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(54) **ULTRASONIC PROBE AND ULTRASONIC PROBE UNIT FOR ARTHROSCOPIC SURGERY**

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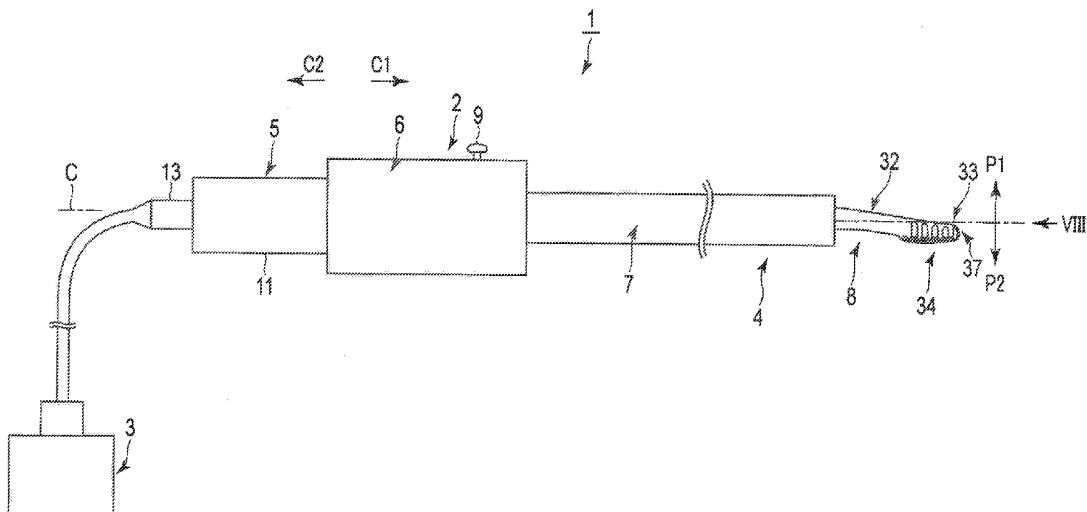
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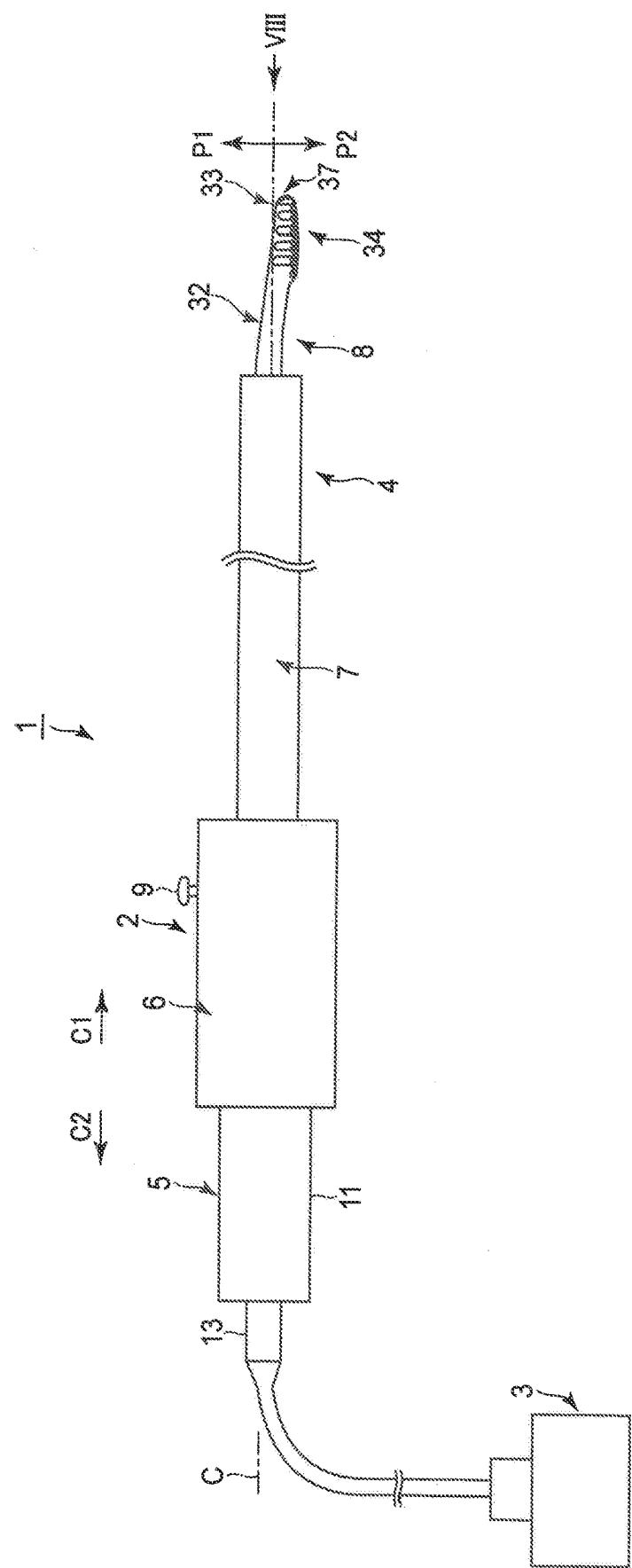
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CPC *A61B 17/320068* (2013.01); *A61B 2017/320074* (2017.08); *A61B 2017/320073* (2017.08)

ABSTRACT

An ultrasonic probe for arthroscopic surgery includes: a bend extending portion which is provided on a distal side of a probe main body and which extends to bend to a side of a second intersecting direction of the probe main body, when a certain direction intersecting the longitudinal axis is a first intersecting direction and a direction opposite to the first intersecting direction is a second intersecting direction; and a treatment portion which is provided on the distal side of the bend extending portion and which is configured to treat a treatment target.





