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(54) ULTRASONIC SURGICAL APPARATUS

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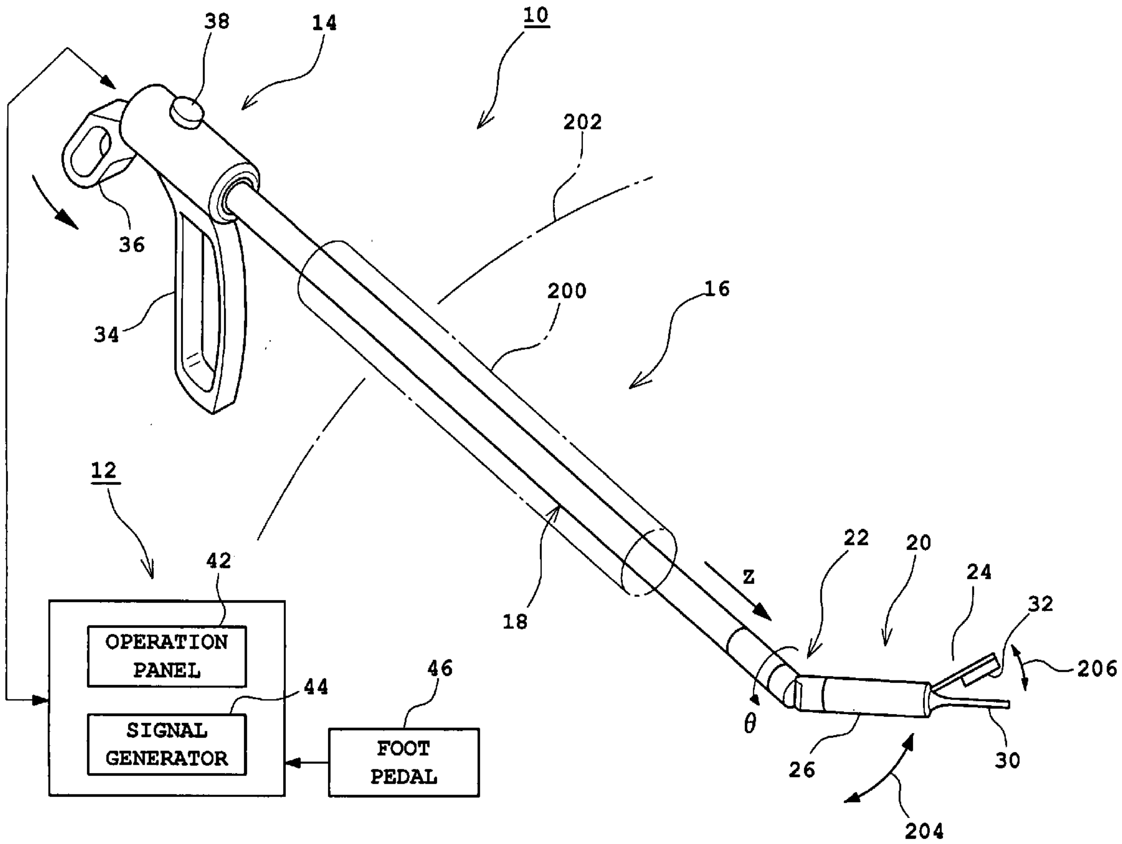
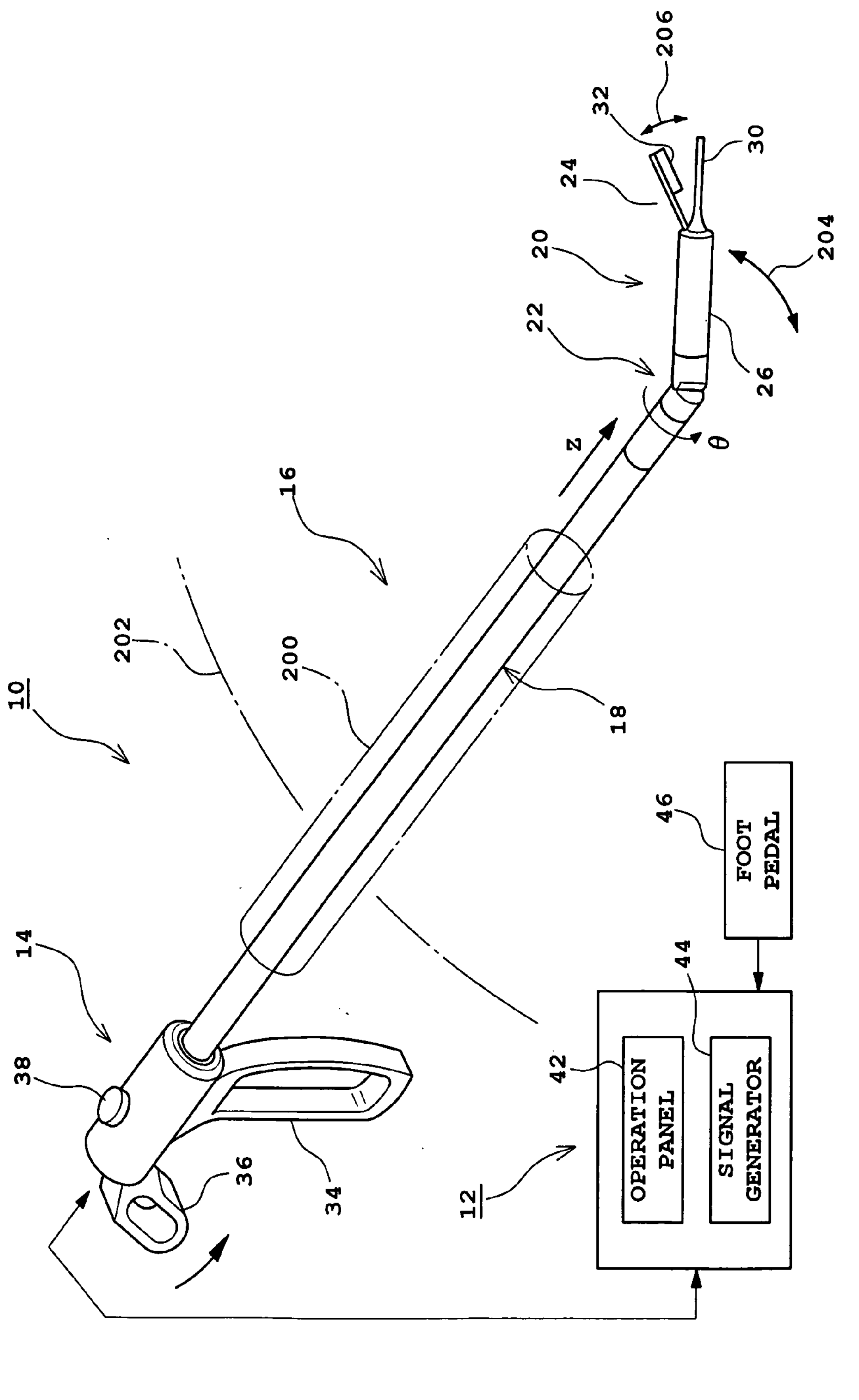
(57) **ABSTRACT**

An ultrasonic surgical apparatus which can be used in laparoscopic surgery. The ultrasonic surgical apparatus includes an inserting unit and an operation unit. The inserting unit is inserted into a guide member called a trocar. The inserting unit includes an elongated member, a tip portion, and also a joint section provided between the elongated member and the tip portion. The tip portion includes a transducer unit and an oscillation member, and preferably further includes a clamp member and an open/close mechanism. The joint section enables the tip portion to be slanted with respect to the elongated member. The operation unit includes a mechanism for operating the joint section, and preferably further includes a mechanism for operating the clamp member. The direction of the oscillation member can be varied by the joint section. Because ultrasonic oscillation is generated in the tip portion, effective transmission of the ultrasonic oscillation to the oscillation member can be achieved.

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OPERATION PANEL
SIGNAL GENERATOR
FOOT PEDAL

Fig.1

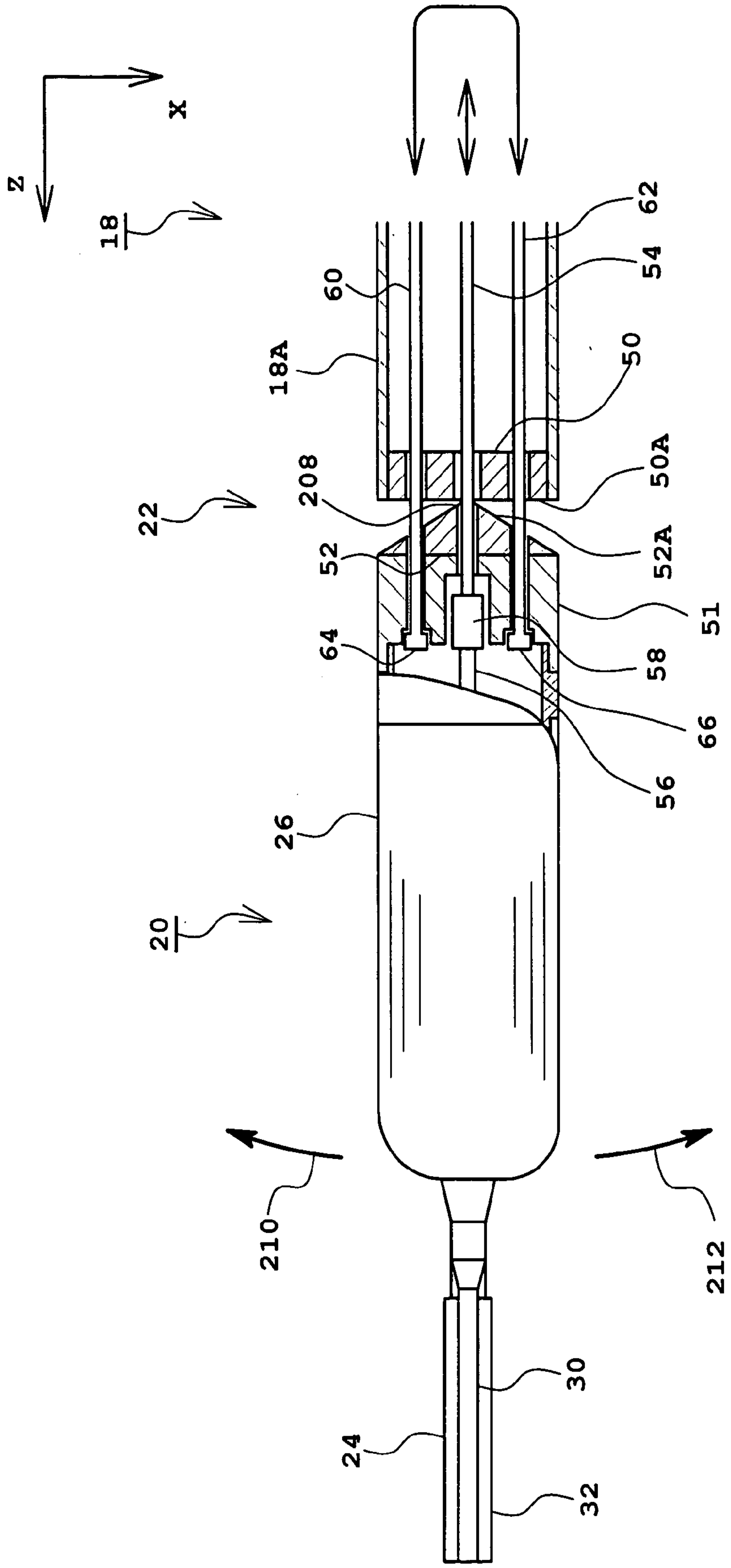
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Fig.2

