramic balls 89. Each of the additional ceramic balls 89 is also held in a part-spherical recess in an inner surface of a coaxially extending cylindrical outer casing 90 of the drive mechanism 88.

[0088] The outer casing 90 acts as a former for a set of circumferential electromagnet coils 85, which thus encircle the permanent magnet 83. The electromagnetic coils 85 extend along substantially a whole length of the drive mechanism 88, such that the permanent magnet 83 is still encircled thereby at any point along its longitudinal motion 81.

[0089] This mechanism is preferably controlled using a two-button, forward/reverse arrangement, similar to that shown in Figure 2. Thus, when the electromagnetic coils 85 are energised, the permanent magnet 83 will be driven distally or proximally within the drive mechanism 88, depending on the direction of the current within the coils 85. The ceramic balls 89 are constrained to travel only within the straight longitudinal grooves 82 on the outer surface of the permanent magnet 83, and so in turn constrain the permanent magnet 83 to purely longitudinal back and forth motion.

[0090] Meanwhile, the ceramic balls 84 bridge between the inner surface of the hollow cylindrical permanent magnet 83 and the helical grooves 87 on the drive shaft 80. Longitudinal motion of the permanent magnet 83 thus constrains the ceramic balls 84 to travel longitudinally, but since they are also constrained to travel within the helical grooves 87, the drive shaft 80 must therefore rotate to allow this, and with it the stack 12c, horn 10, waveguide 3 and effector 3e.

[0091] This structure effectively defines a gearing arrangement between the linear magnetic motor and the rotatable portion of the drive mechanism. Selection of a suitable "stroke length" for the movement of the permanent magnet 63, together with the number and pitch of the helical grooves 87, ensures that the effective gear ratio of this arrangement is sufficient to drive the rotatable portion to rotate without significant resistance, as well as ensuring that the full "stroke length" of the movement of the magnet 83 produces a sufficient rotation of the rotatable portion. A total rotational range of slightly less than a full circle is preferred, for constructional and control reasons. If necessary, the surgeon can supply the last few degrees of adjustment by hand movements, without significant inconvenience or fatigue.

[0092] The fourth embodiment also comprises a potentiometer sensor arrangement for determining the exact rotational position of the drive shaft stack, transducer, horn, waveguide and end effector. In essence, a conductive element is held stationary while bridging a conductive track and a resistive track, which rotate along with the waveguide, etc. An electrically conductive path is thus set up along the conductive track, across the stationary conductive element and back along the resistive track, and the resistance of this path depends on exactly where the conductive element bridges to the resistive track. Hence, a potential across this conductive path is directly related to the relative rotational positions of the tracks and the stationary conductive element.

[0093] One implementation of this approach is shown in Figures 8 to 10. The outer casing 90 of the drive mechanism 88 is fixed to the handpiece of the surgical tool (not shown) and thus does not rotate. An end plate 91 of the drive mechanism 88 is provided with a recess 94 which holds a permanent locating magnet 93 (the function of which is described below).

[0094] A low-friction bearing ring 98, made of PTFE (polytetrafluoroethylene) or the like, is located between the end plate 91 and a front plate 97 of the sensor arrangement, so that the sensor arrangement may rotate freely with respect to the drive mechanism 88. The sensor front plate 97 supports two spring loaded contact pins 95 in respective sockets 96, which contact two corresponding part-circular contact tracks 92 inset into the end plate 91 of the drive mechanism 88. This is a convenient arrangement for electrical power to be supplied to the electromagnet coils 85 of the drive mechanism 88. (The main power lead of such surgical tools generally leads to the transducer stack 12c, i.e. power is supplied to the rotatable components, so special contact arrangements are required for the coils of the drive mechanism which do not rotate).

[0095] A hollow cylindrical sensor housing 99 and a sensor back plate 107 (actually forming part of the proximal end of the drive shaft 80 in this example) cooperate with the sensor front plate 97 to enclose the sensor arrangement itself (in some embodiments, the interior of the sensor arrangement is filled with oil to reduce friction).

[0096] A generally annular printed circuit board 100 is almost completely divided into an outer annulus 101 and an inner annulus 102 by an almost-circular slot 103. The outer annulus 101 bears a circumferential resistive track, while the inner annulus 102 bears a corresponding circumferential conductive track around its surface.

[0097] A sliding contact 104 comprises a conductive flat plate with a permanent ferromagnet 105 extending from its centre, and several sprung contact pins 106 at its periphery. The permanent ferromagnet 105 extends through the slot 103 in the printed circuit board 100 and is strongly coupled to the permanent locating magnet 93 on the drive mechanism 88. This urges the contact pins 106 into contact with the respective tracks on the outer and inner annuli 101, 102 of the printed circuit board 100. When the printed circuit board 100 rotates with the sensor arrangement, this magnetic attraction holds the sliding contact 104 stationary, so it contacts the tracks at a different point. The sliding contact 104 thus provides the conductive bridge between the conductive and resistive tracks, required for the potentiometer arrangement referred to above.

[0098] The sensor back plate 107 carries a range of PCB tracks, electrical connections and so forth, connected to internal wiring, leading for example to the contact pins 95 and the drive mechanism 80, as well as to the printed circuit board 100 and other tool controls. This circuitry is of conventional form and so is not shown, for clarity.

[0099] In an alternative potentiometer arrangement (not shown), the sliding contact plate 104 is replaced by a magnetic conductive sphere. The resistive track still extends around an outer margin of the printed circuit board 100, but the conductive track extends around an adjacent portion of an inner surface of the sensor housing 99. The sphere is magnetically held in alignment with the permanent magnet 93 on the drive mechanism 88, which also holds it in contact with both tracks. The sphere thus remains stationary while the tracks and the sensor arrangement rotate, providing a conductive bridge for the conductive path of the potentiometer arrangement.

[0100] Both arrangements produce a simple voltage output that is accurately dependent on the current rotational position of the sensor arrangement, and hence of the other rotatable components of the surgical tool. This has been found to be superior to optical methods of identifying the rotational position (e.g. with a stationary photocell responding to black lines on an otherwise white rotating element). The optical arrangement only indicates when the rotation has already reached a desired point, for example, necessitating a crash stop to avoid an overshoot. The potentiometric arrangement allows the position to be tracked continuously, permitting far more effective and subtle control. Merely rotating between estimated positions by dead reckoning is far too inaccurate.

[0101] It should be noted that in each case, the surgical tool is set up for the rotatable elements to index between a relatively small number of pre-set rotational positions. This is much easier to control than a system allowing infinite variations of position, while the surgeon can easily adjust the angle of the tool by a few degrees if an indexed position is not quite ideal.

[0102] The control procedure for the rotation of the stack, horn, waveguide and end effector follows the sequence set out in Figures 11a to 11d. Figure 11a shows the whole sequence of operation; Figure 11b expands the structure of the MAIN PROGRAM LOOP from Figure 11a; Figure 11c expands the structure of the CALCULATE CONTROL SIGNAL step from Figure 11b; and Figure 11d expands the structure of the MOVE MOTOR step from Figure 11b.

[0103] Referring to Figure 11a, when the equipment is switched on, a PIC (Peripheral Interface Controller) chip is activated. This is conveniently located within a control unit for the ultrasound generator of the surgical tool. The PIC is set up, and variables described below are set to their default initial values.

[0104] In particular, the variable TARGET, indicating the desired rotational position of the surgical tool, is set to MIDPOINT, corresponding to the midpoint of the possible rotational travel range of the stack, transducer, horn, waveguide and end-effector assembly. Thus, a surgeon will always start with the surgical tool set at this midpoint position and able to rotate in either direction as required.

[0105] The sequence then comprises repeated passes around the MAIN PROGRAM LOOP until the surgeon has completed use of the surgical tool.

[0106] Referring to the expanded structure of the MAIN PROGRAM LOOP in Figure 11b, the first step is to check the FORWARD button of the controls provided. If a signal has been received from operation of this button by the surgeon, the variable TARGET is incremented, indicating that the desired rotational position is forwards/clockwise from the current potential position.

[0107] The next step is to check the REVERSE button of the controls. If a signal has been received, the variable TARGET is decremented, indicating that the desired rotational position is backwards/anti-clockwise from the current rotational position.

[0108] The third step is to check the ACTIVATE button, which is to activate the ultrasound generator to energise the stack, transducer, horn, waveguide and end-effector. If the ACTIVATE button is being operated, a master PIC controller activates the ultrasound generator, and the FORWARD and REVERSE buttons of the controls are inhibited. It is undesirable for the end-effector to be turning during operation of the tool, particularly if it is grasping or otherwise targeting a specific element of body tissue. Accidental operation of the FORWARD and REVERSE buttons is thus prevented. The fourth step is to check the TOGGLE button, which alters the intensity of the ultrasound generated between pre-set levels. Again, operation of the TOGGLE button causes the master PIC controller to alter the intensity, while the FORWARD and REVERSE buttons are inhibited to prevent accidental operation.

[0109] The fifth step, CALCULATE CONTROL SIGNAL, is at the heart of the sequence, and is shown in more detail as a series of sub-steps in Figure 11c.

[0110] The rotational position detector/sensor arrangement of the surgical tool is interrogated in the first sub-step to give the variable CURRENT for the present instantaneous rotational position of the surgical tool.

[0111] In the second sub-step, the variable TARGET is retrieved from memory, including any increments or decrements resulting from the first two steps of the MAIN PROGRAM LOOP.

[0112] A set of further variables are then calculated. The variable ERROR, in the third sub-step, is set to the (vector) difference of the TARGET and CURRENT variables, indicating how far the surgical tool is from the desired rotational position.

[0113] The variable PROPORTIONAL, in the fourth sub-step, is set to the (vector) difference between the TARGET and CURRENT variables, multiplied by a preset constant, K1.

[0114] The variable SPEED, in the fifth sub-step, is set to the (vector) difference between the CURRENT variable and the PREVIOUS variable multiplied by a second pre-set constant, K2. (The PREVIOUS variable corresponds to the value of CURRENT from the previous pass around the MAIN PROGRAM LOOP).