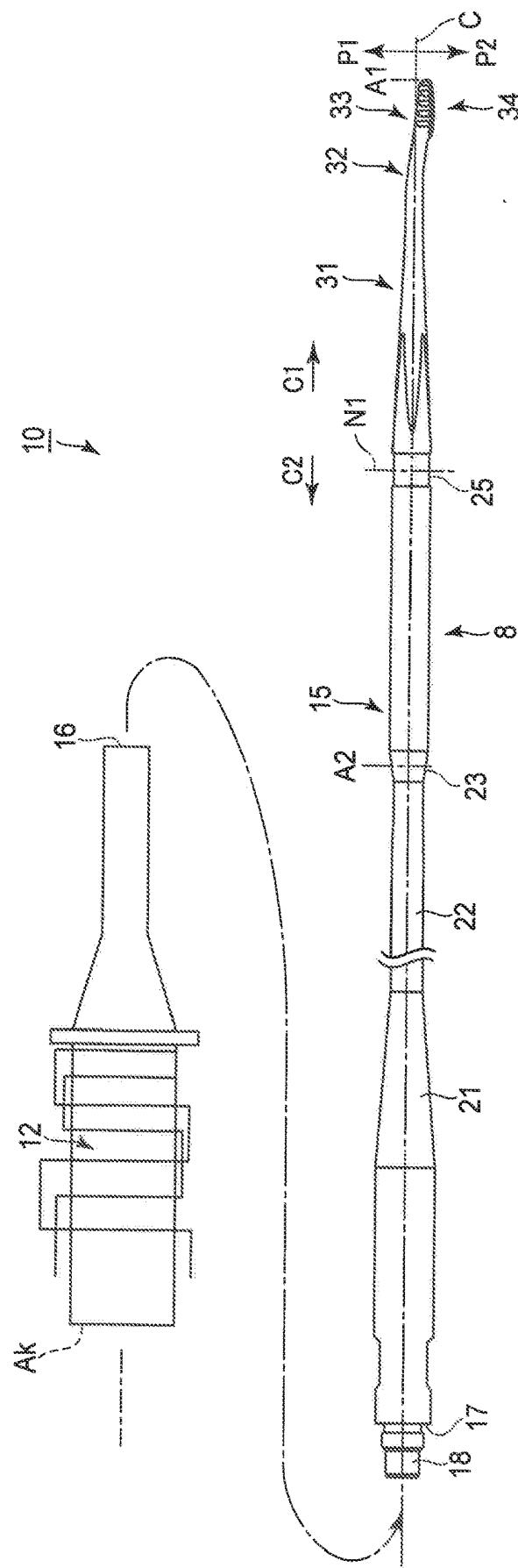


FIG. 2

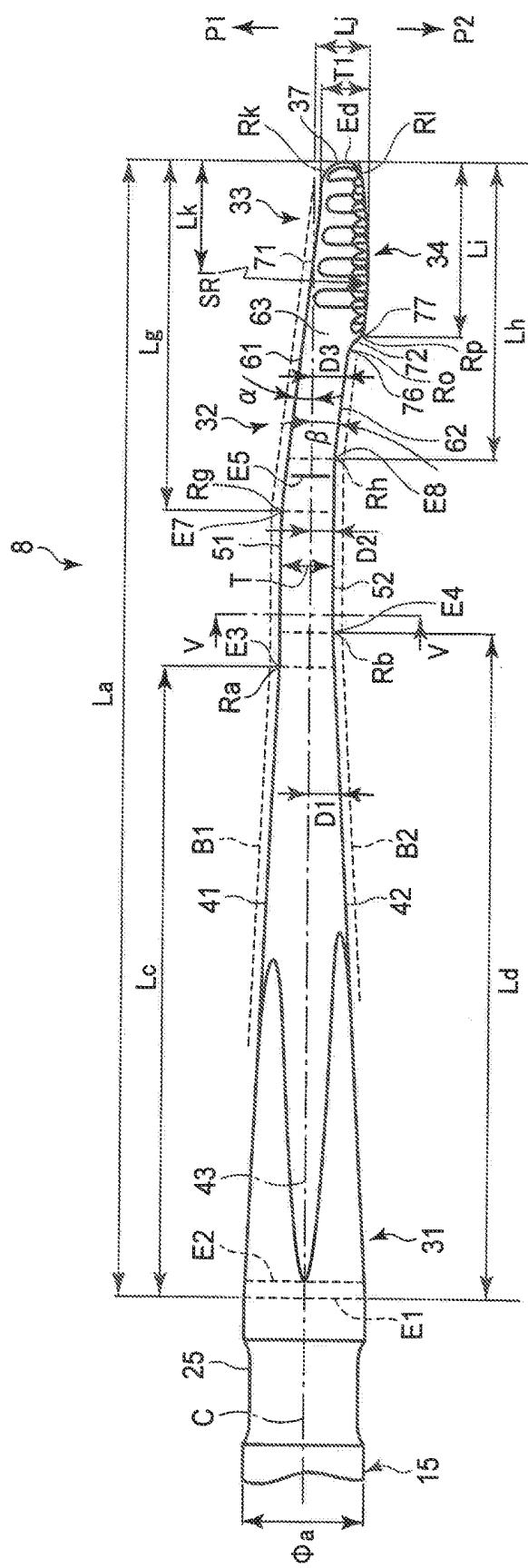


FIG. 3

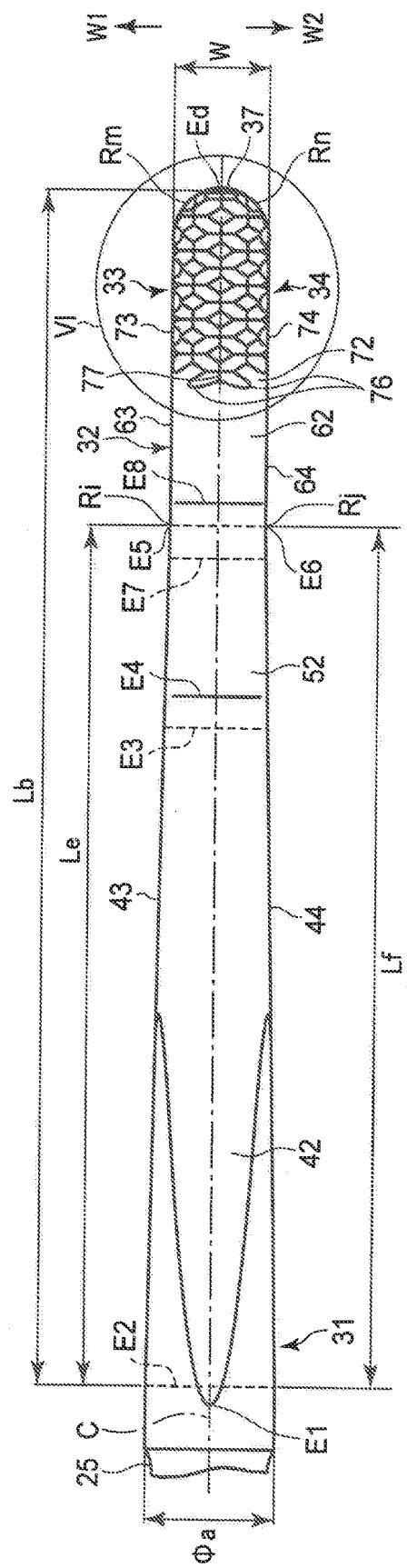


FIG. 4

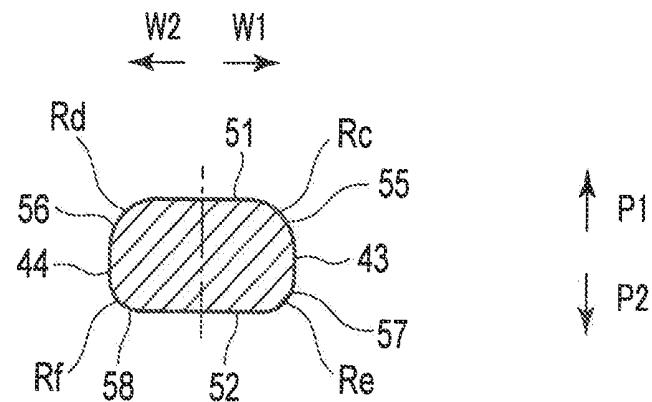


FIG. 5

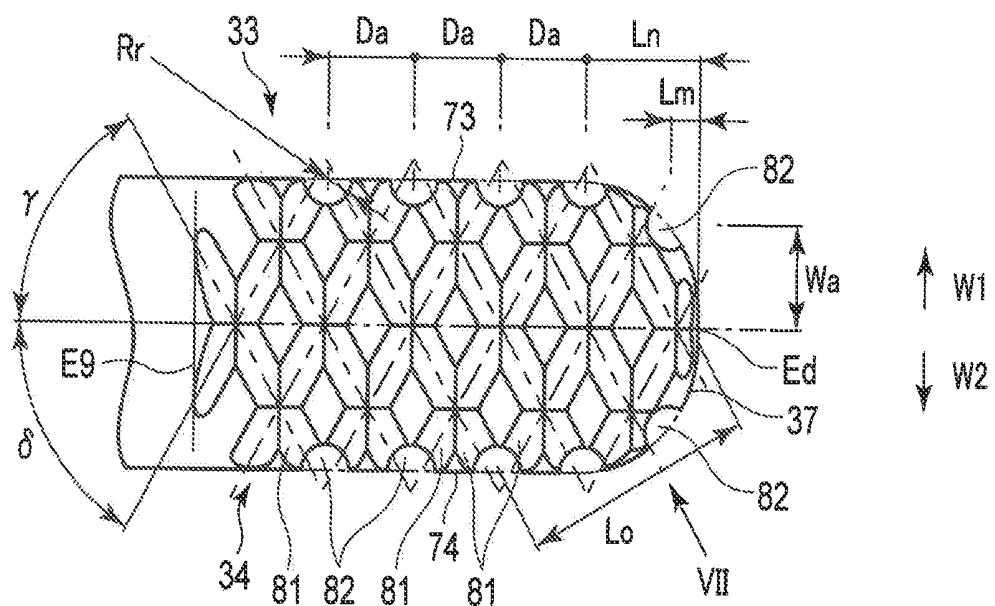


FIG. 6

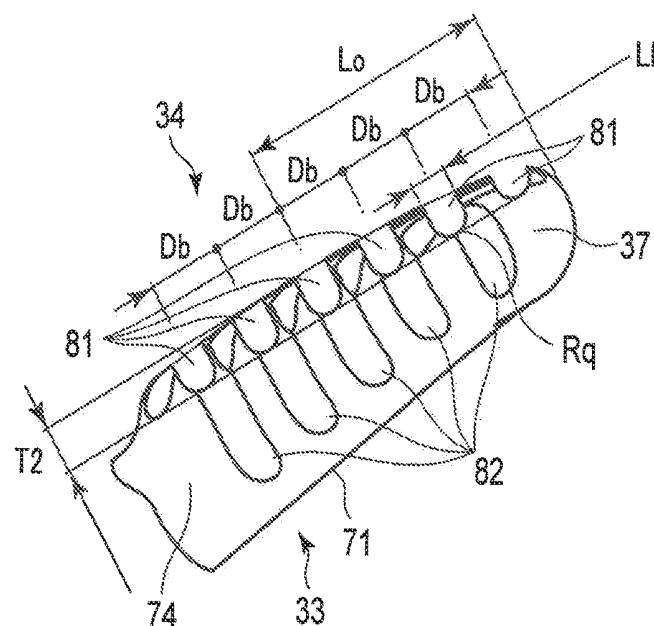


FIG. 7

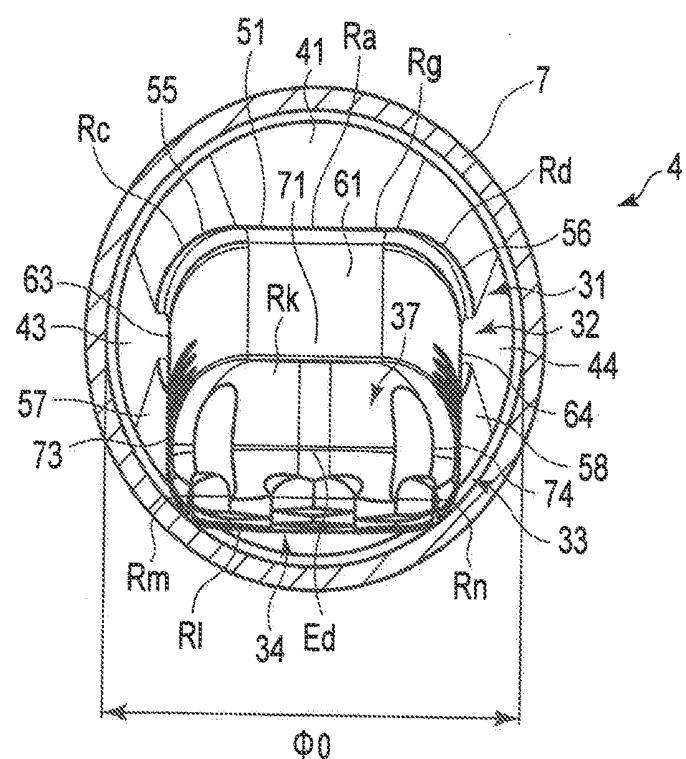


FIG. 8

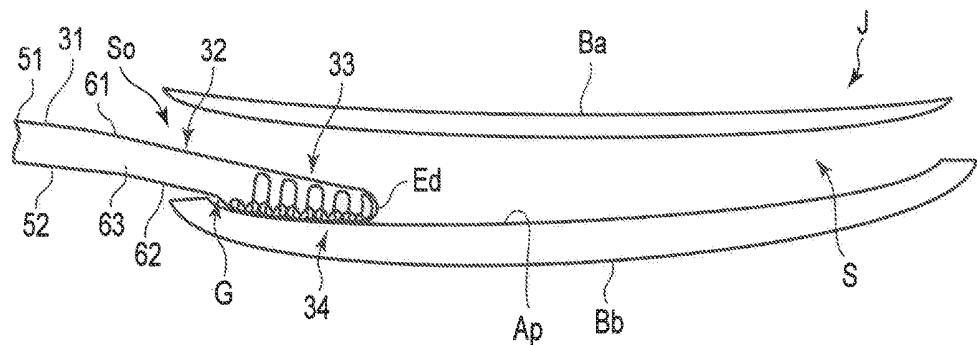


FIG. 9A

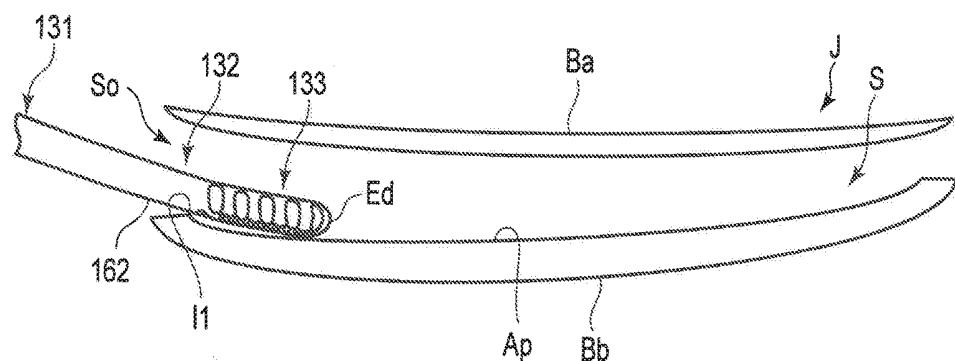


FIG. 9B

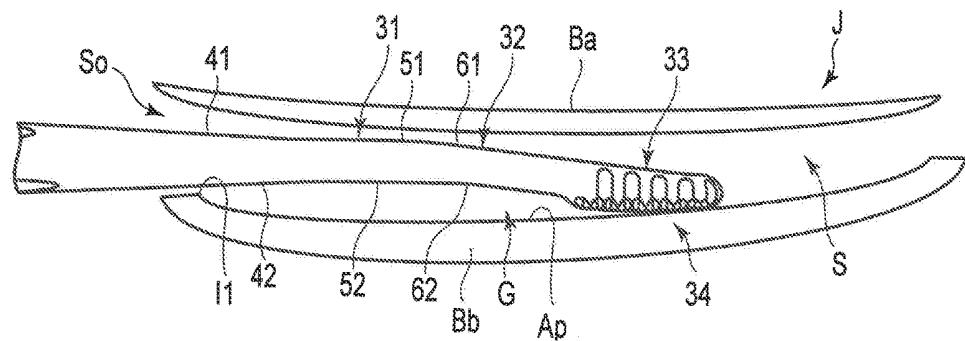


FIG. 10A

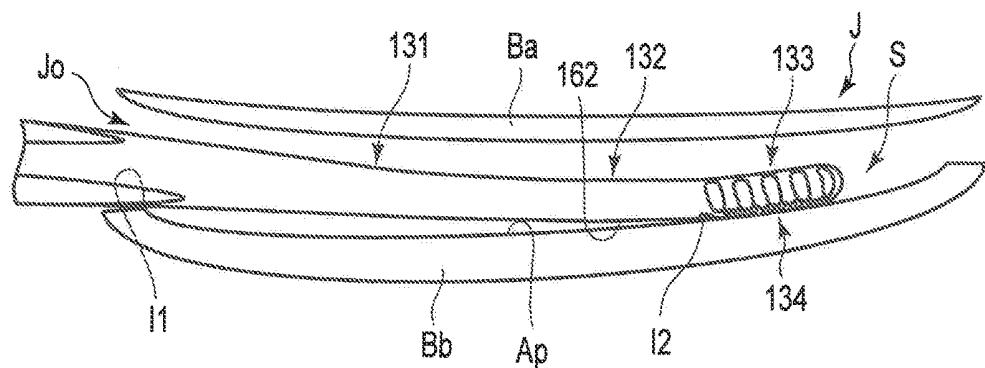


FIG. 10B

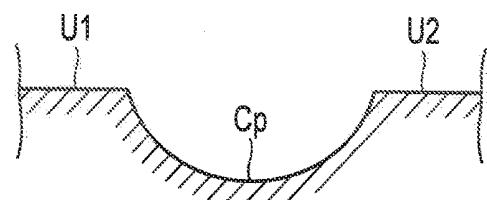


FIG. 11

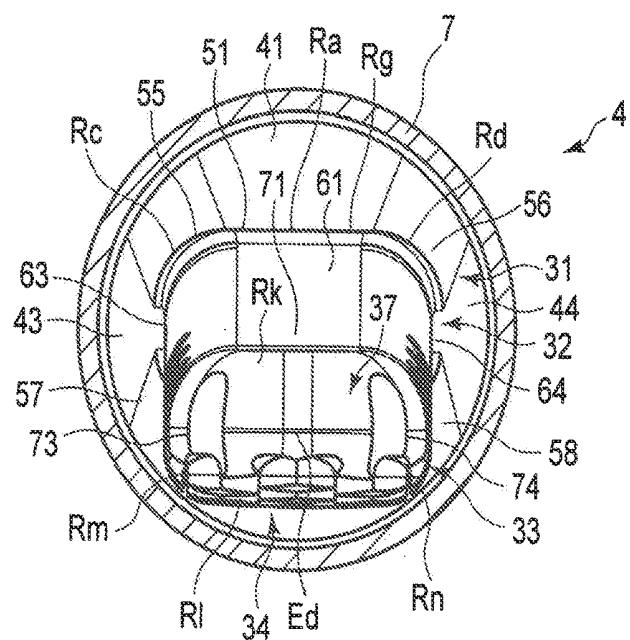
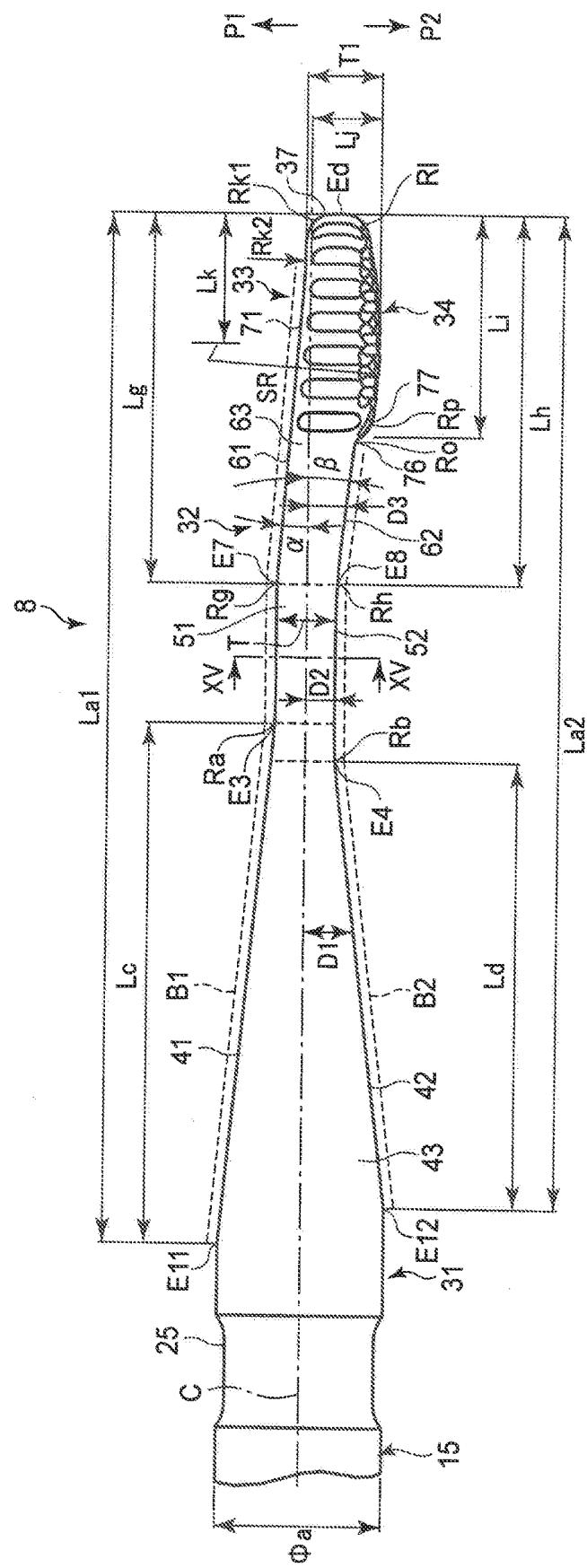