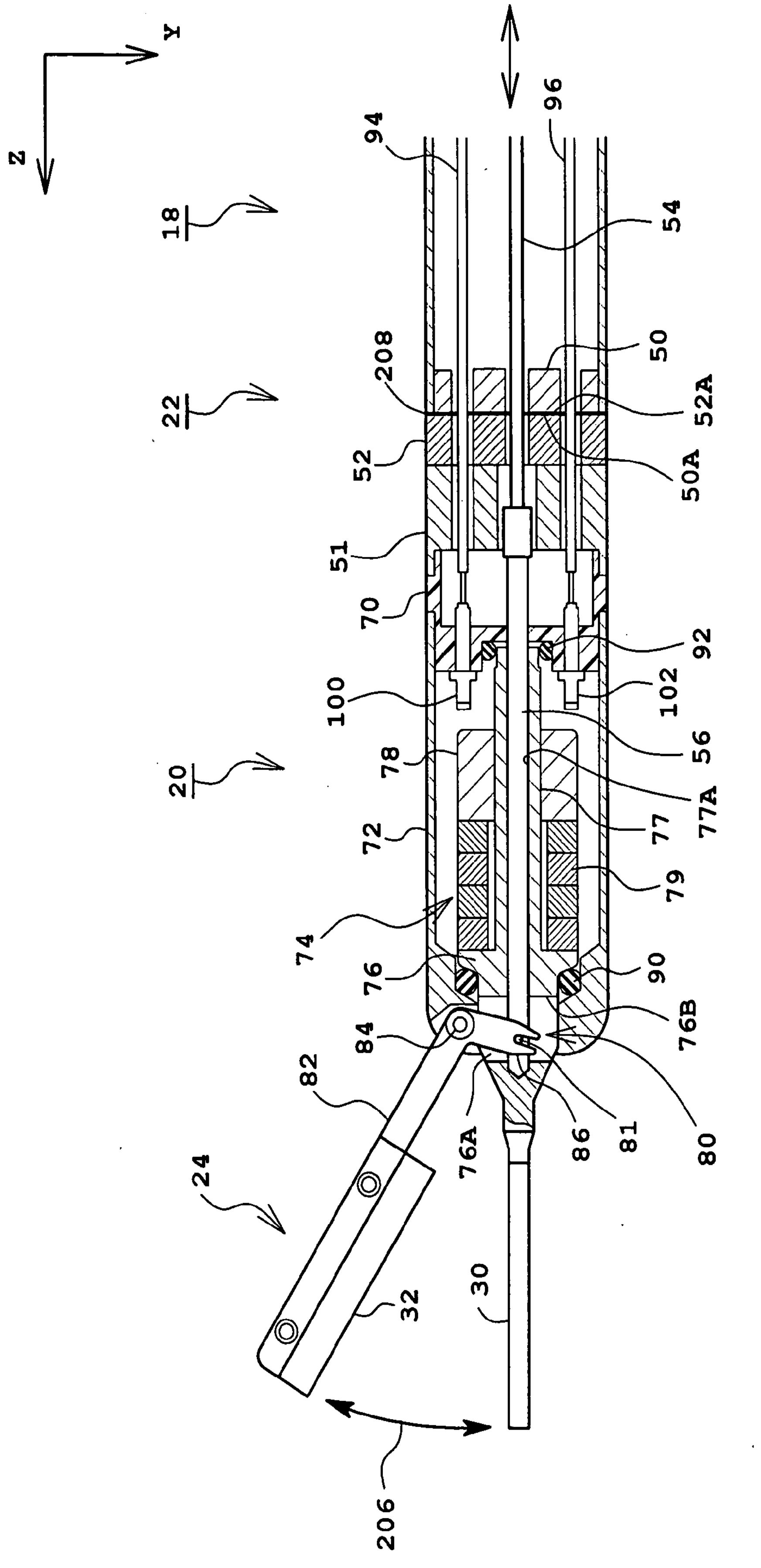

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Fig.3

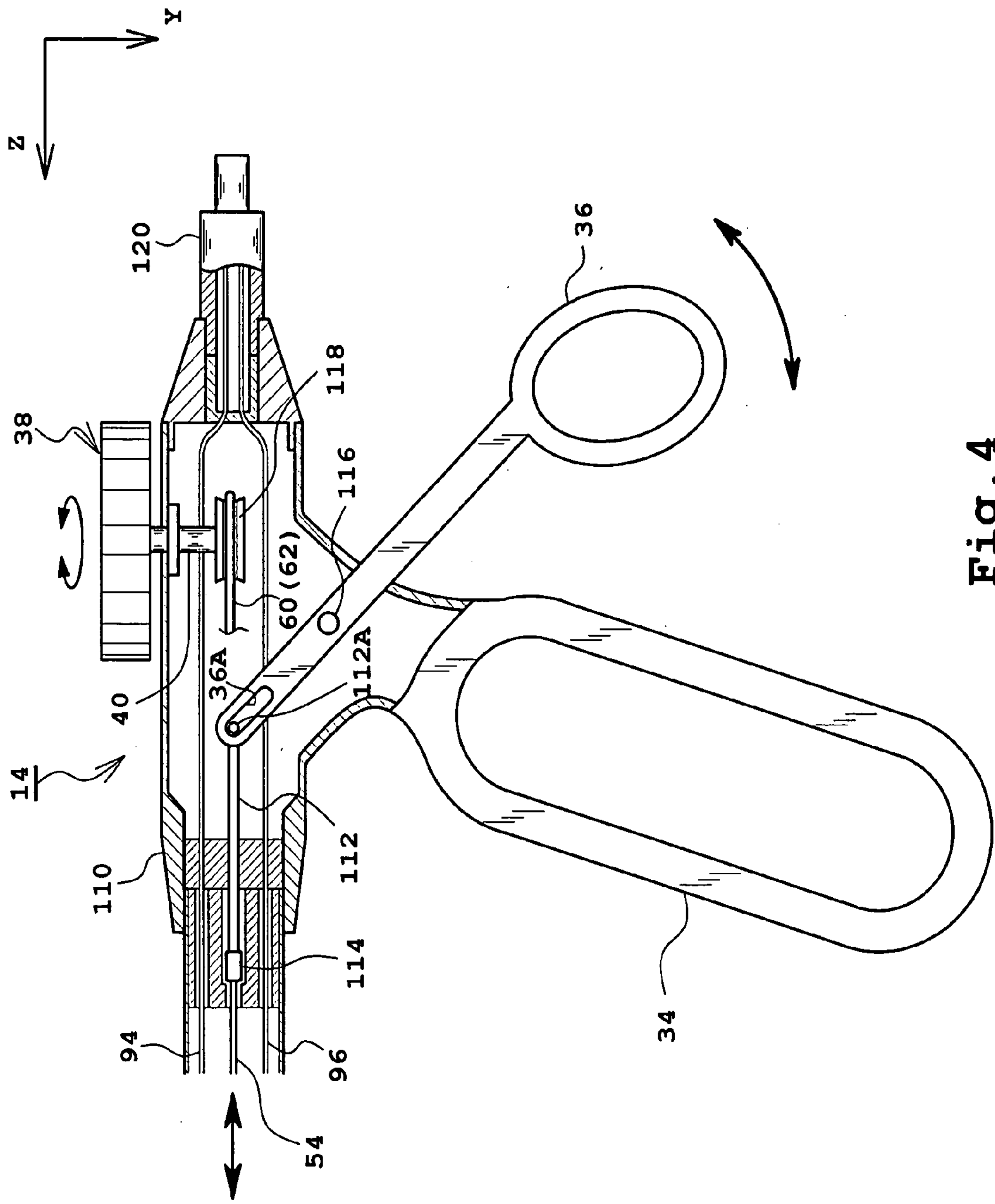


Fig.4

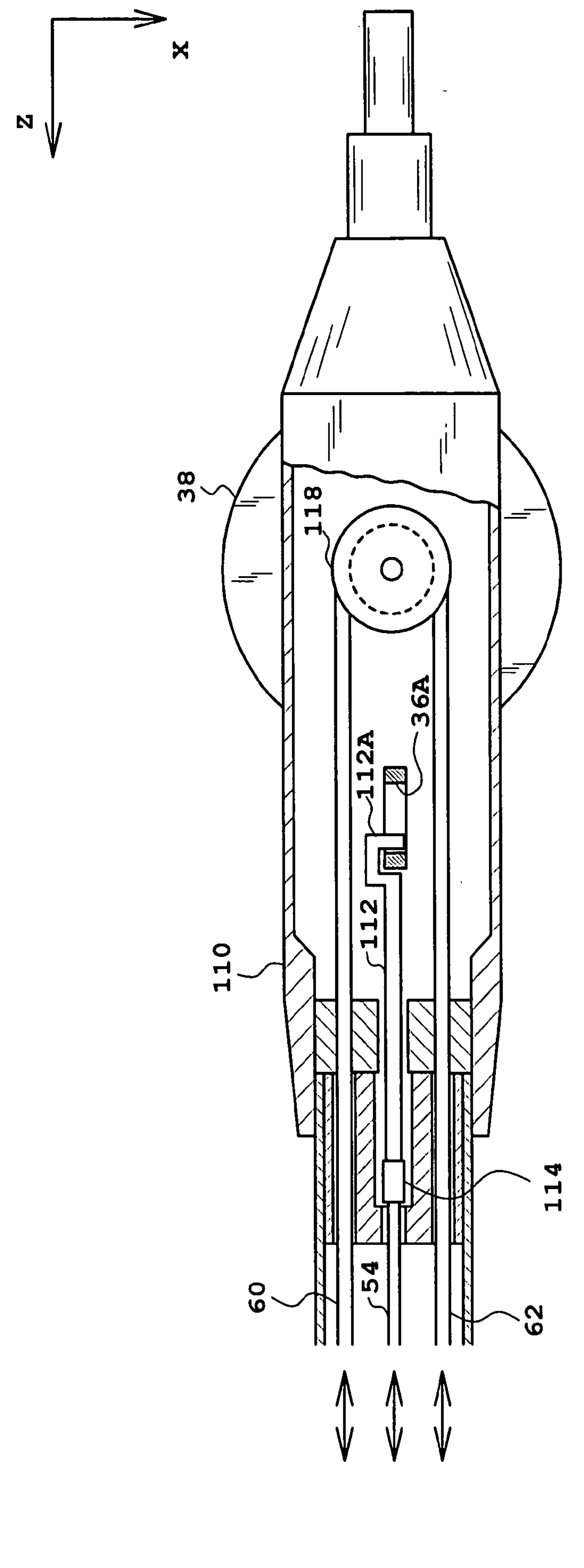


Fig.5

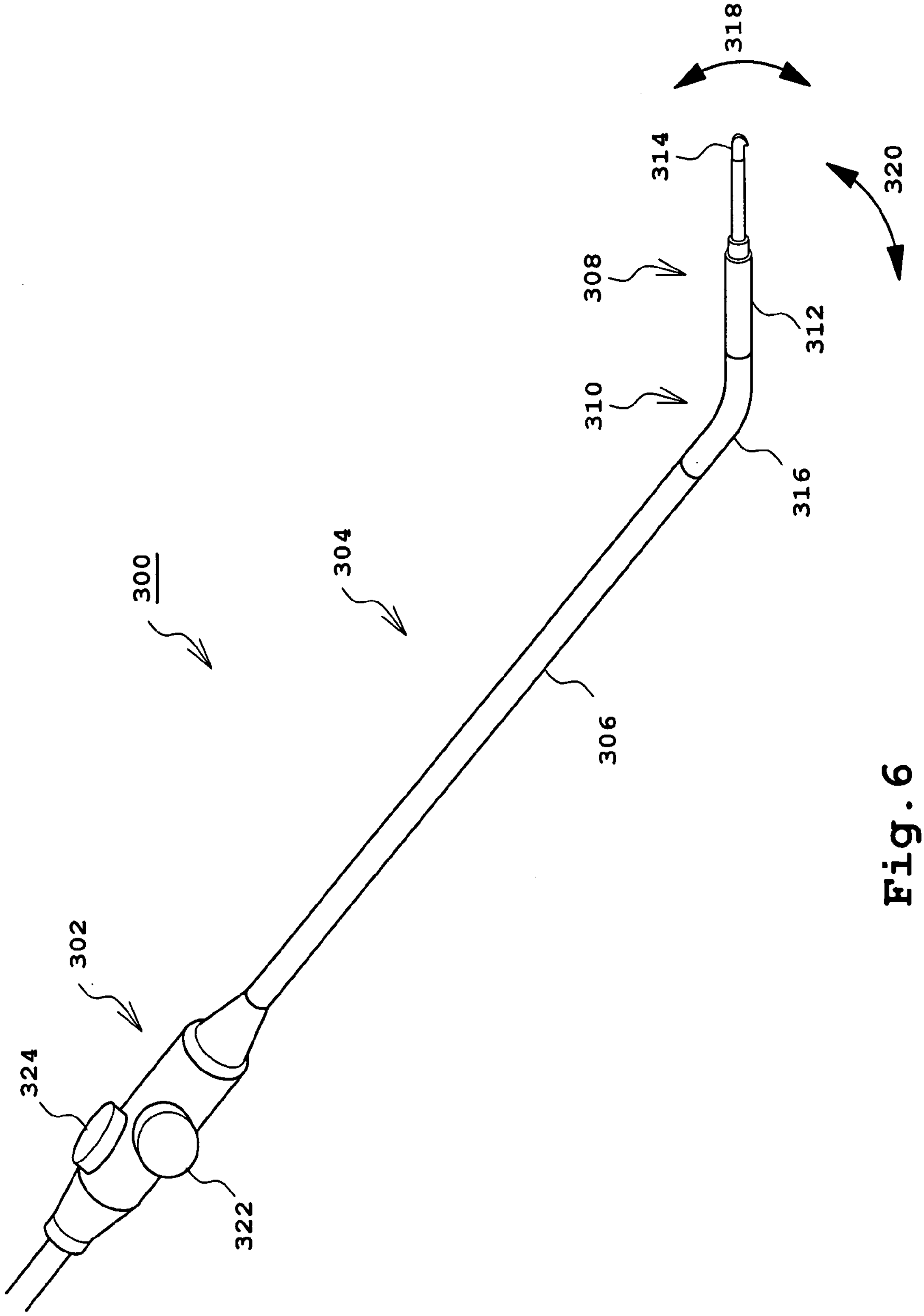


Fig. 6

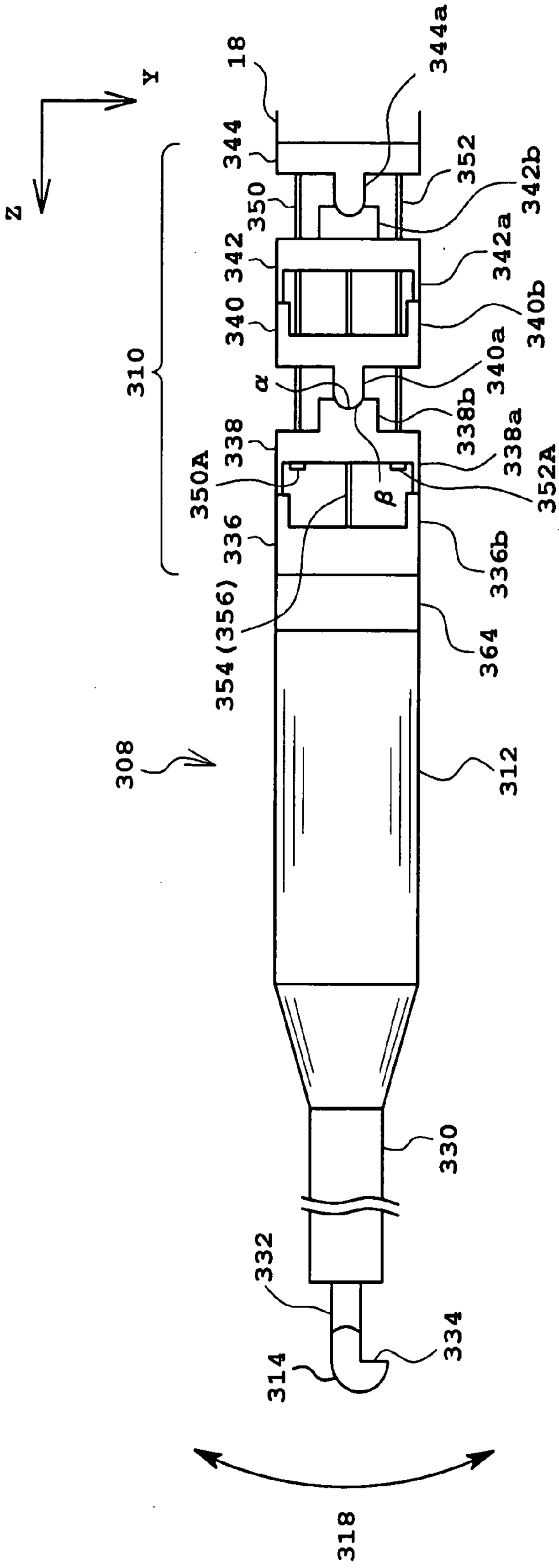
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Fig.7