[0115] The variable INTEGRAL, in the sixth sub-step, is set to the value of INTEGRAL from the previous pass around the MAIN PROGRAM LOOP, incremented or decremented by the value of ERROR, and then multiplied by a third pre-set constant, K3.

[0116] The seventh sub-step comprises the calculation of the CONTROL SIGNAL variable from the sum of the variables PROPORTIONAL, SPEED and INTEGRAL. The value of CONTROL SIGNAL (as described below) governs the speed and direction of rotation of the mechanism. There is a pre-set maximum value for CONTROL SIGNAL to prevent excessive speed of rotation.

[0117] In the eighth sub-step, the variable CONTROL SIGNAL is returned. The net sign of CONTROL SIGNAL indicates whether a FORWARD/clockwise rotation or a REVERSE/anti-clockwise rotation will be produced. The magnitude of CONTROL SIGNAL naturally indicates the amount of power sent to the mechanism. At this sub-step, the magnitude of CONTROL SIGNAL is compared to a pre-set minimum threshold value. If it is below this threshold value, CONTROL SIGNAL is instead set to zero. This prevents the sequence producing a series of small jittery correcting movements, particularly when sufficiently close to a desired TARGET rotational position as to make no practical difference to the surgeon.

[0118] Control then transfers to the sixth step of the MAIN PROGRAM LOOP, which is set out in sub-steps in Figure 11d.

[0119] In the first sub-step, if CONTROL SIGNAL is positive, the signal to the drive mechanism is set up to be in the FORWARDS/clockwise direction. In the second sub-step, if CONTROL SIGNAL is negative, this signal is set up to be in the REVERSE/anticlockwise direction. An asymmetric compensation coefficient may be used to adjust the FORWARD/REVERSE signals to ensure similar motion characteristics in both directions, should physical parameters of the equipment (e.g. an asymmetry in the resistance along the resistive track) cause them to differ.

[0120] In the third sub-step, the signal to the drive mechanism is generated as a PWM (pulse width modulated) current. The ON time of the PWM current is proportional to the magnitude of CONTROL SIGNAL. In the fourth sub-step, the drive mechanism, here indicated as

MOTOR DRIVE, moves in response to the PWM current supplied. After a pre-set time interval, the MOTOR DRIVE is stopped and the control returns to the start of the MAIN PROGRAM LOOP. This loop will be followed, repeating the above steps and sub-steps, until the TARGET position is reached (or the position is sufficiently close that CONTROL SIGNAL is set to zero anyway).

[0121] The benefit of the above control sequence is to produce a smooth, controlled, accurate and proportionate rate of rotation of the mechanism. The rotation will be faster for larger position changes, but the rotation will gradually be slowed as the TARGET position is approached, coming to a controlled rest (rather than a jerky stop as soon as the system "realises" that it has arrived). Adjustment of constants K1, K2 and K3 should allow adjustment of the exact speed profiles produced, depending on the requirements of a particular tool, or even of a particular user.

Claims

1. A surgical tool adapted to be activated by ultrasonic vibrations comprising an elongate waveguide means (3) to transmit ultrasound, said waveguide means (3) being provided adjacent its distal end with effector means (3e) defining a plane of operation of the tool on body tissues; a transducer (12) connected to a proximal end of the elongate waveguide means (3); manipulable handpiece means (1) disposed adjacent a proximal end of the waveguide means (3); and a rotation mechanism adapted controllably to rotate the waveguide means (3) and the effector means (3e) together about a longitudinal axis of the waveguide means (3) so as to align said plane of operation defined by the effector means (3e) in a desired orientation; wherein the rotation mechanism comprises at least first and second elements (6, 7, 9, 9b; 60, 63, 65; 80, 83, 85) co-operably moveable relative to one another; **characterised in that** said first and second elements of the rotation mechanism comprise a longitudinally-displaceable first driving element (9b; 63; 83) operatively engaged through helically-symmetrical engagement means (6h; 67; 87) with a rotatable second driven element (6; 60; 80).

2. A surgical tool as claimed in claim 1, **characterised in that** the helically-symmetrical engagement means comprises a body (6k; 63c; 84) protruding from either one (9b; 63; 83) of the first driving and second driven elements and received within helically-extending groove means (6h; 67; 87) of the other (6; 60; 80) of the first driving and second driven elements.

3. A surgical tool as claimed in claim 2, **characterised in that** said protruding body (6k; 63c; 84) comprises ball means (6k; 63c; 84).

4. A surgical tool as claimed in any one of the preceding claims, **characterised in that** it comprises a linear drive means (61; 85) adapted controllably to displace the longitudinally -displaceable first driving element (63; 83).

5. A surgical tool as claimed in claim 4, **characterised in that** the linear drive means (61; 85) comprises linear electromagnetic motor means (61; 85).

6. A surgical tool as claimed in claim 5, **characterised in that** said linear electromagnetic motor means (61; 85) comprises electromagnet means (65;85) fixedly mounted to the handpiece means (1) of the surgical tool and permanent magnet means (63a; 83) so mounted to the first driving element (63; 83) that activation of the electromagnet means (65; 85) urges the first driving element (63; 83) to move longitudinally of the tool.

7. A surgical tool as claimed in any one of the preceding claims, **characterised in that** a mechanism of the effector means (3e) comprises clamp means (15e) adapted to grasp an element of tissue.

8. A surgical tool as claimed in any one of the preceding claims, **characterised in that** the rotation mechanism comprises a powered rotation mechanism provided with hand-operable activation means (26) operable by a finger of a hand holding the handpiece means (1).

9. A surgical tool as claimed in claim 8, **characterised in that** the rotation mechanism comprises a first (26a) and a second (26b) said hand-operable activation means, operation of each of which activates rotation in opposite senses.

10. A surgical tool as claimed in any one of claims 1 to 3, **characterised in that** the rotation mechanism comprises a manually longitudinally-displaceable first, driving element (9b) engaged with helically-symmetrical engagement means (6h) on a rotatable second, driven element (6).

11. A surgical tool as claimed in any one of the preceding claims, **characterised in that** the surgical tool comprises means (100) to detect a rotational position of the waveguide means (3) and the effector means (3e).

12. A surgical tool as claimed in claim 11, **characterised in that** the surgical tool comprises means to govern the rotational movement of the waveguide means (3) and the effector means (3e), said governing means comprising or being operatively connected

to the means (100) to detect a rotational position of the waveguide means (3) and the effector means (3e).

13. A surgical tool as claimed in claim 12, **characterised in that** said means to govern rotational movement is adapted to regulate a rotational velocity of the waveguide means (3) and the effector means (3e) on the basis of at least a current rotational position of the waveguide means (3) and the effector means (3e) and a target rotational positon thereof selected by a user.

14. A surgical tool as claimed in claim 13, **characterised in that** said means to govern rotational movement is adapted continuously to regulate said rotational velocity on the basis of the current and the target rotational positions of the waveguide means (3) and the effector means (3e).

Patentansprüche

1. Chirurgisches Instrument, das angepasst ist, durch Ultraschallschwingungen aktiviert zu werden, umfassend ein längliches Wellenleitermittel (3) zum Übertragen von Ultraschall, wobei das Wellenleitermittel (3) neben seinem distalen Ende mit einem Effektormittel (3e), das eine Einsatzebene des Instruments auf Körpergewebe definiert, ausgestattet ist; einen Wandler (12), der mit einem proximalen Ende des länglichen Wellenleitermittels (3) verbunden ist; ein manipulierbares Handstückmittel (1), das neben einem proximalen Ende des Wellenleitermittels angeordnet ist; und einen Drehmechanismus, der angepasst ist, steuerbar das Wellenleitermittel (3) und das Effektormittel (3e) zusammen um eine Längsachse des Wellenleitermittels (3) zu drehen, um die durch das Effektormittel (3e) definierte Einsatzebene in einer gewünschten Ausrichtung auszurichten; wobei der Drehmechanismus wenigstens ein erstes und ein zweites Element (6, 7, 9, 9b; 60, 63, 65; 80, 83, 85) umfasst, die zusammenwirkend aufeinander bezogen beweglich sind; **dadurch gekennzeichnet, dass** das erste und das zweite Element des Drehmechanismus ein der Länge nach verschiebbares Antriebselement (9b; 63; 83) umfasst, das durch ein schraubenförmig symmetrisches Eingriffsmittel (6h; 67; 87) betriebsfähig mit einem drehbaren zweiten angetriebenen Element (6; 60; 80) im Eingriff steht.

2. Chirurgisches Instrument nach Anspruch 1, **dadurch gekennzeichnet, dass** das schraubenförmig symmetrische Eingriffsmittel einen Körper (6k; 63c; 84) umfasst, der entweder von einem (9b; 63; 83) des ersten Antriebs- und des zweiten angetriebenen Elements vorsteht und im sich schraubenförmig erstreckenden Rillenmittel (6h; 67; 87) des anderen (6; 60; 80) des ersten Antriebs- und des zweiten angetriebenen Elements aufgenommen ist.

3. Chirurgisches Instrument nach Anspruch 2, **dadurch gekennzeichnet, dass** der vorstehende Körper (6k; 63c; 84) ein Kugelmittel (6k; 63c; 84) umfasst.

4. Chirurgisches Instrument nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** es ein lineares Antriebsmittel (61; 85) umfasst, das angepasst ist, steuerbar das der Länge nach verschiebbare erste antreibende Element (63; 83) zu verschieben.

5. Chirurgisches Instrument nach Anspruch 4, **dadurch gekennzeichnet, dass** das lineare Antriebsmittel (61; 85) ein lineares elektromagnetisches Motormittel (61; 85) umfasst.

6. Chirurgisches Instrument nach Anspruch 5, **dadurch gekennzeichnet, dass** das lineare elektromagnetische Motormittel (61; 85) Folgendes umfasst: ein Elektromagnetmittel (65; 85), das fest an dem Handstückmittel (1) des chirurgischen Instruments befestigt ist, und ein Dauermagnetmittel (63a; 83), das derart an dem ersten antreibenden Element (63; 83) befestigt ist, dass ein Aktivieren des Elektromagnetmittels (65; 85) das erste antreibende Element (63; 83) dazu drängt, sich der Länge des Instruments nach zu bewegen.

