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(54) **SURGICAL OPERATION DEVICE**

(57) A vibration transmitting member used with a clamp portion and configured to transmit vibration from an ultrasonic transducer, is extended from a proximal portion toward a distal portion, includes a ridge portion at the distal portion along a longitudinal axis extending from the proximal portion to the distal portion and located on a surface along an opening/closing direction in which the clamp portion is configured to move by turning, and

is configured to transmit the vibration from the proximal portion to the distal portion thereof when the vibration is input to the proximal portion thereof. A thickness thereof along the opening/closing direction in which the clamp portion is configured to move by turning is smaller than a width of the distal portion thereof in a width direction perpendicular to the opening/closing direction.

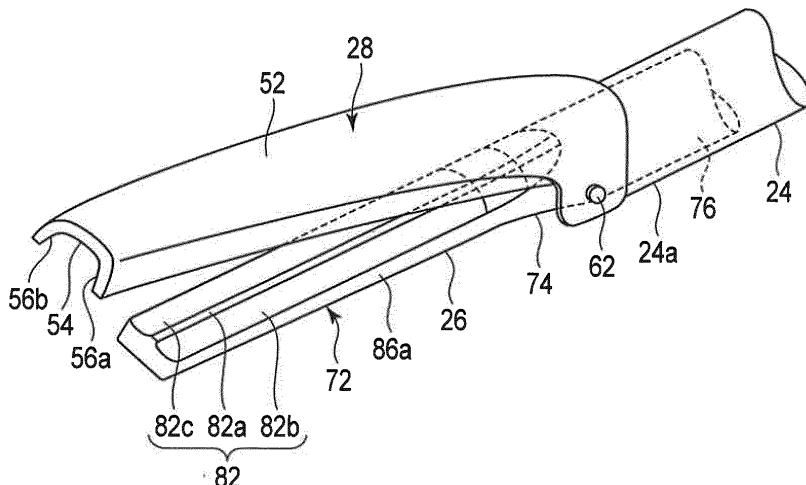


FIG. 2

**Description**

## Technical Field

**[0001]** The present invention relates to a vibration transmitting member and a surgical apparatus. 5

## Background Art

**[0002]** For example, US 2011/288451 A1 discloses a surgical apparatus enabling dissection of living tissue during coagulation of the living tissue with use of high-frequency output and ultrasonic output in a state in which the living tissue is grasped. 10

**[0003]** A distal end of a vibration transmitting member of such a surgical apparatus and a clamp portion opposed to the vibration transmitting member to enable approach to and separation from the vibration transmitting member by turning are formed to be thin in consideration of a dissection performance of living tissue. Thus, each of contact area between the vibration transmitting member and the living tissue and between the clamp portion and the living tissue is small. Accordingly, such a surgical apparatus may not be suitable when treatment of crushing and shattering living tissue such as a liver is conducted. Also, when the treatment of crushing and shattering the living tissue is conducted, a blood vessel may be buried. In this case, surface pressure between the vibration transmitting member and clamp portion and the blood vessel at the time of grasping the blood vessel is required to be lowered. 15, 20, 25, 30

## Summary of Invention

**[0004]** An object of the present invention is to provide a vibration transmitting member and a surgical apparatus enabling treatment of crushing and shattering living tissue such as a liver to be conducted appropriately and enabling a blood vessel or the like buried in the living tissue to be grasped appropriately. 35

**[0005]** A vibration transmitting member according to an aspect of the present invention used with a clamp portion and enabling vibration from an ultrasonic transducer to be transmitted is extended from a proximal portion toward a distal portion, and is provided at the distal portion with a ridge portion formed along a longitudinal axis extending from the proximal portion to the distal portion, the vibration is input from the ultrasonic transducer to cause the vibration to be transmitted from the proximal portion to the distal portion, and a thickness along an opening/closing direction in which the clamp portion is to move by turning is smaller than a width of the distal portion in a width direction perpendicular to the opening/closing direction. 40, 45, 50, 55

## Brief Description of Drawings

**[0006]**

Fig. 1 is a schematic view illustrating a surgical system according to first to fifth embodiments.

Fig. 2 is a schematic perspective view illustrating a part around a distal portion of a vibration transmitting member and a clamp portion in a surgical apparatus of the surgical system according to the first embodiment.

Fig. 3A is a schematic side view illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the first embodiment.

Fig. 3B is a schematic horizontal cross-sectional view along the line 3B-3B in Fig. 3A illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the first embodiment.

Fig. 3C is a schematic horizontal cross-sectional view along the line 3C-3C in Fig. 3A illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the first embodiment.

Fig. 3D is a schematic top view illustrating the distal portion of the vibration transmitting member in the surgical apparatus of the surgical system according to the first embodiment.

Fig. 4A is a schematic side view illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the second embodiment.

Fig. 4B is a schematic horizontal cross-sectional view along the line 4B-4B in Fig. 4A illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the second embodiment.

Fig. 4C is a schematic horizontal cross-sectional view along the line 4C-4C in Fig. 4A illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the second embodiment.

Fig. 4D is a schematic top view illustrating the distal portion of the vibration transmitting member in the surgical apparatus of the surgical system according to the second embodiment.

Fig. 5 is a schematic perspective view illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the third embodiment.

Fig. 6 is a schematic side view illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the fourth

embodiment.

Fig. 7A is a schematic side view illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the fifth embodiment.

Fig. 7B is a schematic horizontal cross-sectional view along the line 7B-7B in Fig. 7A illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the fifth embodiment.

Fig. 7C is a schematic horizontal cross-sectional view along the line 7C-7C in Fig. 7A illustrating the part around the distal portion of the vibration transmitting member and the clamp portion in the surgical apparatus of the surgical system according to the fifth embodiment.

#### Description of Embodiments

**[0007]** Hereinbelow, embodiments of the present invention will be described with reference to the drawings.

**[0008]** A first embodiment will be described with reference to Figs. 1 to 3D.

**[0009]** As illustrated in Fig. 1, a surgical system 10 according to the present embodiment includes a surgical apparatus 12, an ultrasonic transducer 14, and a controller 16. The controller 16 includes an energy source (not illustrated) supplying the ultrasonic transducer 14 with energy generating appropriate ultrasonic vibration. The ultrasonic transducer 14 is arranged at a proximal end of a below-mentioned vibration transmitting member 26 and generates ultrasonic vibration to enable the vibration to be transmitted from the proximal portion to a distal portion along a longitudinal axis (center axis) C of the vibration transmitting member 26.

**[0010]** The not-illustrated energy source of the controller 16 can preferably generate the ultrasonic vibration in the transducer 14 and apply high-frequency output to living tissue grasped between the below-mentioned vibration transmitting member 26 serving as a first electrode of the surgical apparatus 12 and electrode portions 56a and 56b included in a below-mentioned clamp portion 28 serving as a second electrode. Meanwhile, the controller 16 includes a processor including a CPU, an ASIC, or the like.

**[0011]** As illustrated in Figs. 1 to 3A, the surgical apparatus 12 includes a handle unit 22, a cylindrical sheath 24, the vibration transmitting member (rod-like member) 26, and the clamp portion 28 used with the vibration transmitting member 26 and enabling approach to and separation from the vibration transmitting member 26. The vibration transmitting member 26 is used with the clamp portion 28 and can transmit vibration from the ultrasonic transducer 14.

**[0012]** As illustrated in Fig. 1, the handle unit 22 includes a housing 32 including a fixed handle 32a, and a

movable handle 34. Inside the sheath 24, a driving member 42 (refer to Fig. 3A) operating along an axial direction of the center axis C, interlocking with an operation of the movable handle 34, is arranged. The driving member 42 is preferably formed in a cylindrical shape concentrically with the sheath 24. The movable handle 34 can move between a separation position (open position) illustrated in Fig. 1 separating from the fixed handle 32a of the housing 32 and an approach position (close position) approaching to the fixed handle 32a of the housing 32. In the present embodiment, when the movable handle 34 is at the separation position, the clamp portion 28 is at a separation position from a distal portion (treatment portion) 26a of the vibration transmitting member 26 as illustrated in Figs. 1 and 2. Also, when the movable handle 34 is at the approach position, the clamp portion 28 is at an approach position to the distal portion 26a of the vibration transmitting member 26 as illustrated in Fig. 3A.

**[0013]** Meanwhile, it is to be understood that the clamp portion 28 may be at the approach position to the distal portion 26a of the vibration transmitting member 26 when the movable handle 34 is at the separation position and that the clamp portion 28 may be at the separation position from the distal portion 26a of the vibration transmitting member 26 when the movable handle 34 is at the approach position.

**[0014]** At a distal portion 24a of the sheath 24, the clamp portion 28 is turnably supported. As illustrated in Figs. 2, 3B, and 3C, the clamp portion 28 includes a clamp portion main body (turning body) 52, a pressing pad 54 provided in the main body 52, and the pair of electrode portions 56a and 56b provided in the main body 52.

**[0015]** The main body 52 of the clamp portion 28 may be formed by a single body or by plural bodies such as two bodies. In a case in which the main body 52 is formed by the plural bodies, a known so-called seesaw jaw or wiper jaw can be used.