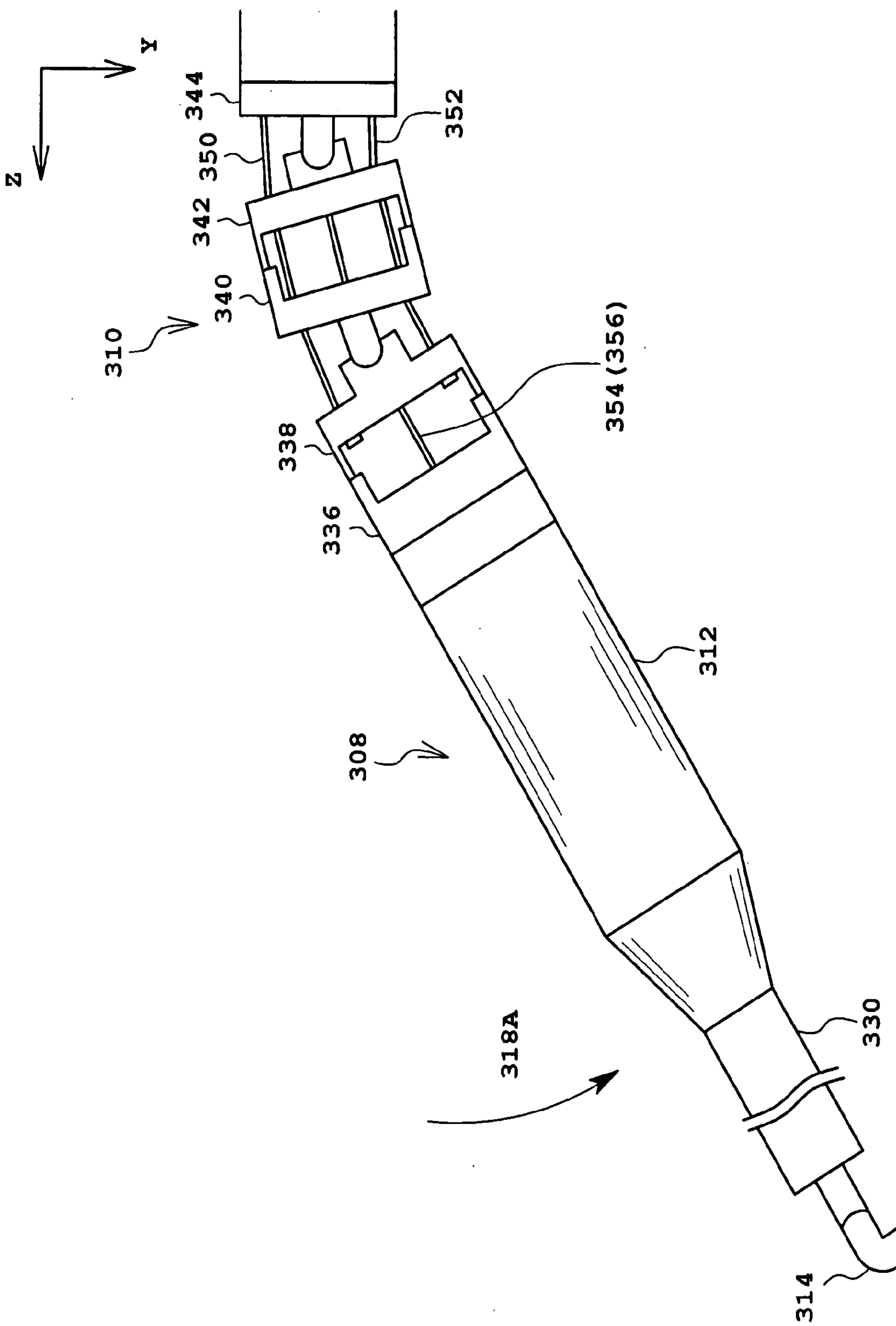


Fig.8

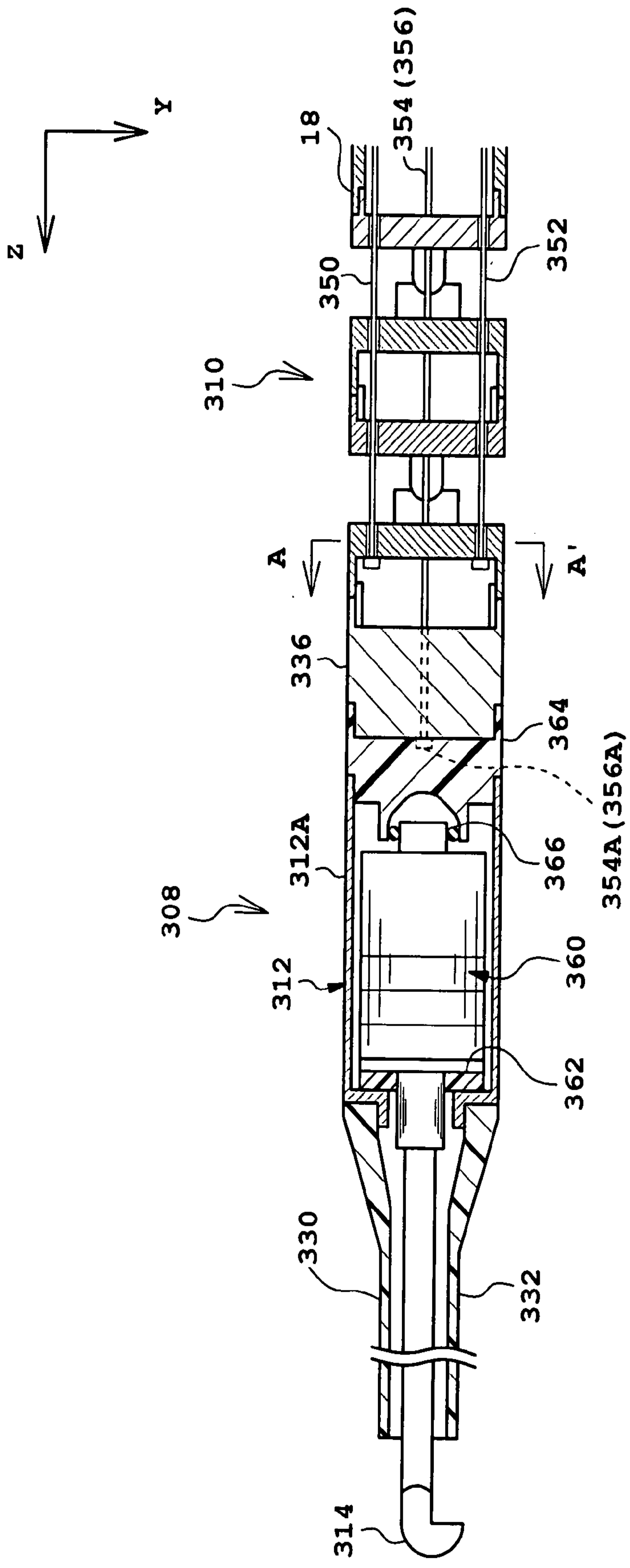
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Fig.9

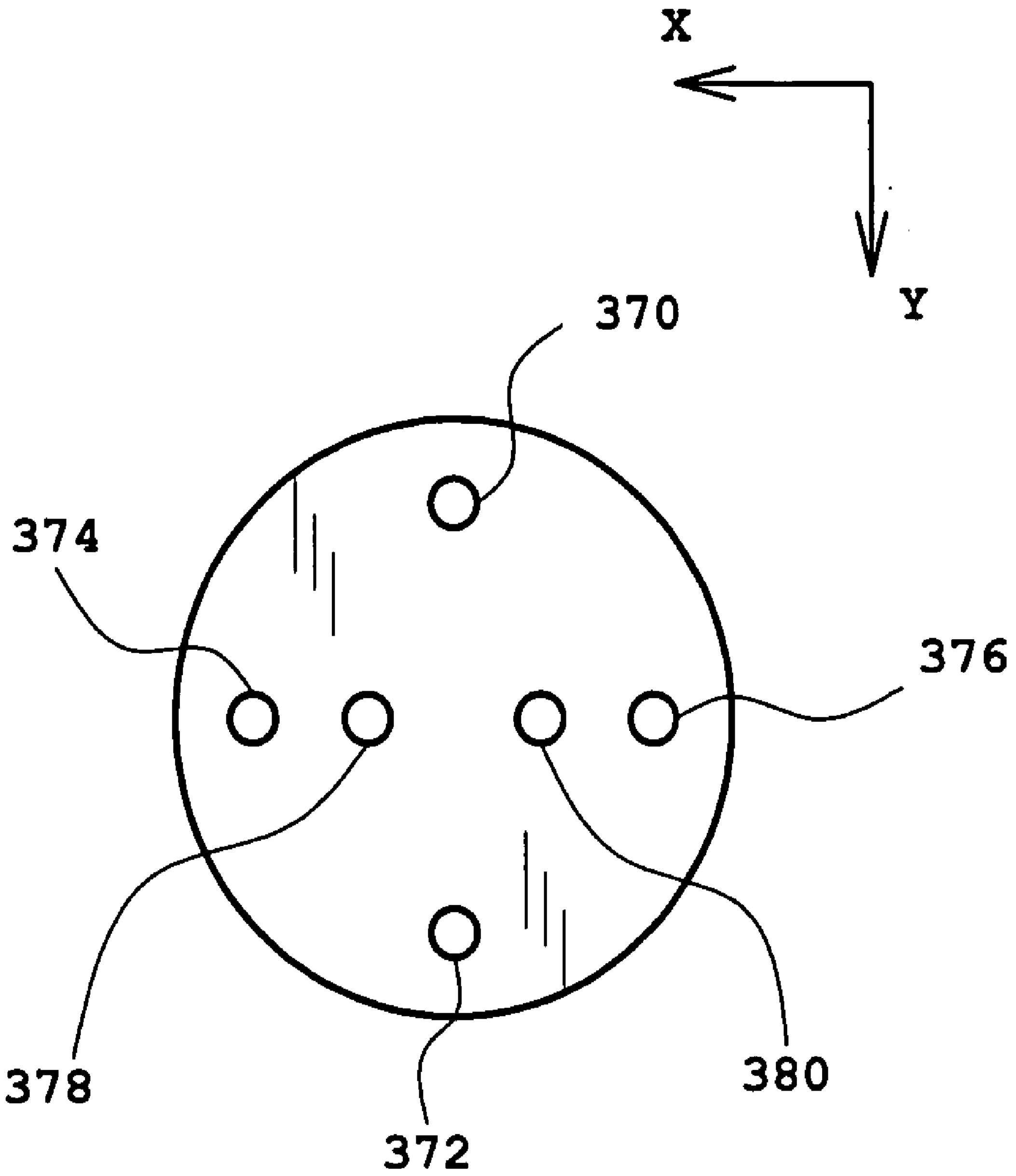


Fig.10

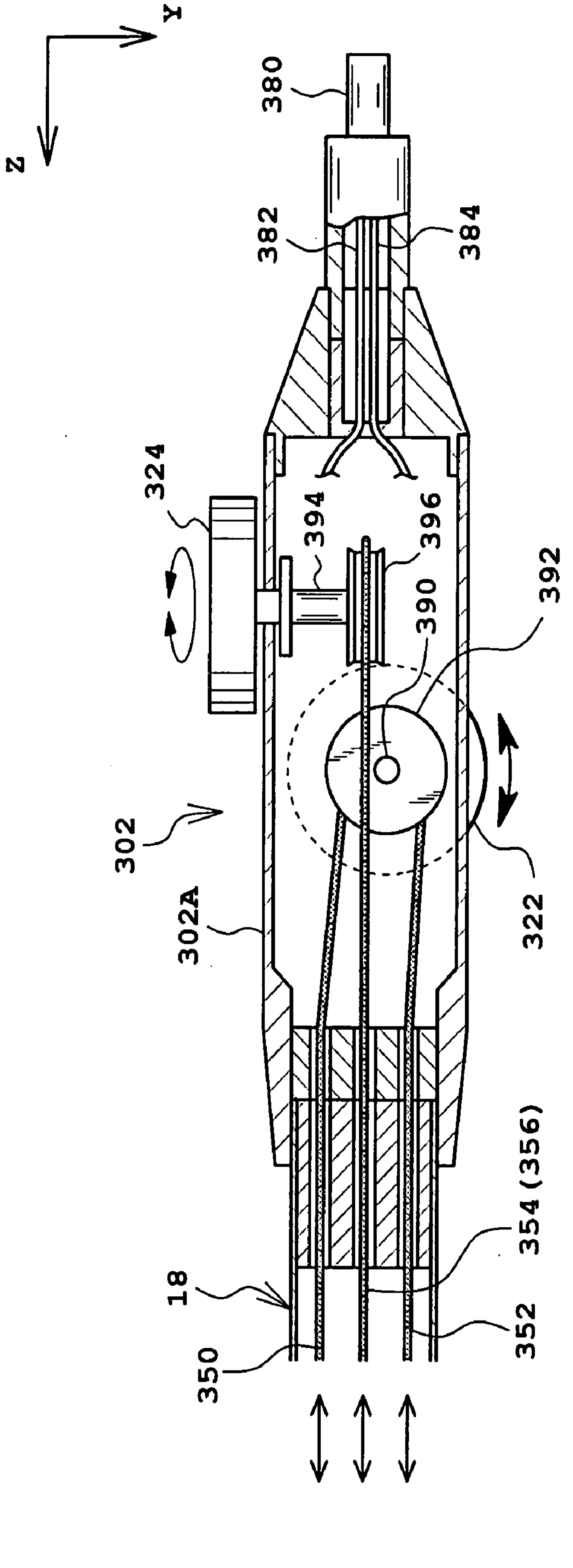
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Fig.11