FIG. 12



13
G.
E.

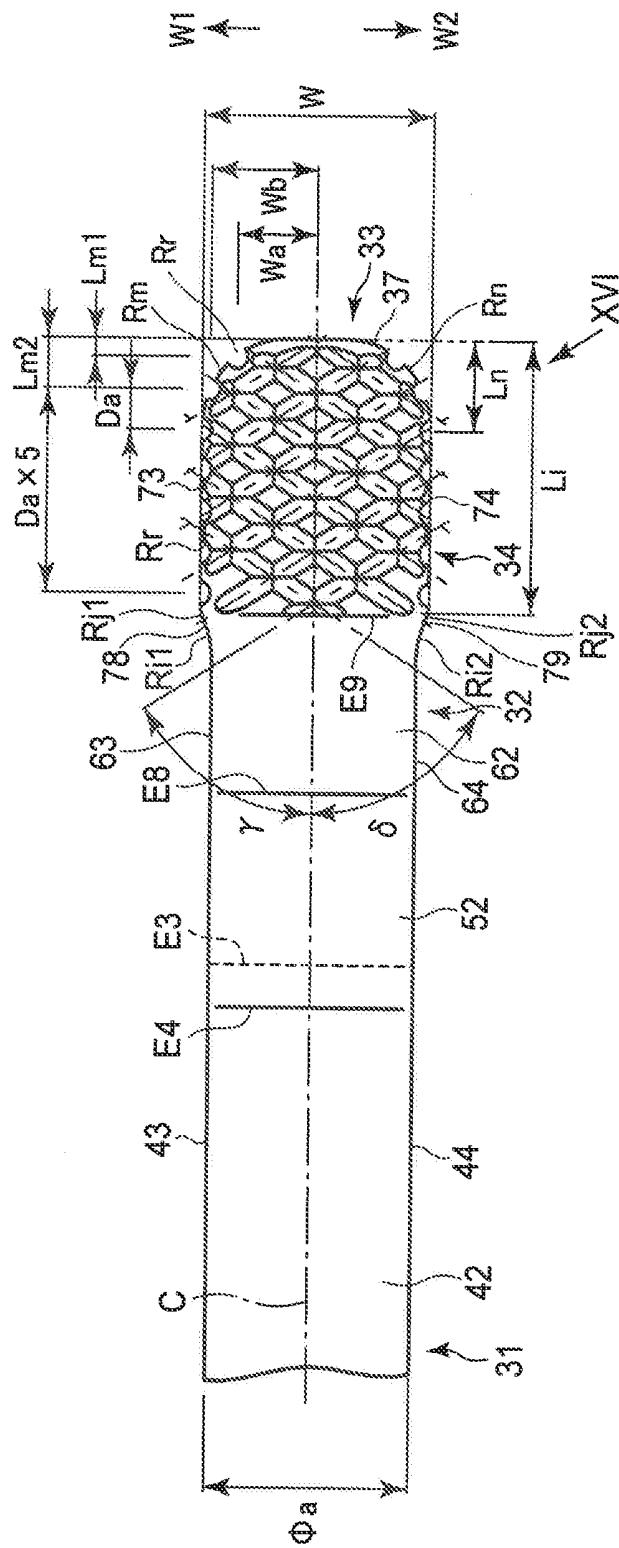


FIG. 14

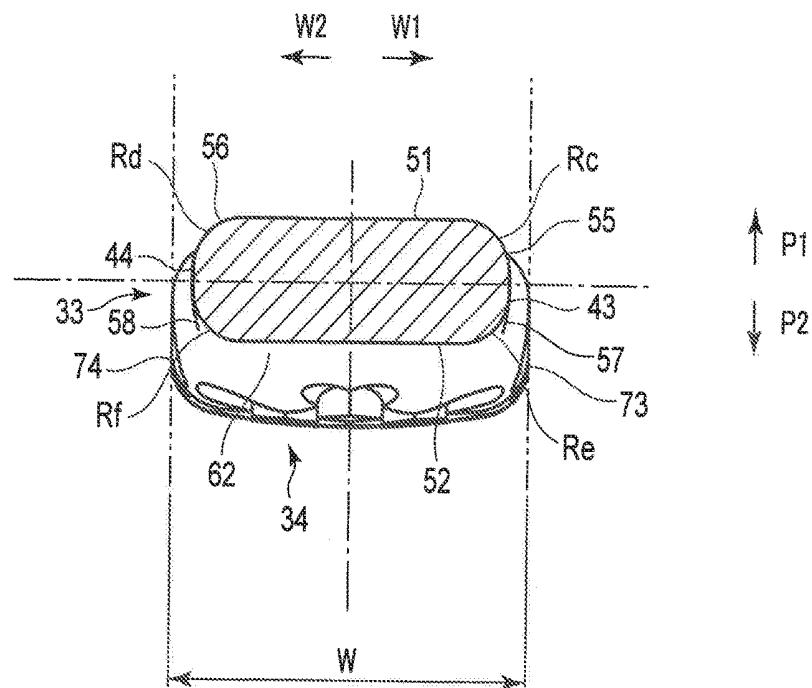


FIG. 15

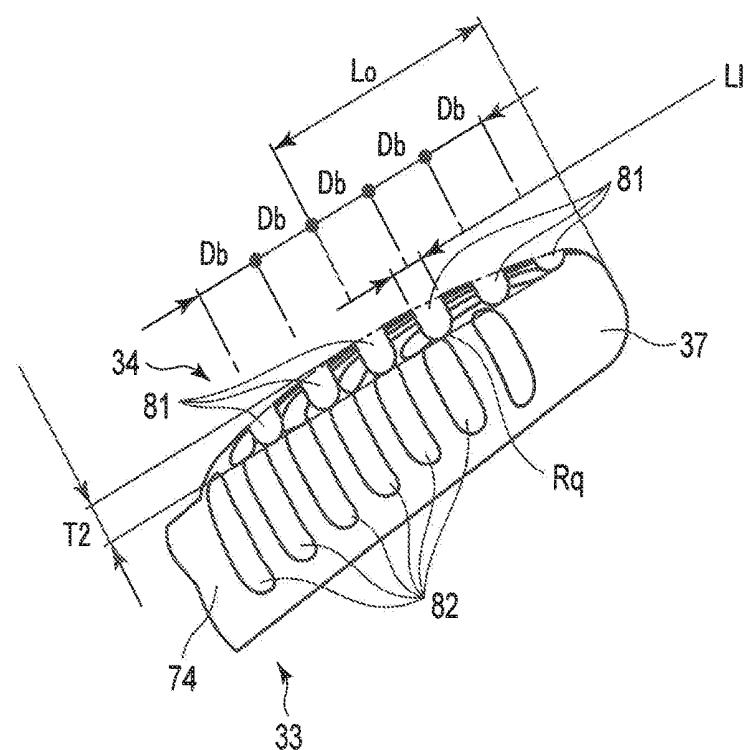


FIG. 16

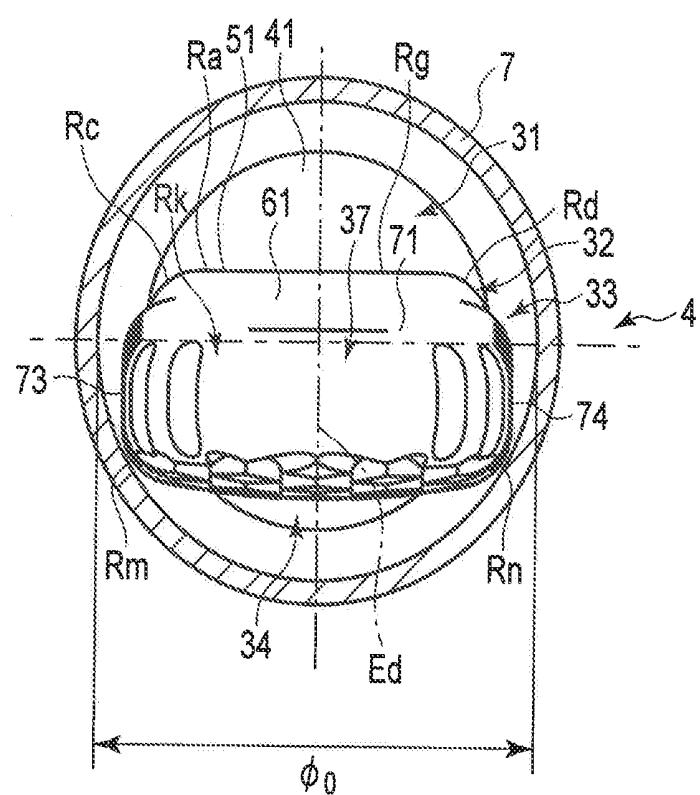
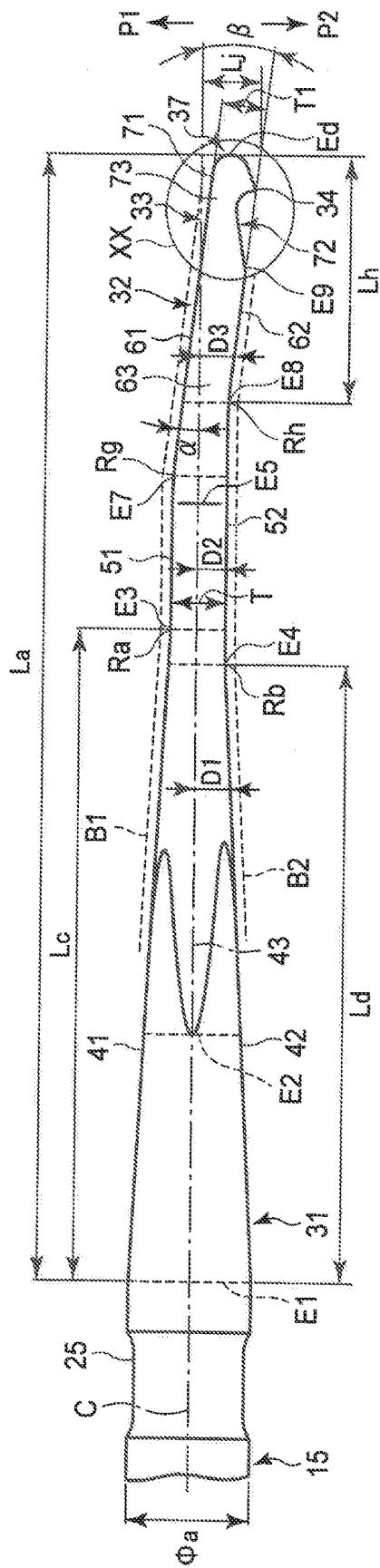


FIG. 17



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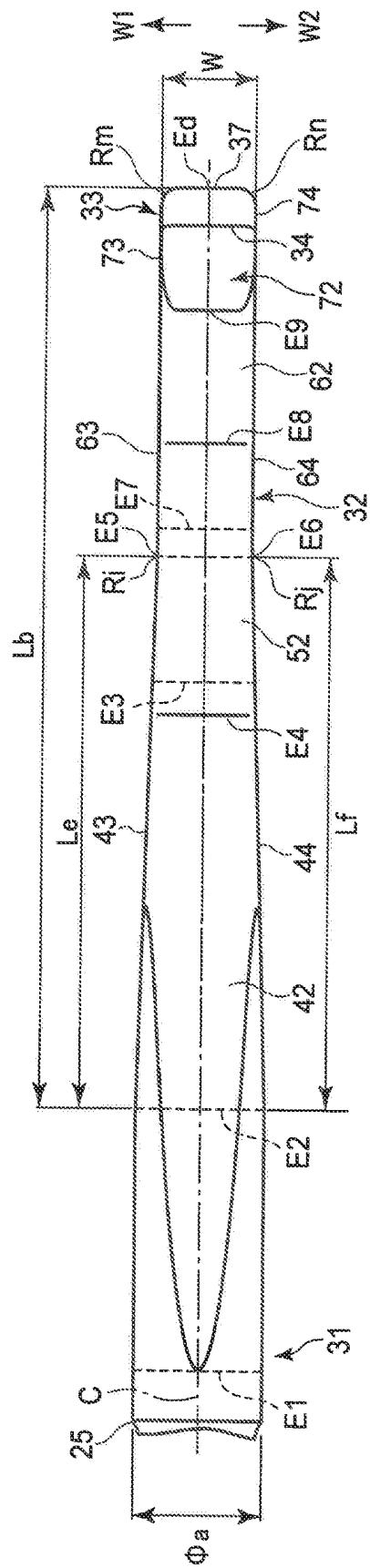