**[0016]** The main body 52 of the clamp portion 28 is supported at the distal portion 24a of the sheath 24 to be turnable by a main turning shaft 62, for example. The main body 52 is supported at a distal portion of the driving member 42 to be turnable by a moving and turning shaft (distal-side turning shaft) 64. It is preferable for the main turning shaft 62 and the moving and turning shaft (distal-side turning shaft) 64 to be parallel to each other and be perpendicular to the center axis C. When the driving member 42 moves forward along the center axis (longitudinal axis) C with respect to the sheath 24 in response to an operation of the movable handle 34 with respect to the housing 32, the driving member 42 presses the main body 52 to a front side of the sheath 24 approximately in parallel with the center axis C by means of the moving and turning shaft 64. Since positional relationship among the main turning shaft 62, the main body 52, and the distal portion 24a of the sheath 24 does not change, the main body 52 closes toward the distal portion 26a of the vibration transmitting member 26. Conversely, when the driving member 42 moves backward along the center axis

C with respect to the sheath 24 in response to an operation of the movable handle 34, the driving member 42 pulls the main body 52 to a backside of the sheath 24 in parallel with the center axis C by means of the moving and turning shaft 64. Thus, the main body 52 opens away from the distal portion 26a of the vibration transmitting member 26. That is, the main body 52 of the clamp portion 28 is movable between the approach position (close position) approaching to the vibration transmitting member 26 and the separation position (open position) separating from the vibration transmitting member 26 by means of the operations of the movable handle 34.

**[0017]** The pressing pad 54 is provided at a position in the main body close to a below-mentioned treatment surface 82 at the distal portion 26a of the vibration transmitting member 26 in a state of being opposed to the treatment surface 82. The pressing pad 54 is arranged between the electrode portions 56a and 56b in the main body 52. The pressing pad 54 contacts with a below-mentioned dissecting area 82a of the treatment surface 82 at the distal portion 26a of the vibration transmitting member 26 when the main body 52 is at the approach position and the pressing pad 54 separates from the treatment surface 82 at the distal portion 26a of the vibration transmitting member 26 along with movement of the main body 52 when the main body 52 is at the separation position. The pressing pad 54 is made of a material having electric insulation, heat resistance, and abrasion resistance. As a material for the pressing pad 54, a PTFE material can be used, for example.

**[0018]** In the present embodiment, in a case in which the clamp portion 28 is at the approach position, especially the dissecting area 82a of the treatment surface 82 at the distal portion 26a of the vibration transmitting member 26 can contact with on the pressing pad 54 but does not contact with the electrode portions 56a and 56b. Thus, when the treatment surface 82 at the distal portion 26a of the vibration transmitting member 26 is used as one electrode while the electrode portions 56a and 56b of the clamp portion 28 are used as the other electrode, and living tissue is clamped between the electrodes, bipolar treatment can be conducted to the living tissue.

**[0019]** Meanwhile, a heater may be used instead of the electrode portions 56a and 56b, or an equal material to the pressing pad 54 may be provided on the surface instead of the electrode portions 56a and 56b.

**[0020]** The vibration transmitting member (rod-like member) 26 is inserted into the sheath 24. The vibration transmitting member 26 is made of a material having a good vibration transmitting characteristic such as a titanium alloy material, an aluminum alloy material and the like. The vibration transmitting member 26 extends from the proximal portion to which the ultrasonic transducer 14 is connected toward the distal portion. In the vibration transmitting member 26, vibration is transmitted from the proximal portion toward the distal portion in response to input of vibration from the ultrasonic transducer 14. The vibration transmitting member 26 is conductive when the

vibration transmitting member 26 is used as one of high-frequency electrodes. The vibration transmitting member 26 is preferably arranged on the center axis C of the sheath 24.

**[0021]** From the proximal end to the distal end of the vibration transmitting member 26, vibration having an appropriate frequency is transmitted by the ultrasonic transducer 14 attached to the proximal end of the vibration transmitting member 26. Thus, a length from the proximal portion to the distal portion of the vibration transmitting member 26 is set in accordance with the frequency of the vibration output by the ultrasonic transducer 14. Particularly, the distal end of the vibration transmitting member 26 is set at an antinode position of the vibration since the distal end conducts appropriate treatment to living tissue in a state in which the vibration is transmitted. An outer circumferential surface of the vibration transmitting member 26 located at a node position of the vibration in a state in which the vibration is transmitted to the vibration transmitting member 26 is provided between the outer circumferential surface and an inner circumferential surface of the sheath 24 with a ring-like member 27 having electric insulation and heat resistance. That is, in the treatment portion 26a of the vibration transmitting member 26, a distal end corresponds to the antinode position of the vibration while a proximal end corresponds to the node position of the vibration inside the sheath 24, and a length of the treatment portion 26a corresponds to a quarter wavelength of the vibration (vibrational wave) output by the ultrasonic transducer 14. Meanwhile, the treatment portion 26a is preferably formed to be symmetric or approximately symmetric across an opening/closing surface including the center axis C to which the clamp portion 28 turns. Also, the treatment portion 26a is preferably formed to be symmetric or approximately symmetric across the center axis C in a direction along an opening/closing direction of the clamp portion 28.

**[0022]** As illustrated in Fig. 3A, the distal portion or the treatment portion 26a of the vibration transmitting member 26 according to the present embodiment includes a treatment area (parallel area) 72 provided to be parallel to or approximately parallel to the center axis C and adapted to conduct treatment to living tissue, a middle area 74 formed on a proximal side of the treatment area 72, and a rod-like area 76 formed on a proximal side of the middle area 74. The rod-like area 76 preferably has an approximately equal diameter, for example, has a circular horizontal cross-sectional surface, and is formed in a rod shape at an appropriate position along the center axis C. Meanwhile, in the present embodiment, a first node position of the vibration from the distal end is located in the rod-like area 76. In the middle area 74, a horizontal cross-sectional surface thereof smoothly changes from the rod-like area 76 at the proximal end thereof to the treatment area 72 at a distal end thereof. In the present embodiment, in the middle area 74, a thickness along the opening/closing direction in which the clamp portion 28 moves by turning is preferably smaller gradually from

the proximal end to the distal end along the center axis C in Figs. 3A and 3D. At this time, the middle area 74 is preferably formed to have a symmetric or approximately symmetric thickness across the center axis C. Conversely, in the present embodiment, in the middle area 74, a length in a width direction perpendicular to the opening/closing direction of the clamp portion 28 is preferably approximately equal regardless of an appropriate position along the center axis C in Figs. 3A and 3D.

**[0023]** The treatment area 72 includes the treatment surface 82, a back surface 84 opposed to the treatment surface 82, and side surfaces 86a and 86b between the treatment surface 82 and the back surface 84. In the treatment area 72 of the treatment portion 26a, a thickness T along the opening/closing direction in which the clamp portion 28 is to move by turning is smaller than a width W along the width direction perpendicular to the opening/closing direction. Thus, the treatment portion 26a is formed approximately in a flat shape. In the present embodiment, the width W in the width direction is preferably equal from a distal portion of the treatment area 72 of the treatment portion 26a to an appropriate position such as the rod-like area 76 at the proximal portion of the treatment portion 26a. As illustrated in Figs. 3B and 3C, in the present embodiment, a thickness (height) TU of an upper part and a thickness (height) TL of a lower part with respect to the longitudinal axis C are preferably equal.

**[0024]** The treatment surface 82 includes the dissecting area 82a which is able to abutment on the pressing pad 54 and which is able to dissect living tissue when transmitting ultrasonic vibration to the treatment surface 82, and sealing areas 82b and 82c which is formed adjacent to the dissecting area 82a in the width direction and able to coagulate and to seal the living tissue by means of high-frequency output generated by electric conduction between the sealing areas 82b and 82c and the electrode portions 56a and 56b of the clamp portion 28 via the living tissue. As illustrated in Figs. 3B and 3C, the dissecting area 82a and the sealing areas 82b and 82c are formed along the longitudinal axis C. The dissecting area 82a is at a top portion along the opening/closing direction of the clamp portion 28 and has an appropriate width, for example, to form a ridge portion (ridge line). This dissecting area (ridge portion) 82a extends along the longitudinal axis C and is located on the opening/closing surface to which the clamp portion 28 is to move by turning. The sealing areas 82b and 82c are formed successively to the dissecting area 82a and are respectively formed as inclined surfaces elongated along the longitudinal axis C. The sealing areas 82b and 82c may be flat surfaces or curved surfaces. As illustrated in Figs. 3B and 3C, the thickness T of the treatment area 72 is thinner at a position farther than a position including the center axis C (position including the dissecting area 82a) along the width direction.

**[0025]** As illustrated in Fig. 1, the housing 32 is provided with first and second switches 92 and 94. When the

first switch 92 is pressed, bipolar high-frequency output is performed between the vibration transmitting member 26 serving as the first electrode and the electrode portions 56a and 56b of the clamp portion 28 serving as the second electrode. Thus, by pressing the first switch 92, coagulation of living tissue or sealing of a blood vessel is conducted between the vibration transmitting member 26 and the electrode portions 56a and 56b of the clamp portion 28. When the second switch 94 is pressed, ultrasonic output and bipolar high-frequency output are performed. Thus, living tissue is dissected while the living tissue is coagulated, or a blood vessel is dissected while the blood vessel is sealed.

**[0026]** Next, actions of the surgical system 10 according to the present embodiment will be described. Here, description is provided, using liver tissue as a treated target, for example.