7. Chirurgisches Instrument nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** ein Mechanismus des Effektormittels (3e) ein Klemmmittel (15e) umfasst, das angepasst ist, ein Element von Gewebe zu erfassen.

8. Chirurgisches Instrument nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Drehmechanismus einen betriebenen Drehmechanismus umfasst, der mit einem von Hand betreibbaren Aktivierungsmittel (26), das durch einen Finger einer Hand, die das Handstückmittel (1) hält, betrieben werden kann, ausgestattet ist.

9. Chirurgisches Instrument nach Anspruch 8, **dadurch gekennzeichnet, dass** der Drehmechanismus ein erstes (26a) und ein zweites (26b) des von Hand betreibbaren Aktivierungsmittels umfasst, deren Betrieb jeweils ein Drehen in entgegengesetzte Richtungen aktiviert.

10. Chirurgisches Instrument nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** der Drehmechanismus ein manuell, der Länge nach verschiebbares erstes antreibendes Element (9b) umfasst, das auf einem drehbaren zweiten angetriebenen Element (6) mit einem schraubenförmig symmetrischen Eingriffsmittel (6h) im Eingriff steht.

11. Chirurgisches Instrument nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** das chirurgische Instrument ein Mittel (100) zum Erkennen einer Drehposition des Wellenleitermittels (3) und des Effektormittels (3e) umfasst.

12. Chirurgisches Instrument nach Anspruch 11, **dadurch gekennzeichnet, dass** das chirurgische Instrument ein Mittel zum Regeln der Drehbewegung des Wellenleitermittels (3) und des Effektormittels (3e) umfasst, wobei das Regelungsmittel das Mittel (100) zum Erkennen einer Drehposition des Wellenleitermittels (3) und des Effektormittels (3e) umfasst oder damit wirkverbunden ist.

13. Chirurgisches Instrument nach Anspruch 12, **dadurch gekennzeichnet, dass** das Mittel zum Regeln von Drehbewegung angepasst ist, eine Rotationsgeschwindigkeit des Wellenleitermittels (3) und des Effektormittels (3e) auf der Grundlage wenigstens einer aktuellen Drehposition des Wellenleitermittels (3) und des Effektormittels (3e) und einer von einem Benutzer gewählten Zieldrehposition davon einzustellen.

14. Chirurgisches Instrument nach Anspruch 13, **dadurch gekennzeichnet, dass** das Mittel zum Regeln von Drehbewegung angepasst ist, kontinuierlich die Rotationsgeschwindigkeit auf der Grundlage der aktuellen und der Zieldrehposition des Wellenleitermittels (3) und des Effektormittels (3e) einzustellen.

Revendications

1. Outil chirurgical adapté pour être activé par des vibrations ultrasonores comprenant un moyen de guide d'ondes allongé (3) pour transmettre les ultrasons, ledit moyen de guide d'ondes (3) étant placé à côté de son extrémité distale avec un moyen effecteur (3e) définissant un plan d'opération de l'outil sur les tissus cellulaires ; un transducteur (12) raccordé à une extrémité proximale du moyen de guide d'ondes allongé (3) ; un moyen de pièce à main manipulable (1) disposé à côté d'une extrémité proximale du moyen de guide d'ondes (3) ; et un mécanisme de rotation adapté de façon contrôlable pour faire pivoter conjointement le moyen de guide d'ondes (3) et le moyen effecteur (3e) autour d'un axe longitudinal du moyen de guide d'ondes (3) de façon à aligner ledit plan d'opération défini par le moyen effecteur (3e) dans un sens souhaité ; où le mécanisme de rotation comprend au moins des premier et deuxième éléments (6, 7, 9, 9b ; 60, 63, 65 ; 80, 83, 85) pouvant être déplacés de manière co-opérationnelle l'un par rapport à l'autre ; **caractérisé en ce que** lesdits premier et deuxième éléments du mécanisme de rotation comprennent un premier élément de commande pouvant être déplacé longitudinalement (9b ; 63 ; 83) opérationnellement engrené par un moyen d'engrènement à symétrie hélicoïdale (6h ; 67 ; 87) avec un deuxième élément rotatif commandé (6 ; 60 ; 80).

2. Outil chirurgical selon la revendication 1, **caractérisé en ce que** le moyen d'engrènement à symétrie hélicoïdale comprend un corps (6k ; 63c ; 84) faisant saillie depuis l'un (9b ; 63 ; 83) du premier élément de commande et du deuxième élément commandé et logé à l'intérieur d'un moyen d'encoche s'étendant de façon hélicoïdale (6h ; 67 ; 87) de l'autre (6 ; 60 ; 80) du premier élément de commande et du deuxième élément commandé.

3. Outil chirurgical selon la revendication 2, **caractérisé en ce que** ledit corps protubérant (6k ; 63c ; 84) comprend un moyen à billes (6k ; 63c ; 84).

4. Outil chirurgical selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**il comprend un moyen de commande linéaire (61 ; 85) adapté de manière contrôlable pour déplacer le premier élément de commande pouvant être déplacé longitudinalement (63 ; 83).

5. Outil chirurgical selon la revendication 4, **caractérisé en ce que** le moyen de commande linéaire (61 ; 85) comprend un moyen de moteur électromagnétique linéaire (61 ; 85).

6. Outil chirurgical selon la revendication 5, **caractérisé en ce que** ledit moyen de moteur électromagnétique linéaire (61 ; 85) comprend un moyen d'électroaimant (65 ; 85) fixé de façon rigide au moyen de pièce à main (1) de l'outil chirurgical et un moyen d'aimant permanent (63a ; 83) fixé au premier élément de commande (63 ; 83) de telle sorte que l'activation du moyen d'électroaimant (65 ; 85) force le premier élément de commande (63 ; 83) à déplacer longitudinalement l'outil.

7. Outil chirurgical selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**un mécanisme du moyen effecteur (3e) comprend un moyen de serrage (15e) adapté pour saisir un élément de tissu.

8. Outil chirurgical selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le mécanisme de rotation comprend un mécanisme de rotation motorisé équipé d'un moyen d'activation à commande manuelle (26) actionnable par un doigt d'une main tenant le moyen de pièce à main (1).

9. Outil chirurgical selon la revendication 8, **caractérisé en ce que** le mécanisme de rotation comprend un premier (26a) et un deuxième (26b) dudit moyen d'activation à commande manuelle (26), dont l'actionnement active la rotation dans des directions opposées.

10. Outil chirurgical selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** le mécanisme de rotation comprend un premier élément de commande pouvant être déplacé longitudinalement à la main (9b) engrené avec un moyen d'engrènement à symétrie hélicoïdale (6h) sur un deuxième élément rotatif commandé (6).

11. Outil chirurgical selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'outil chirurgical comprend un moyen (100) pour détecter une position rotative du moyen de guide d'ondes (3) et du moyen effecteur (3e).

12. Outil chirurgical selon la revendication 11, **caractérisé en ce que** l'outil chirurgical comprend un moyen de régulation du mouvement rotatif du moyen de guide d'ondes (3) et du moyen effecteur (3e), ledit moyen de régulation comprenant ou étant raccordé de manière opérationnelle au moyen (100) pour détecter une position rotative du moyen de guide d'ondes (3) et du moyen effecteur (3e).

13. Outil chirurgical selon la revendication 12, **caractérisé en ce que** ledit moyen de régulation du mouvement rotatif est adapté pour réguler une vitesse de rotation du moyen de guide d'ondes (3) et du moyen effecteur (3e) sur la base d'au moins une position rotative actuelle du moyen de guide d'ondes (3) et du moyen effecteur (3e) et une position rotative cible correspondante choisie par un utilisateur.

14. Outil chirurgical selon la revendication 13, **caractérisé en ce que** ledit moyen de régulation du mouvement rotatif est adapté de façon continue pour réguler ladite vitesse de rotation sur la base de la position rotative actuelle et de la position rotative cible du moyen de guide d'ondes (3) et du moyen effecteur (3e).