FIG. 19

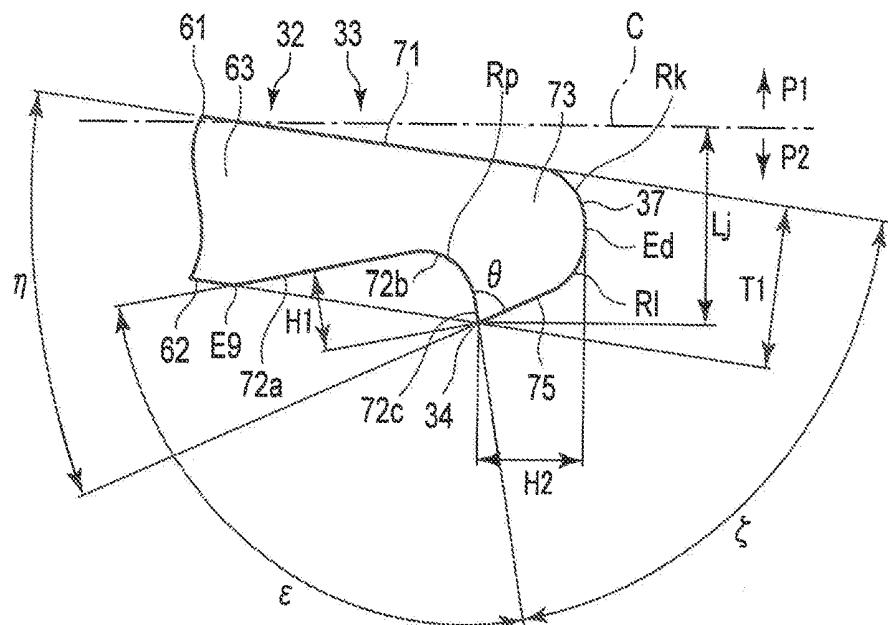


FIG. 20

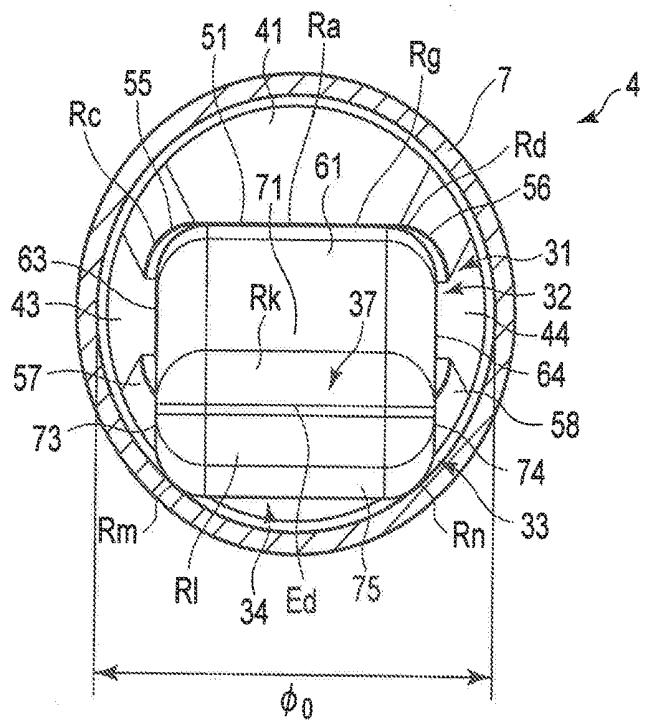


FIG. 21

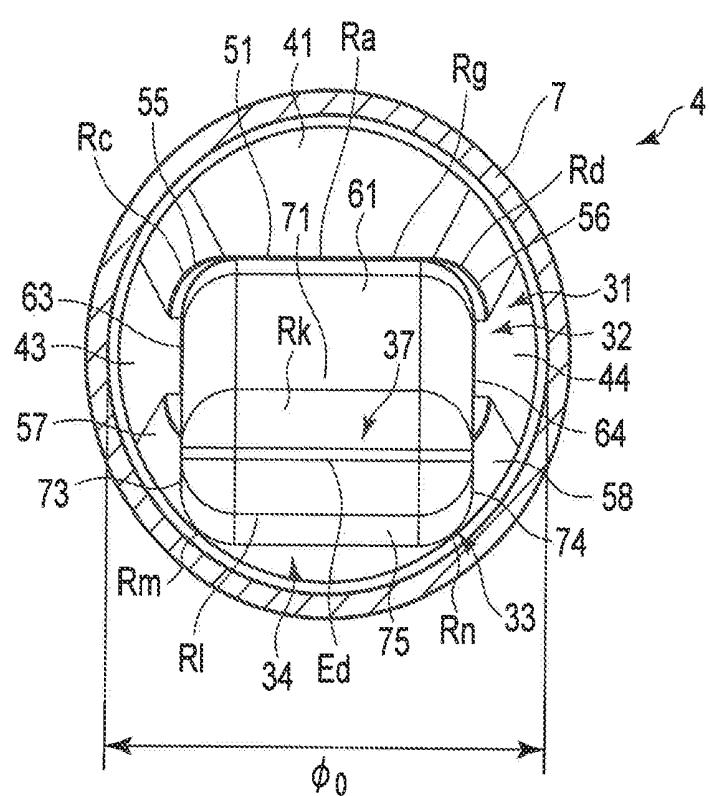


FIG. 22

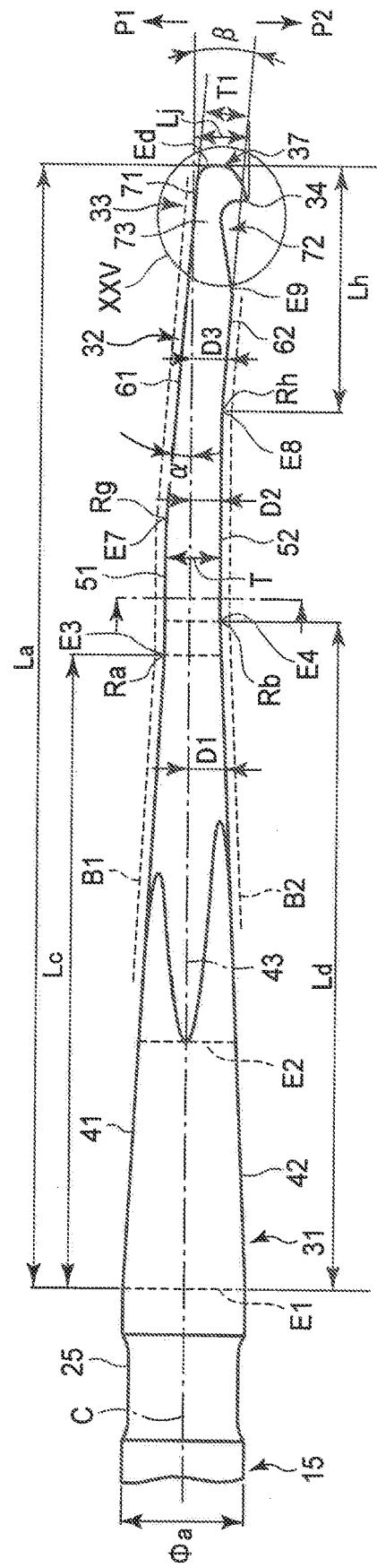


FIG. 23

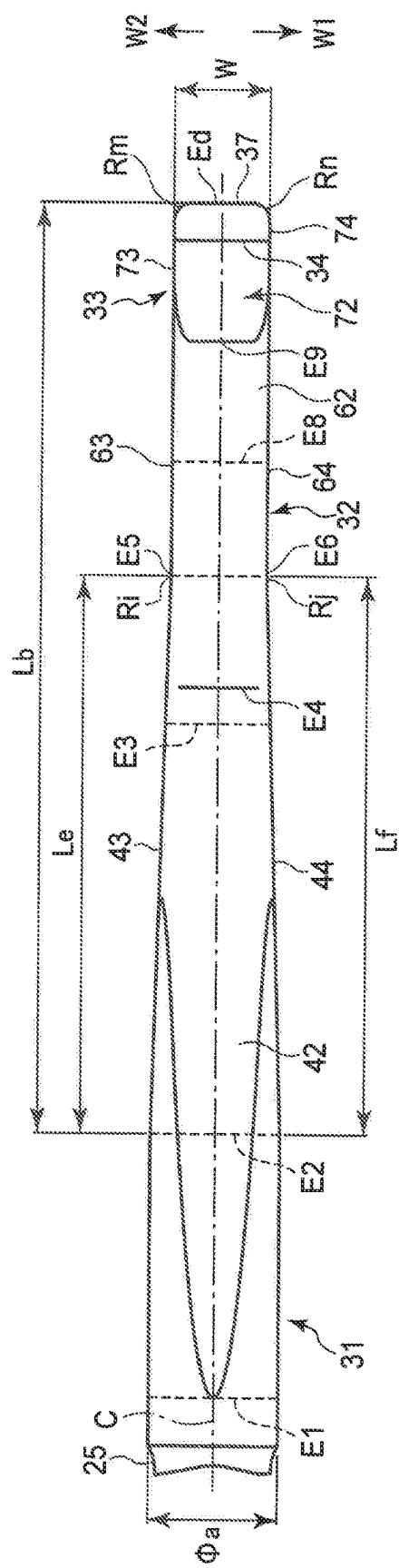


FIG. 24

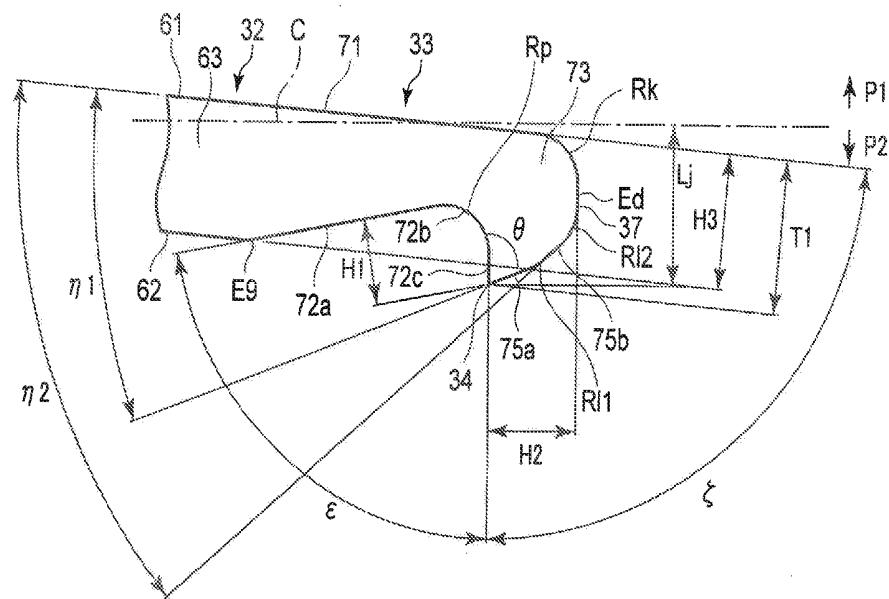


FIG. 25

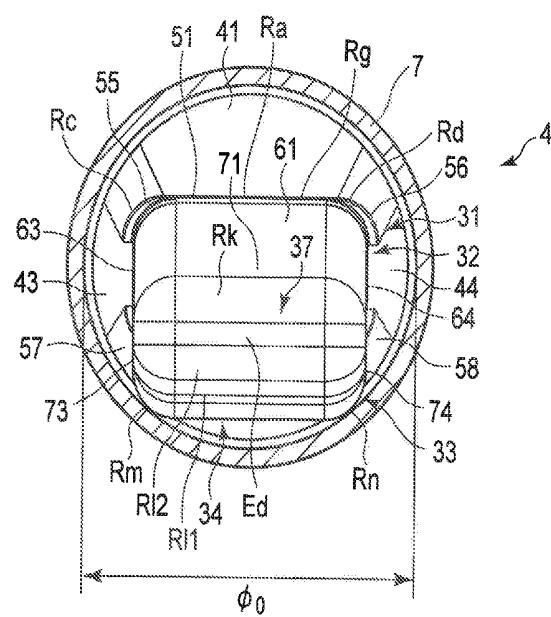


FIG. 26

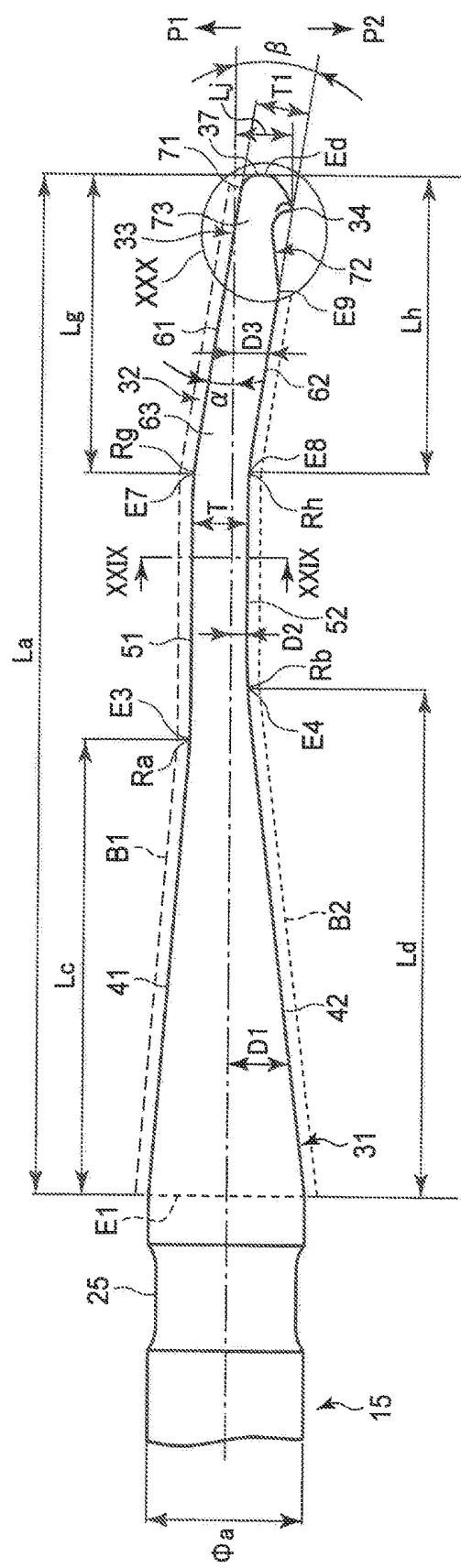


FIG. 27

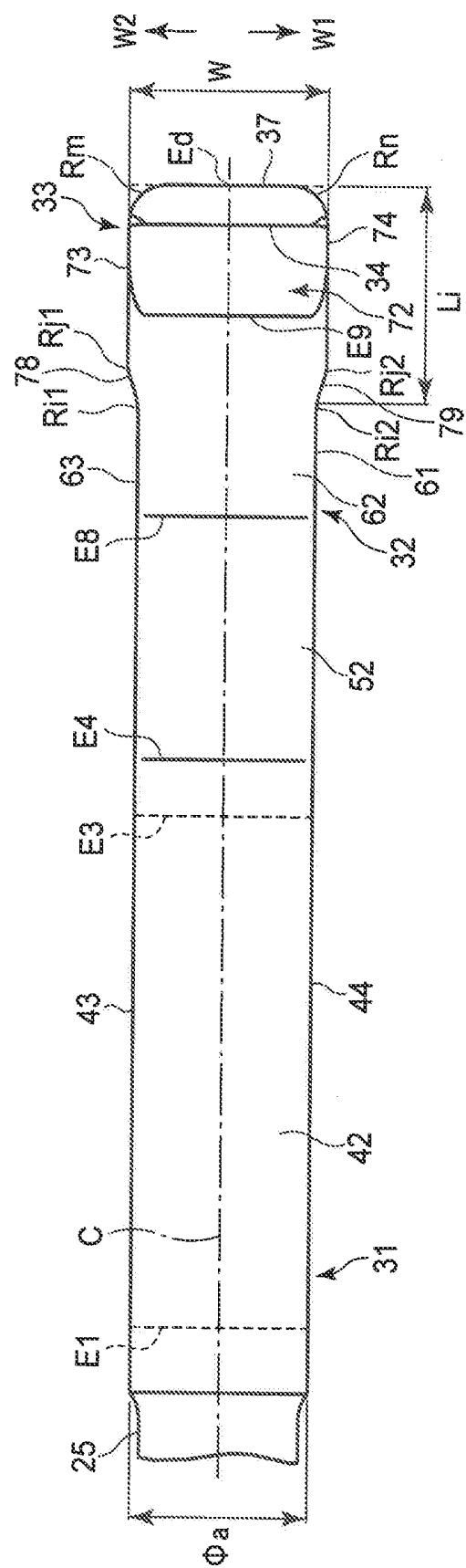


FIG. 28

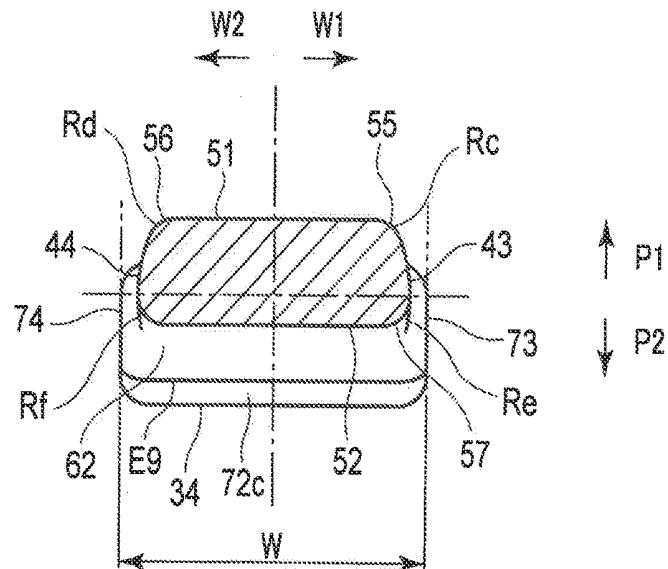


FIG. 29

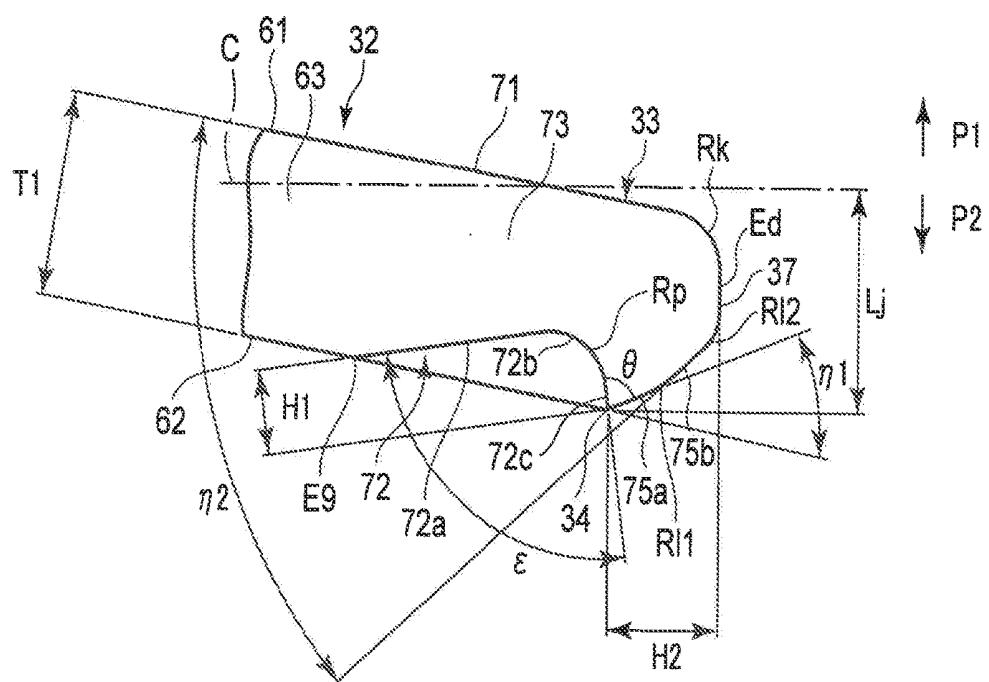


FIG. 30

ULTRASONIC PROBE AND ULTRASONIC PROBE UNIT FOR ARTHROSCOPIC SURGERY

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation Application of PCT Application No. PCT/JP2016/053246, filed Feb. 3, 2016 and based upon and claiming the benefit of U.S. Provisional Application No. 62/196,158, filed Jul. 23, 2015, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an ultrasonic probe and an ultrasonic probe unit for arthroscopic surgery which are used for an operation in a joint and transmit ultrasonic vibration.

2. Description of the Related Art

[0003] In Jpn. Pat. Appln. KOKAI Publication No. 2003-116870, there is disclosed an ultrasonic treatment instrument including an ultrasonic probe (an ultrasonic horn). In this ultrasonic treatment instrument, ultrasonic vibration generated in a vibration generating section (an ultrasonic vibration mechanism) is transmitted from a proximal side to a distal side in the ultrasonic probe. In a distal portion of the ultrasonic probe, a scalpel portion is formed as a cutting region. In a state where the cutting region is in contact with a treatment target, the ultrasonic vibration is transmitted to the scalpel portion, whereby the treatment target (e.g., a bone or the like) is cut.