**[0027]** The movable handle 34 is moved closer to the fixed handle 32a of the housing 32 to move the clamp portion 28 closer to the treatment surface 82 of the vibration transmitting member 26. Liver tissue is then grasped between the pressing pad 54 and the electrode portions 56a and 56b of the clamp portion 28 and the treatment surface 82 of the vibration transmitting member 26. At this time, the width W of the treatment surface 82 of the vibration transmitting member 26 is formed to be longer than the thickness T, and a width of the clamp portion 28 is similarly formed to be long to correspond to the width W of the treatment surface 82 of the vibration transmitting member 26. Thus, an area of the treatment surface is formed to be large. Accordingly, since the width of the treatment surface 82 is long, a contact area of the treatment surface 82 of the vibration transmitting member 26 and the clamp portion 28 is large at the time of contacting the liver tissue, and the treatment surface 82 of the vibration transmitting member 26 and the clamp portion 28 are easily hung with the liver tissue. The pressing pad 54 and the electrode portions 56a and 56b of the clamp portion 28 and the treatment surface 82 of the vibration transmitting member 26 are formed to clamp the liver tissue therebetween. Also, when the living tissue is grasped between the pressing pad 54 and the electrode portions 56a and 56b of the clamp portion 28 and the treatment surface 82 of the vibration transmitting member 26, and a compressing force (grasping force) is applied, the compressing force is distributed over the contact surface since the contact area between the treatment surface 82 and the living tissue is large. Accordingly, in the treatment surface 82, an action of widely pressing and crushing the living tissue is larger than an action of dissecting the living tissue by focusing the compressing force on a part. The treatment surface 82 is suitable for crushing the liver tissue, especially liver parenchyma.

**[0028]** Meanwhile, at this time, no operation of the first switch 92 or the second switch 94 is required. That is, in a case in which treatment of crushing and shattering the liver tissue is conducted by means of the surgical apparatus 12 according to the present embodiment, the high-

frequency output and the ultrasonic output are not required.

**[0029]** In case of grasping a blood vessel between the clamp portion 28 and the treatment surface 82 of the vibration transmitting member 26, the contact area between the treatment surface 82 of the vibration transmitting member 26 and the living tissue is large. Thus, surface pressure when the blood vessel is grasped between the clamp portion 28 and the treatment surface 82 of the vibration transmitting member 26 is distributed. Accordingly, when the blood vessel in the liver tissue is grasped between the clamp portion 28 and the treatment surface 82 of the vibration transmitting member 26, it is possible to prevent the blood vessel from being damaged and bleeding by a mechanical force of the compressing force (grasping force).

**[0030]** The movable handle 34 is moved away from the fixed handle 32a of the housing 32 to move the clamp portion 28 away from the treatment surface 82 of the vibration transmitting member 26. The movable handle 34 is then moved closer to the fixed handle 32a of the housing 32 again to move the clamp portion 28 closer to the treatment surface 82 of the vibration transmitting member 26, and adjacent liver tissue is crushed in a similar manner to the above.

**[0031]** As described above, when the liver tissue is crushed, the blood vessel in the liver may appear. In this case, the blood vessel is grasped between the pressing pad 54 of the clamp portion 28 and the treatment surface 82 of the vibration transmitting member 26. When the first switch 92 is pressed in this state, the blood vessel is coagulated by the action of the high-frequency output. Also, when the second switch 94 is pressed, the blood vessel is dissected mainly by the action of the ultrasonic vibration while the blood vessel is coagulated mainly by the action of the high-frequency output. Specifically, the blood vessel is dissected at the dissecting area 82a of the treatment surface 82 by the action of the ultrasonic output while the blood vessel is coagulated at the sealing areas 82b and 82c of the treatment surface 82 by the action of the high-frequency output.

**[0032]** As described above, the present embodiment can achieve the following things.

**[0033]** The width W of the treatment surface 82 in the vibration transmitting member 26 opposed to the clamp portion 28 is longer than the thickness T, and the vibration transmitting member 26 is formed approximately in the flat shape. Accordingly, an area in the treatment surface 82 of the vibration transmitting member 26 abutting on liver tissue or the like can be large, and tissue having a larger area can be clamped and crushed between the clamp portion 28 and the treatment surface 82. Also, even in a case in which a blood vessel is unintentionally grasped when the treatment surface 82 is hung with the liver tissue or the like, the contact area between the blood vessel and the treatment surface 82 is set to be large, and the surface pressure of the treatment surface 82 to the blood vessel can be dispersed. Accordingly, when

the blood vessel is grasped between the treatment surface 82 of the vibration transmitting member 26 and the clamp portion 28, it is possible to prevent the blood vessel from being damaged and bleeding by a mechanical force of the compressing force (grasping force).

**[0034]** When the blood vessel is grasped, the blood vessel can be coagulated by the high-frequency output. Also, the blood vessel can be dissected while being coagulated by the high-frequency output and the ultrasonic output.

**[0035]** Thus, the present embodiment can provide the vibration transmitting member 26 and the surgical apparatus 12 enabling treatment of crushing and shattering living tissue such as a liver to be conducted appropriately and enabling a blood vessel or the like buried in the living tissue to be grasped appropriately.

**[0036]** Next, a second embodiment will be described with reference to Figs. 4A to 4D. The present embodiment is a modification example of the first embodiment. Members identical to or having identical functions to those described in the first embodiment are shown with the same reference numerals as much as possible, and detailed description of the duplicate components is omitted.

**[0037]** As illustrated in Figs. 4A to 4D, the treatment portion 26a as the distal portion of the vibration transmitting member 26 according to the present embodiment has a different width in the width direction and a different horizontal cross-sectional shape depending on a position along the longitudinal axis C.

**[0038]** The treatment area 72 of the treatment portion 26a is preferably formed to be symmetric or approximately symmetric across the center axis C in the width direction. The treatment area 72 of the treatment portion 26a includes a distal area 72a, a width change area 72b provided on a proximal side of the distal area 72a, and a proximal area 72c provided on a proximal side of the width change area 72b. That is, the treatment area 72 of the treatment portion 26a includes the width change area 72b between the distal area 72a and the proximal area 72c, as well as the distal area 72a and the proximal area 72c, in a quarter wavelength area of the vibrational wave output by the ultrasonic transducer 14 from the distal portion to the proximal side (area approximately over the entire length of the treatment portion 26a). The distal area

72a illustrated in Fig. 4B has an approximately constant width W1 in the width direction and an approximately constant horizontal cross-sectional shape from a position close to a distal end thereof to the proximal end. As a matter of course, the distal end of the distal area 72a is formed in an obtuse shape.

As illustrated in Fig. 4D, a width of the width change area 72b in the width direction is gradually, such as successively, reduced from the proximal end of the distal area 72a to a distal end of the proximal area 72c. That is, the width change area 72b has a longer width in the width direction and a larger horizontal cross-sectional area at a position closer to the distal area 72a and has a shorter width in the width direction and a smaller horizontal cross-sectional area at

a position closer to the proximal area 72c. Further, the proximal area 72c has an approximately constant width W2 in the width direction and an approximately constant horizontal cross-sectional shape from a position close to the distal end thereof to a proximal end thereof. Accordingly, the width W1 of the distal area 72a in the width direction perpendicular to the longitudinal axis C is longer than the width W2 of the proximal area 72c in the width direction. That is, in the treatment portion 26a, the width W1 in the width direction on a cross-section of the distal area 72a perpendicular to the longitudinal axis C is longer than the width W2 in the width direction on a cross-section of the proximal area 72c.

**[0039]** Also, a cross-sectional area D1 in the distal area 72a illustrated in Fig. 4B is larger than a cross-sectional area D2 in the proximal area 72c illustrated in Fig. 4C. Also, a cross-sectional area of the width change area 72b is as large as a cross-sectional area between the cross-sectional area D1 in the distal area 72a and the cross-sectional area D2 in the proximal area 72c although it is not illustrated. More specifically, the cross-sectional area of the width change area 72b is gradually reduced from the proximal end of the distal area 72a to the distal end of the proximal area 72c. The cross-sectional area of the width change area 72b preferably corresponds at a distal end thereof to the cross-sectional area D1 of the proximal end of the distal area 72a and corresponds at the proximal end thereof to the cross-sectional area D2 of the distal end of the proximal area 72c. Accordingly, the cross-sectional area D1 of the distal area 72a perpendicular to the longitudinal axis C is larger than the cross-sectional area D2 of the proximal area 72c perpendicular to the longitudinal axis C.

**[0040]** In the treatment area 72 of the treatment portion 26a, the width change area 72b and the distal area 72a are formed to be wider than the proximal area 72c. That is, the proximal area 72c is formed to be narrower than the width change area 72b and the distal area 72a. Thus, in a case in which the width change area 72b or the distal area 72a is checked from the proximal side of the vibration transmitting member 26 and the clamp portion 28 with use of an endoscope (not illustrated), for example, the width change area 72b or the distal area 72a can be checked through a part at which no flesh exists. Accordingly, the treatment portion 26a of the vibration transmitting member 26 according to the present embodiment is formed to facilitate check of a treatment state with use of the endoscope.