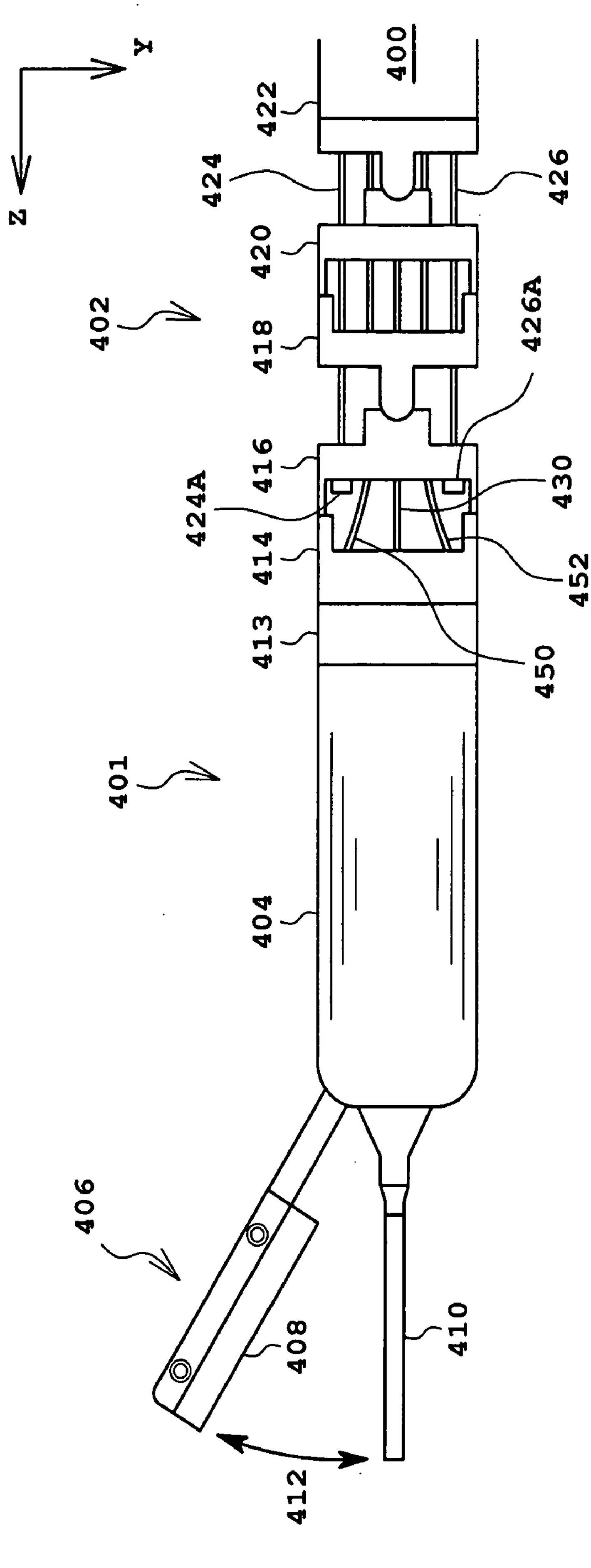
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Fig.12

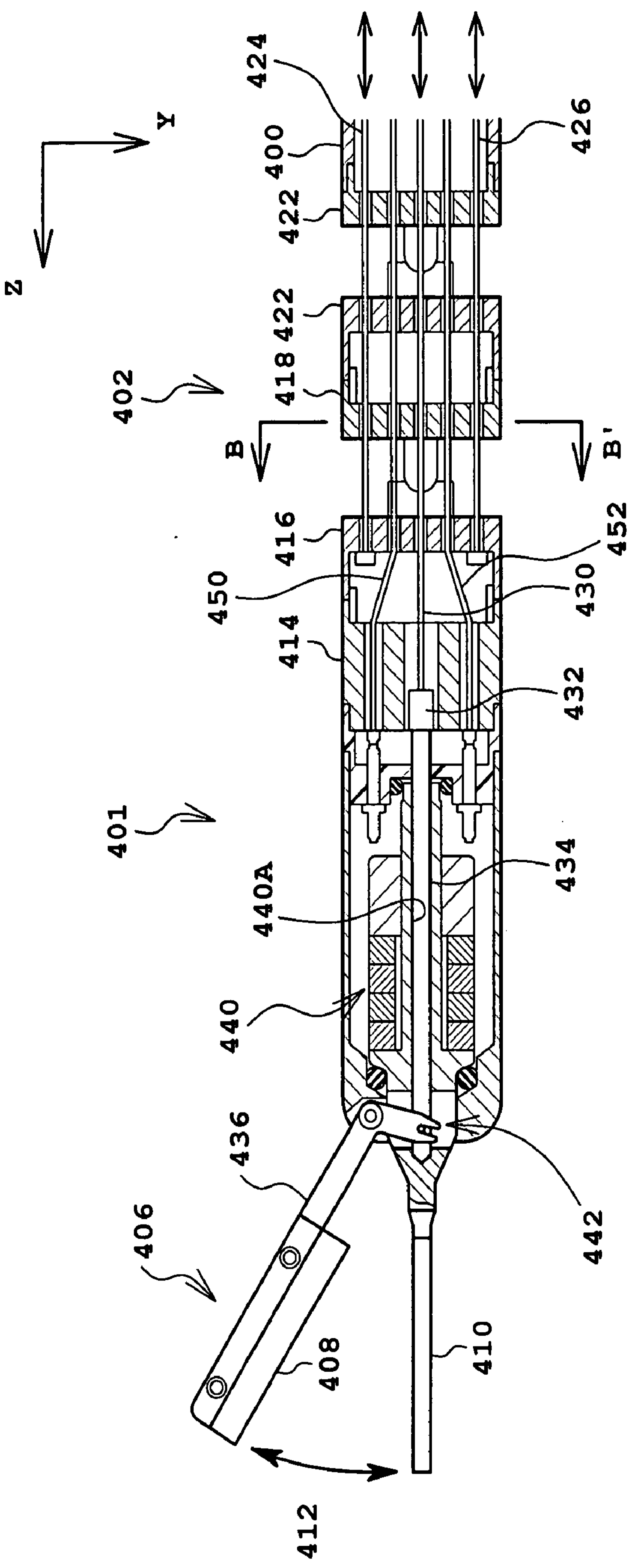
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Fig.13

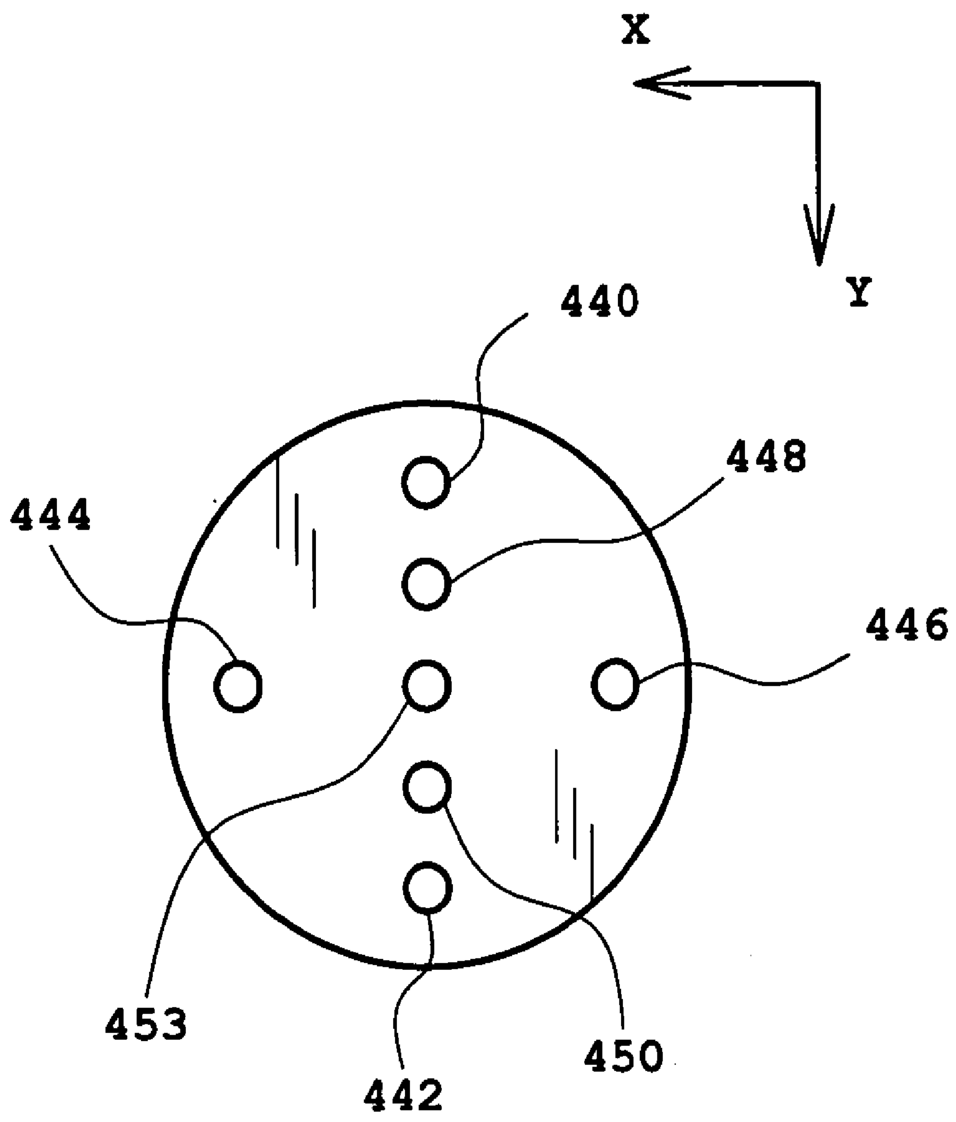


Fig.14

# ULTRASONIC SURGICAL APPARATUS

## BACKGROUND OF THE INVENTION

**[0001]** 1. Field of the Invention

**[0002]** The present invention relates to an ultrasonic surgical apparatus, and more particularly to an ultrasonic surgical apparatus for use in laparoscopic surgery.

**[0003]** 2. Description of Related Art

**[0004]** In the field of surgical treatment as commonly practiced today, surgical operations using a laparoscope are common. In laparoscopic surgery, a tubular guide member called a trocar is introduced into the peritoneal cavity, and various surgical instruments are inserted through this guide member. Usually, a plurality of guide members are used simultaneously, with various instruments such as an endoscope and forceps, and an inserting unit of an ultrasonic surgical apparatus, as desired, are inserted into each guide member.

**[0005]** Conventional ultrasonic surgical apparatuses used for laparoscopic surgery as described above generally include an operation unit having an ultrasonic transducer provided therein and an elongated inserting unit having an oscillation transmission member or a waveguide to which ultrasonic oscillation or ultrasonic vibration is transmitted from the ultrasonic transducer. The inserting unit has, at its leading end, an oscillation member serving as an ultrasonic scalpel, an ultrasonic blade, or an ultrasonic end-effector, to which ultrasonic oscillation generated within the operation unit is transmitted. The oscillation member is brought into contact with body tissue so as to effect ultrasonic surgery including cutting and coagulating the tissue. In conventional ultrasonic surgical apparatuses as described above, ultrasonic oscillation is generated outside a human body and transmitted to the oscillation member introduced into the human body as described above. When positioning the oscillation member within the body, the inserting direction and depth of the oscillation member is adjusted by moving and locating the operation unit.

**[0006]** Published Japanese translation of unexamined PCT application (Kohyo) No. 8-505801 (corresponding to International Laid-Open Publication No. WO94/16631) discloses an ultrasonic surgical apparatus which, in use, sandwiches target issue between an oscillation member and a clamp member. Again, the ultrasonic transducer of the disclosed apparatus is located outside a human body.

**[0007]** Published Japanese translation of unexamined PCT application (Kohyo) No. 2003-527155 (corresponding to International Laid-Open Publication No. WO01/24714) also discloses an ultrasonic surgical apparatus which has an oscillation member and a clamp member. **FIG. 23** and other figures of this publication show an oscillation member having a gently curving shape. Yet again, the ultrasonic transducer of the disclosed apparatus is located outside a human body.

**[0008]** Japanese Patent Laid-Open Publication No. Hei 11-56867 discloses an ultrasonic surgical apparatus in which a disposable ultrasonic transducer is mounted on the leading edge of a holding rod which is to be inserted in a trocar placed within a human body. The ultrasonic transducer is provided with an ultrasonic surgical blade. The leading edge of the holding rod is inserted into the ultrasonic transducer so that both are secured to each other, and the ultrasonic transducer is removable from the holding rod. The diameter of the ultrasonic transducer is greater than that of the holding rod. In other words, the ultrasonic transducer has an increased diameter. It is not possible to change the direction of the blade with respect to the holding rod when the ultrasonic transducer is coupled to the holding rod.

**[0009]** Japanese Patent Laid-Open Publication No. Hei 1-232948 discloses an ultrasonic surgical apparatus having an ultrasonic transducer provided at the base end (outside the body) of an inserting unit and an operation rod capable of forward/backward movement and extending through the ultrasonic transducer.

**[0010]** Japanese Patent Laid-Open Publication No. Hei 1-232949 also discloses an ultrasonic surgical apparatus having an ultrasonic transducer provided at the base end (outside the body) of an inserting unit and a rod-shape member (auxiliary member for cutting tissue) capable of forward and backward movement and extending through the ultrasonic transducer.