BRIEF SUMMARY OF THE INVENTION

[0004] According to one aspect of the present invention, there is provided an ultrasonic probe for arthroscopic surgery which is for use in an operation of a joint and which is configured to transmit ultrasonic vibration from a proximal side to a distal side thereof, includes: a probe main body which extends from the proximal side to the distal side along a linear longitudinal axis and to which an ultrasonic transducer to generate the ultrasonic vibration is connected to the proximal side; a narrowing portion which is continuous with the distal side of the probe main body and whose sectional area vertical to the longitudinal axis decreases from the proximal side toward the distal side; a bend extending portion which is provided on the distal side of the narrowing portion and which extends in a state of bending in an intersecting direction to the longitudinal axis when the intersecting direction intersecting the longitudinal axis is prescribed; and a treatment portion which is provided on the distal side of the bend extending portion, and which includes a cutting region that is configured to cut a bone or a cartilage by use of the ultrasonic vibration in the joint at a position more away from the longitudinal axis than the bend extending portion in the intersecting direction, wherein in projection seen from the distal side, the narrowing portion, the bend extending portion and the treatment portion are arranged in a range inner than a minimum inner diameter of a sheath into which the ultrasonic probe is inserted.

[0005] Advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. Advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0006] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.

[0007] FIG. 1 is a schematic view showing an ultrasonic treatment system according to a first embodiment;

[0008] FIG. 2 is a schematic view showing a constitution of a vibrating body unit according to the first embodiment;

[0009] FIG. 3 is a schematic view of a distal portion of an ultrasonic probe according to the first embodiment which is seen from one side in a width direction;

[0010] FIG. 4 is a schematic view of the distal portion of the ultrasonic probe according to the first embodiment which is seen from the side of a second intersecting direction;

[0011] FIG. 5 is a cross-sectional view taken along the V-V line of FIG. 3;

[0012] FIG. 6 is a schematic view of a cutting region of a treatment portion according to the first embodiment which is seen from the second intersecting direction side;

[0013] FIG. 7 is a schematic view of the treatment portion according to the first embodiment seen from a direction of an arrow VII of FIG. 6;

[0014] FIG. 8 is a schematic view of a sheath and the ultrasonic probe according to the first embodiment seen from a distal side thereof;

[0015] FIG. 9A is a schematic view showing one example of a state where the treatment portion of the ultrasonic probe according to the first embodiment is made to access a space of a joint cavity to cut a treatment target with the cutting region of the treatment portion;

[0016] FIG. 9B is a schematic view showing one example of a state where a treatment portion of an ultrasonic probe according to a reference example is made to access a space of a joint cavity to cut a treatment target with a cutting region of the treatment portion;

[0017] FIG. 10A is a schematic view showing one example of a state where the treatment portion of the ultrasonic probe according to the first embodiment is made to access a position inner than a position shown in FIG. 9A in the space of the joint cavity to cut the treatment target with the cutting region of the treatment portion;

[0018] FIG. 10B is a schematic view showing one example of a state where the treatment portion of the ultrasonic probe according to the reference example is made to access a position inner than a position shown in FIG. 9B in a space of a joint cavity to cut a treatment target with a cutting region of the treatment portion;

[0019] FIG. 11 is a schematic view showing a treatment target cut with the cutting region according to the first embodiment;

[0020] FIG. 12 is a schematic view of a sheath and an ultrasonic probe according to a modification of the first embodiment which are seen from a distal side thereof;

[0021] FIG. 13 is a schematic view of a distal portion of an ultrasonic probe according to a second embodiment which is seen from one side in a width direction;

[0022] FIG. 14 is a schematic view of the distal portion of the ultrasonic probe according to the second embodiment which is seen from the side of a second intersecting direction;

[0023] FIG. 15 is a cross-sectional view taken along the XV-XV line of FIG. 13;

[0024] FIG. 16 is a schematic view of a treatment portion according to the second embodiment which is seen from a direction of an arrow VII of FIG. 6;

[0025] FIG. 17 is a schematic view of a sheath and an ultrasonic probe according to a modification of the second embodiment which are seen from a distal side thereof;

[0026] FIG. 18 is a schematic view of a distal portion of an ultrasonic probe according to a third embodiment which is seen from one side in a width direction;

[0027] FIG. 19 is a schematic view of the distal portion of the ultrasonic probe according to the third embodiment which is seen from the side of a second intersecting direction;

[0028] FIG. 20 is a schematic view of a cutting region of a treatment portion according to the third embodiment which is seen from one side in a width direction;

[0029] FIG. 21 is a schematic view of a sheath and the ultrasonic probe according to the third embodiment which are seen from a distal side thereof;

[0030] FIG. 22 is a schematic view of a sheath and an ultrasonic probe according to a modification of the third embodiment which are seen from a distal side thereof;

[0031] FIG. 23 is a schematic view of a distal portion of an ultrasonic probe according to a fourth embodiment which is seen from one side in a width direction;

[0032] FIG. 24 is a schematic view of the distal portion of the ultrasonic probe according to the fourth embodiment which is seen from the side of a second intersecting direction;

[0033] FIG. 25 is a schematic view of a cutting region of a treatment portion according to the fourth embodiment which is seen from the one side in the width direction;

[0034] FIG. 26 is a schematic view of a sheath and the ultrasonic probe according to the fourth embodiment which are seen from a distal side thereof;

[0035] FIG. 27 is a schematic view of a distal portion of an ultrasonic probe according to a fifth embodiment which is seen from one side in a width direction;

[0036] FIG. 28 is a schematic view of the distal portion of the ultrasonic probe according to the fifth embodiment which is seen from the side of a second intersecting direction;

[0037] FIG. 29 is a cross-sectional view taken along the XXIX-XXIX line of FIG. 27; and

[0038] FIG. 30 is a schematic view of the distal portion of the ultrasonic probe according to the fifth embodiment which is seen from the one side in the width direction.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

[0039] A first embodiment will be described with reference to FIG. 1 to FIG. 12. FIG. 1 is a view showing an ultrasonic treatment system 1 of the present embodiment.

FIG. 2 is a view showing a constitution of a vibrating body unit 10 including an ultrasonic probe 8 and an ultrasonic transducer 12 which will be described later. As shown in FIG. 1, the ultrasonic treatment system 1 includes an ultrasonic treatment instrument (a hand piece) 2, an energy controller 3, and a transducer unit 5. The ultrasonic treatment instrument 2 has a substantially linear virtual longitudinal axis C. Here, one side of a direction along the longitudinal axis C (a longitudinal direction) is a distal side (an arrow C1 side), and a side opposite to the distal side is a proximal side (an arrow C2 side). Furthermore, the ultrasonic treatment instrument 2 is for use in an operation of arthroscopically cutting a bone or a cartilage in a joint such as a knee joint, a shoulder joint or an elbow joint.

[0040] The ultrasonic treatment instrument 2 includes a housing 6 which is able to be held, a sheath 7, and the ultrasonic probe 8 which is used for arthroscopic surgery. The sheath 7 and the ultrasonic probe 8 form an ultrasonic probe unit 4 for the arthroscopic surgery. The housing 6 extends along the longitudinal axis C and the sheath 7 is coupled with the housing 6 from the distal side. The sheath 7 is a hollow member extending along the longitudinal axis C and having the longitudinal axis C as a substantially central axis. The ultrasonic probe (a vibration transmitting member) 8 is inserted through the sheath 7. A distal portion of the ultrasonic probe 8 projects from a distal end of the sheath 7 toward the distal side. Furthermore, an operation button 9 that is an energy operation input section to be operated by an operator is attached to the housing 6.

[0041] The transducer unit 5 includes a transducer case 11, and the ultrasonic transducer 12 (see FIG. 2) provided in the transducer case 11. The transducer case 11 is coupled with the housing 6 from the proximal side. Furthermore, in the housing 6, the ultrasonic transducer 12 is connected to the ultrasonic probe 8 from the proximal side. The transducer unit 5 is connected to the energy controller 3 via a cable 13. The energy controller 3 includes an electric power source, a conversion circuit that converts an electric power from the electric power source into electric energy to be supplied to the ultrasonic transducer 12, a processor or the like (a control section) including a CPU (central processing unit), an ASIC (application specific integrated circuit) or the like, and a storage medium such as a memory. The energy controller 3 detects input of the operation in the operation button 9 to output the electric energy to the ultrasonic transducer 12.

[0042] When the electric energy is supplied to the ultrasonic transducer 12, ultrasonic vibration is generated in the ultrasonic transducer 12. Then, the generated ultrasonic vibration is transmitted to the ultrasonic probe 8, and in the ultrasonic probe 8, the ultrasonic vibration is transmitted from the proximal side to the distal side. In this case, the vibrating body unit 10 constituted of the ultrasonic transducer 12 and the ultrasonic probe 8 vibrates (longitudinally vibrates) at any frequency in a prescribed frequency range. For example, the vibrating body unit 10 is designed in a state of transmitting the ultrasonic vibration therethrough, thereby performing the longitudinal vibration at 47 kHz, and the vibrating body unit actually longitudinally vibrates at any frequency in the frequency range of 46 kHz or more and 48 kHz or less. Furthermore, in the state where the vibrating body unit 10 longitudinally vibrates at any frequency in the prescribed frequency range as shown in FIG. 2, a vibration antinode A1 of the longitudinal vibration is positioned in the

distal portion of the ultrasonic probe **8** and a vibration antinode A_k of the longitudinal vibration is positioned at a proximal end of the ultrasonic transducer **12**. Here, the vibration antinode **A1** is positioned most distally among vibration antinodes A_i ($i=1, 2, \dots, k$) of the longitudinal vibration, and the vibration antinode A_k is positioned most proximally among the vibration antinodes A_i .

[0043] The ultrasonic transducer **12** extends along the substantially linear virtual longitudinal axis **C** that is the substantially central axis. At a distal end of the ultrasonic transducer **12**, a transducer contact surface **16** is formed. The ultrasonic probe **8** includes a probe main body **15** extending along the substantially linear longitudinal axis **C**. The probe main body **15** extends along the longitudinal axis **C** that is the substantially central axis. At a proximal end of the probe main body **15**, a probe contact surface **17** is formed. Furthermore, in the ultrasonic probe **8**, there is provided an engaging protrusion **18** projecting from the probe contact surface **17** (the proximal end of the probe main body **15**) to the proximal side. The engaging protrusion **18** engages with an engagement groove (not shown) provided in the ultrasonic transducer **12** (e.g., an external thread of the engaging protrusion **18** is screwed into an internal thread of the engagement groove), whereby the ultrasonic probe **8** is connected to the distal side of the ultrasonic transducer **12**. In other words, the ultrasonic transducer **12** that generates the ultrasonic vibration is connected to the proximal side of the probe main body **15**. In a state where the ultrasonic probe **8** is connected to the ultrasonic transducer **12**, the probe contact surface **17** of the probe main body **15** contacts the transducer contact surface **16** of the ultrasonic transducer **12**, and the ultrasonic vibration is transmitted to the ultrasonic probe **8** (the probe main body **15**) from the ultrasonic transducer **12** through the transducer contact surface **16** and the probe contact surface **17**.

[0044] The probe main body **15** includes a horn **21**, a sectional area uniform portion **22** provided on the distal side of the horn **21** and having a uniform sectional area, a sectional area increasing portion **23** provided on the distal side of the sectional area uniform portion **22**, and a supported portion **25** provided on the distal side of the sectional area increasing portion **23**. A sectional area of the horn **21** which is vertical to the longitudinal axis **C** decreases from the proximal side toward the distal side. In a longitudinally vibrating state of the vibrating body unit **10** at any frequency in the prescribed frequency range (e.g., a range of 46 kHz or more and 48 kHz or less), each vibration antinode A_i of the longitudinal vibration is positioned away from the horn **21**. Consequently, in the horn **21**, an amplitude of the longitudinal vibration is enlarged. A sectional area of the sectional area increasing portion **23** which is vertical to the longitudinal axis **C** increases from the proximal side toward the distal side. In the longitudinally vibrating state of the vibrating body unit **10** at any frequency in the prescribed frequency range, a vibration antinode **A2** of the longitudinal vibration is positioned in the sectional area increasing portion **23**. Consequently, in the sectional area increasing portion **23**, the amplitude of the longitudinal vibration hardly decreases. In the longitudinally vibrating state of the vibrating body unit **10** at any frequency in the prescribed frequency range, for example, when the longitudinal vibration having an amplitude of 18 μm is transmitted to a proximal end of the probe main body **15** (the probe contact surface **17**), the amplitude of the longitudinal vibration is 80

μm at the vibration antinode **A1** positioned in the sectional area increasing portion **23**. It is to be noted that the vibration antinode **A2** is positioned secondly distally among the vibration antinodes A_i of the longitudinal vibration.

[0045] The supported portion **25** is formed into a groove shape dented on an inner peripheral side along the whole periphery around the longitudinal axis **C**. An elastic member (not shown) having electric insulating properties and heat resisting properties is attached to an outer peripheral surface of the supported portion **25**. In the supported portion **25**, the ultrasonic probe **8** is supported by the sheath **7** via the elastic member. In the longitudinally vibrating state of the vibrating body unit **10** at any frequency in the prescribed frequency range (the range of 46 kHz or more and 48 kHz or less), a vibration node **N1** of the longitudinal vibration is positioned in the supported portion **25**. Here, the vibration node **N1** is positioned most distally among vibration nodes N_j ($j=1, 2, \dots, k-1$) of the longitudinal vibration. The distal end of the sheath **7** is positioned on the distal side of the supported portion **25**. Consequently, in the longitudinally vibrating state of the vibrating body unit **10** at any frequency in the prescribed frequency range, the most distal vibration node **N1** is positioned in the sheath **7**.

[0046] FIG. 3 and FIG. 4 are views showing a constitution of the distal portion of the ultrasonic probe **8**. Here are prescribed a first intersecting direction (a direction of an arrow **P1**) that is a certain direction intersecting (being substantially vertical to) the longitudinal axis **C**, and a second intersecting direction (a direction of an arrow **P2**) opposite to the first intersecting direction (a first vertical direction). Furthermore, there are prescribed width directions (directions of an arrow **W1** and an arrow **W2**) of the ultrasonic probe **8** which are substantially vertical to (intersect) the first intersecting direction (the first vertical direction) and the second intersecting direction (a second vertical direction). Each of FIG. 2 and FIG. 3 is a view of the ultrasonic probe **8** seen from one side (e.g., an arrow **W1** side shown in FIG. 4) in the width direction, and FIG. 4 is a view of the ultrasonic probe **8** seen from a second intersecting direction **P2** side.

[0047] As shown in FIG. 2 to FIG. 4, the ultrasonic probe **8** includes a narrowing portion **31** continuous with the distal side of the probe main body **15**, and a bend extending portion **32** provided on the distal side of the narrowing portion **31**. The bend extending portion **32** extends in a state of bending to the second intersecting direction **P2** side of the longitudinal axis **C**. A treatment portion **33** that treats a treatment target is provided on the distal side of the bend extending portion **32**. The treatment portion **33** includes a distal outer surface **37** in the form of a curved surface that forms a distal end **Ed** of the ultrasonic probe **8**. The treatment portion **33** has a cutting region **34** that cuts a bone or a cartilage by use of the ultrasonic vibration in a joint. The cutting region **34** is provided at a position more away from the longitudinal axis **C** than the bend extending portion **32** in the second intersecting direction **P2**. It is to be noted that in this embodiment, the cutting region **34** of the treatment portion **33** is formed into a file shape.