**[0041]** As illustrated in Fig. 4D, when a line along an external edge (side surface 86a or 86b) in the width direction of the width change area 72b is virtually extended toward the longitudinal axis C, an angle  $\theta$  between the longitudinal axis C and the virtual line illustrated by the dashed line is preferably set to 30° or less, for example. It is empirically found that, when the angle  $\theta$  is around 5°, for example, generation of mist, that is, generation of cavitation, can be restricted in the width change area 72b between the distal area 72a and the proximal area 72c

in a state in which vibration is transmitted from the ultrasonic transducer 14 to the vibration transmitting member 26. This angle  $\theta$  can be changed to 10°, 20°, or the like as appropriate. Also, although each of the side surfaces 86a and 86b of the width change area 72b is a linearly-extended inclined surface in the above embodiment, each of the side surfaces 86a and 86b may be formed to change the width continuously by combining a plurality of inclined surfaces. For example, each of the side surfaces 86a and 86b may be formed to change the width

5 from the proximal area 72c toward the distal area 72a in a multistage manner, in which an area whose angle  $\theta$  between the longitudinal axis C and the virtual line is 5°, an area whose angle  $\theta$  is 10°, and the like are arranged.

10 Also, although each of the side surfaces 86a and 86b of the width change area 72b is the linearly-extended inclined surface in the above embodiment, each of the side surfaces 86a and 86b of the width change area 72b may be formed as a curved surface, and the angle  $\theta$  between

15 a tangential line of the curved surface and the longitudinal axis C may be 30° or less.

**[0042]** Especially at the time of treatment, the distal end of the treatment portion 26a of the vibration transmitting member 26 and the distal end of the clamp portion

20 28 are moved finely. The width change area 72b and the proximal area 72c are formed to be narrower than the distal area 72a. Thus, even in a case in which the temperature of the treatment portion 26a of the vibration transmitting member 26 is higher than a temperature de-

25 naturalizing protein of living tissue (e.g., approximately 60°C) due to the high-frequency output or the like, for example, the width change area 72b and the proximal area 72c are harder to contact the living tissue than in a state in which the width change area 72b and the proximal area 72c have the same widths as that of the distal area 72a. Accordingly, by using the vibration transmitting member 26 according to the present embodiment, generation of thermal spread can be restricted when the treatment portion 26a of the vibration transmitting mem-

30 ber 26 and the clamp portion 28 are moved as appropriate.

**[0043]** Thus, the present embodiment can provide the vibration transmitting member 26 and the surgical apparatus 12 enabling restriction of thermal spread while se-  
35 curing insertability into a small hole and visibility of a distal portion.

**[0044]** Next, a third embodiment will be described with reference to Fig. 5. The present embodiment is a modi-  
40 fication example of the first and second embodiments.

50 Members identical to or having identical functions to those described in the first and second embodiments are shown with the same reference numerals as much as possible, and detailed description of the duplicate components is omitted. It is to be understood in the present embodiment that the treatment portion 26a of the vibration transmitting member 26 may be either one having a constant width as described in the first embodiment or one having the distal area 72a, the width change area

72b, and the proximal area 72c and changing a width depending on a position as described in the second embodiment.

**[0045]** As illustrated in Fig. 5, the treatment area 72 of the distal portion 26a of the vibration transmitting member 26 is bent at a bent portion 78 in one direction from a straight state. Similarly, the clamp portion 28, as well as the treatment portion 26a of the vibration transmitting member 26, is bent at a bent portion 58 in one direction from a straight state. Here, as an example, a part from the distal end to the bent portion 78 of the vibration transmitting member 26 is bent, and a part from the bent portion 78 to the proximal side is straight. Similarly, a part from the distal end to the bent portion 58 of the clamp portion 28 is bent, and a part from the bent portion 58 to the proximal side is straight.

**[0046]** Meanwhile, it is to be understood that a part from the distal end of the treatment area 72 to the distal end of the middle area 74 in the treatment portion 26a of the vibration transmitting member 26 is preferably bent to form the bent portion 78. That is, the treatment portion 26a of the vibration transmitting member 26 has only to include the bent portion 78 between the distal end of the treatment area 72 and the distal end of the middle area 74. Thus, the treatment area 72 of the treatment portion 26a includes the bent portion 78 between the distal end of the treatment area 72 and the proximal end of the treatment area 72 in the quarter wavelength area of the vibrational wave output by the ultrasonic transducer 14 from the distal portion to the proximal side (area approximately over the entire length of the treatment portion 26a). The shape of the treatment portion 26a of the vibration transmitting member 26 may be formed as appropriate as long as easiness of treatment is secured as described below.

**[0047]** In a case in which treatment of crushing liver tissue in a curved shape is to be conducted without using energy, when the distal portion 26a of the vibration transmitting member 26 is straight as described in the first and second embodiments, a single-time treatment area is in a straight shape. Thus, to conduct the treatment of crushing the liver tissue in the curved shape, small straight-shaped treatment needs to be repeated while the direction of the distal portion 26a is changed. Conversely, since the treatment portion 26a of the vibration transmitting member 26 according to the present embodiment is bent in one direction, a single-time treatment area is approximately in an arc. Accordingly, the operation of repeating the small straight-shaped treatment can be omitted at the time of forming the treatment area in the curved shape. For this reason, when the liver tissue is to be dissected annularly, for example, existence of the bent portion 78 enables single treatment to be longer in length than the small straight-shaped treatment and to be conducted in a wider range. Accordingly, in a case in which the treatment portion 26a includes the bent portion 78, the number of times of opening/closing the clamp portion 28 with respect to the treatment portion 26a can be de-

creased. That is, the number of times of movement of the vibration transmitting member 26 and the clamp portion 28 and the number of times of turning of the clamp portion 28 can be decreased. Also, due to the bent portion 78, at the time of forming the treatment area in the curved shape, it is possible to prevent excessive dissection of a dissected target such as liver tissue and to form a smoother treatment area.

**[0048]** Also, since the distal portion 26a of the vibration transmitting member 26 is bent, visibility of the clamp portion 28 and the distal portion 26a of the vibration transmitting member 26 with use of a not-illustrated endoscope in laparoscopic surgery can be improved.

**[0049]** Next, a fourth embodiment will be described with reference to Fig. 6. The present embodiment is a modification example of the first to third embodiments. Members identical to or having identical functions to those described in the first to third embodiments are shown with the same reference numerals as much as possible, and detailed description of the duplicate components is omitted. In the present embodiment, the treatment portion 26a of the vibration transmitting member 26 may be straight as described in the first and second embodiments or bent as described in the third embodiment.

**[0050]** As illustrated in Fig. 6, a distal end of the back surface 84 opposed to the treatment surface 82 in the treatment area 72 of the distal portion 26a of the vibration transmitting member 26 is provided with a cavitation generating surface 84a actively generating cavitation in an intended direction when vibration from the ultrasonic transducer 14 is transmitted to the distal end of the vibration transmitting member 26. The cavitation generating surface 84a is formed as a curved surface. The cavitation generating surface 84a generates the cavitation in a normal direction thereof when the vibration from the ultrasonic transducer 14 is transmitted to the distal end of the vibration transmitting member 26.

**[0051]** In this manner, the curved cavitation generating surface 84a is formed at the distal end of the back surface 84 in the treatment area 72 of the distal portion 26a of the vibration transmitting member 26. Thus, for example, the cavitation generating surface 84a can be brought into contact with liver tissue, and when the vibration from the ultrasonic transducer 14 is transmitted to the distal end of the vibration transmitting member 26, the liver tissue can be emulsified by the cavitation and shattered.

**[0052]** Next, a fifth embodiment will be described with reference to Figs. 7A to 7C. The present embodiment is a modification example of the first to fourth embodiments. Members identical to or having identical functions to those described in the first to fourth embodiments are shown with the same reference numerals as much as possible, and detailed description of the duplicate components is omitted.

**[0053]** As illustrated in Figs. 7A to 7C, when the clamp portion 28 is closed with respect to the vibration transmitting member 26, the distal portion 26a of the vibration transmitting member 26 is supplied around a proximal

end of the pressing pad 54 with highest stress. As illustrated in Fig. 7A, the middle area 74 of the treatment portion 26a of the vibration transmitting member 26 according to the present embodiment includes a short area 74a on the side of the treatment surface 82 and a long area 74b on the side of the back surface 84. The long area 74b on the side of the back surface 84 is longer than the short area 74a on the side of the treatment surface 82. Proximal positions of the short area 74a and the long area 74b along the center axis C are at equal or approximately equal positions, that is, at a position of a distal end of the rod-like area 76. The short area 74a is formed continuously to the treatment surface 82. The long area 74b is formed continuously to the back surface 84 on a proximal side of the back surface 84. Thus, the middle area 74 of the distal portion 26a of the vibration transmitting member 26 according to the present embodiment has an upper side and a lower side asymmetric across the longitudinal axis C in Fig. 7A and forms a longer thick part than the middle area 74 of the distal portion 26a of the vibration transmitting member 26 described in the first to fourth embodiments. That is, the treatment area 72 according to the present embodiment includes not only a parallel part to the center axis C but also a part of a thick portion 88.

**[0054]** Here, as illustrated in Figs. 7A and 7B, in the middle area 74, the distance TU from the center axis C to the top portion (dissecting area) 82a of the treatment surface 82 is shorter than a distance TL1 from the center axis C to a top portion 85 of the back surface 84. Thus, the long area 74b of the middle area 74 is provided with the thick portion 88, which is thicker than the short area 74a. That is, the long area 74b of the middle area 74 includes the thick portion 88. Meanwhile, as illustrated in Figs. 7A and 7C, in the treatment area 72, the distance TU from the center axis C to the top portion (dissecting area) 82a of the treatment surface 82 is approximately equal to the distance TL from the center axis C to the top portion 85 of the back surface 84. Meanwhile, the top portion (dissecting area) 82a of the treatment surface 82 is an abutting surface on which the pressing pad 54 is to abut.