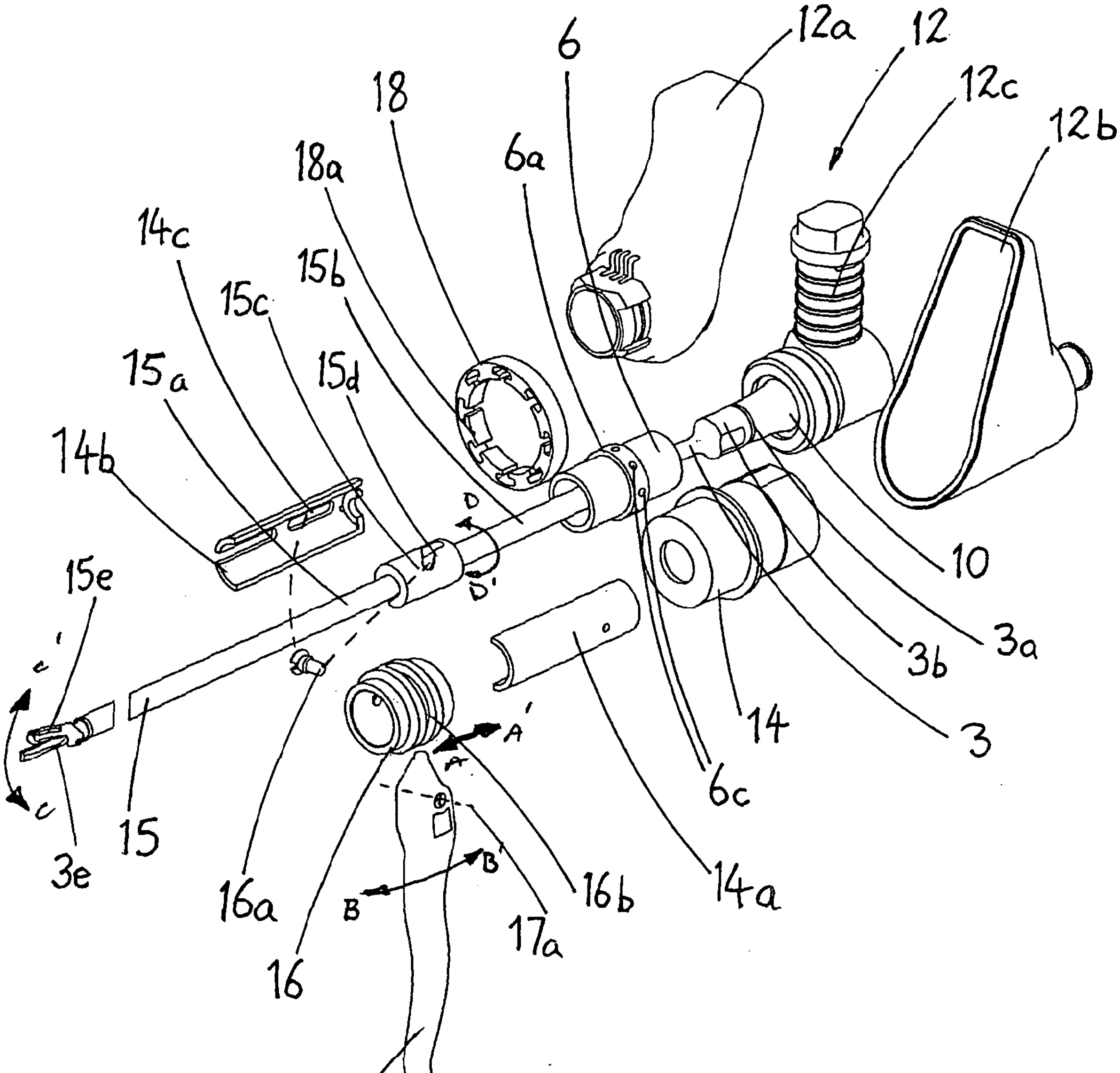

12a
12
12c
12b
6
18
18a
6a
14c
15c
15b
15a
15d
14b
D
D'
15e
C'
C
3e
15
16a
A'
A
B
B'
16
17a
16b
14a
6c
14
3
3b
3a
10
17