**[0011]** For ultrasonic surgery using a laparoscope, if the inserting unit to be inserted into the guide member is a simple rod-like member whose shape cannot be changed, the following problems occur when guiding an oscillation member serving as a surgical instrument toward a target site of the surgery. One problem, for example, is that it is difficult to bring the oscillation member into contact with tissue located at the back of certain tissue. As another example, the ultrasonic surgical operation must be performed with the inserting unit being held at a forced angle, which lowers operability of the apparatus or makes it difficult to increase safety. Even with an oscillation member having a curving shape, the above problems remain unsolved as long as the degree of the curvature is fixed. The degree of curvature must be determined such that the curving oscillation member can be inserted into the guide member. Further, when the oscillation member is greatly curved, unnecessary lateral oscillation is likely to occur.

**[0012]** U.S. Pat. No. 6,063,098 describes an ultrasonic surgical device having a surgical blade, a clamp member, and a joint section. The joint section enables the surgical blade and the clamp member to change their position and direction within the body. Ultrasonic oscillation generated in the ultrasonic transducer located outside the body is transmitted to the surgical blade through a long waveguide, which is formed by a plurality of members connected together so as to have flexibility by itself. The above-described structure suffers from a problem in that energy is lost during transmission of ultrasonic oscillation.

**[0013]** U.S. Pat. No. 5,413,107 discloses an ultrasonic probe having a joint section. However, this is not an ultrasonic surgical apparatus.

## SUMMARY OF THE INVENTION

**[0014]** The present invention advantageously provides an ultrasonic surgical apparatus capable of achieving increased operability and a high level of safety during ultrasonic surgery.

**[0015]** The present invention advantageously provides an ultrasonic surgical apparatus which advantageously achieves a high degree of freedom for positioning of a surgical unit for effecting coagulation and cutting of tissue.

[0016] The present invention advantageously provides an ultrasonic surgical apparatus in which the size of a tip portion to be inserted into a living body can be reduced.

[0017] (1) In accordance with one aspect of the present invention, there is provided an ultrasonic surgical apparatus comprising an inserting unit, and an operation unit which is provided at an end of the inserting unit to be located outside of a living body, the inserting unit including an elongated member, a tip portion provided at the leading end of the elongated member, and a joint section which varies the direction of the tip portion with respect to the elongated member, and the tip portion further including a transducer unit for generating ultrasonic oscillation, and an oscillation member to which the ultrasonic oscillation generated in the transducer unit is transmitted and which comes into contact with tissue of a living body.

[0018] With the above-described structure, the joint section provided in the inserting unit enables the tip portion to change its direction with respect to the elongated member. More specifically, the tip portion is provided with the oscillation member for effecting coagulation and cutting of body tissue, and the position and orientation of the oscillation member can be varied easily by operation of the joint section. This facilitates ultrasonic surgery toward target tissue located on the back side of certain tissue and also allows a variation of methods in which the oscillation member approaches the target tissue, thereby increasing safety. When inserting the inserting unit into a guide member and extracting the inserting unit from. the guide member, a state in which a virtual central axis in elongated member is matched to a virtual central axis in the tip portion (non-bending state of the joint section) is generally established. The joint section is formed by one or more joint mechanisms (bending mechanisms). The joint section may include a rotating mechanism for causing the tip portion to rotate about the central axis of the elongated member or may include a mechanism for causing the tip portion to oscillate in an arbitrary three-dimensional direction.

[0019] With this structure, a transducer unit is provided within the tip portion which is to be introduced into a living body, and ultrasonic oscillation is generated within the living body. As a result, unlike in the conventional devices, it is not necessary to transmit ultrasonic oscillation from the operation unit side (namely from outside the body) to the tip portion (namely to inside the body). Further, because the transducer unit is provided beyond the joint section toward the forefront end of the apparatus, the necessity of transmitting ultrasonic oscillation via the joint section can be eliminated. Consequently, a problem of energy loss caused when transmitting ultrasonic oscillation over a long distance or via the joint section to the tip portion can be solved.

[0020] Preferably, the joint section causes the tip portion to move in at least one direction with respect to the elongated member. Alternatively, the joint section causes the tip portion to move in an arbitrary direction with respect to the elongated member. The direction of movement of the tip portion is set fixedly or arbitrarily. The range in which the movement of the tip portion is allowed is set fixedly or arbitrarily.

[0021] Preferably, the tip portion further includes a clamp member for sandwiching the tissue with the oscillation member, and an open/close mechanism for causing the clamp member to open and close. With this structure, the oscillation member and the clamp member form a surgical unit. With body tissue being held by the surgical unit, ultrasonic oscillation is transmitted from the oscillation member to the body tissue for effecting coagulation and cutting of the tissue.

[0022] The tip portion may also include, in addition to the open/close mechanism, a mechanism for generating an open/close drive force. However, in order to reduce the size of the tip portion, it is desirable to provide a mechanism for generating an open/close drive force on the operation unit side and transmit the open/close drive force from the mechanism to the open/close mechanism via the joint section. Further, while a mechanism for generating a bending drive force may be provided on the joint section, in order to reduce the size of the inserting unit, it is desirable to provide such a mechanism for generating a bending drive force on the operation unit, which then transmits the bending drive force to the joint section.

[0023] A clamp member having a plurality of different clamp surfaces may be provided in the tip portion. In this case, a clamp surface to be actually used is selected by rotation of the clamp member itself, for example. Similarly, the oscillation member may have a plurality of different tissue contact surfaces. In this case, a tissue contact surface to be actually used is selected by, for example, rotation of the oscillation member itself, or by rotation of the clamp member about the oscillation member which serves as a rotation center. Also, the tip portion may include a mechanism for rotating the oscillation member and the clamp member together. While it is desirable to form each of the oscillation member and the clamp member in a linear shape, they may be gently curved.

[0024] Preferably, the operation unit includes a first driving mechanism which generates a first drive force for causing the open/close mechanism to operate, and the inserting unit further includes a first transmission mechanism for transmitting the first drive force from the first driving mechanism to the open/close mechanism. The first driving mechanism generates a drive force by user operation, or electrically.

[0025] Preferably, the first transmission mechanism includes a first transmission member extending from the elongated member to the open/close mechanism in the tip portion via the joint section, and the open/close mechanism causes the clamp member to be opened or closed in accordance with forward or backward movement of the first transmission member. It is desirable to employ, as the first transmission member, a rod member which can transmit a drive force in both directions by forward and backward movement. However, other members including a wire member, a belt member, and the like may also be used.

[0026] Preferably, the first transmission member extends along a central axis of the joint section within the joint section. It is desirable to provide the first transmission member so as to extend along the central axis of the joint section, because it is generally recognized that the route along the central axis in the joint section does not change its length or changes its length only slightly even when the joint section is subjected to bending. In other words, it is desirable that the first transmission mechanism be configured such that it is not affected by the bending movement of the joint section.

[0027] Preferably, the transducer unit has a central hole formed along the central axis thereof, and a leading end portion of the first transmission member is inserted into the central hole. With this structure, in which the first transmission member can be guided to the open/close mechanism through the interior of the transducer unit, it is possible to effectively use the dead space to thereby prevent enlargement of the size of the tip portion.

[0028] Preferably, the transducer unit further includes a lateral hole communicating with the central hole, the open/close mechanism includes a link member extending through the lateral hole, the link member including a first end portion engaged with the leading end of the first transmission member and a second end portion coupled with the clamp member, forward or backward movement of the first transmission member is transformed into rotation movement of the link member, and the rotation movement of the link member causes the clamp member to be opened and closed. With this structure, when the first transmission member moves linearly within the central hole, the link member engaged with the leading end of the first transmission member rotates and this rotation causes the clamp member to be closed or opened. The lateral hole communicates with the central hole and serves as an opening which the link member can pass through. Alternatively, a further lateral hole may be formed on the opposite side of the lateral hole with the central hole interposed between them. Such a symmetrical structure can suppress disturbance of ultrasonic oscillation and also can be advantageous in terms of manufacturing and assembling.

[0029] Preferably, the position where the link member engages with the leading end portion of the first transmission member is set to a position of a node of ultrasonic oscillation or in the vicinity thereof. With this structure, even when the above-described structure is incorporated in the transducer unit, influence of the structure on the ultrasonic oscillation can be reduced. In particular, it is possible to prevent disturbance of oscillation mode caused in accordance with the open/close state of the clamp member.

[0030] Preferably, the central hole is a non through hole having a closed leading end. While it is possible to form the whole oscillation member as a hollow member, it is desirable to form the whole or the main portion of the oscillation member as a solid member.

[0031] Preferably, the operation unit includes a second driving mechanism which generates a second drive force for causing the joint section to operate, and the inserting unit further includes a second transmission mechanism for transmitting the second drive force from the second driving mechanism to the joint section. The second driving mechanism is formed as a mechanism which generates the second drive force by user operation or electrically.

[0032] Preferably, the second transmission mechanism includes a second transmission member extending from the operation unit to the joint section, and movement of the second transmission member causes the joint section to operate. While it is desirable to use, as the second transmission member, a pair of wire members as will be described below, other members may also be used.

[0033] Preferably, the second transmission member includes a pair of wire members, and the pair of wire members is formed by two wire members passing through two positions, respectively, which, in the joint section, are displaced from each other in the bending direction of the wire members, with the central axis of the joint section being disposed therebetween. Alternatively, it is preferable that the second transmission member includes a first pair of wire members and a second pair of wire members, the first pair of wire members including two wire members disposed at two positions, respectively, which, in the joint section are displaced from each other in a first bending direction of the wire members, with the central axis of the joint section being disposed therebetween, and the second pair of wire members including two wire members disposed at two positions, respectively, which, in the joint section, are displaced from each other in a second bending direction of the wire members, with the central axis of the joint section being disposed therebetween.

[0034] With the above structure, when one wire member is pulled in, the route length of the other wire member is extended to cause the joint section to bend in the direction toward the one wire member. When the other wire member is pulled in, the apparatus operates vice versa. When the joint section can be bent in a plurality of directions, it is desirable to provide a pair of wire members for each bending direction.

[0035] Preferably, the oscillation member has a hook shape at the leading end. With this hook shape, it is possible to perform ultrasonic surgery while body tissue is being hooked on the leading end of the oscillation member. The leading end of the oscillation member may have a shape other than the hook shape. Preferably, the cross section of the tip portion is of substantially the same size as the cross section of the elongated member. It is desirable that the tip portion does not have an increased size with respect to the elongated member in order to allow smooth insertion and smooth extraction of the inserting unit into and out of the guide member. Specifically, it is desirable that the cross section of the tip portion (in particular, the drive unit excluding the surgical unit) has the same size as the cross section of the elongated member (or that the former is smaller than the latter). The tip portion may have a tapered shape as a whole.

[0036] (2) In accordance with another aspect of the present invention, there is provided an ultrasonic surgical apparatus comprising an inserting unit to be inserted into a tubular guide member, and an operation unit which is provided at an end of the inserting unit to be located outside of a living body, the inserting unit including an elongated member, a tip portion provided at the leading end of the elongated member, and a joint section which varies the direction of the tip portion with respect to the elongated member, and the tip portion further including a transducer unit for generating ultrasonic oscillation, an oscillation member to which the ultrasonic oscillation generated in the transducer unit is transmitted and which comes into contact with tissue of a living body, a clamp member for sandwiching the tissue with the oscillation member, and an open/close mechanism for causing the clamp member to open and close.

[0037] With the above structure, the body tissue is sandwiched by a surgical unit formed by the oscillation member and the clamp member, and ultrasonic oscillation is transmitted from the oscillation member to the tissue in this state. Thus, coagulation and/or cutting of the tissue is performed. Because the direction of the surgical unit can be varied by the joint section, the operability and safety of the apparatus can be increased. Further, because ultrasonic oscillation is generated beyond the joint section toward the forefront end of the apparatus, the necessity for transmitting ultrasonic oscillation via the joint section can be eliminated. Thus, because ultrasonic oscillation which is generated can be transmitted to the oscillation member directly or via a short route, high level transmission efficiency can be achieved.

[**0038**] Preferably, the operation section includes a first driving mechanism having a first operation member which is operated by a user, for generating a first drive force which causes the open/close mechanism to operate, and a second driving mechanism having a second operation member which is operated by a user, for generating a second drive force which causes the joint section to operate, and the inserting unit further includes a first transmission mechanism for transmitting the first drive force from the first driving mechanism to the open/close mechanism, and a second transmission mechanism for transmitting the second drive force from the second driving mechanism to the joint section. With this structure, a user can easily control the open/close operation of the clamp member and the bending operation of the joint section.

[**0039**] Preferably, the first transmission mechanism is provided in the joint section and the transducer unit along central axes of the joint section and the transducer unit. The length of the route on the central axis does not change or changes only slightly even when the joint section is subjected to bending. It is therefore desirable to provide the first transmission mechanism on the central axis.

[**0040**] Preferably, the first transmission mechanism includes a rod member, the second transmission mechanism includes a wire member, the inserting unit further includes a plurality of signal lines connected with the transducer unit, and the joint section includes a first guide structure for guiding the rod member of the first transmission mechanism, a second guide structure for guiding the wire member of the second transmission mechanism, and a third guide structure for guiding the plurality of signal lines extracted from the transducer unit. It is desirable that each guide structure smoothly guides the bending movement of each member extending through the joint section when the joint section is subjected to bending movement. It is also desirable that each guide structure smoothly guides forward/backward movement of each member extending through the joint section. The joint section may be covered with a bendable sheath tube or the like as necessary, so that tissue can be prevented from being caught in the joint section, for example.

[**0041**] Preferably, each of the signal lines includes an amount of slack for allowing movement of the joint section. Such a slack can solve the problem that the movement of the joint section is limited by the plurality of signal lines.

[**0042**] While it is preferable that the above structures are adopted in a surgical apparatus for use in ultrasonic surgery only, they may also be used in a surgical apparatus for use in both ultrasonic surgery and electrosurgery. For the latter, a high frequency signal for electrosurgery may be supplied from the operation unit side to the oscillation member via the joint section.