**[0055]** Consequently, in the present embodiment, the treatment area (parallel area) 72 provided to be parallel to or approximately parallel to the center axis C and adapted to conduct treatment to living tissue is shorter on the back surface 84 than those described in the first to fourth embodiments. On the other hand, the treatment area (parallel area) 72 provided to be parallel to or approximately parallel to the center axis C and adapted to conduct treatment to living tissue is preferably formed on the treatment surface 82 to be similar to those described in the first to fourth embodiments. That is, the thick portion 88 of the back surface 84 has a part which is not parallel to the longitudinal axis C. As a matter of course, a part of the back surface 84 located further on the distal side than the thick portion 88 is preferably parallel to the longitudinal axis C.

**[0056]** In this manner, the thick portion 88 is formed on the back surface 84 on the opposite side of the treatment surface 82 with the longitudinal axis C, extended from the proximal portion to the distal portion around an abutting part on which the proximal end of the pressing pad 54 along the longitudinal axis C in the dissecting area 82a abuts, interposed therebetween. The thick portion 88 is thicker than the part continued to the treatment surface 82 with the longitudinal axis C interposed therebetween from the distal side toward the proximal side along the longitudinal axis C. Also, in a state in which the proximal end of the pressing pad 54 of the clamp portion 28 abuts on the dissecting area 82a, the proximal end of the pressing pad 54 of the clamp portion 28 is located between a distal end and a proximal end of the thick portion 88 along the longitudinal axis C. That is, the thick portion 88 is formed to be gradually thicker along the longitudinal axis C from a part in the dissecting area 82a further on the distal side than the proximal position of the pressing pad 54 along the longitudinal axis C toward a part further on the proximal side than the proximal position.

**[0057]** Thus, due to the thick portion 88, the distal portion 26a of the vibration transmitting member 26 according to the present embodiment, especially the proximal end of the pressing pad 54, can improve resistance to stress more than the distal portion 26a of the vibration transmitting member 26 described in the first to fourth embodiments. Consequently, the amount of deformation of the treatment area 72 of the distal portion 26a of the vibration transmitting member 26 can be restricted. Thus, according to the present embodiment, it is possible to provide the vibration transmitting member 26 and the surgical apparatus 12 enabling resistance to stress in grasping to be secured without influencing treatment performance even in a case of proceeding with size reduction (diameter reduction) of the vibration transmitting member 26 and to restrict to the minimum changes in center of gravity on respective vertical cross-sectional surfaces to the longitudinal axis C and vibration destabilizing elements resulting from the discontinuous changes.

**[0058]** Meanwhile, the bent portion 78 described in the fourth embodiment is preferably formed at an appropriate position although it is not illustrated. That is, for example, the bent portion 78 may be formed at a part including the thick portion 88, at the treatment area 72, or at both the parts.

**[0059]** Several embodiments have specifically been described above with reference to the drawings. However, the present invention is not limited to the aforementioned embodiments but includes every embodiment carried out without departing from the spirit and scope thereof.

## 55 Claims

1. A vibration transmitting member used with a clamp portion and configured to transmit vibration from an

ultrasonic transducer, wherein  
the vibration transmitting member is extended from  
a proximal portion toward a distal portion,  
the vibration transmitting member includes a ridge  
portion at the distal portion formed along a longitudi- 5  
nal axis extending from the proximal portion to the  
distal portion and located on a surface along an  
opening/closing direction in which the clamp portion  
is configured to move by turning,  
the vibration transmitting member is configured to 10  
transmit the vibration from the proximal portion to  
the distal portion thereof when the vibration is input  
to the proximal portion of the vibration transmitting  
member, and  
a thickness of the vibration transmitting member 15  
along the opening/closing direction in which the  
clamp portion is configured to move by turning is  
smaller than a width of the distal portion of the vibra-  
tion transmitting member in a width direction perpen-  
dicular to the opening/closing direction. 20

2. The vibration transmitting member according to  
claim 1, wherein:  
the distal portion includes a treatment area, and 25  
a width on a distal side in the treatment area is  
larger than a width on a proximal side.

3. The vibration transmitting member according to  
claim 1, wherein the distal portion includes a cava-  
tation generating surface which is provided on a back  
surface on an opposite side of a surface opposed to  
the clamp portion, and which is configured to gener-  
ate cavitation when the vibration is transmitted to the  
distal portion. 30 35

4. The vibration transmitting member according to  
claim 1, wherein the distal portion includes a treat-  
ment area and a middle area formed on a proximal  
side of the treatment area and includes a bent portion  
between a distal end of the treatment area and a 40  
distal end of the middle area.

5. A surgical apparatus comprising:  
the vibration transmitting member according to 45  
claim 1; and  
a clamp portion which is able to approach to and  
separate from the vibration transmitting mem-  
ber. 50

6. The surgical apparatus according to claim 5, where-  
in:  
the distal portion of the vibration transmitting 55  
member includes a treatment surface opposed  
to the clamp portion, and  
the ridge portion of the treatment surface is a

dissecting area which is configured to dissect  
the living tissue to transmit ultrasonic vibration  
to the ridge portion, and  
the treatment surface includes a sealing area  
which is formed adjacent to the dissecting area  
in the width direction and which is configured to  
coagulate and seal the living tissue by means  
of electric conduction between the sealing area  
and the clamp portion.