[0048] As shown in FIG. 3 and FIG. 4, the narrowing portion **31** includes a first narrowing outer surface **41** directed to a first intersecting direction side (an arrow **P1** side), a second narrowing outer surface **42** directed to the second intersecting direction side (the arrow **P2** side), a third narrowing outer surface **43** directed to one side (the arrow

W1 side) in the width direction, and a fourth narrowing outer surface **44** directed to the other side (an arrow W2 side) in the width direction. Each of the narrowing outer surfaces **41** to **44** approaches the longitudinal axis C from the proximal side toward the distal side along the longitudinal axis C. It is to be noted that a structure is also preferable where in the narrowing outer surfaces **41** to **44**, at least one or two narrowing outer surfaces only approach the longitudinal axis C from the proximal side toward the distal side along the longitudinal axis C.

[0049] Here, when a cross section vertical to the longitudinal axis C is taken, portions of the first and second narrowing outer surfaces **41** and **42** in the cross section excluding portions around after-mentioned boundary positions E3 and E4 have a substantially equal distance to the longitudinal axis C.

[0050] The narrowing portion **31** includes a first relay surface **51** directed to the first intersecting direction side (the arrow P1 side) on the distal side of the first narrowing outer surface **41**, and a second relay surface **52** directed to the second intersecting direction side (the arrow P2 side) on the distal side of the second narrowing outer surface **42**. It is preferable that the first and second relay surfaces **51** and **52** are parallel or substantially parallel to each other. Furthermore, it is preferable that the first and second relay surfaces **51** and **52** are parallel to the longitudinal axis C. In particular, the first and second relay surfaces **51** and **52** are parallel to the longitudinal axis C between the boundary position E4 and a boundary position E7.

[0051] A boundary position E1 (i.e., the distal end of the probe main body **15** and a proximal end of the narrowing portion **31**) between the probe main body **15** and the first and second narrowing outer surfaces **41** and **42** of the narrowing portion **31** is positioned on the distal side from the supported portion **25** of the probe main body **15**. In a certain example, at the boundary position E1 (i.e., the distal end of the probe main body **15**), a sectional shape of the ultrasonic probe **8** vertical to the longitudinal axis C is a round shape having an outer diameter φa of 2.9 mm to 3.8 mm. A boundary position E2 (i.e., the distal end of the probe main body **15** and the proximal end of the narrowing portion **31**) between the probe main body **15** and the third and fourth narrowing outer surfaces **43** and **44** of the narrowing portion **31** is positioned on the distal side from the supported portion **25** of the probe main body **15**. Here, the boundary position E1 is disposed closer to the proximal side along the longitudinal axis C than the boundary position E2, but may be closer to the distal side, and the position may be at a position equal to a distance (the same dimension) from the distal end Ed of the treatment portion **33** of the ultrasonic probe **8** along the longitudinal axis C to the boundary position E2.

[0052] The distal end of the sheath **7** shown in FIG. 1 is positioned on the distal side from the boundary positions E1 and E2 between the probe main body **15** and the narrowing portion **31**. Consequently, an outer peripheral side of a proximal portion of the narrowing portion **31** is covered with the sheath **7**. However, an outer periphery of a region other than the proximal portion in the narrowing portion **31** and an outer periphery of the bend extending portion **32** are not covered with the sheath **7**. Consequently, in the ultrasonic probe **8**, the region other than the proximal portion in the narrowing portion **31** and the bend extending portion **32** project from the distal end of the sheath **7** to the distal side.

[0053] In a certain example, a dimension La from the distal end Ed of the treatment portion **33** of the ultrasonic probe **8** to the boundary position E1 between the probe main body **15** and the narrowing portion **31** in a direction along the longitudinal axis C (a longitudinal direction) is from 30.3 mm to 32.5 mm. Furthermore, in the certain example, a dimension Lb from the distal end Ed of the treatment portion **33** of the ultrasonic probe **8** to the boundary position E2 between the probe main body **15** and the narrowing portion **31** in the direction along the longitudinal axis C (the longitudinal direction) is from 20 mm to 32 mm.

[0054] The boundary position E3 in FIG. 3 and FIG. 4 is determined by a distal end of the first narrowing outer surface **41** and a proximal end of the first relay surface **51**. The first narrowing outer surface **41** extends toward the distal side in the direction along the longitudinal axis C from the boundary position (a narrowing start position) E1 between the probe main body **15** and the narrowing portion **31** to the boundary position (a narrowing end position) E3. Consequently, in the first narrowing outer surface **41** between the boundary position E1 and the boundary position E3, a dimension of the narrowing portion **31** from the longitudinal axis C in the first intersecting direction P1 (i.e., a thickness direction of the narrowing portion **31**) decreases from the proximal side toward the distal side. In the certain example, a dimension Lc from the boundary position E1 to the boundary position E3 in the direction along the longitudinal axis C is 18 mm.

[0055] The boundary position E4 in FIG. 3 and FIG. 4 is determined by a distal end of the second narrowing outer surface **42** and a proximal end of the first relay surface **52**. The second narrowing outer surface **42** extends toward the distal side in the direction along the longitudinal axis C from the boundary position (the narrowing start position) E1 between the probe main body **15** and the narrowing portion **31** to the boundary position (the narrowing end position) E4. Consequently, in the second narrowing outer surface **42** between the boundary position E1 and the boundary position E4, a dimension of the narrowing portion **31** from the longitudinal axis C in the second intersecting direction P2 (i.e., the thickness direction of the narrowing portion **31**) decreases from the proximal side toward the distal side. In the certain example, a dimension Ld from the boundary position E1 to the boundary position E4 in the direction along the longitudinal axis C is from 17 mm to 19 mm.

[0056] Here, the boundary positions E3 and E4 are different positions along the longitudinal axis C. In other words, the boundary positions E3 and E4 are not positions having the same dimension from the distal end Ed of the treatment portion **33** of the ultrasonic probe **8** along the longitudinal axis C. In particular, the boundary position E3 is disposed closer to the proximal side than the boundary position E4. A curved surface having a suitable radius Ra is formed at the boundary position E3 between the distal end of the first narrowing outer surface **41** and the proximal end of the first relay surface **51**. It is to be noted that a curved surface having a suitable radius Rb is formed at the boundary position E4 between the distal end of the second narrowing outer surface **42** and the proximal end of the second relay surface **52**.

[0057] The third narrowing outer surface **43** extends toward the distal side in the direction along the longitudinal axis C from the boundary position (the narrowing start position) E2 between the probe main body **15** and the

narrowing portion 31 to a boundary position (a narrowing end position) E5. Consequently, in the third narrowing outer surface 43 between the boundary position E2 and the boundary position E5, a dimension of the narrowing portion 31 from the longitudinal axis C in a first width direction W1 (i.e., the width direction of the narrowing portion 31) decreases from the proximal side toward the distal side. In the certain example, a dimension Le from the boundary position E2 to the boundary position E5 along the longitudinal axis C is from 11 mm to 23 mm.

[0058] The fourth narrowing outer surface 44 extends toward the distal side in the direction along the longitudinal axis C from the boundary position (the narrowing start position) E2 between the probe main body 15 and the narrowing portion 31 to a boundary position (a narrowing end position) E6. Consequently, in the fourth narrowing outer surface 44 between the boundary position E2 and the boundary position E6, a dimension of the narrowing portion 31 from the longitudinal axis C in a second width direction W2 (i.e., the width direction of the narrowing portion 31) decreases from the proximal side toward the distal side. Therefore, a sectional area of the narrowing portion 31 which is vertical to the longitudinal axis C decreases from the proximal side toward the distal side. In the certain example, a dimension Lf from the boundary position E2 to the boundary position E6 along the longitudinal axis C is from 11 mm to 23 mm.

[0059] Consequently, the boundary positions E5 and E6 are positions having an equal distance (the same dimension) from the distal end Ed of the treatment portion 33 of the ultrasonic probe 8 along the longitudinal axis C. Therefore, a center of gravity of the narrowing portion 31 does not shift from the longitudinal axis C in the width direction of the narrowing portion 31. It is to be noted that positions of the boundary positions E5 and E6 may be at a position equal to a distance (the same dimension) from the distal end Ed of the treatment portion 33 of the ultrasonic probe 8 along the longitudinal axis C to the boundary position E3, or may be at a position equal to a distance (the same dimension) from the distal end Ed along the longitudinal axis C to the boundary position E4.

[0060] Here, as described above, the boundary positions E3 and E4 shift forward and backward along the longitudinal axis C. In particular, the boundary position E3 of the first narrowing outer surface 41 is disposed closer to the proximal side than the boundary position E4 of the second narrowing outer surface 42. Furthermore, a dimension between the first relay surface 51 and the longitudinal axis C is larger than a dimension between the second relay surface 52 and the longitudinal axis C. A distance between the first relay surface 51 and the second relay surface 52, i.e., a thickness T of a distal portion of the narrowing portion 31 is from 1.55 mm to 1.65 mm in the certain example. In this case, a distance between the longitudinal axis C and the first relay surface 51 is from 0.95 mm to 1.1 mm, and the distance between the longitudinal axis C and the second relay surface 52 is from 0.45 mm to 0.7 mm. Consequently, the center of gravity of the distal portion of the narrowing portion 31 shifts to the first intersecting direction P1 side of the longitudinal axis C.

[0061] The sectional area of the narrowing portion 31 which is vertical to the longitudinal axis C decreases from the proximal side toward the distal side. In other words, in the treatment portion between the narrowing start position

(the boundary position) E1 and the narrowing end position (the boundary position) E3 or E4 and between the narrowing start position (the boundary position) E2 and the narrowing end position (the boundary position) E5 or E6, the sectional area of the narrowing portion 31 which is vertical to the longitudinal axis C decreases from the proximal side toward the distal side.

[0062] FIG. 5 is a cross-sectional view along the V-V line of FIG. 3, but drawing of the treatment portion 33 is omitted. FIG. 5 shows a sectional area vertical to the longitudinal axis C between the boundary position (the narrowing end position) E4 and a boundary position (a narrowing end position) E7 in the direction along the longitudinal axis C. As shown in FIG. 5, a curved surface (a first curved surface) 55 having a radius Rc is formed between the first relay surface 51 of the narrowing portion 31 and the third narrowing outer surface 43, and a curved surface (a second curved surface) 56 having a radius Rd is formed between the first relay surface 51 and the fourth narrowing outer surface 44. Furthermore, a curved surface (a third curved surface) 57 having a radius Re is formed between the second relay surface 52 of the narrowing portion 31 and the third narrowing outer surface 43, and a curved surface (a fourth curved surface) 58 having a radius Rf is formed between the second relay surface 52 and the fourth narrowing outer surface 44. In the certain example, each of the radii Rc and Rd is 0.75 mm and each of the radii Re and Rf is 0.5 mm.

[0063] Each of the curved surfaces 55 to 58 is not only formed between the boundary positions (the narrowing end positions) E4 and E7, but also extends in a range from the treatment portion 33 to the distal portion of the narrowing portion 31 in the direction along the longitudinal axis C. For example, each of the curved surfaces 55 and 56 extends in a range shown with a broken line B1 of FIG. 3 and each of the curved surfaces 57 and 58 extends in a range shown with a broken line B2 of FIG. 3. Therefore, in the distal portion of the narrowing portion 31, the bend extending portion 32 and the treatment portion 33, the curved surface 55 is formed between a region of an outer surface which is directed to the first intersecting direction P1 side and a region of the outer surface which is directed to one side (the arrow W1 side) in the width direction, and the curved surface 56 is formed between a region of the outer surface which is directed to the first intersecting direction side and a region of the outer surface which is directed to the other side (the arrow W2 side) in the width direction. Furthermore, in each of the distal portion (a relay extending portion) of the narrowing portion 31, the bend extending portion 32 and the treatment portion 33, the curved surface 57 is formed between a region of the outer surface which is directed to the second intersecting direction P2 side and a region of the outer surface which is directed to one side (the arrow W1 side) in the width direction, and the curved surface 58 is formed between a region of the outer surface which is directed to the second intersecting direction P2 side and a region of the outer surface which is directed to the other side (the arrow W2 side) in the width direction.

[0064] As shown in FIG. 2 to FIG. 4, distal ends of the first and second relay surfaces 51 and 52 and distal ends of the third and fourth narrowing outer surfaces 43 and 44 are positioned in the bend extending portion 32. The bend extending portion 32 includes a first extending surface 61 directed to the first intersecting direction side, a second

extending surface 62 directed to the second intersecting direction side, a third extending surface 63 directed to the one side (the arrow W1 side) in the width direction, and a fourth extending surface 64 directed to the other side (the arrow W2 side) in the width direction. The first extending surface 61 is continuous with the distal side of the first relay surface 51 via the boundary position E7. The second extending surface 62 is continuous with the distal side of the second relay surface 52 via a boundary position E8. It is preferable that the first and second extending surfaces 61 and 62 are parallel to each other. The first extending surface 61 approaches or intersects the longitudinal axis C from the proximal side toward the distal side. The second extending surface 62 comes away from the longitudinal axis C from the proximal side toward the distal side. Furthermore, the cutting region 34 is provided on the side of the second extending surface 62.

[0065] The treatment portion 33 of the distal portion of the bend extending portion 32 includes a first continuous surface 71 continuous with the first extending surface 61, a second continuous surface 72 continuous with the second extending surface 62, the cutting region 34 directed to the second intersecting direction side (the arrow P2 side), a first extending end face 73 continuous with the third extending surface 63, and a second extending end face 74 continuous with the fourth extending surface 64. The first continuous surface 71 is directed to the first intersecting direction side (the arrow P1 side). The second continuous surface 72 is directed to the second intersecting direction side (the arrow P2 side). The cutting region 34 is directed to the second intersecting direction side (the arrow P2 side). Furthermore, the cutting region 34 is provided on the distal side of the second continuous surface 72. The first extending end face 73 is directed to the one side (the arrow W1 side shown in FIG. 4 and FIG. 6) in the width direction. The second extending end face 74 is directed to the other side (the arrow W2 side shown in FIG. 4 and FIG. 6) in the width direction. The continuous surface 71, the cutting region 34 and the first and second extending end faces 73 and 74 are continuous with the distal outer surface 37 on the distal side.

[0066] In addition, according to the present embodiment, a dimension W between the first extending end face 73 and the second extending end face 74 in the width direction is from 2.6 mm to 2.8 mm. Furthermore, in the present embodiment, the dimension W of the narrowing portion 31 in the width direction is from 2.6 mm to 2.8 mm at the narrowing end positions (the boundary positions) E5 and E6. It is to be noted that in this embodiment, the dimension W in the width direction is the same in regions on the distal side from the boundary positions E5 and E6 of the distal portion of the narrowing portion 31, i.e., the bend extending portion 32 and the treatment portion 33.

[0067] The boundary position E7 shown in FIG. 3 and FIG. 4 is determined by the distal end of the first relay surface 51 and a proximal end of the first extending surface 61. The first extending surface 61 approaches the longitudinal axis C from the boundary position E7 toward the distal side. The first extending surface 61 tilts at an angle α to the longitudinal axis C directed from the distal side toward the proximal side. Furthermore, the first continuous surface 71 of the treatment portion 33 which is continuous with the first extending surface 61 intersects the longitudinal axis C. The boundary position E8 in FIG. 3 and FIG. 4 is determined by the distal end of the second relay surface 52 and a proximal

end of the second extending surface 62. The second extending surface 62 comes away from the longitudinal axis C from the boundary position E8 toward the distal side. The second extending surface 62 tilts at an angle β to the longitudinal axis C from the proximal side toward the distal side. A curved surface having a suitable radius Rg is formed at the boundary position E7 between the distal end of the first relay surface 51 and the proximal end of the first extending surface 61. A curved surface having a suitable radius Rh is formed at the boundary position E8 between the distal end of the second relay surface 52 and the proximal end of the second extending surface 62. In the certain example, each of the angles α and β is 7.50. It is to be noted that a suitable distance Lg from the distal end Ed of the treatment portion 33 to the boundary position E7 is prescribed. A distance Lh from the distal end Ed of the treatment portion 33 to the boundary position E8 is from 7.5 mm to 8.5 mm in the certain example.