[**0043**] As described above, according to the above structures, the operability of the apparatus can be improved and safety of the ultrasonic surgery can be ensured. In addition, the degree of freedom for the position and posture of the surgical unit which performs coagulating, cutting, and the like of the tissue can be increased. Also, it is possible to reduce the size of the tip portion to be inserted into a body.

## BRIEF DESCRIPTION OF THE DRAWINGS

[**0044**] Preferred embodiments of the present invention will be described in further detail with reference to the following drawings, wherein:

[**0045**] **FIG. 1** is a conceptual view showing an ultrasonic surgical apparatus according to a first embodiment of the present invention;

[**0046**] **FIG. 2** is an X-Z cross sectional view of the inserting unit of the first embodiment of the present invention;

[**0047**] **FIG. 3** is an Y-Z cross sectional view of the inserting unit of the first embodiment of the present invention;

[**0048**] **FIG. 4** is an X-Z cross sectional view of the operation unit of the first embodiment of the present invention;

[**0049**] **FIG. 5** is an Y-Z cross sectional view of the operation unit of the first embodiment of the present invention;

[**0050**] **FIG. 6** is a conceptual view showing an ultrasonic surgical apparatus according to a second embodiment of the present invention;

[**0051**] **FIG. 7** is a view showing the inserting unit of the second embodiment of the present invention in a linear state;

[**0052**] **FIG. 8** is a view showing the inserting unit of the second embodiment of the present invention in a bending state;

[**0053**] **FIG. 9** is an Y-Z cross sectional view of the inserting unit of the second embodiment of the present invention;

[**0054**] **FIG. 10** is a cross sectional view taken along line A-A' of **FIG. 9**;

[**0055**] **FIG. 11** is an Y-Z cross sectional view of the operation unit of the second embodiment of the present invention;

[**0056**] **FIG. 12** is a conceptual view showing an ultrasonic surgical apparatus according to a third embodiment of the present invention;

[**0057**] **FIG. 13** is an Y-Z cross sectional view of the inserting unit of the third embodiment of the present invention; and

[**0058**] **FIG. 14** is a cross sectional view taken along line B-B' of **FIG. 13**.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[**0059**] Preferred embodiments of the present invention will be described in detail with reference to the drawings.

[0060] FIGS. **1** to **5** show a first embodiment of an ultrasonic surgical apparatus according to the present invention. An ultrasonic surgical apparatus performs coagulation and cutting with respect to tissue of a living body.

[0061] Referring to **FIG. 1**, an ultrasonic surgical apparatus is formed roughly by a handpiece **10** and a control unit **12** which are electrically connected to each other via a cable or the like. The ultrasonic surgical apparatus is used for a surgical operation employing a laparoscope. In **FIG. 1**, a tubular guide member (trocar) **200** is inserted, through a surface of a living body (an abdomen surface) **202**, into a peritoneal cavity.

[0062] The handpiece **10** includes an operation unit **14** to be located outside the body and an inserting unit to be inserted into the body. In laparoscopic surgery, the inserting unit **16** is used while it is being inserted into the guide member **200**, as shown in **FIG. 1**. The ultrasonic surgical apparatus shown in **FIG. 1** can also be used in normal open surgery for which a guide member is not used. The inserting unit **16** includes an elongated member **18** serving as a main shaft portion and a tip portion **20** provided at the leading end of the inserting unit **16**. The inserting unit **16** also includes a joint section **22** provided spanning over the elongated member **16** and the tip portion **20** (or between the elongated member **16** and the tip portion **20**). The elongated member **18** is of a cylindrical shape extending in the Z direction, and the tip portion **20** has a similar elongated shape. A surgical unit **24** is mounted toward the leading end of the tip portion. The outer diameter of the elongated member **18** is the same as the outer diameter of a drive unit **26** of the tip portion **20**. In other words, the tip portion **20** does not have an increased diameter in the embodiment.

[0063] The tip portion **20** includes the surgical unit **24** and the drive unit **26**, as described above. The drive unit **26** includes a transducer unit and an open/close mechanism, as will be detailed below. The surgical unit **24** includes an oscillation member (an ultrasonic end-effector) **30** and a clamp member **32**. The clamp member **32** is opened and closed under control of the open/close mechanism. An ultrasonic surgical operation of tissue is performed with the tissue being sandwiched between the oscillation member **30** and the clamp member **32**. In **FIG. 1**, the open/close movement of the clamp member **32** is shown by arrows **206**.

[0064] The joint section **22** is a mechanism for allowing slanting or bending movement of the tip portion **20** with respect to the elongated member **18**. The joint section **22** is formed by one or more joint mechanisms, each of which is capable of bending by itself. **FIG. 1** shows a typical example of a joint section **22** having a single joint mechanism, which allows the tip portion **20** to slant in the predetermined direction, as shown in arrows **204** in **FIG. 1**. In the structure example shown in **FIG. 1**, assuming that the direction of the central axis of the elongated member **18** is defined as the Z direction, it is possible to cause the tip portion **20** to bend on a plane defined by the Z direction and the predetermined direction which is orthogonal to the Z direction. The movable range of the tip portion **20** is determined as ±60°, for example, although a greater or smaller range be selected as preferable.

[0065] The θ direction is defined as the direction around the Z direction axis. A separate mechanism for rotating the joint section **22** (or the tip portion **20**) in the θ direction may be provided. This structure enables the tip portion **20** to bend at an arbitrary angle and in an arbitrary direction. Further, a ball joint mechanism may be provided as the joint section **22**. More specifically, the apparatus may be configured so as to allow slant movement of the tip portion **20** in an arbitrary three-dimensional direction.

[0066] The joint section **22** is conceptually shown in **FIG. 1**. In addition to the mechanisms shown in **FIGS. 2 and 3** described below, the joint section **22** may also adopt various known mechanisms having, for example, a structure similar to a human backbone. It is desirable to cover the entire joint section **22** with a sheath tube, that is a flexible tube in order to prevent catching of a tissue by the joint section **22** and entrance of a body fluid into the joint section **22**. Alternatively, the joint section **22** may be covered with a deformable member having a bellows structure. The tip portion **20** may be detachably mounted with respect to the elongated member **18**.

[0067] In a device with the above structure, the clamp member **32** may be configured such that a plurality of clamp surfaces having different shapes are provided and a clamp surface to be actually used is selected by rotating the clamp member **32**. Similarly, the oscillation member **30** may be configured such that a plurality of tissue contact surfaces having different shapes are provided and a tissue contact surface to be actually used is selected by rotating the oscillation member **30** or by rotating the clamp member **32** about the oscillation member **30**.

[0068] The operation unit **14** is located outside the human body during ultrasonic surgery, as shown, and is held and operated by the user. The operation unit **14** includes a grip **34** and a lever member **36**. The user may insert the fingers of one hand, other than the thumb, through the opening of the grip **34** and insert their thumb through the opening of the lever member **36**, for example. When the user shuts their hand in this state, the lever member **36** is moved toward the grip **34**. The drive force generated at this time is transmitted as a drive force for closing the clamp member **32**. This will be described in detail below with reference to FIGS. **2** to **5**.

[0069] The operation unit **14** includes an operation knob **38**. By rotating the operation knob **38** clockwise or counterclockwise, the joint section **22** is driven to thereby cause the tip portion **20** to bend in one direction or in the opposite direction, as will be described in detail with reference to **FIGS. 2 and 3**. A variety of structures may be employed for the operation unit **14**, among which **FIG. 1** shows only one example. It is possible to adopt a mechanism for opening or closing the clamp member **32** by operating a lever similar to the trigger of a pistol. While the drive force for the joint section **22** and the drive force for the clamp member **32** are both generated by user operation in this embodiment, these drive forces may be generated electrically using a drive motor or the like.

[0070] In order to perform ultrasonic surgery, the inserting unit **16** is inserted into the guide member **200**. Prior to this insertion, it is usually necessary to make the center axis of the elongated member **18** coincide with the center axis of the tip portion **20**, namely to place the tip portion **20** in a non-slanted state. In addition, prior to the insertion of the inserting unit **16**, the clamp member **32** is placed in a closed state. With the above preparation, the inserting unit **16** is ready for insertion into the guide member **200**. Specifically, it is possible to prevent the tip portion **20** or the clamp member **32** from striking against the inlet of the guide member **200** at the time of insertion. By adjusting the position and posture of the inserting unit **16** while it is inserted into a body cavity or by operating the joint section **22** to adjust the slanting angle of the tip portion **20**, it is possible to enable the surgical unit **24** to approach the target tissue at an appropriate angle from an appropriate position. This makes it possible to perform safe ultrasonic surgery with respect to target tissue located at the back of a certain tissue. The target tissue is sandwiched between the clamp member **32** and the oscillation member **30**, and is subjected to coagulation and cutting when ultrasonic oscillation is transmitted from the oscillation member **30** to the tissue in this state. When the ultrasonic surgery is completed, the tip portion **20** is placed back to a non-slant state, namely returned to a center position, and the clamp member **20** is closed. Then, the inserting unit **16** is pulled out of the guide member **200**.

**[0071]** In order to ensure that the tip portion **20** is not in a slanted state at the time of insertion and extraction, it is desirable to provide a marker indicative of the center position on the operation knob **38**. It is also preferable to provide a micro switch on the joint section **22** for electrically detecting that the tip portion **20** is at the center position and to provide a display indicating the detection result on the operation unit **14** or the control unit **12**. Similarly, it is desirable to provide a display indicating that the clamp member **32** is closed or opened on the operation unit **14** or the control unit **12**.

**[0072]** The control unit **12** includes an operation panel **42** and a signal generator **44**, as shown in **FIG. 1**. The operation panel **42** is formed by various input switches, a display device, or the like. The signal generator **44** is a module which, in response to an ON signal supplied from a foot pedal **46**, generates an electrical drive signal for generating ultrasonic oscillation. The foot pedal **46** is operated by being stepped by the user of the handpiece **10**.

**[0073]** While the ultrasonic surgical apparatus shown in **FIG. 1** is used only for the purpose of ultrasonic surgery, the present invention is also applicable to a surgical apparatus which can be used for both ultrasonic surgery and electrosurgery. In that case, a signal line for supplying a high frequency signal for electrosurgery to the tip portion **20** can be provided in addition to the above structure. When electrosurgery is performed, it is possible to operate the oscillation member **30** in monopolar mode or operate the oscillation member **30** and the clamp member **32** in bipolar mode.

**[0074]** A specific example structure of the tip portion **20** and the joint section **22** will be described with reference to **FIGS. 2 and 3**. The X and Y directions are defined as directions orthogonal to the Z direction. The X direction and the Y direction are orthogonal to each other. **FIG. 2** shows an X-Z cross section and **FIG. 3** shows an Y-Z cross section.

**[0075]** Referring to **FIG. 2**, the tip portion **20** is mounted on the leading end of the elongated member **18**, as described above. The tip portion **20** includes the oscillation member **30** and the clamp member **32** serving as the surgical unit **24**. The joint section **22** is formed spanning over both the leading end of the elongated member **18** and the trailing end of the tip portion **20**.

**[0076]** A case **18**A of the elongated member **18** is provided, on the edge portion, with a member **50** having an end surface **50**A which is a flat surface orthogonal to the Z axis. On the other hand, the tip portion **20** includes a base **51** which is provided, at its end, with an abut member **52** having an isosceles triangle cross section. As shown, the abut member **52** has two slant surfaces **52**A, and the line where these two slant surfaces **52**A contact forms a ridge-line **208**. The abut member **52** pivots about the ridge-line **208** on the end surface **50**A. Due to the pivot movement of the abut member **52**, the whole tip portion **20** performs rocking movement, namely slanting movement in the directions shown in the arrows **210** and **212**.

**[0077]** As shown in **FIG. 2**, first and second wire members **60** and **62** are leading from the elongated member **18** toward the tip portion **20**, with end portions **64** and **66** thereof being fixed in the base **51**. The first wire member **60** and the second wire member **62** pass through two positions in the elongated member **18**, respectively, which are displaced from the center of the elongated member **18** in the X direction. In order to cause each wire member **60** or **62** pass through, corresponding guide holes are formed in each of the member **50**, the abut member **52** and the base **51**. The first wire member **60** and the second wire member **62** are connected with each other in the operation unit, so that backward movement of one member causes the other member to move forward.

**[0078]** Consequently, when the first wire member **60** is moved backward or retreated to the right in **FIG. 2**, the tip portion **20** rotates about the ridge-line **208** serving as a rotation axis in the direction shown in the arrow **210**. On the other hand, when the second wire member **62** is moved backward or retreated to the right in **FIG. 2**, the tip portion **20** rotates about the ridge-line **208** serving as a rotation axis in the direction shown in the arrow **212**. The tip portion **20** can be rotated until one of the slant surfaces **52**A comes in complete contact with the end surface **50**A. When it is desired to further increase the slanting angle of the tip portion **20**, such a large angle can be achieved by providing and connecting a plurality of mechanisms as shown in **FIG. 2** in series, or by coupling, in series, a plurality of block members having a structure like human backbone. Further, a first rod member **54** is provided along the central axis of the elongated member **18**. The leading end of the first rod member **54** is coupled, through guide holes formed at the centers of the member **50**, the abut member **52** and the base **51**, respectively, to the trailing end of a second rod member **56** via a joint member **58**.

**[0079]** The first rod member **54** and the second rod member **56** together form a first transmission mechanism for opening and closing the clamp member **32**. The first wire member **60** and the second wire member **62** described above together form a second transmission mechanism for causing the joint section **22** to bend.

**[0080]** Referring to **FIG. 3**, the specific structure of the tip portion **20** will be described. **FIG. 3** shows an Y-Z cross section of the tip portion **20** and the joint section **22**. The tip portion **20** includes a case **72**, and an intermediate member **70** which is formed by a resin member between the case **72** and the base **51** described above. As shown, a transducer unit **74** is provided within the case **72**. The transducer unit **74** includes front block **76**, a bolt **77**, and a rear block **78**. A plurality of stacked ring-shape piezoelectric plates **79** are sandwiched between the front block **76** and the rear block **78**. In other words, the transducer unit **74** forms a so-called bolt joint type ultrasonic transducer. In the embodiment shown in **FIG. 3**, the front block **76** is integrally formed with the bolt **77**. The threaded portion formed on the rear block **78** engages with the threaded portion of the bolt **77**. In **FIG. 3**, a plurality of electrode plates in the transducer unit **74** are not shown.