Fig 1a

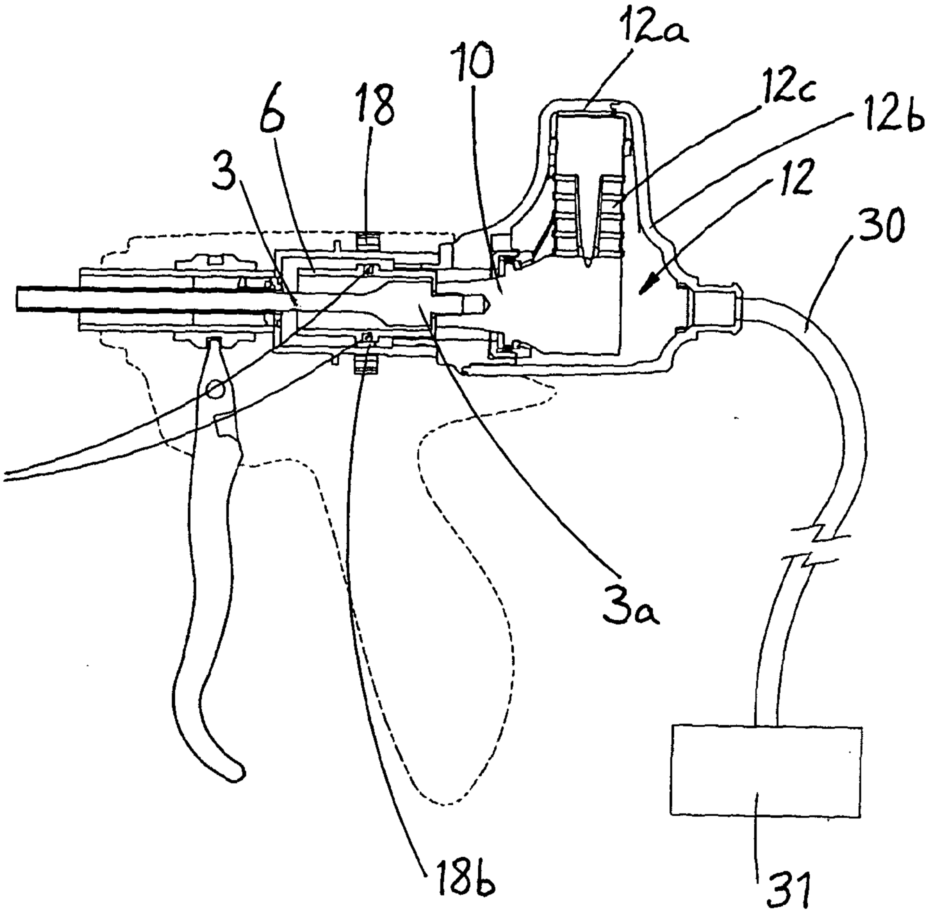


Fig 1c

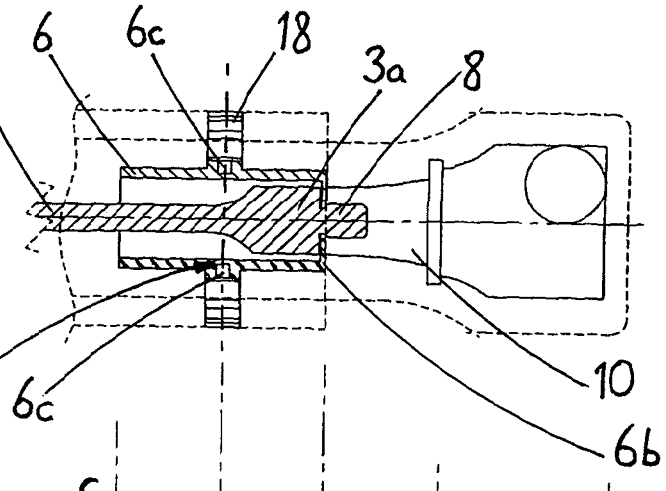


Fig 1b

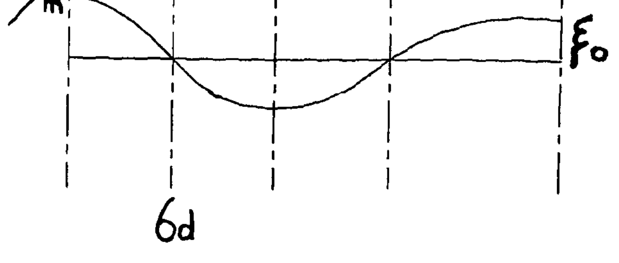


Fig 1d

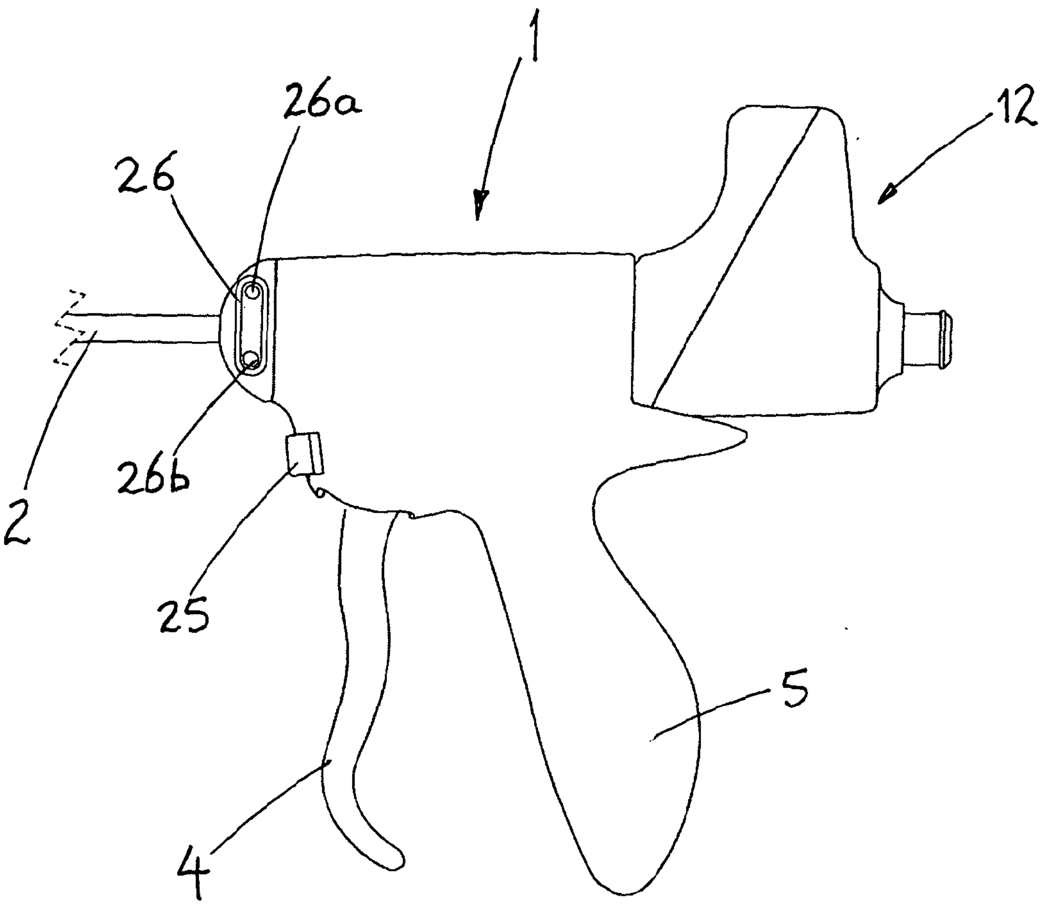
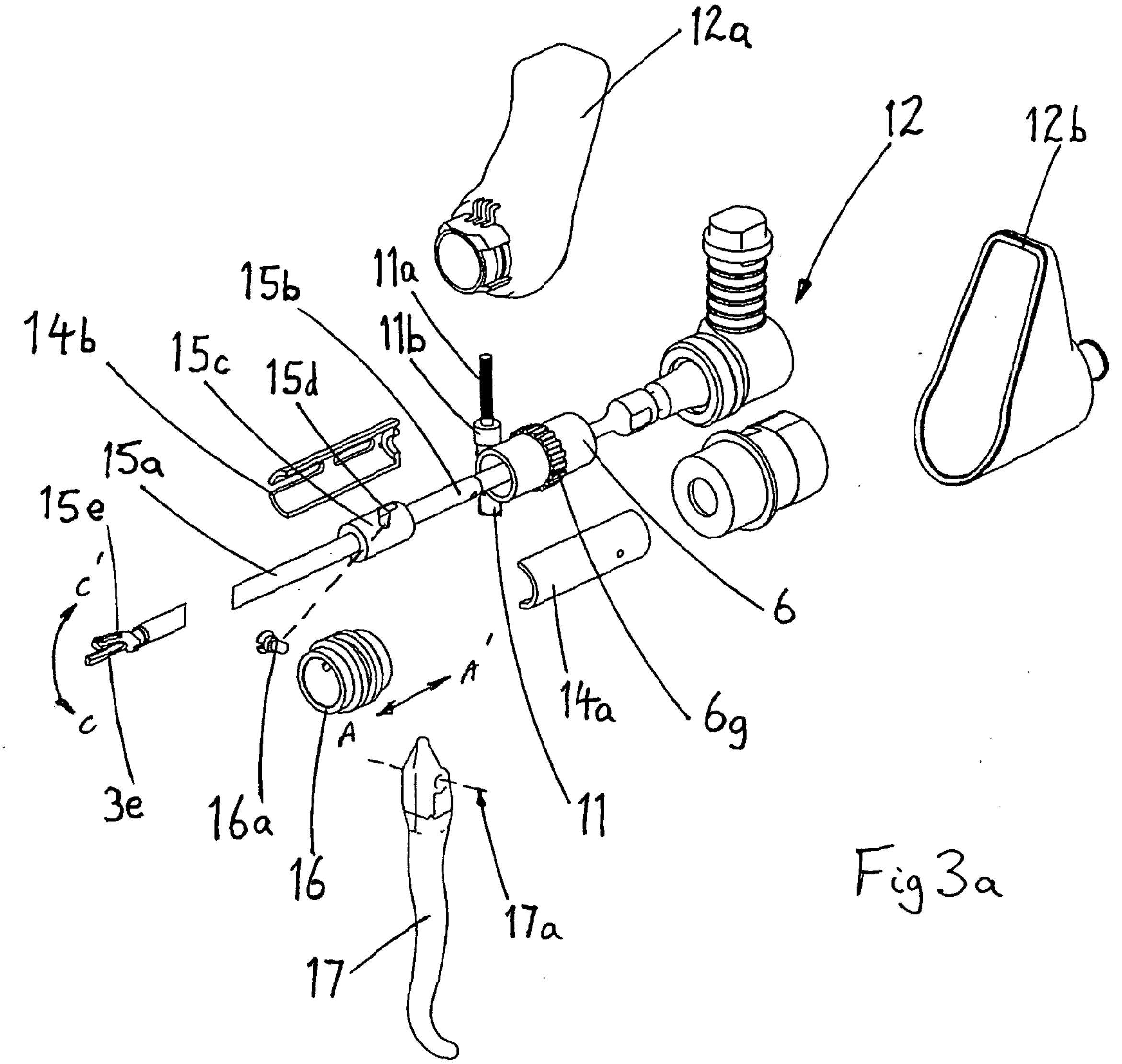


Fig 2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15b
11b
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15c
15d
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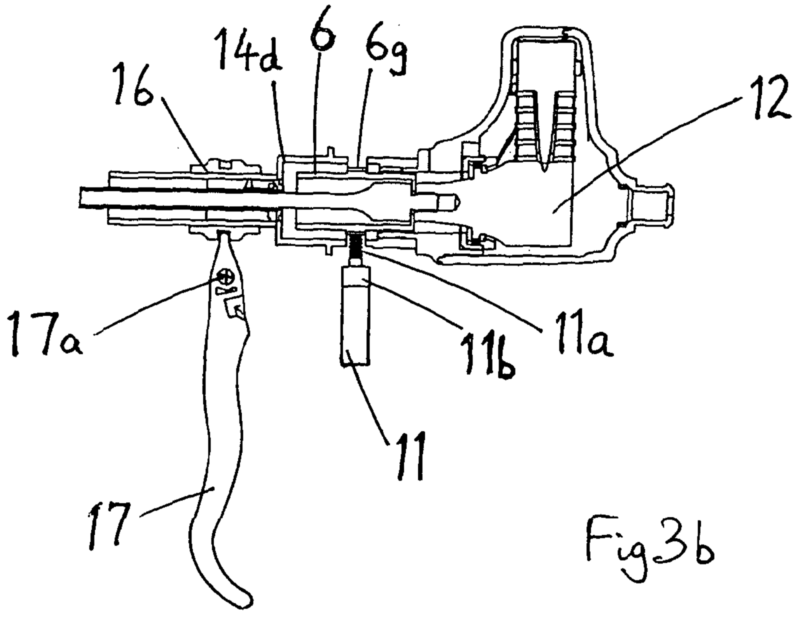
C'
C
A'
A
6
14a
6g
3e
16a
16
11
17a
17