[0068] The boundary position E5 in FIG. 3 and FIG. 4 is determined by the distal end of the third narrowing outer surface 43 and a proximal end of the third extending surface 63. The boundary position E6 is determined by the distal end of the fourth narrowing outer surface 44 and a proximal end of the fourth extending surface 64. A curved surface having a suitable radius Ri is formed at the boundary position E5 between the distal end of the third narrowing outer surface 43 and the proximal end of the third extending surface 63. A curved surface having a suitable radius Rj is formed at the boundary position E6 between the distal end of the fourth narrowing outer surface 44 and the proximal end of the fourth extending surface 64.

[0069] A curved surface having a radius Rk is formed between the distal outer surface 37 of the treatment portion 33 and the first continuous surface 71. A curved surface having a radius R1 is formed between the distal outer surface 37 and the cutting region 34. A curved surface having a radius Rm is formed between the distal outer surface 37 and the first extending end face 73. A curved surface having a radius Rn is formed between the distal outer surface 37 and the second extending end face 74. Therefore, the distal outer surface 37 is continuous with each of the continuous surface 71, the first extending end face 73, the second extending end face 74 and the cutting region 34 of the treatment portion 33.

[0070] In the certain example, the radius Rk is 0.75 mm, the radius R1 is 0.5 mm, and each of the radii Rm and Rn is 1.25 mm. It is to be noted that in the present embodiment, the cutting region 34 is formed as a part of a spherical surface. A spherical surface radius SR of the cutting region 34 is 15 mm in the certain example.

[0071] The distal end of the second extending surface 62 determines a boundary position E9 (see FIG. 6) with the second continuous surface 72 of the treatment portion 33. In other words, a proximal end of a region of the treatment portion 33 on the second intersecting direction (the arrow P2 direction) side is determined by the boundary position E9. A curved surface 76 having a radius Ro is formed at the boundary position E9 between the distal end of the second extending surface 62 and a proximal end of the second continuous surface 72. The second continuous surface 72 continuous with a distal end of the second extending surface 62 via the curved surface 76 comes away toward the second intersecting direction (the arrow P2 direction) side of the longitudinal axis C. Consequently, due to the curved surface 76, a projecting amount of the second continuous surface 72

extending farther to the second intersecting direction side than the second extending surface 62 increases toward the distal side of the longitudinal axis C. The proximal end of the treatment portion 33 on the second intersecting direction (the arrow P2 direction) side is determined by the curved surface 76. A curved surface 77 having a radius Rp is formed on the distal side of the curved surface 76 along the longitudinal axis C. A distal end of the second continuous surface 72 is determined by the curved surface 77. The radius Rp of the curved surface 77 is continuous with the spherical surface radius SR of the cutting region 34. The curved surface 77 forms an edge of a proximal portion of the cutting region 34. In the certain example, the radius Ro is 0.75 mm and the radius Rp is 0.5 mm. A length of an operating region of the cutting region 34 that contributes to the cutting of the bone, the cartilage or the like is a distance Li from the distal end Ed of the treatment portion 33 to the edge of the proximal portion of the cutting region 34. The distance Li is 5 mm in the certain example.

[0072] A thickness T1 between a distal end of the first continuous surface 71 of the treatment portion 33 and the cutting region 34 is from 1.25 mm to 1.5 mm in the certain example. Here, when a cross section parallel to the longitudinal axis C and vertical to the first and second relay surfaces 51 and 52 is taken, the thickness T2 indicates a thickness of the cross section at a position where the cutting region 34 is farthest from the longitudinal axis C in a plane of the cross section. A distance Lj between the longitudinal axis C and the cutting region 34 is from 1.5 mm to 1.7 mm in the certain example. In the same manner as described above, the distance Lj indicates a distance at the position where the cutting region 34 is farthest from the longitudinal axis C in the plane of the cross section, when the cross section parallel to the longitudinal axis C and vertical to the first and second relay surfaces 51 and 52 is taken. Furthermore, a distance Lk between the distal end Ed of the treatment portion 33 and the position where the cutting region 34 is farthest from the longitudinal axis C is from 3 mm to 3.2 mm in the certain example.

[0073] FIG. 6 and FIG. 7 are views showing a constitution of the treatment portion 33. FIG. 6 shows a state where the cutting region 34 of the treatment portion 33 is seen from the second intersecting direction (the arrow P2) side, and FIG. 7 shows a state where the treatment portion 33 is seen from a direction of an arrow VII of FIG. 6.

[0074] As shown in FIG. 6, the cutting region 34 is formed into a reticulated crosshatch pattern that is tilted to the longitudinal axis C. Grooves 81 are crossed in the cutting region 34. Each groove 81 is straightly formed in the present embodiment. As shown in FIG. 7, a distance L1 between edges of the grooves 81 is 0.4 mm in the certain example. Furthermore, the edges of the respective grooves 81 contribute to the cutting of the bone, the cartilage or the like. Each of tilt angles γ and δ of the respective grooves 81 to the longitudinal axis C from the distal side toward the proximal side shown in FIG. 6 is 60° in the certain example. A radius Rq of each groove 81 in a depth direction is 0.2 mm in the certain example.

[0075] A concave portion 82 having a radius Rr is formed every suitable interval Da along the longitudinal axis C in each of the first and second extending end faces 73 and 74 of the cutting region 34 in the width direction. The concave portions 82 are continuous with the grooves 81. For example, two grooves 81 are continuous with a certain

concave portion 82 of the first extending end face 73. Similarly, two grooves 81 are continuous with a certain concave portion 82 of the second extending end face 74.

[0076] In the certain example, the radius Rr is, for example, 0.25 mm. The interval Da between centers of the respective concave portions 82 along the longitudinal axis C is 0.9 mm in the certain example.

[0077] The concave portions 82 are also formed in the distal outer surface 37 mentioned above. The distal end Ed of the distal outer surface 37 of the treatment portion 33 is disposed away from the concave portion 82 of the distal outer surface 37 as much as a width Wa in the width direction to the longitudinal axis C and as much as a distance Lm in an axial direction. In the certain example, the width Wa is 1 mm and the distance Lm is 0.3 mm. A distance Ln between the distal end Ed of the distal outer surface 37 and the most distal concave portion 82 along the longitudinal axis C in each of the first and second extending end faces 73 and 74 which are continuous with the distal outer surface 37 is 1.2 mm in the certain example.

[0078] As shown in FIG. 7, a depth T2 of the groove 81 is about 0.5 mm at maximum. Furthermore, the respective grooves 81 are disposed away from each other at an interval Db of 0.8 mm in the certain example as seen from a direction of the angles γ and δ to the longitudinal axis C. A distance Lo between the distal end Ed of the distal outer surface 37 and the groove 81 continuous with the third concave portion 82 from the distal end Ed on the proximal side is 2.85 mm in the certain example.

[0079] FIG. 8 is a view of the sheath 7 and the ultrasonic probe 8 which are seen from the distal side. As shown in FIG. 8, the sheath 7 has a minimum inner diameter ϕ_0 . The minimum inner diameter ϕ_0 of the sheath 7 is larger than the outer diameter ϕ_a of the ultrasonic probe 8 at the boundary position E1 between the probe main body 15 and the narrowing portion 31. In an example where the outer diameter ϕ_a is 3.8 mm, the minimum inner diameter ϕ_0 of the sheath 7 is 4 mm. In an example where the outer diameter ϕ_a is 2.9 mm, the minimum inner diameter ϕ_0 of the sheath 7 is 3.4 mm. In projection seen from the distal side, the narrowing portion 31, the bend extending portion 32 and the treatment portion 33 are arranged in a range inner than the minimum inner diameter ϕ_0 of the sheath 7.

[0080] Next, operations and effects of the ultrasonic probe 8 and the ultrasonic treatment instrument 2 of the present embodiment will be described. The ultrasonic treatment system 1 is for use in a treatment of cutting the bone, the cartilage or the like in a joint such as the knee joint, the shoulder joint, the elbow joint or the like under a viewing field of an unshown arthroscope. The ultrasonic probe 8 of the present embodiment is also usable in the shoulder joint, but is preferably for use in a treatment of a comparatively narrow joint such as the knee joint, the elbow joint or the like.

[0081] In the treatment, the distal portion of the ultrasonic probe 8 and a distal portion of the sheath 7 shown in FIG. 1 are inserted into a joint cavity of a joint J through a port (not shown) formed by a cannula or the like. Then, the cutting region 34 of the treatment portion 33 is brought into contact with a treatment target (e.g., an affected part formed in the bone, the cartilage or the like) Ap in the joint cavity. Then, in a state where the cutting region 34 is in contact with the treatment target Ap, the operator performs operation input with the operation button 9. Consequently, the ultra-

sonic vibration is generated in the ultrasonic transducer 12 shown in FIG. 2, and the ultrasonic vibration generated in the vibrating body unit 10 is transmitted from the proximal side to the distal side. In a state where the ultrasonic vibration is being transmitted, the vibrating body unit 10 performs longitudinal vibration in a vibrating direction substantially parallel to the longitudinal axis C. Thus, the treatment portion 33 longitudinally vibrates along the longitudinal axis C in the state where the cutting region 34 is in contact with the treatment target Ap, whereby the treatment target (the bone, the cartilage or the like) is cut.

[0082] FIG. 9A and FIG. 10A are views showing one example of a state of cutting the treatment target Ap in the joint cavity of the joint J with the cutting region 34. As shown in FIG. 9A and FIG. 10A, it is required to cut the treatment target Ap in a narrow space of the joint cavity. For example, there is a case of cutting the affected part Ap that is the treatment target in the narrow space denoted with sign S between a bone Ba and a bone Bb. It is necessary to bring the cutting region 34 into contact with the treatment target Ap in the narrow space S, and hence an angle range of an intruding angle (i.e., an approach angle of the cutting region 34 to the treatment target Ap) of the cutting region 34 when the cutting region 34 approaches the treatment target Ap is limited to a small range.

[0083] Here is described a shape of a range (a range shown with the broken line B2 in FIG. 3) of the second narrowing outer surface 42, the second relay surface 52 and the second extending surface 62 on the second intersecting direction P2 side in the ultrasonic probe 8. In the second narrowing outer surface 42 of the narrowing portion 31, a distance (a first distance) D1 on the second intersecting direction P2 side which is perpendicular to the straight longitudinal axis C increases from the distal side toward the proximal side along the longitudinal axis C. In a region between the distal end of the second relay surface 52 of the narrowing portion 31 (the boundary position E8) and the proximal end thereof (the boundary position E4), a distance (a second distance) D2 to the longitudinal axis C is smaller than the distance D1 and uniform. The distance D2 to the longitudinal axis C is also uniform at the distal end of the second narrowing outer surface 42 (the boundary position E4) and the proximal end of the second extending surface 62 (the boundary position E8). In the second extending surface 62 of the bend extending portion 32, a distance D3 (>D2) to the longitudinal axis C on the second intersecting direction P2 side increases toward the distal side. Furthermore, the distance Lj between the longitudinal axis C and the cutting region 34 is larger than the distance (a third distance) D3 at any position. Consequently, as described above, the cutting region 34 is provided at a position more away from the longitudinal axis C than the bend extending portion 32 in the second intersecting direction P2 from the longitudinal axis C. Therefore, according to the ultrasonic probe 8 of this embodiment, in the state where the cutting region 34 is in contact with the treatment target Ap, it is easy to form a gap (space) G (see FIG. 9A and FIG. 10A) between a tissue or the like adjacent to the proximal side of the cutting region 34 and each of the second relay surface 52 and the second extending surface 62. The gap G can contribute to inhibition of interference with the tissue or the like adjacent to the proximal side of the cutting region 34.

[0084] FIG. 9A and FIG. 10A show a state where the treatment portion 33 of the ultrasonic probe 8 is brought into

contact with the affected part Ap in the narrow space S of the joint cavity between the upper bone Ba and the lower bone Bb. In the probe 8 of the present embodiment, as described above, the distal side of the narrowing portion 31 is bent in the bend extending portion 32 on the second intersecting direction P2 side, and the probe 8 has the cutting region 34 in the bent portion on the second intersecting direction P2 side. In other words, on the proximal side of the cutting region 34, the gap (space) G is formed by the second extending surface 62 of the bend extending portion 32 and the second relay surface 52 of the narrowing portion 31. Consequently, when the cutting region 34 of the treatment portion 33 is brought into contact with the affected part Ap from an opening So of the narrow space S of the joint cavity on a left side of FIG. 9A, a position in the vicinity of the opening So of the narrow space S of the joint cavity is hard to interfere with the second extending surface 62. Furthermore, as shown in FIG. 10A, also when the cutting region 34 of the treatment portion 33 is brought into contact with the affected part Ap at a position inner than the position shown in FIG. 9A from the opening So of the narrow space S of the joint cavity on a left side of FIG. 10A, the position in the vicinity of the opening So of the narrow space S of the joint cavity is hard to interfere with the narrowing portion 31 and the bend extending portion 32.

[0085] FIG. 9B and FIG. 10B show, as a reference, an example where a shape of a distal portion of a narrowing portion 131 to a treatment portion 133 is different from the present embodiment. A bend extending portion 132 is bent from the distal portion of the narrowing portion 131 of a probe 108 of this reference example to a first intersecting direction P1 side opposite to the side of the present embodiment. Consequently, when a cutting region 134 of the treatment portion 133 is brought into contact with an affected part Ap from an opening So of a narrow space S of a joint cavity on a left side of FIG. 9B, the opening So of the narrow space S of the joint cavity which is an interfering area I1 is likely to interfere with a second extending surface 162 of the bend extending portion 132. Furthermore, as shown in FIG. 10B, also when the cutting region 134 of the treatment portion 133 is brought into contact with the affected part Ap at a position inner than the position shown in FIG. 9B from the opening So of the narrow space S of the joint cavity on a left side of FIG. 10B, the opening So of the narrow space S of the joint cavity which is the interfering area I1 is likely to interfere with the second extending surface 162 of the bend extending portion 132, and a position denoted with sign 12 as an interfering region in a proximal portion of the cutting region 134 is likely to interfere with the affected part Ap. In other words, in the example shown as the reference in FIG. 9B and FIG. 10B, the gap G from the treatment target shown in FIG. 9A and FIG. 10A is not formed.

[0086] Thus, in the ultrasonic probe 8 according to the present embodiment, the bend extending portion 32 is provided on the distal side of the narrowing portion 31. The bend extending portion 32 extends in the state of bending to the second intersecting direction P2 side of the longitudinal axis C. Furthermore, in the bend extending portion 32, the cutting region 34 is formed toward the second intersecting direction P2 side. Due to the above-mentioned constitution, the cutting region 34 can first come in contact with the affected part Ap even in the narrow space S of the joint cavity in which the angle range of the approach angle to the

treatment target Ap is limited to a small range, and hence a region of the ultrasonic probe 8 excluding the cutting region 34 is prevented from interfering with the tissue or the like other than the treatment target Ap (e.g., an area other than the affected part Ap in the bone Ba). Consequently, a position of the treatment target Ap excluding an area in contact with the cutting region 34 is hard to come in contact with the ultrasonic probe 8 , and hence unintended cutting by the ultrasonic vibration can be inhibited. In consequence, also in the narrow space S , the cutting region 34 that is a blade region appropriately comes in contact with the treatment target Ap , a treatment performance in the treatment of cutting the treatment target Ap is acquired, and the treatment can efficiently be performed.