**[0081]** The front block **76** is coupled with the oscillation member **30**. The front block **76** and the oscillation member **30** may be integrally formed into a single member or may be formed separately. As shown in **FIG. 3**, the transducer unit **74** includes a central hole **77A** serving as a non-through hole along the center axis thereof. The central hole **77A** specifically extends to the trailing end of the oscillation member **30**. At the position of the leading end of the central hole **77A**, lateral holes **76A** and **76B** are formed in the Y direction. The lateral holes **76A** and **76B** open to the opposite directions and have the same shape. Although it is essentially necessary to provide only the lateral hole **76A** in order to cause an arm member **82** which will be described below to move, it is possible to effectively prevent generation of unnecessary lateral oscillation by forming the two symmetrical lateral holes **76A** and **76B** as in the present embodiment. Here, the leading end (a closed surface) of the central hole **77A** is positioned such that the forward movement of the second rod member **56**, namely the opening movement of the clamp member **32** can be sufficiently secured. In the structure shown in **FIG. 3**, the leading end of the central hole **77A** is positioned at the portion of the front block **76** having a larger diameter.

**[0082]** An open/close mechanism **80** will next be described. The second rod member **56** has, at its leading end portion, a pin **81**, with which the arm member **82** is engaged. More specifically, the first end of the arm member **82** has a bifurcated shape **86** and the pin **81** is inserted into the recess of the bifurcated part. The arm member **82** rotates about a rotation axis **84**. On the second end of the arm member **82**, the clamp member **32** is provided.

**[0083]** When the first rod member **54** is moved backward to the right in **FIG. 3**, the second rod member **56** is also moved backward to the right accordingly. As a result of the engagement of the pin **81** and the bifurcated portion **86**, this backward movement is transmitted to the arm **82**, which then rotates counterclockwise about the rotation axis **84**. In other words, the arm **82** moves toward the closing direction. When the first rod member **54** is moved forward to the left in **FIG. 3**, on the other hand, the second rod member **56** is also moved forward to the right. As a result of the engagement of the pin **81** and the bifurcated portion **86**, the arm **82** member rotates clockwise about the rotation axis **84**. In other words, the arm **82** moves toward the opening direction. By employing the first transmission mechanism formed by the two rod members connected in series and causing the first transmission mechanism to move forward or backward as described above, it is possible to control the opening and closing of the clamp member **32** easily and reliably at the base end portion of the apparatus, namely outside the human body.

**[0084]** As shown in **FIG. 2**, the first rod member **54** passes through the central axis of the joint section **22**. The second rod member **56** is formed by a material which is bendable and transmits drive force in the forward and backward directions. While the first rod member **54** also bends according to the bending of the joint section **22**, the first rod member **54** can be caused to smoothly move forward and backward, namely the clamp member **32** can be caused to smoothly open and close, even when the joint section **22** is in a bending state. In order to reduce the load applied to the first rod member **54** when it is bent, a flexible tube may be provided for protecting the bending portion of the first rod member **54**. Such a protecting structure can be similarly provided to the first and second wire members **60** and **62** shown in **FIG. 2** and also to signal lines **94** and **96** which will be described below.

**[0085]** In **FIG. 3**, the intermediate member **70** is provided with two electrode members **100** and **102** which are spaced apart from each other by a predetermined distance in the Y direction. These electrode members **100** and **102** function as positive and negative electrode members, respectively, and are electrically connected to a plurality of electrodes (not shown) in the transducer unit **74** via a plurality of signal lines. A pair of signal lines **94** and **96** are inserted through the elongated member **18**, as shown. The leading end of the signal line **94** is electrically connected to the electrode member **100**, and the leading end of the signal line **96** is electrically connected to the electrode member **102**. The signal lines **94** and **96** pass through the through holes formed in the member **50**, the abut member **52**, and the base **51**, respectively. Each of the signal lines **94** and **96** includes a predetermined amount of slack, so that the movement of the joint section **22** cannot be hindered even when a tensioning force or the like is applied to the signal lines **94** and **96** due to the bending of the joint section **22**. The signal lines **94** and **96** may be connected to the electrode members **100** and **102** using soldering, or using a connector.

**[0086]** The transducer unit **74** is held within the case **72** by means of O-rings **90** and **92**. The distance between the leading surface of the oscillation member **30** and the rear surface of the bolt **77** corresponds to a half the wavelength of ultrasound. At the position of a node of the oscillation or in the vicinity thereof, the holding position for the O-ring **90** and the lateral holes **76A** and **76B** are located. This structure can minimize the effect of the O-ring **90** onto the ultrasonic oscillation and also the effect caused by formation of the lateral holes **76A** and **76B**. It is desirable that the O-ring **92** holds the rear end of the bolt **77** loosely. In addition to the function of holding the transducer unit **74** as described above, the O-ring **90** also has a sealing function. This is also true to the O-ring **92**.

**[0087]** The open/close mechanism **80** of **FIG. 3** is shown for the illustrative purpose only and other structures may be used. For example, the arm member **82** may be driven using a wire or the like. With the structure shown in **FIG. 3**, in which the second rod member **56** is inserted within the central hole **77A** provided along the central axis of the bolt **77** and in which the first end portion of the arm member **82** is coupled with the rod member within the interior space of the transducer unit **74**, it is possible to effectively utilize the dead space so that the size of the tip portion **20** can be reduced.

**[0088]** A specific example of the operation unit **14** shown in **FIG. 1** will be described with reference to **FIGS. 4 and**

5. **FIG. 4** shows an Y-Z cross section of the operation unit **14** and corresponds to **FIG. 3** with regard to the direction of the cross section. **FIG. 5** shows an X-Z cross section of the operation unit **14** and corresponds to **FIG. 4** with regard to the direction of the cross section.

**[0089]** The operation unit **14** includes the grip **34** and the lever member **36**, as described above. Within the case **110**, the lever member **36** has an elongated hole **36**A formed at its operative end. A hook **112** A, which forms one end of a link member **112**, engages the elongated hole **36**A. The other end of the link member **112** is coupled to the first rod member **54** via a joint member **114**. Accordingly, when the lever member **36** rotates, the first rod member **54** moves forward or backward depending on the direction of rotation. In **FIG. 4**, numeral **116** denotes the rotation axis of the lever member **36**.

**[0090]** The signal lines **94** and **96** are guided from the elongated member through the interior of the operation unit **14** to a connector portion **120**. A cable used for electrically connecting the handpiece with the control unit is coupled to the connector portion **120**.

**[0091]** A pulley **118** is coupled to an axis **40** of the operation knob **38**. The pulley **118** has a wire member wounded around, the wire member forming the first wire member **60** and the second wire member **62** described above. Therefore, with this structure, rotation of the operation knob **38** causes the wire members to advance or retreat in accordance with the rotation direction of the knob **38**, whereby a drive force is transmitted to the joint section.

**[0092]** As described above, the operation unit **14** includes a mechanism for generating a drive force for the clamp member and a drive force for the joint section. More specifically, the drive force for the clamp member is generated by movement of the lever member **36**, and the drive force for the joint section is generated by the rotation of the operation knob **38**. These drive forces may instead be generated using a drive motor or the like, as described above.

**[0093]** **FIG. 5** shows an X-Z cross section of the operation unit **14**. The hook **112**A engages with the elongated hole **36**A, as described above, and in **FIG. 5**, the movement of the hook **112**A to the right and left has been transformed to the movement of the link member **112** to the right and left. When the joint section is formed by a plurality of joint mechanisms so as to realize a plurality of bending directions, a plurality of operation knobs may be provided corresponding to the respective bending directions. This structure is advantageous in that the tip portion can be bent in any three-dimensional direction. Further, when a rotating mechanism for rotating the joint section itself is provided at the leading end of the elongated member, an operation knob for actuating the rotating mechanism may be provided on the operation unit **14**.

**[0094]** When the present invention is configured as in the above-described embodiment, because the transducer unit is disposed beyond the joint section toward the leading end of the apparatus, it is not necessary to transmit the ultrasonic oscillation generated outside a living body to the tip portion, especially through the joint section. It is also possible to operate the joint section and the open/close mechanism in the operation unit. In this case, the open/close mechanism can be advantageously operated regardless of the operation of the joint section. Further, the structure in which the rod member is inserted through the central hole formed along the central axis of the transducer unit can achieve an advantage of reduction in size of the tip portion.

**[0095]** A second embodiment of the present invention will next be described with reference to FIGS. **6** to **11**.

**[0096]** **FIG. 6** is a perspective view of an ultrasonic surgical apparatus according to the second embodiment. In **FIG. 6**, only a handpiece is shown and a control unit is omitted. As in the first embodiment, a handpiece **300** includes an operation unit **302** and an inserting unit **304**. When the apparatus is in use, the operation unit **302** is located outside a body, and the inserting unit **302** is inserted into a guide member (not shown). Namely, the inserting unit **304** is introduced into the body. The inserting unit **304** includes an elongated member **306**, a tip portion **308**, and a joint section **310** provided between the elongated member **310** and the tip portion **308**. The joint section **310** allows the direction of the tip portion **308** to be changed in an arbitrary direction with respect to the elongated member **306**. Assuming that the direction of insertion corresponds to the Z direction, it is possible to cause the joint section **310** to bend both in the X direction (see numeral **320**) and in the Y direction (see numeral **318**) orthogonal to the Z direction. Further, the tip portion **308** may be bent in other directions.

**[0097]** The tip portion **308** includes a drive unit **312** and an oscillation member **314**. The drive unit **312** includes a transducer unit which will be described below. The oscillation member **314** comes in contact with tissue of a living body and transmits ultrasonic oscillation to the tissue for effecting coagulation and cutting of the tissue. The oscillation member **314** has a hook at its leading end, which catches tissue of a living body for effecting ultrasonic surgery in that state. In the second embodiment, a clamp member is not provided on the tip portion **308**. The oscillation member **314** may have any of various shapes at its leading end.

**[0098]** **FIG. 7** shows an enlarged view of the tip portion **308** and the joint section **310**. In **FIG. 7**, as well as in FIGS. **8** to **10**, a plurality of signal lines connected to the transducer unit within the tip portion are omitted. Further, in **FIG. 7**, as well as in FIGS. **8** to **10**, a flexible outer tube covering the whole joint section is also omitted.

**[0099]** In the tip portion **308** shown in **FIG. 7**, a cover **330** is provided at the leading end of the drive unit **312**. The oscillation member **314** is formed by a shaft portion **332** and a hook portion **334**, with most part of the shaft portion **332** being covered with the cover **330**. In the example shown in **FIG. 7**, the joint section **310** includes a plurality of blocks **336**, **338**, **340**, **342**, and **344** which are coupled in series. The forefront block **336** is fixed to the tip portion **308**. More specifically, the block **336** functions as a base formed at the trailing end of the tip potion **308**, in other words, the block **336** forms a part of the tip portion **308**. The last block **344** is fixed to the elongated member **306**. More specifically, the block **344** functions as a cap provided at the front end of the elongated member **306**, namely forms a part of the elongated member **306**.

**[0100]** The block **336** includes two contact portions **336*b*** spaced apart from each other in the Y direction by a predetermined distance. Each contact portion **336*b*** is formed to project to the right in **FIG. 7**. The block **338** includes two contact portions **338***a* spaced apart by a predetermined distance from each other in the Y direction. Each contact portion **338***a* is formed to project to the left in **FIG. 7**. Each of the two contact portions **336***b* has a curved concave portion and each of the two contact portions **338***a* has a curved convex portion. Between the two blocks **336** and **338**, two Y-axis rotation mechanisms which are spaced apart by a predetermined distance from each other in the Y direction are formed. Each of the Y-axis rotation mechanisms is formed by a concave portion and a convex portion which are contact with each other in such a manner that they can mutually rotate about the Y axis.

**[0101]** The block **338** includes two contact portions **338***b* spaced apart from each other in the X direction by a predetermined distance. Each contact portion **338***b* is formed to project to the right in **FIG. 7**. The block **340** includes two contact portions **340***a* spaced apart from each other in the X direction by a predetermined distance. Each contact portion **340***a* is formed to project to the left in **FIG. 7**. Each of the two contact portions **338***b* has a curved concave portion (α) and each of the two contact portions **340***a* has a curved convex portion (β). Between the two blocks **338** and **340**, two X-axis rotation mechanisms which are spaced apart from each other in the X direction by a predetermined distance are formed. Each of the X-axis rotation mechanisms is formed by a concave portion (α) and a convex portion (β) which are coupled with each other in such a manner that they can mutually rotate about the X axis.

**[0102]** The structure which is similar to that provided between the blocks **336** and **338** as described above is also provided between the block **340** and the block **342**. Specifically, the block **340** includes two contact portions **340***b* which are spaced apart from each other in the Y direction by a predetermined distance, and the block **342** includes two contact portions **342***a* which are spaced apart from each other in the Y direction by a predetermined distance. Further, the structure which is similar to that provided between the blocks **338** and **340** as described above is also provided between the block **342** and the block **344**. Specifically, the block **342** includes two contact portions **342***b* which are spaced apart from each other in the X direction by a predetermined distance, and the block **344** includes two contact portions **344***a* which are spaced apart from each other in the X direction by a predetermined distance.

**[0103]** Two wire members **350** and **352** are provided through the plurality of blocks **338**, **340**, **342**, and **344** in such a manner that the two wire members **350** and **352** are spaced apart from each other by a predetermined distance in the Y direction and are disposed in parallel to each other. The leading ends **350**A and **352**A of the two wire members **350** and **352** are fixed to the second block **338**. Further, two wire members **354** and **356** are provided through the plurality of blocks **338, 340, 342**, and **344** in such a manner that the two wire members **354** and **356** are spaced apart from each other by a predetermined distance in the X direction and are disposed in parallel to each other. The leading ends (not shown) of the two wire members **354** and **356** are fixed to the intermediate member which will be described below or to the forefront block **336**.