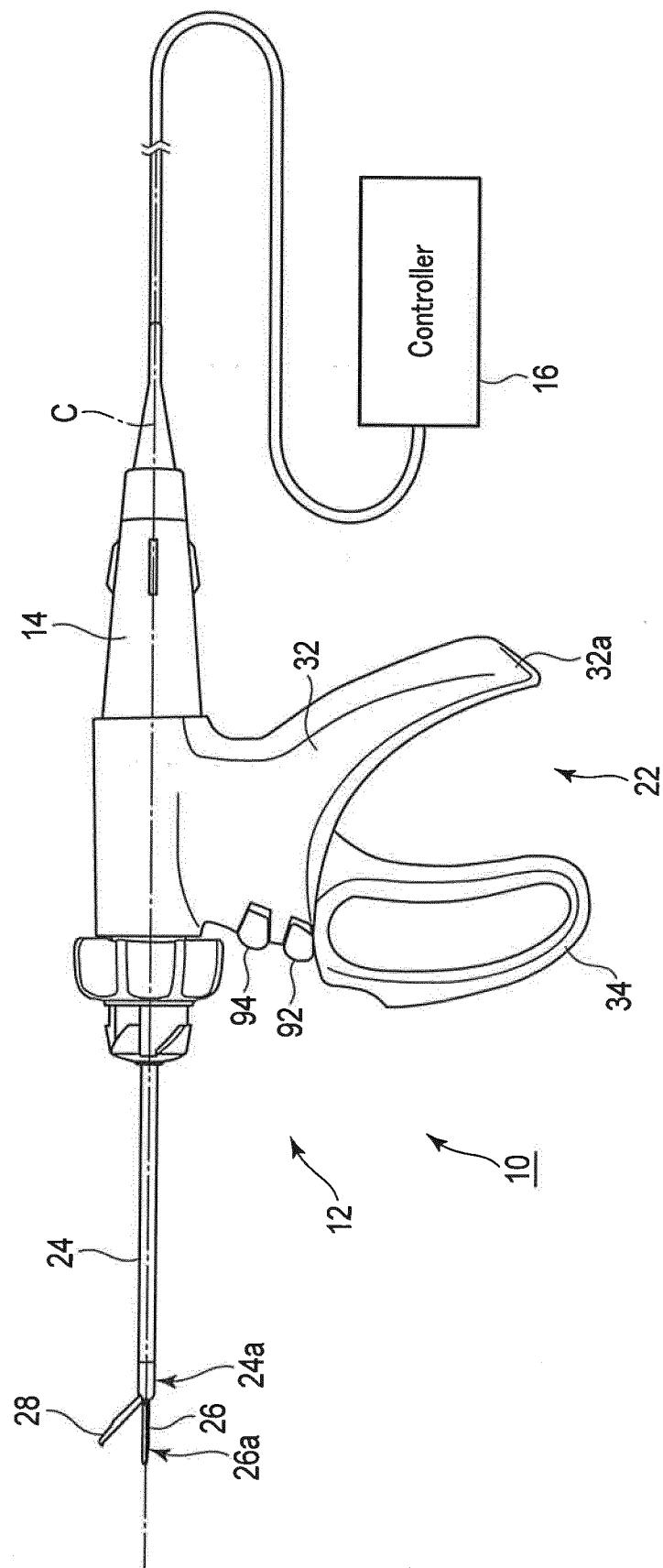


FIG. 1

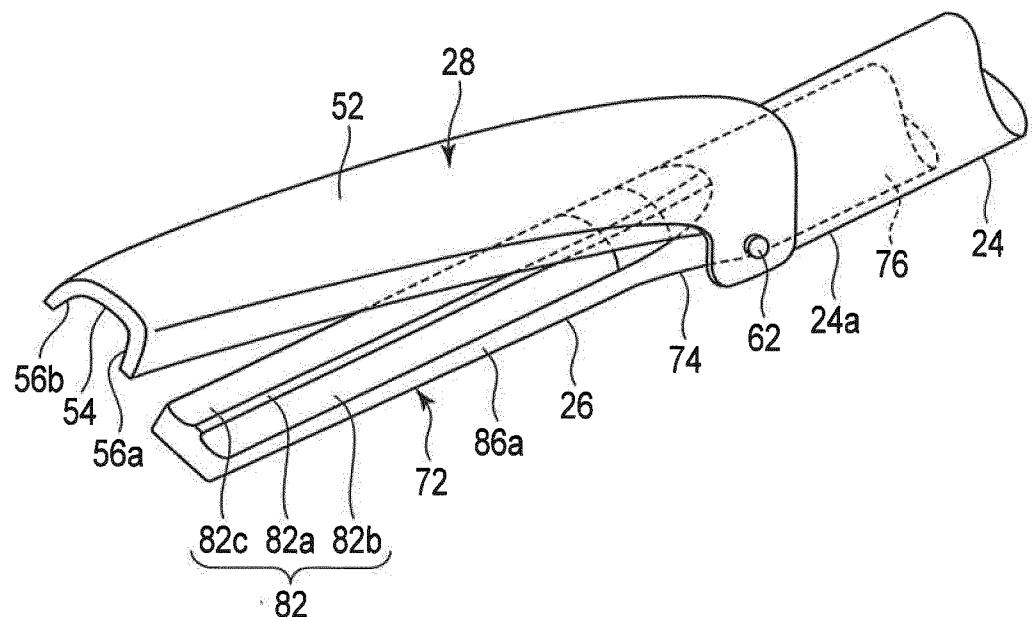


FIG. 2

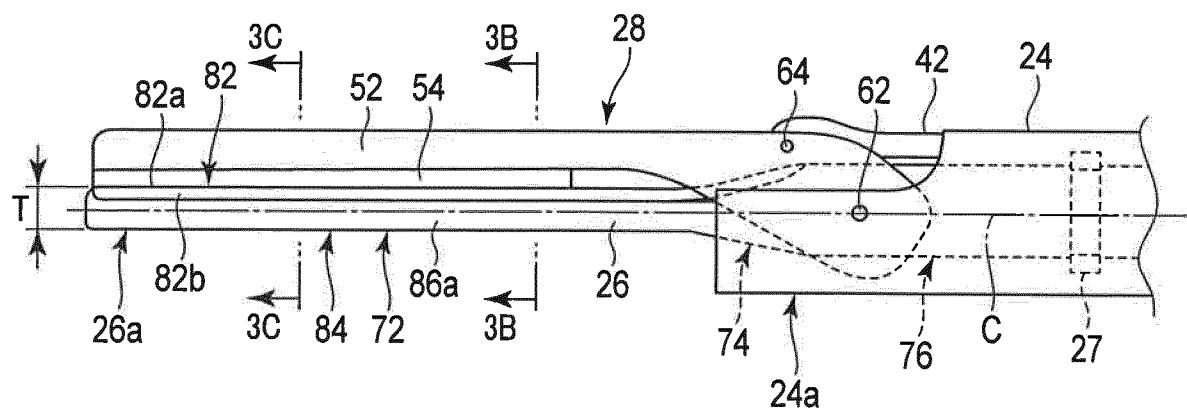


FIG. 3A

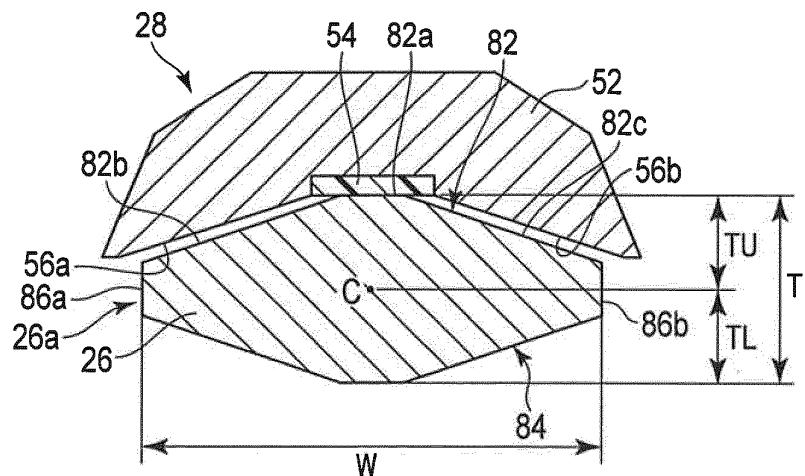


FIG. 3B

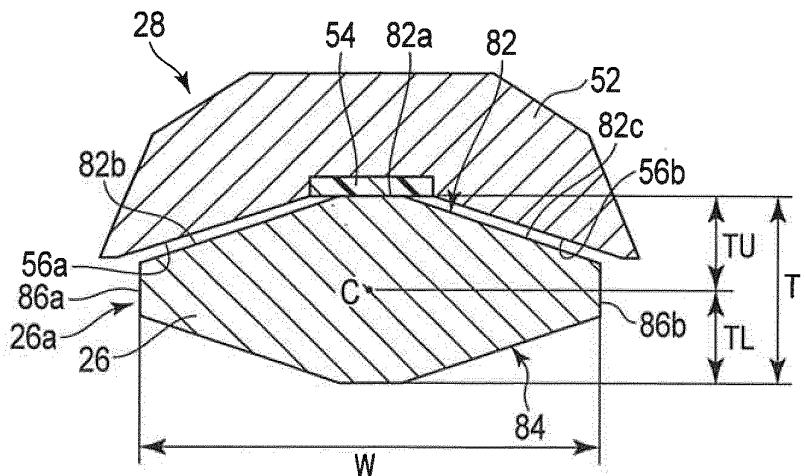


FIG. 3C

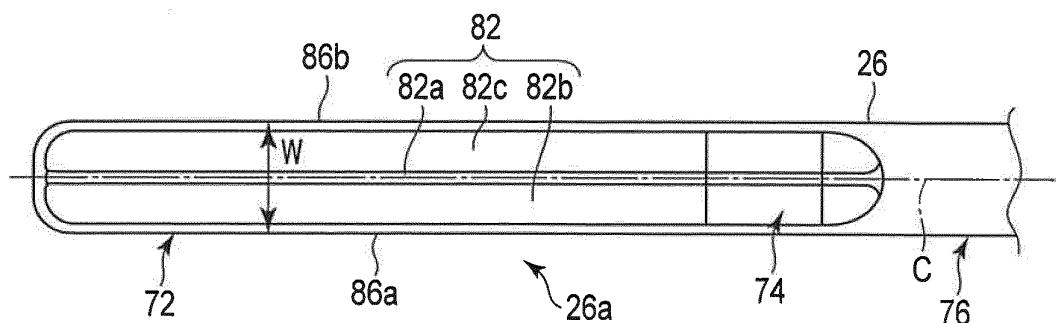


FIG. 3D

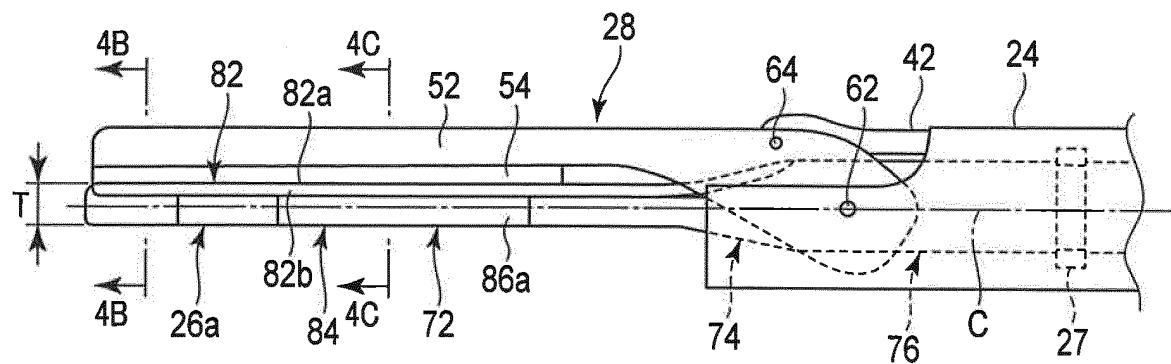


FIG. 4A

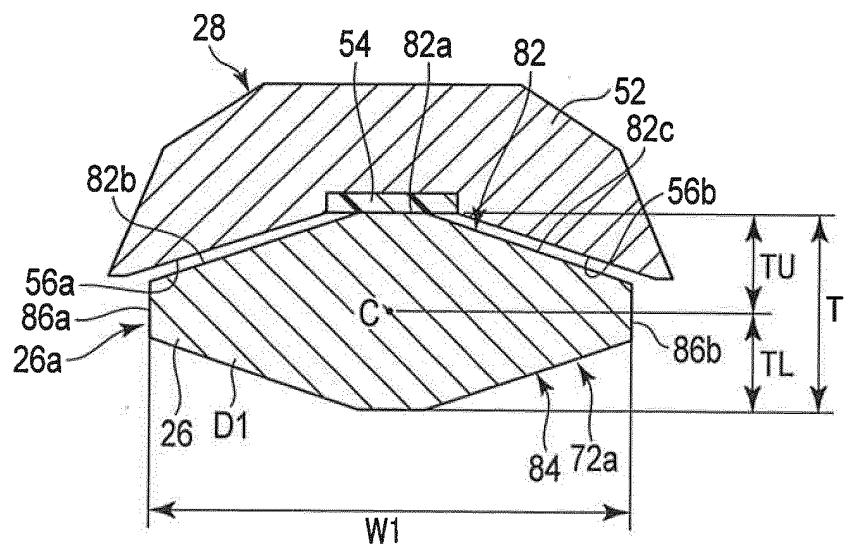


FIG. 4B

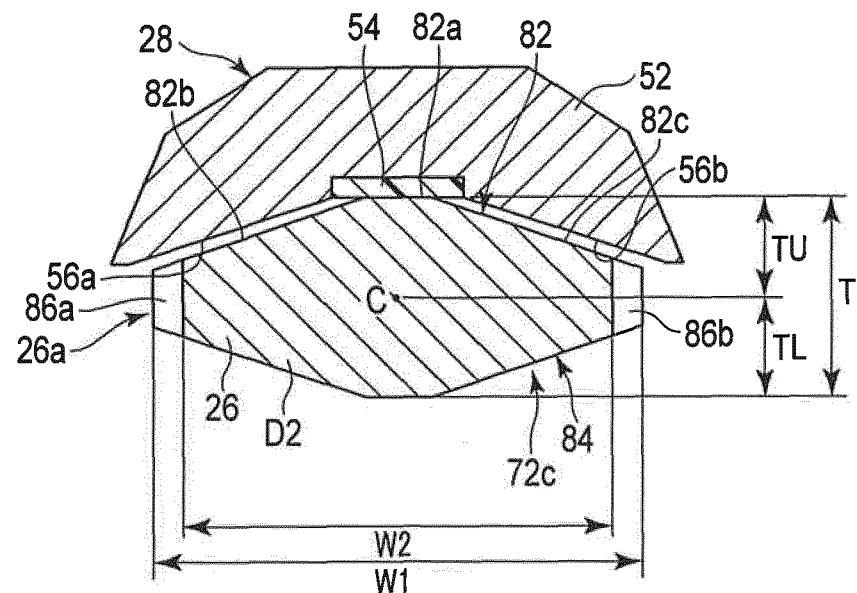


FIG. 4C

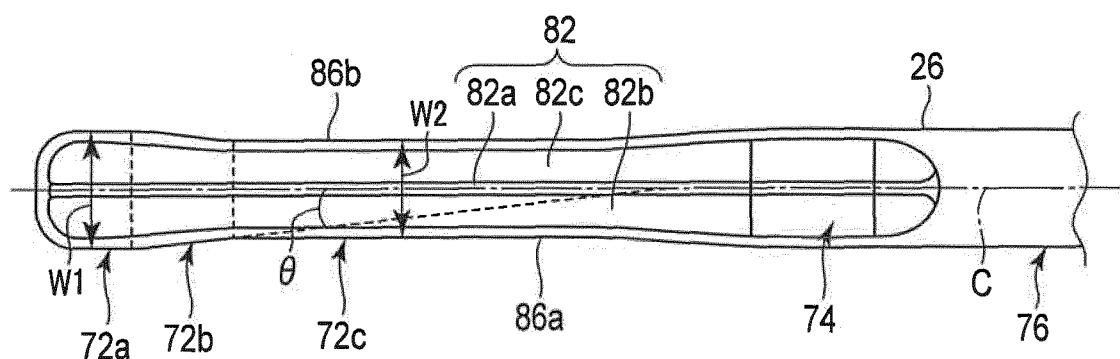


FIG. 4D

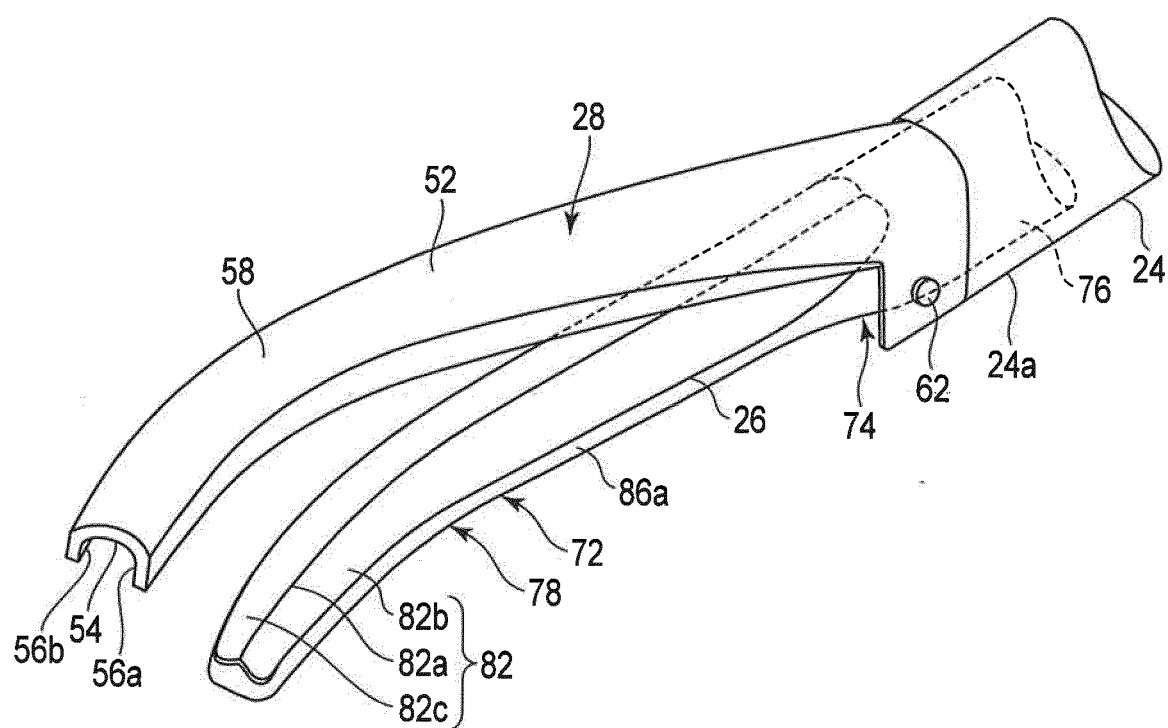


FIG. 5

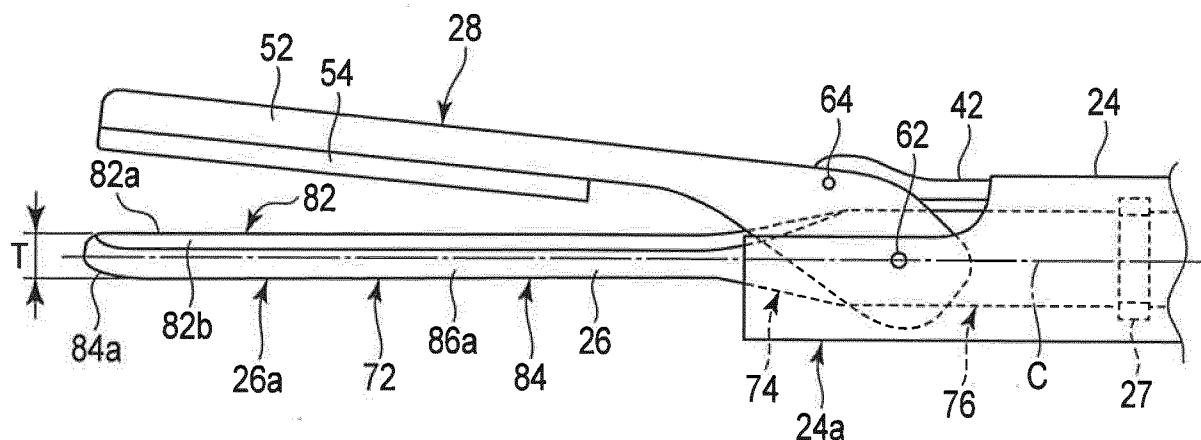


FIG. 6

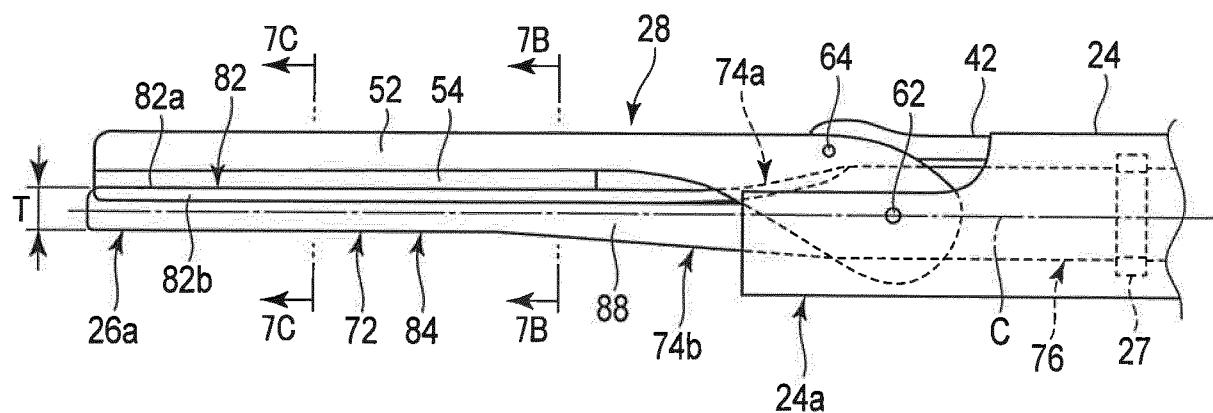


FIG. 7A

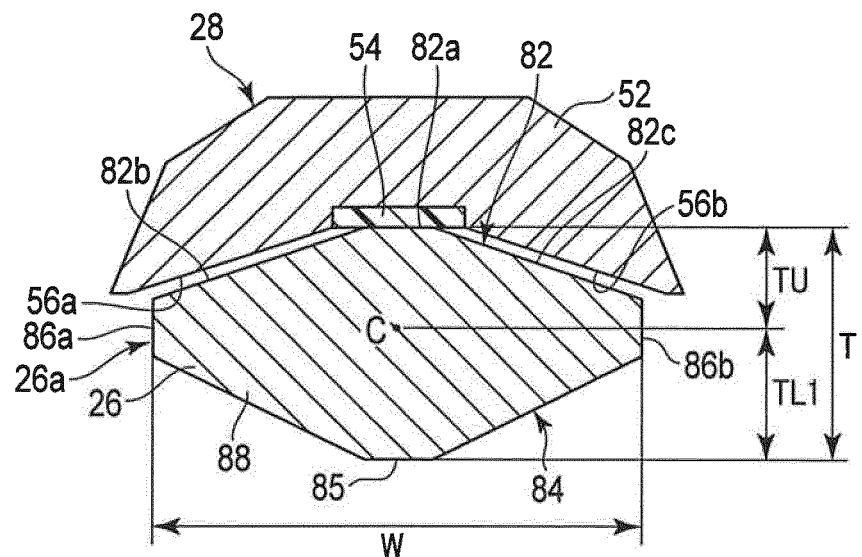


FIG. 7B

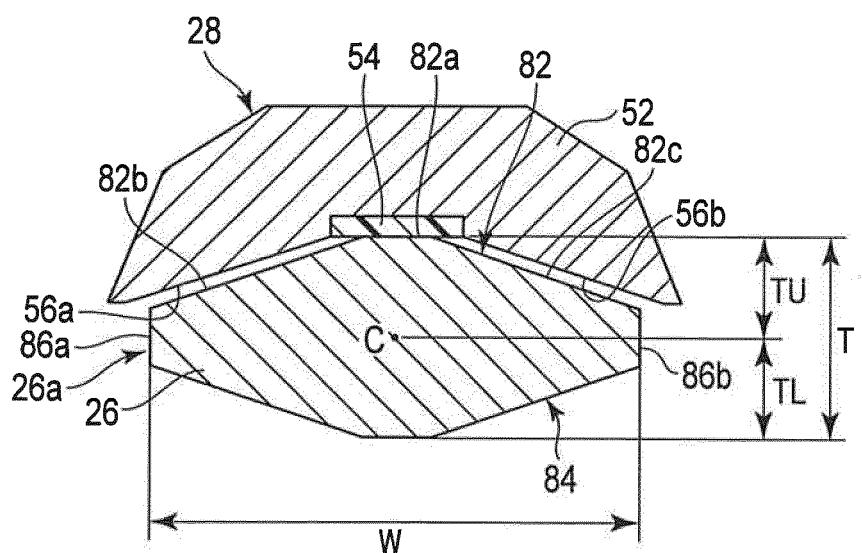


FIG. 7C

INTERNATIONAL SEARCH REPORT		International application No. PCT/JP2016/064640						
5	A. CLASSIFICATION OF SUBJECT MATTER A61B17/32(2006.01)i, A61B18/14(2006.01)i							
10	According to International Patent Classification (IPC) or to both national classification and IPC							
15	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) A61B17/32, A61B18/14							
20	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016 Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016							
25	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)							
30	C. DOCUMENTS CONSIDERED TO BE RELEVANT							
35	<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X Y</td> <td>WO 2015/029518 A1 (Olympus Medical Systems Corp.), 05 March 2015 (05.03.2015), paragraphs [0017] to [0019], [0030] to [0043]; fig. 1 to 7 &amp; JP 5797353 B2 &amp; US 2016/0045770 A1 paragraphs [0030] to [0032], [0043] to [0056]; fig. 1 to 7 &amp; CN 105246423 A</td> <td>1, 4-6 2-3</td> </tr> </tbody> </table>		Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X Y	WO 2015/029518 A1 (Olympus Medical Systems Corp.), 05 March 2015 (05.03.2015), paragraphs [0017] to [0019], [0030] to [0043]; fig. 1 to 7 & JP 5797353 B2 & US 2016/0045770 A1 paragraphs [0030] to [0032], [0043] to [0056]; fig. 1 to 7 & CN 105246423 A	1, 4-6 2-3
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.						
X Y	WO 2015/029518 A1 (Olympus Medical Systems Corp.), 05 March 2015 (05.03.2015), paragraphs [0017] to [0019], [0030] to [0043]; fig. 1 to 7 & JP 5797353 B2 & US 2016/0045770 A1 paragraphs [0030] to [0032], [0043] to [0056]; fig. 1 to 7 & CN 105246423 A	1, 4-6 2-3						
40	<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.							
45	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed							
50	Date of the actual completion of the international search 20 June 2016 (20.06.16)	Date of mailing of the international search report 05 July 2016 (05.07.16)						
55	Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.						

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INTERNATIONAL SEARCH REPORT		International application No. PCT/JP2016/064640
C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
5		
10	X JP 8-505801 A (Ultracision, Inc.), Y 25 June 1996 (25.06.1996), page 18, line 6 to page 22, line 15; page 26, lines 17 to 24; fig. 1 to 3, 8i to 8j & US 5322055 A & WO 1994/016631 A1 page 12, line 5 to page 17, line 7; page 22, lines 3 to 11; fig. 1 to 3, 8i to 8j & EP 681457 A1	1, 5 2-3