Fig 3a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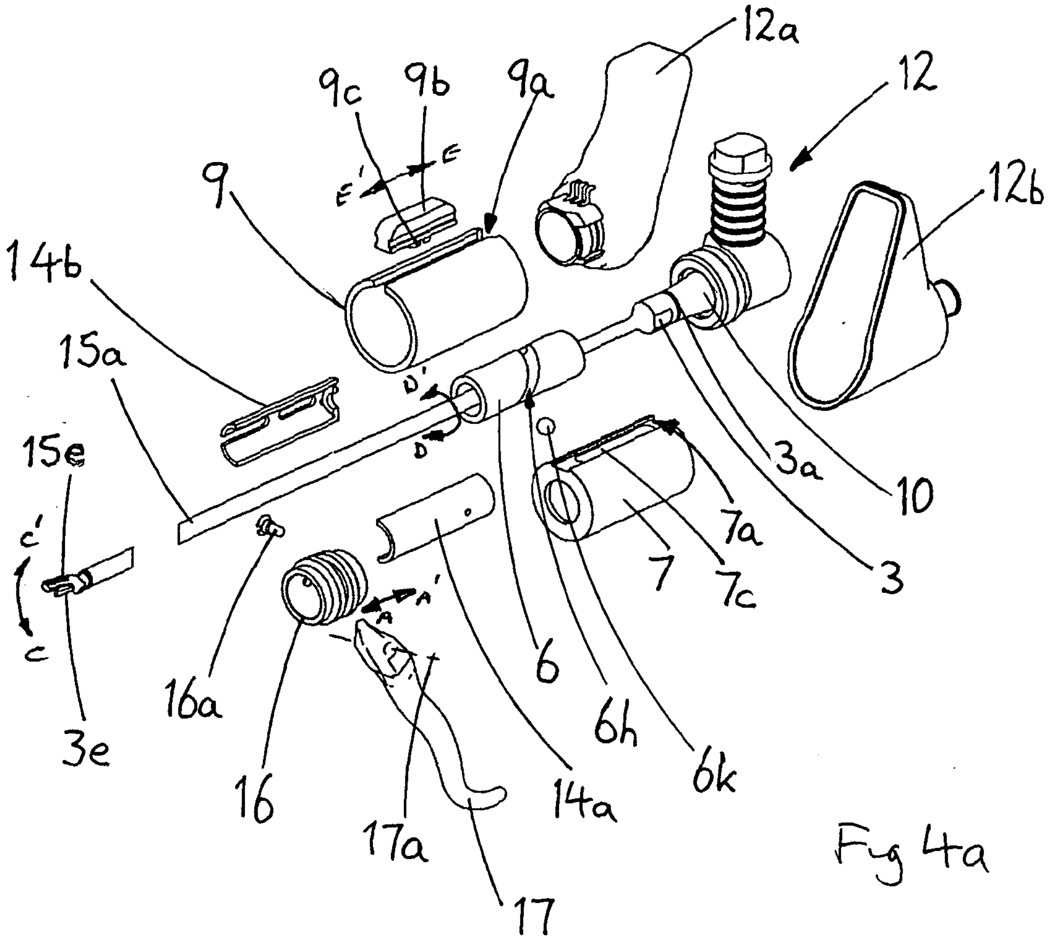
6g
12
17a
11b
11a
11
17

Fig3b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9c
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9a
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9
14b
15a
D'
D
15e
C'
C
3a
10
7a
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7c
3
16a
3e
16
A
A'
6
6h
6k
14a
17a
17

Fig 4a

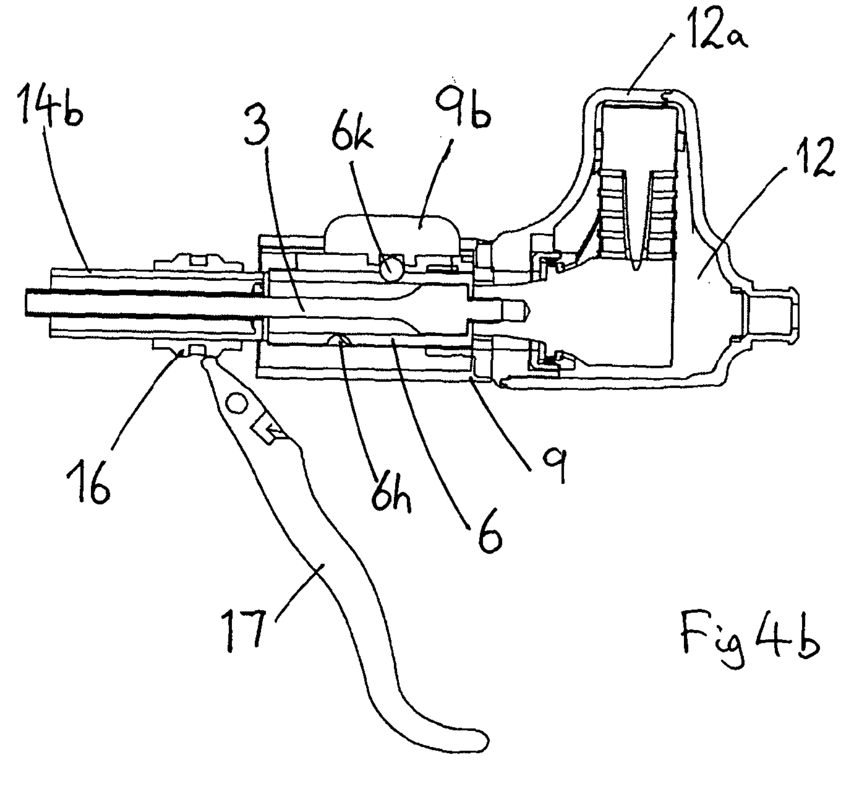
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Fig4b