**[0104]** As can be understood from the structure described above, when one of the two wire members **350** and **352** is pulled to the right in **FIG. 7**, the joint section **310** is bent in the up-down direction as shown by arrows **318**, which causes the tip portion **308** to change its direction on the Y-Z plane. **FIG. 8** shows the resultant state caused by pulling the wire member **352**. When one of the wire members **354** and **356** is pulled to the right in **FIG. 7**, on the other hand, the joint section **310** is bent in the direction passing through the sheet plane in **FIG. 7**, which causes the tip portion **308** to change its direction on the X-Z plane. Thus, by pulling one of the two wire members **350** and **352** and one of the two wire members **354** and **356** simultaneously to the right in **FIG. 7**, the joint section **310** can be bent in any three-dimensional direction, thereby allowing the tip portion **308** to be directed in arbitrary three-dimensional direction.

**[0105]** **FIG. 9** is a cross sectional view of the tip portion **308** and the joint section **310** described above. A transducer unit **360**, which has a bolt joint type ultrasonic transducer, is provided within a case **312** of the tip portion **308**. The rear portion of the transducer unit **360** is held by an O-ring **366** provided on the intermediate member **364**. The front of the transducer unit **360** is held by the case **312** via a ring-shape packing **362**. The oscillation member **314** is fixed to the leading end of the transducer unit **360**, so that ultrasonic oscillation generated in the transducer unit **360** is transmitted directly to the oscillation member **314**. The oscillation member **314** includes a shaft portion **332** covered with a cover **330**, the components having a gap between them. The leading ends **354**A and **356**A of the two wire members **354** and **356** for use in X-direction driving are fixed to the intermediate member **364** (or the forefront block **336**).

**[0106]** **FIG. 10** is a cross sectional view showing an A-A' cross section (a cross section of the second block) in **FIG. 9**. In **FIG. 10**, numerals **370** and **372** indicate two through holes through which the two wire members **350** and **352** shown in **FIG. 9** pass, respectively, numerals **374** and **376** indicate two through holes through which the two wire members **354** and **356** shown in **FIG. 9** pass, respectively, and numerals **378** and **380** indicate two through holes through which two signal lines pass, respectively.

**[0107]** **FIG. 11** is a cross sectional view of the operation unit **302** in the second embodiment described above. A pulley **392** is coupled with a shaft **390** of an operation knob **322**. The wire members **350** and **352** are formed into a single wire member within the operation unit **302**, and the single wire member is wound around the pulley **396**. Similarly, a pulley **396** is coupled with a shaft **394** of an operation knob **324**. The wire members **354** and **356** are formed into a single wire member within the operation unit **302**, and the single wire member is wound around the pulley **376**. Accordingly, rotation of the operation knob **322** causes the two wire members **350** and **352** to move in the opposite directions, thereby making the joint section bend in the Y direction. Further, rotation of the operation knob **324** causes the two wire members **354** and **356** to move in opposite directions, thereby making the joint section bend in the X direction. By rotating both of the two operation knobs **322** and **324**, it is possible to tilt the joint section in any three-dimensional direction. A change in the bending direction of the joint section depends on the ratio of rotation amounts of the two operation knobs **322** and **324**. It is desirable to provide indicators showing the rotation amount on each of the operation knobs **322** and **324**. The two signal lines **382** and **384** are connected to the connector **380**.

[0108] As in the first embodiment, according to the second embodiment, the direction of the tip portion can be changed by the joint section within a body, and because ultrasonic oscillation can be generated in the tip portion, the necessity to transmit ultrasonic oscillation via the joint section can be eliminated, thereby allowing effective transmission of ultrasonic oscillation to living tissue. In particular, because the tip portion can be directed in any three-dimensional direction, the operability and integrity of the apparatus can be enhanced.

[0109] A third embodiment of the present invention will next be described with reference to FIGS. **12** to **14**.

[0110] **FIG. 12** shows a tip portion **401** and a joint section **402** of an ultrasonic surgical apparatus. In **FIG. 12**, and also in **FIG. 13**, a tube covering the joint section is omitted. Referring to **FIG. 12**, the joint section **402** is provided between the tip portion **401** and the elongated member **400**. The joint section **402** has basically the same structure as the joint section in the second embodiment described above, except that the joint section **402** additionally includes a rod member **430** which will be described below. The joint section **402** is formed by a plurality of blocks **414**, **416**, **418**, **420**, and **422** which are coupled in series. Two wire members **424** and **426** for Y-direction driving pass through the blocks **416**, **418**, **420**, and **422**, and the leading ends **424**A and **426**A of the two wire members **424** and **426** are fixed to the second block **416**. On the other hand, two wire members (not shown) for X-direction driving pass through the plurality of blocks **414**, **416**, **418**, **420**, and **422**, and the leading ends (not shown) of the two wire members are fixed to an intermediate member **413** or to the forefront block **414**. In addition, two signal lines **450** and **452** pass through the plurality of blocks **414**, **416**, **418**, **420**, and **422**. The tip portion **401** has a structure similar to that of the tip portion in the first embodiment. Specifically, the tip portion **401** includes a drive unit **404** and a surgical unit **406**. The surgical unit **406** includes an oscillation member **410** and a clamp member **408**.

[0111] **FIG. 13** is a cross sectional view of the tip portion **401** and the joint section **402**. A transducer unit **440** has a central hole **440**A formed along the Z direction. A second rod member **434** is provided in the central hole **440**A in such a manner that the second rod member can move forward and backward. The second rod member **434** has a pin at its leading end, and a bifurcated edge of an arm member **436** engages with the pin. When the first rod member **430** is moved forward or backward, the second rod member **434** also moves accordingly. This forward or backward movement is transformed into rotating movement of the arm member **436**, which results in open/close movement of the clamp member **408** (see arrows **412**).

[0112] **FIG. 14** shows a B-B' cross section (a cross section of the second block) in **FIG. 13**. In **FIG. 14**, numerals **440** and **442** indicate two through holes through which two wire members **424** and **426** for Y-direction driving shown in **FIG. 13** pass, respectively, numerals **444** and **446** indicate two through holes through which two wire members for X-direction driving pass, respectively, and numerals **448** and **450** indicate two through holes through which two signal lines **450** and **452** shown in **FIG. 13** pass, respectively. Through a through hole **453** formed at the center, the first rod member **430** shown in **FIG. 13** passes.

[0113] In the third embodiment, it is desirable to provide an operation unit (not shown) which is similar to the operation unit **14** shown in **FIG. 1**. More specifically, the operation unit includes a mechanism for controlling the open/close movement of the clamp member, a mechanism for causing the joint section to bend in the Y direction, and a mechanism for causing the joint section to bend in the X direction.

[0114] According to the third embodiment, as in the first and second embodiments, the direction of the tip portion can be changed by the joint section within a body, and because ultrasonic oscillation can be generated in the tip portion, the necessity to transmit ultrasonic oscillation via the joint section can be eliminated, thereby allowing effective transmission of ultrasonic oscillation to living tissue. In particular, because the tip portion can be directed in any three-dimensional direction, the operability and integrity of the apparatus can be enhanced. Also, the tip portion can be reduced in size by utilizing the dead space within the transducer unit.

[0115] While the preferred embodiments of the present invention have been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the appended claims.

What is claimed is:

**1**. An ultrasonic surgical apparatus comprising:

an inserting unit; and

an operation unit which is provided at an end of the inserting unit to be located outside of a living body,

the inserting unit including an elongated member, a tip portion provided at the leading end of the elongated member, and a joint section which varies the direction of the tip portion with respect to the elongated member, and

the tip portion further including a transducer unit for generating ultrasonic oscillation, and an oscillation member to which the ultrasonic oscillation generated in the transducer unit is transmitted and which comes into contact with tissue of a living body.

**2**. An ultrasonic surgical apparatus according to claim 1, wherein

the joint section causes the tip portion to move in at least one direction with respect to the elongated member.

**3**. An ultrasonic surgical apparatus according to claim 1, wherein

the joint section causes the tip portion to move in an arbitrary direction with respect to the elongated member.

**4**. An ultrasonic surgical apparatus according to claim 1, wherein

the tip portion further includes:

a clamp member for sandwiching the tissue with the oscillation member; and

an open/close mechanism for causing the clamp member to open and close.

5. An ultrasonic surgical apparatus according to claim 4, wherein

the operation unit includes a first driving mechanism which generates a first drive force for causing the open/close mechanism to operate, and

the inserting unit further includes a first transmission mechanism for transmitting the first drive force from the first driving mechanism to the open/close mechanism.

6. An ultrasonic surgical apparatus according to claim 5, wherein

the first transmission mechanism includes a first transmission member extending from the elongated member to the open/close mechanism in the tip portion via the joint section, and

the open/close mechanism causes the clamp member to open or close in accordance with forward or backward movement of the first transmission member.

7. An ultrasonic surgical apparatus according to claim 6, wherein

the first transmission member extends along a central axis of the joint section within the joint section.

8. An ultrasonic surgical apparatus according to claim 6, wherein

the transducer unit has a central hole formed along the central axis thereof, and

a leading end portion of the first transmission member is inserted into the central hole.

9. An ultrasonic surgical apparatus according to claim 8, wherein

the transducer unit further includes a lateral hole communicating with the central hole,

the open/close mechanism includes a link member extending through the lateral hole, the link member including a first end portion engaged with the leading end of the first transmission member and a second end portion coupled with the clamp member,

forward or backward movement of the first transmission member is transformed into rotation movement of the link member, and

the rotation movement of the link member causes the clamp member to open and close.

10. An ultrasonic surgical apparatus according to claim 9, wherein

the position where the link member engages with the leading end portion of the first transmission member is set to a position of a node of ultrasonic oscillation or in the vicinity thereof.

11. An ultrasonic surgical apparatus according to claim 8, wherein

the central hole is a non through hole having a closed leading end.

12. An ultrasonic surgical apparatus according to claim 1, wherein

the operation unit includes a second driving mechanism which generates a second drive force for causing the joint section to operate, and

the inserting unit further includes a second transmission mechanism for transmitting the second drive force from the second driving mechanism to the joint section.

13. An ultrasonic surgical apparatus according to claim 12, wherein

the second transmission mechanism includes a second transmission member extending from the operation unit to the joint section, and

movement of the second transmission member causes the joint section to operate.

14. An ultrasonic surgical apparatus according to claim 13, wherein

the second transmission member includes a pair of wire members, and

the pair of wire members is formed by two wire members passing through two respective positions, which, in the joint section, are displaced from each other in the bending direction of the wire members, with the central axis of the joint section being disposed therebetween.

15. An ultrasonic surgical apparatus according to claim 13, wherein

the second transmission member includes a first pair of wire members and a second pair of wire member,

the first pair of wire members includes two wire members disposed at two respective positions, which, in the joint section, are displaced from each other in a first bending direction of the wire members, with the central axis of the joint section being disposed therebetween, and

the second pair of wire members includes two wire members disposed at two respective positions, which, in the joint section, are displaced from each other in a second bending direction of the wire members, with the central axis of the joint section being disposed therebetween.

16. An ultrasonic surgical apparatus according to claim 1, wherein

the oscillation member has a hook shape at the leading end.

17. An ultrasonic surgical apparatus according to claim 1, wherein

the cross section of the tip portion is of substantially the same size as the cross section of the elongated member.

18. An ultrasonic surgical apparatus comprising:

an inserting unit to be inserted into a tubular guide member; and

an operation unit which is provided at an end of the inserting unit to be located outside of a living body,

the inserting unit including an elongated member, a tip portion provided at the leading end of the elongated member, and a joint section which varies the direction of the tip portion with respect to the elongated member, and

the tip portion further including a transducer unit for generating ultrasonic oscillation, an oscillation member to which the ultrasonic oscillation generated in the transducer unit is transmitted and which comes into contact with tissue of a living body, a clamp member for sandwiching the tissue with the oscillation member, and an open/close mechanism for causing the clamp member to open and close.

**19**. An ultrasonic surgical apparatus according to claim 18, wherein

the operation section includes:

a first driving mechanism provided with a first operation member which is operated by a user, for generating a first drive force which causes the open/close mechanism to operate; and

a second driving mechanism provided with a second operation member which is operated by a user, for generating a second drive force which causes the joint section to operate, and

the inserting unit further includes:

a first transmission mechanism for transmitting the first drive force from the first driving mechanism to the open/close mechanism; and

a second transmission mechanism for transmitting the second drive force from the second driving mechanism to the joint section.

**20**. An ultrasonic surgical apparatus according to claim 19, wherein

the first transmission mechanism is provided in the joint section and the transducer unit along central axes of the joint section and the transducer unit.

**21**. An ultrasonic surgical apparatus according to claim 19, wherein

the first transmission mechanism includes a rod member,

the second transmission mechanism includes a wire member,

the inserting unit further includes a plurality of signal lines connected with the transducer unit, and

the joint section includes a first guide structure for guiding the rod member of the first transmission mechanism, a second guide structure for guiding the wire member of the second transmission mechanism, and a third guide structure for guiding the plurality of signal lines extracted from the transducer unit.

**22**. An ultrasonic surgical apparatus according to claim 21, wherein

each of the signal lines includes an amount of slack for allowing movement of the joint section.

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摘要(译)

一种可用于腹腔镜手术的超声外科手术设备。超声外科手术设备包括插入单元和操作单元。插入单元插入称为套管针的引导构件中。插入单元包括细长构件，尖端部分，以及设置在细长构件和尖端部分之间的接合部分。尖端部分包括换能器单元和振动构件，并且优选地还包括夹紧构件和打开/关闭机构。接合部分使尖端部分相对于细长构件倾斜。操作单元包括用于操作接合部分的机构，并且优选地还包括用于操作夹紧构件的机构。振动构件的方向可以通过连接部分改变。因为在尖端部分中产生超声波振荡，所以可以实现超声波振荡到振荡构件的有效传输。