15	Y JP 2001-309925 A (ETHICON ENDO-SURGERY, INC.), 06 November 2001 (06.11.2001), paragraphs [0013] to [0015]; fig. 1 to 5 & US 6423082 B1 column 3, line 57 to column 4, line 12; fig. 1 to 5 & EP 1138264 A1	2
20	Y WO 2014/088899 A1 (ETHICON ENDO-SURGERY, INC.), 12 June 2014 (12.06.2014), paragraphs [00105] to [00113]; fig. 4 to 11 & JP 2015-536760 A & US 2014/0163595 A1 & EP 2928392 A & CN 104837420 A & KR 10-2015-0095748 A	2
25	Y JP 2008-136845 A (Olympus Medical Systems Corp.), 19 June 2008 (19.06.2008), paragraphs [0056] to [0057]; fig. 9 & US 2008/0132927 A1 paragraphs [0058] to [0059]; fig. 9 & EP 1927321 A1 & CN 101190138 A	3
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**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- US 2011288451 A1 [0002]

专利名称(译)	外科手术设备		
公开(公告)号	<a href="#">EP3305223A1</a>	公开(公告)日	2018-04-11
申请号	EP2016799879	申请日	2016-05-17
[标]申请(专利权)人(译)	奥林巴斯株式会社		
申请(专利权)人(译)	OLYMPUS CORPORATION		
当前申请(专利权)人(译)	OLYMPUS CORPORATION		
[标]发明人	KANO AKIHITO AKAGANE TSUNETAKA		
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IPC分类号	A61B17/32 A61B18/14		
CPC分类号	A61B17/320092 A61B18/1442 A61B18/1445 A61B2017/2825 A61B2017/320078 A61B2017/320094 A61B2017/320095 A61B2018/00083 A61B2018/00101 A61B2018/00529 A61B2018/00607 A61B2018 /0063 A61B2018/00994 A61N7/00		
代理机构(译)	SCHICKER , SILVIA		
优先权	2015107773 2015-05-27 JP		
其他公开文献	<a href="#">EP3305223A4</a>		
外部链接	<a href="#">Espacenet</a>		

### 摘要(译)

与夹持部分一起使用并且被构造成传递来自超声换能器的振动的振动传递构件从近侧部分朝向远侧部分延伸，在远侧部分处包括沿着从近侧部分延伸到远侧的纵向轴线的脊部分并且位于沿着其中夹紧部分通过转动而移动的打开/闭合方向的表面上，并且构造成当振动输入到其近侧部分时将振动从近侧部分传递到远侧部分。沿着夹持部构造成通过转动而移动的打开/闭合方向的厚度小于其在与打开/关闭方向垂直的宽度方向上的远侧部的宽度。

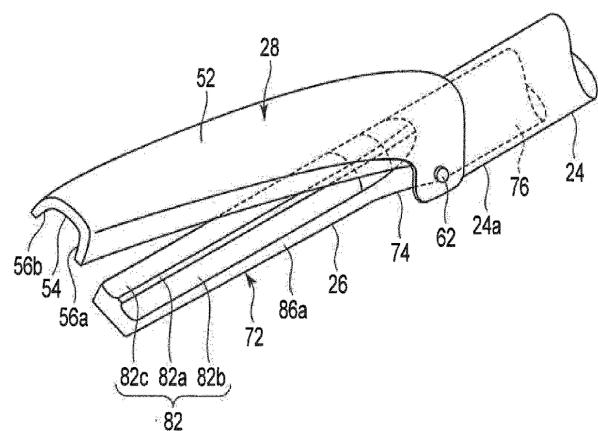


FIG. 2