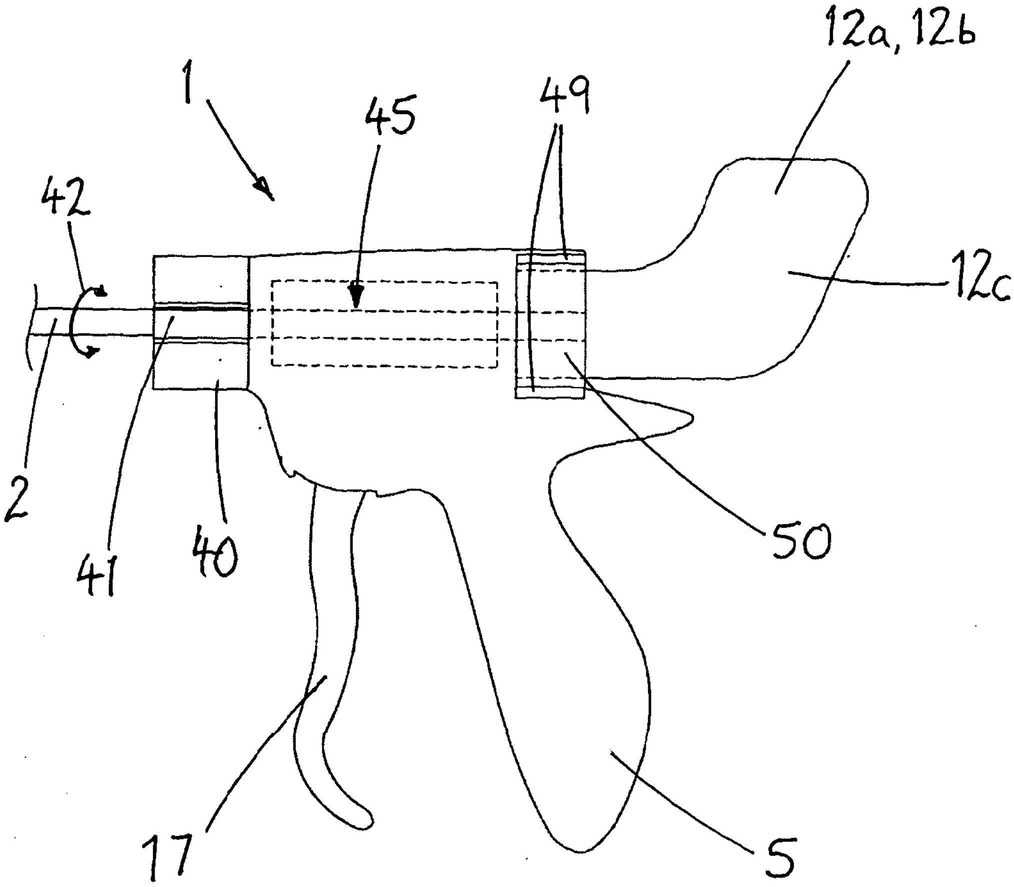


Fig 5

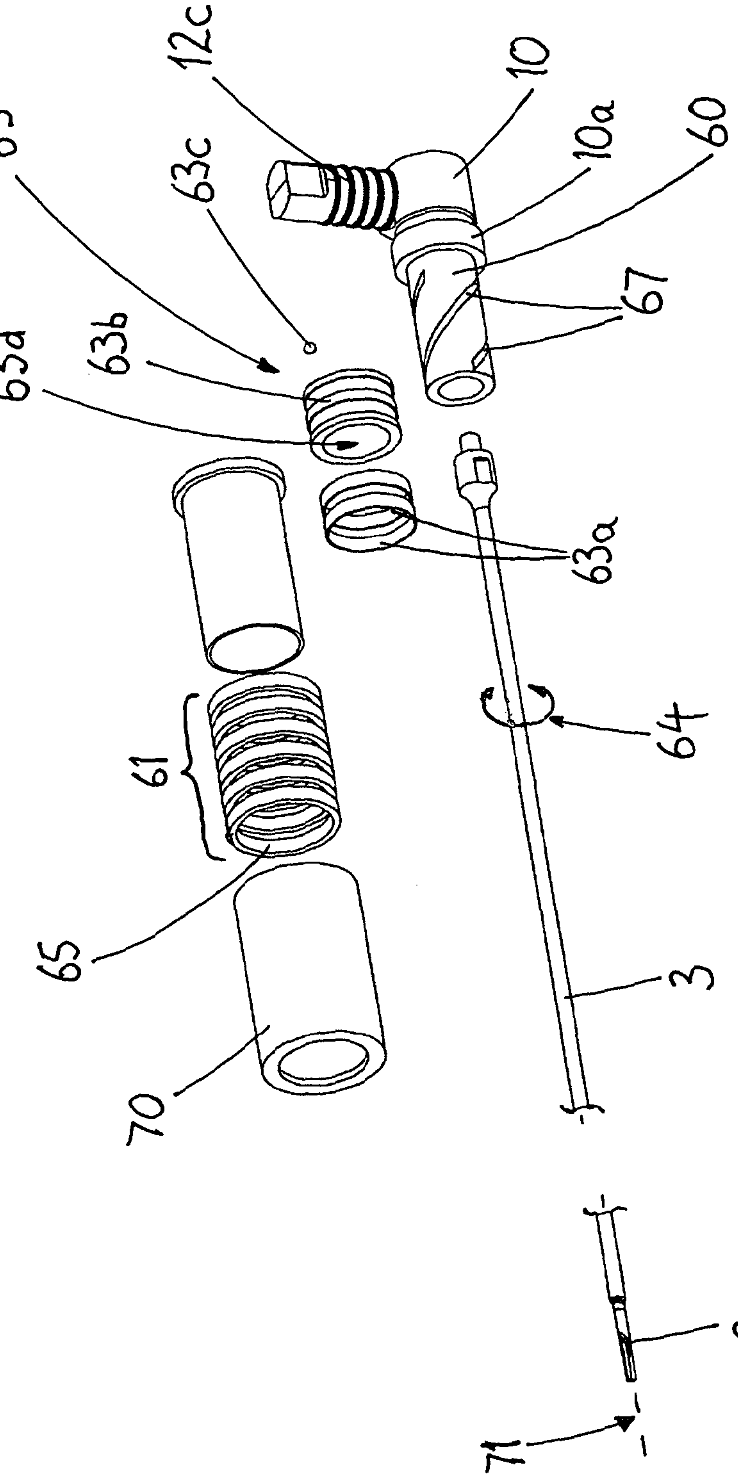


Fig 6

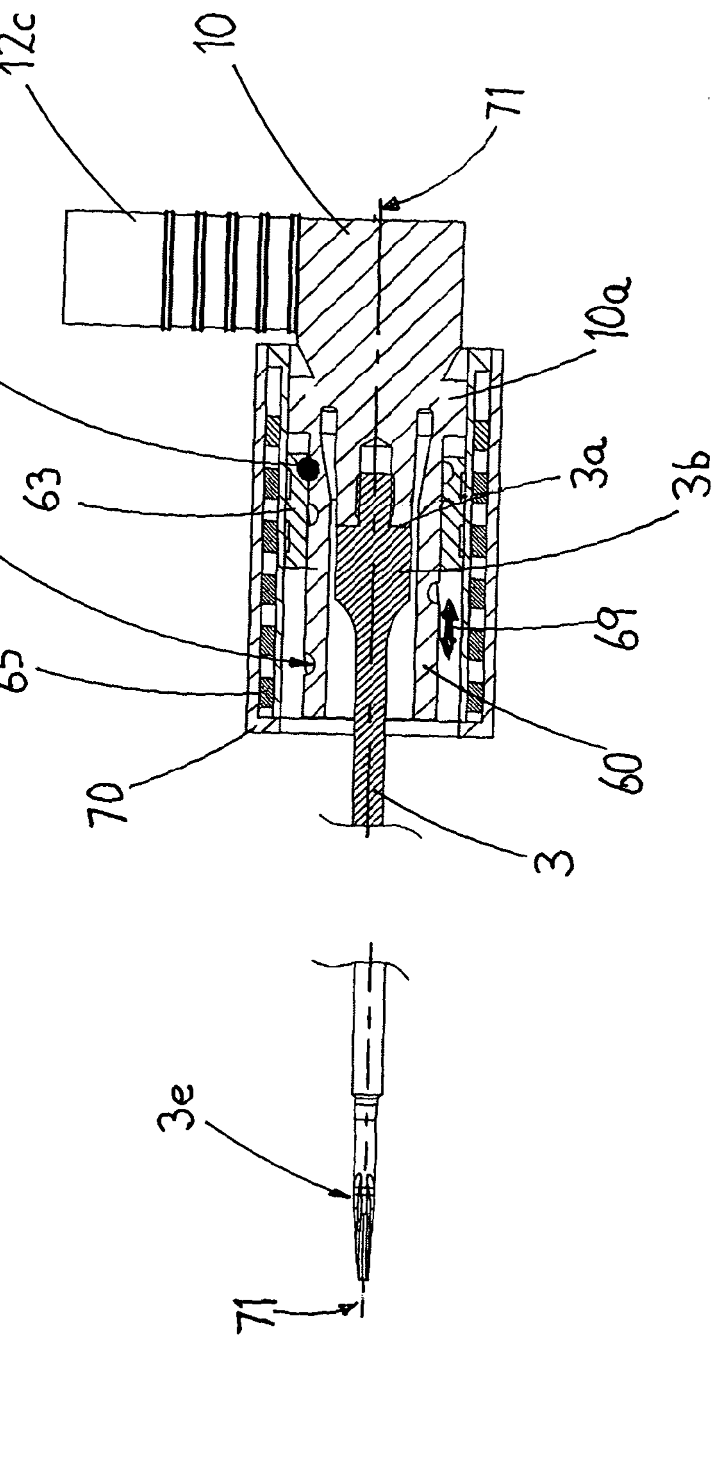
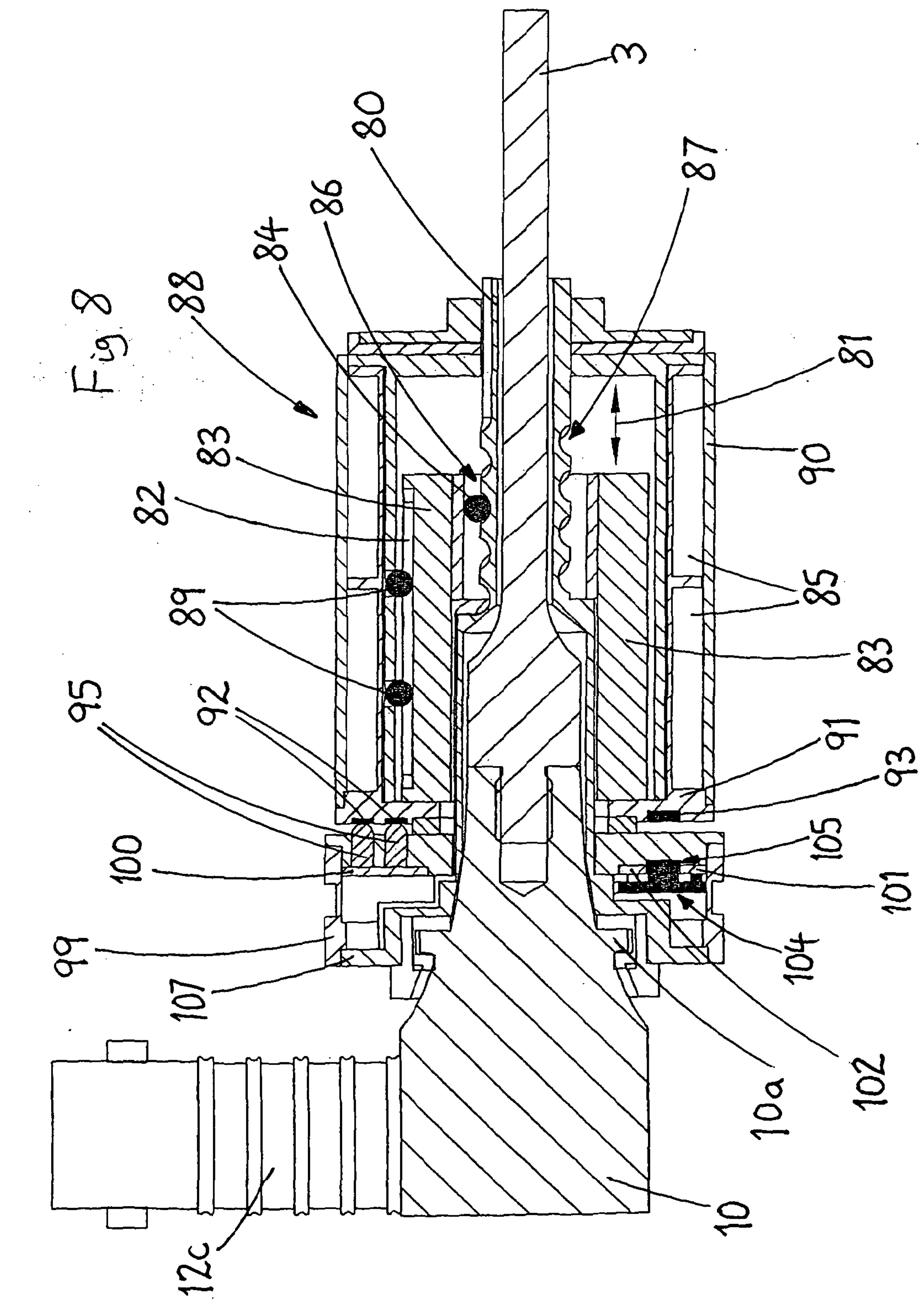


Fig 7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104
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10a
102
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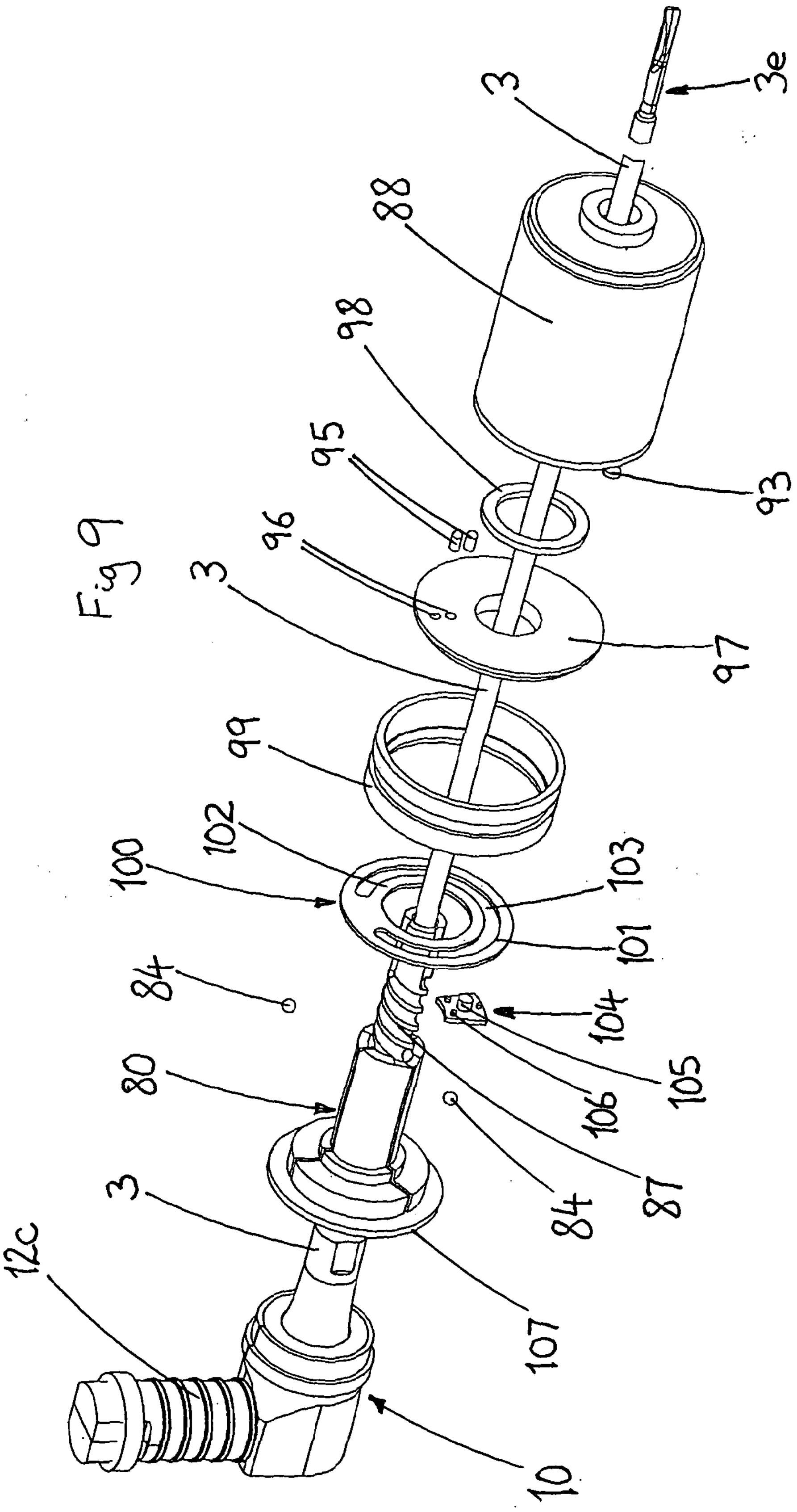
12c

Fig 8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107
12c
10
Fig 9

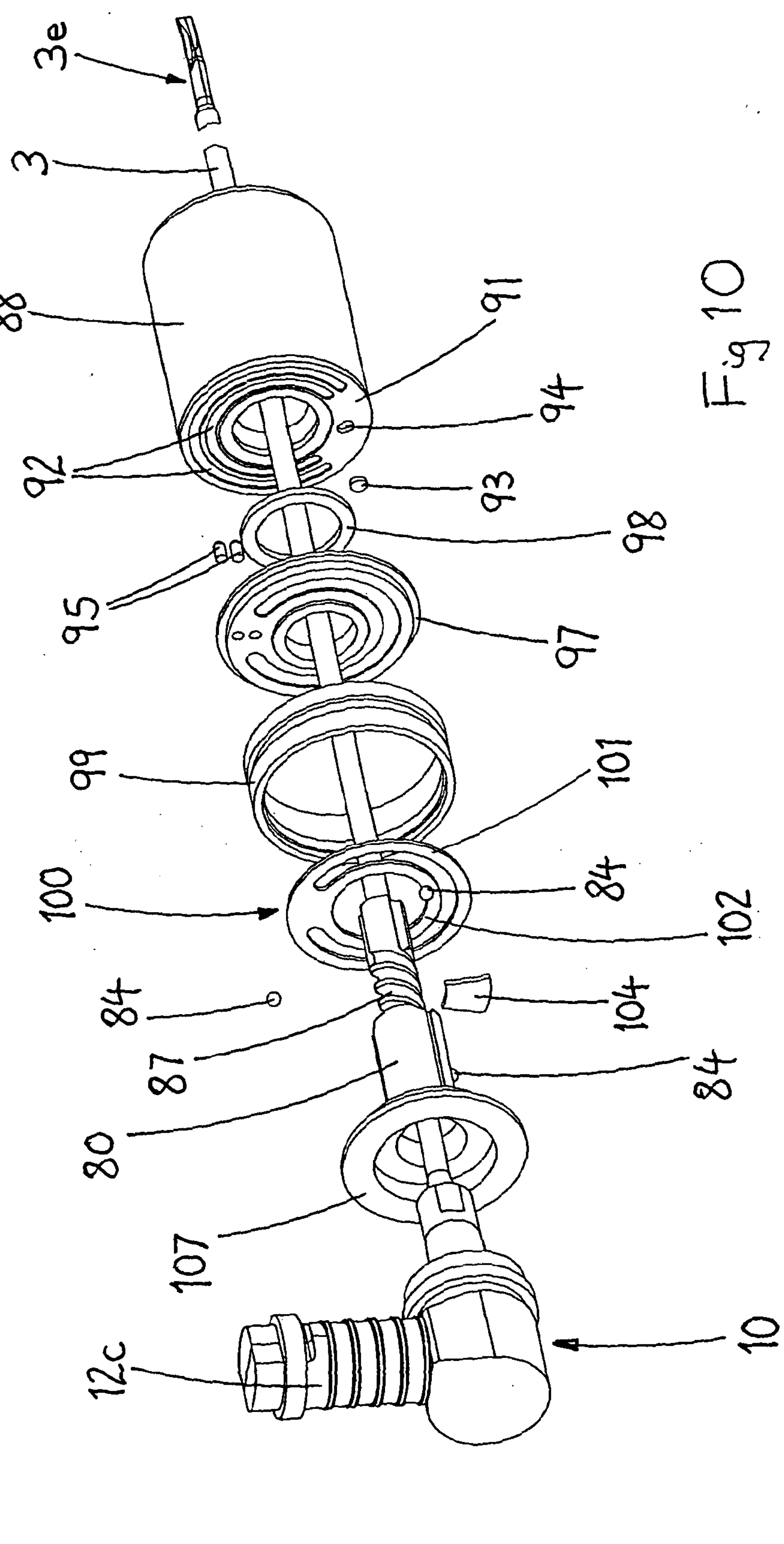

Fig 10

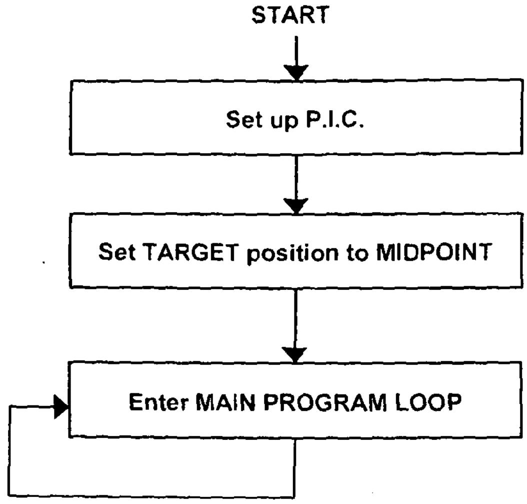

Fig 11a

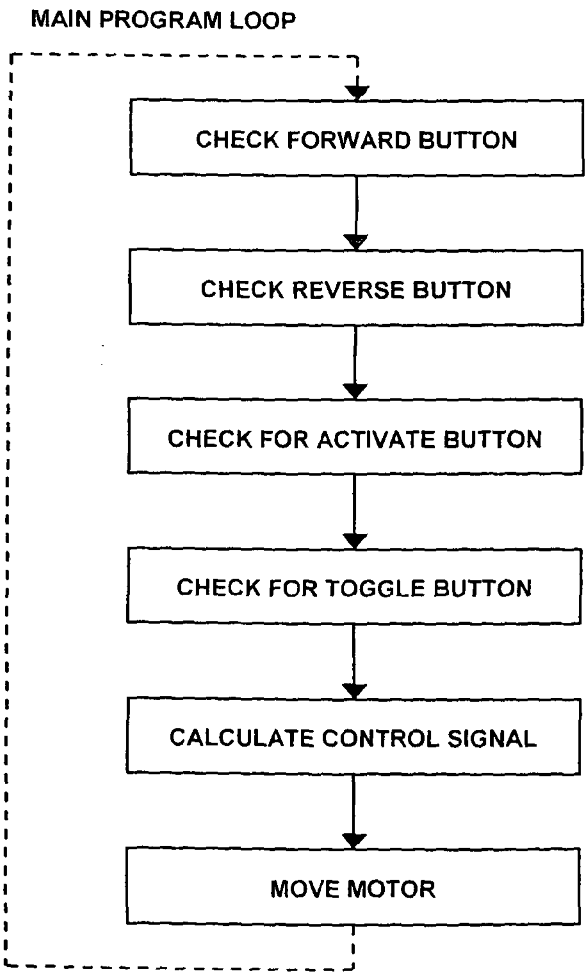

Fig 11b

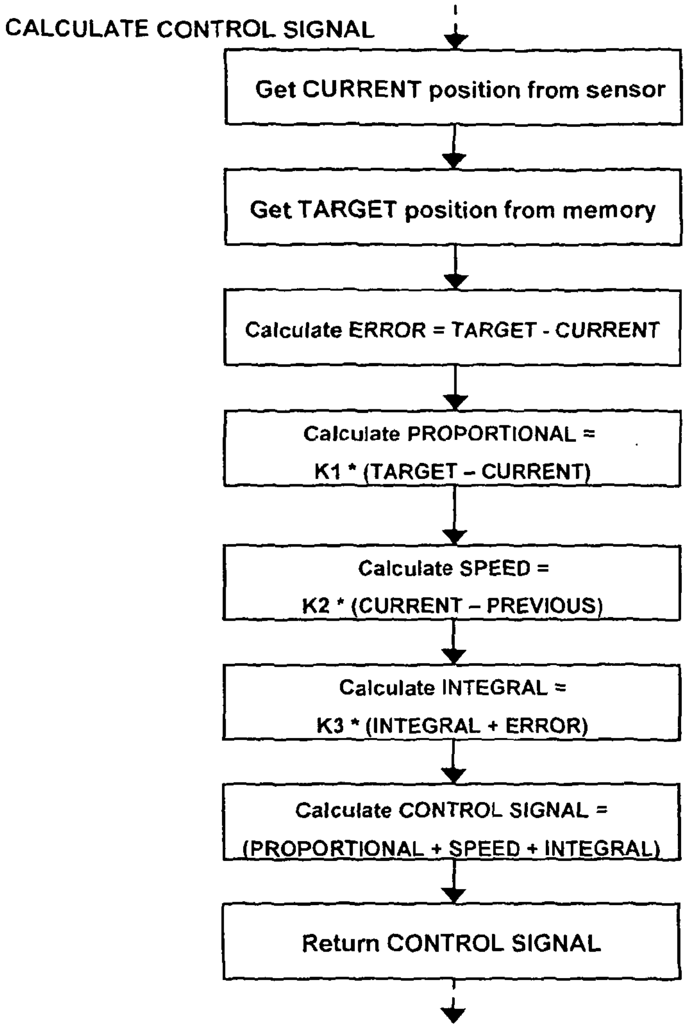

Fig 11c

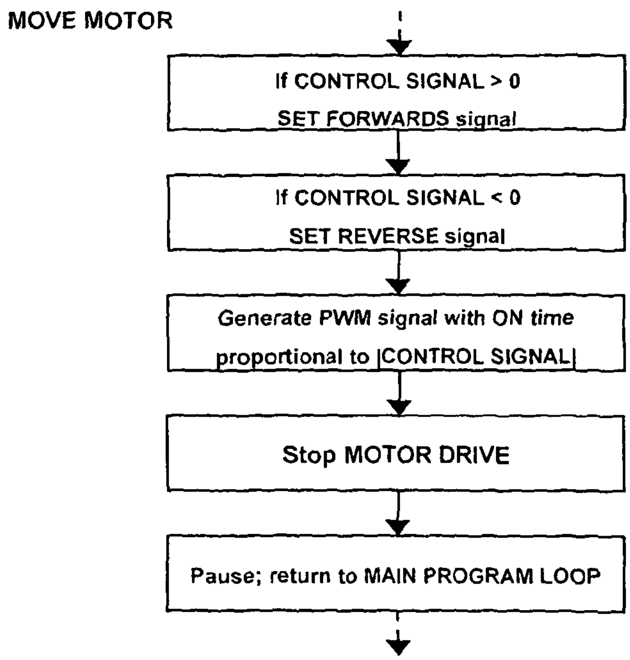

Fig 11d

REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	符合人体工程学的手机，用于腹腔镜和开放手术
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申请日	2011-10-24
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申请(专利权)人(译)	SRA DEVELOPMENTS LIMITED
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优先权	2011002034 2011-02-04 GB 2010020672 2010-12-06 GB 2010019794 2010-11-22 GB 2010017968 2010-10-23 GB
其他公开文献	EP2629685A1
外部链接	Espacenet

摘要(译)

具有细长轴的手术工具在其远端具有定向操作元件，该手术工具设置有使轴和操作元件绕纵向轴线旋转的机构。这允许操作元件与组织元件对准，而不会由使用者进行过多的手移动。在优选方案中，该机构是电动的并且被调节以在所选择的旋转位置之间产生平滑，受控，精确的运动。该机构可包括线性磁电机驱动器，以沿着工具纵向移动驱动元件。该驱动元件与驱动轴上的螺旋结构接合，使得驱动元件的纵向运动被转换成驱动轴以及轴和操作元件的旋转运动，轴安装到该轴和操作元件上。