[0087] Furthermore, in the present embodiment, as shown in FIG. 8, the narrowing portion 31 , the bend extending portion 32 and the treatment portion 33 are arranged in the range inner than the minimum inner diameter ϕ_0 of the sheath 7 in the projection seen from the distal side. Consequently, in the narrow space S of the joint cavity, the region other than the cutting region 34 in the ultrasonic probe 8 is further effectively prevented from interfering with the tissue or the like other than the treatment target Ap . Consequently, in the narrow space S , the cutting region 34 that is the blade region further appropriately comes in contact with the treatment target Ap .

[0088] The present embodiment has a constitution where the narrowing portion 31 , the bend extending portion 32 and the treatment portion 33 are arranged in the range inner than the minimum inner diameter ϕ_0 of the sheath 7 . Consequently, it is easy to insert the ultrasonic probe 8 through the sheath 7 . In consequence, time and labor in assembling the ultrasonic treatment instrument 2 are decreased.

[0089] FIG. 11 is a view showing the treatment target cut with the cutting region 34 . As described above, the cutting region 34 is formed as a part of the substantially spherical surface having the radius SR . Consequently, in the present embodiment, as shown in FIG. 11, edges having acute angles are not formed between a cut plane Cp obtained by removing the treatment target and each of uncut planes $U1$ and $U2$ adjacent to the cut plane Cp in the bone, the cartilage or the like. Furthermore, the cutting region 34 is formed as a part of the spherical surface, and hence the cut plane Cp from which the treatment target is removed has a dented area having a substantially circular cross section.

[0090] Furthermore, in the present embodiment, the vicinity of the distal portion of the narrowing portion 31 (a region where the first and second relay surfaces 51 and 52 and the third and fourth narrowing outer surfaces 43 and 44 form a ring-shaped outer peripheral surface) shifts to the first intersecting direction $P1$ side of the longitudinal axis C . On the other hand, the bend extending portion 32 extends in the state of bending to the second intersecting direction $P2$ side of the longitudinal axis C . Consequently, the vicinity of the distal portion of the narrowing portion 31 and the center of gravity in the whole bend extending portion 32 including the treatment portion 33 do not noticeably shift from the longitudinal axis C in the first intersecting direction $P1$ and the second intersecting direction $P2$. Therefore, in the ultrasonic probe 8 according to the present embodiment, there is inhibited transverse vibration (improper vibration) in a vibrating direction substantially parallel to the first intersecting direction $P1$ and the second intersecting direction $P2$.

[0091] In this embodiment, it has been described that the second relay surface 52 is parallel to the longitudinal axis C (the distance $D2$ is uniform) as shown in FIG. 3, but the second relay surface does not have to be parallel. Also in this case, it is preferable that a relation of the distance $D1 > D2$ is established. Furthermore, at the boundary position $E4$, the distance $D1$ matches the distance $D2$. Furthermore, needless to say, the distance $D2$ may be adjusted to change in accordance with a position along the longitudinal axis C as in the distances $D1$ and $D3$.

[0092] It is to be noted that in the ultrasonic probe 8 according to the present embodiment, the width directions $W1$ and $W2$ are set symmetrically to the longitudinal axis C . Consequently, there is inhibited the transverse vibration (the improper vibration) in the vibrating direction substantially parallel to the width directions $W1$ and $W2$.

[0093] The treatment portion 33 of the ultrasonic probe 8 to the sheath 7 is not limited to the example shown in FIG. 8, and it is also preferable that the treatment portion is formed as in a modification shown in FIG. 12.

[0094] FIG. 12 shows a state where in projection seen from the distal side of the longitudinal axis C , the narrowing portion 31 , the bend extending portion 32 and the treatment portion 33 are arranged in a range inner than the outer diameter ϕ_a of the ultrasonic probe 8 at the boundary position $E1$. Furthermore, the narrowing portion 31 , the bend extending portion 32 and the treatment portion 33 are capable of performing the treatment as described in the first embodiment, even in the state where the portions are arranged in the range inner than the outer diameter ϕ_a of the ultrasonic probe 8 at the boundary position $E1$ as shown in FIG. 12. Therefore, as long as the portions are arranged in a range inner than the inner diameter ϕ_0 of the sheath 7 , the treatment portion 33 may be in contact with the outer diameter ϕ_a of the ultrasonic probe 8 .

Second Embodiment

[0095] Next, a second embodiment will be described with reference to FIG. 13 to FIG. 17. This embodiment is a modification of the first embodiment, the same members or members having the same functions as in the members described in the first embodiment are denoted with the same signs to the utmost, and detailed description is omitted.

[0096] An ultrasonic probe 8 according to this embodiment has an outer diameter ϕ_a larger than that described in the first embodiment, and is preferably for use mainly in a treatment of a shoulder joint. The ultrasonic probe 8 according to this embodiment has the outer diameter ϕ_a of, for example, 4.9 mm.

[0097] The ultrasonic probe 8 of the present embodiment has about the same shape as in the ultrasonic probe 8 described in the first embodiment, and is suitably different in dimension. Consequently, different portions between both the embodiments will mainly be described.

[0098] As shown in FIG. 13, first and second extending surfaces 61 and 62 are not parallel to each other in this embodiment. In a certain example, an angle α is 5° and an angle β is 7.5° .

[0099] As shown in FIG. 14, in a narrowing portion 31 , third and fourth narrowing outer surfaces 43 and 44 are parallel to each other. Consequently, a boundary position $E2$ prescribed in the first embodiment is not prescribed in this embodiment. In this embodiment, a boundary position $E5$ is not present between the third narrowing outer surface 43 and

a third extending surface **63**. Similarly, a boundary position **E6** is not present between the fourth narrowing outer surface **44** and a fourth extending surface **64**. Consequently, the third narrowing outer surface **43** and the third extending surface **63** are parallel to the fourth narrowing outer surface **44** and the fourth extending surface **64**, respectively. Therefore, here, radii R_i and R_j (see FIG. 4) are not prescribed.

[0100] In a region between a bend extending portion **32** and a treatment portion **33**, the third extending surface **63** is continuous with a first extending end face **73** on a distal side of the third extending surface via a curved surface **78**. The fourth extending surface **64** is continuous with a second extending end face **74** on a distal side of the fourth extending surface via a curved surface **79**. Consequently, a dimension W in a width direction is uniform in the treatment portion **33**, but in this embodiment, the dimension is not the same in a region on the distal side from boundary positions **E3** and **E4** of a distal portion of the narrowing portion **31**, i.e., in the bend extending portion **32** and the treatment portion **33**.

[0101] In the curved surface **78** between a distal end of the third extending surface **63** and a proximal end of the first extending end face **73**, suitable radii R_{i1} and R_{j1} are continuous from a proximal side toward the distal side. Due to the radius R_{i1} , a distance of the first extending end face **73** from a longitudinal axis **C** is larger than that of the third extending surface **63**. The proximal end of the first extending end face **73** is determined with the radius R_{j1} . Similarly, in the curved surface **79** between a distal end of the fourth extending surface **64** and a proximal end of the second extending end face **74**, suitable radii R_{i2} and R_{j2} are continuous from the proximal side toward the distal side. Due to the radius R_{i2} , a distance of the second extending end face **74** from the longitudinal axis **C** is larger than that of the fourth extending surface **64**. The proximal end of the second extending end face **74** is determined with the radius R_{j2} .

[0102] Here, the boundary position **E1** described in the first embodiment is not the same as in first and second narrowing outer surfaces **41** and **42**, and separate boundary positions **E11** and **E12** are prescribed, respectively. In the certain example, a dimension L_{a1} from a distal end **Ed** of the treatment portion **33** of the ultrasonic probe **8** to the boundary position **E11** between a probe main body **15** and the narrowing portion **31** on the side of the first narrowing outer surface **41** in a direction along the longitudinal axis **C** (a longitudinal direction) is 27.8 mm. A dimension L_{a2} from the distal end **Ed** of the treatment portion **33** of the ultrasonic probe **8** to the boundary position **E12** between the probe main body **15** and the narrowing portion **31** on the side of the second narrowing outer surface **42** in the direction along the longitudinal axis **C** (the longitudinal direction) is 26.8 mm. In other words, the boundary positions **E11** and **E12** may shift along the longitudinal axis **C** on the sides of the first and second narrowing outer surfaces **41** and **42**.

[0103] The dimension L_b prescribed in the first embodiment is not prescribed here. This is because in the present embodiment, a distance from the longitudinal axis **C** to an outer surface directed in the width direction is uniform from a distal end of a supported portion **25** to the bend extending portion **32**. Furthermore, dimensions L_e and L_f are not prescribed similarly.

[0104] It is to be noted that a dimension L_c is 14 mm and a dimension L_d is 12 mm. Each of distances L_g and L_h is 10 mm, a distance L_i is 6 mm, a distance L_j is 2.05 mm, a

distance L_k is 3.5 mm, and a distance L_1 is 0.5 mm. A distance L_n is 2 mm and a distance L_o is 3.7 mm.

[0105] Here, the distal end **Ed** of a distal outer surface **37** of the treatment portion **33** is disposed away from concave portions **82** of the distal outer surface **37** as much as widths W_a and W_b in the width direction to the longitudinal axis **C** and as much as distances L_{m1} and L_{m2} in an axial direction. The width W_a is 1.9 mm, the width W_b is 2.55 mm, the distance L_{m1} is 0.4 mm, and the distance L_{m2} is 1.1 mm.

[0106] FIG. 15 is a cross-sectional view along the XV-XV line of FIG. 13. FIG. 15 shows a cross section vertical to the longitudinal axis **C** between the boundary position (a narrowing end position) **E4** and a boundary position **E7** in a direction along the longitudinal axis **C** or between the boundary position (the narrowing end position) **E4** and a boundary position **E8**. In the certain example, each of radii R_c , R_d , R_e and R_f is 0.75 mm.

[0107] Furthermore, curved surfaces having radii R_{k1} and R_{k2} are formed between the distal outer surface **37** of the treatment portion **33** and a first continuous surface **71**. The radius R_{k1} is 0.75 mm and the radius R_{k2} is 15 mm.

[0108] A radius R_1 is 0.75 mm, each of radii R_m and R_n is 2 mm, a radius R_o is 0.3 mm, a radius R_p is 0.75 mm, a radius R_q is 0.25 mm, a radius R_r is 0.25 mm, and a radius R_s is 12.5 mm.

[0109] A thickness T_1 between a distal end of the first continuous surface **71** and a cutting region **34** is 2.2 mm in the certain example.

[0110] A distance between a first relay surface **51** and a second relay surface **52**, i.e., a thickness T is 1.75 mm in the certain example. In this case, a distance between the longitudinal axis **C** and the first relay surface **51** is 0.9 mm and a distance D_2 between the longitudinal axis **C** and the second relay surface **52** is 0.85 mm. Consequently, a center of gravity of the distal portion of the narrowing portion **31** shifts to a first intersecting direction **P1** side of the longitudinal axis **C** in the same manner as described in the first embodiment.

[0111] The dimension W in the width direction is 5.5 mm in the treatment portion **33**. On the other hand, a dimension of each of the narrowing portion **31** and the bend extending portion **32** in the width direction is the same as an outer diameter ϕ_a .

[0112] As shown in FIG. 16, it is preferable that each groove **81** is straightly formed also in the present embodiment. In the certain example, the radius R_r of the concave portion **82** is 0.25 mm, and an interval D_a between centers of the concave portions **82** along the longitudinal axis **C** is 0.9 mm. The radius R_q of each groove **81** in a depth direction is 0.25 mm in the certain example. In the certain example, a depth T_2 of the groove **81** is 0.6 mm. Furthermore, the respective grooves **81** are disposed away from each other at an interval D_b of 1 mm in the certain example seen from a direction of angles γ and δ to the longitudinal axis **C**.

[0113] Here is described a shape of a range (a range shown with a broken line **B2** in FIG. 13) of the second narrowing outer surface **42**, the second relay surface **52** and the second extending surface **62** on a second intersecting direction **P2** side in the ultrasonic probe **8**. In the second narrowing outer surface **42** of the narrowing portion **31**, a distance (a first distance) D_1 on the second intersecting direction **P2** side which is perpendicular to the straight longitudinal axis **C** increases from the distal side toward the proximal side along

the longitudinal axis C. In a region between a distal end of the second relay surface **52** of the narrowing portion **31** (the boundary position E8) and a proximal end thereof (the boundary position E4), the distance (a second distance) D2 to the longitudinal axis C is smaller than the distance D1 and uniform. The distance D2 to the longitudinal axis C is also uniform at a distal end of the second narrowing outer surface **42** (the boundary position E4) and a proximal end of the second extending surface **62** (the boundary position E8). In the second extending surface **62** of the bend extending portion **32**, a distance D3 (>D2) to the longitudinal axis C on the second intersecting direction P2 side increases toward the distal side. Furthermore, the distance Lj between the longitudinal axis C and the cutting region **34** is larger than the distance D3 at any position. Consequently, as described above, the cutting region **34** is provided at a position more away from the longitudinal axis C than the bend extending portion **32** in the second intersecting direction P2. Therefore, according to the ultrasonic probe **8** of this embodiment, in the state where the cutting region **34** is in contact with a treatment target Ap, it is easy to form a gap (space) G (see FIG. 9A and FIG. 10A) between a tissue or the like adjacent to the proximal side of the cutting region **34** and each of the second relay surface **52** and the second extending surface **62**. The gap G can contribute to inhibition of interference with the tissue or the like adjacent to the proximal side of the cutting region **34**.

[0114] FIG. 17 is a view of a sheath **7** and the ultrasonic probe **8** from the distal side. A minimum inner diameter ϕ_0 of the sheath **7** is larger than the outer diameter ϕ_a of the ultrasonic probe **8** at the boundary position E11 between the probe main body **15** and the narrowing portion **31**. In projection seen from the distal side, the narrowing portion **31** and the bend extending portion **32** are arranged in a range inner than the minimum inner diameter ϕ_0 of the sheath **7**.

Third Embodiment

[0115] Next, a third embodiment will be described with reference to FIG. 18 to FIG. 21. This embodiment is a modification of the first and second embodiments, the same members or members having the same functions as in the members described in the first and second embodiments are denoted with the same signs to the utmost, and detailed description is omitted.

[0116] As shown in FIG. 18 to FIG. 21, a treatment portion **33** of a probe **8** according to this embodiment is formed into a rake shape (a hook shape). Similarly to the probe described in the first and second embodiments, also in the probe **8** according to this embodiment, a bend extending portion **32** is present on a distal side of a narrowing portion **31** and the treatment portion **33** is present on a distal side of the bend extending portion **32**.

[0117] Here, a distance between a first relay surface **51** and a second relay surface **52**, i.e., a thickness T of a distal portion of the narrowing portion **31** is 1.7 mm in a certain example. In this case, a distance between a longitudinal axis C and the first relay surface **51** is 0.8 mm and a distance D2 between the longitudinal axis C and the second relay surface **52** is 0.9 mm. Consequently, a center of gravity of the distal portion of the narrowing portion **31** to a second intersecting direction P2 side of the longitudinal axis C in this embodiment.

[0118] Here, on the distal side of the narrowing portion **31**, due to the bend extending portion **32** bent to the second

intersecting direction P2 side, a first extending surface **61** tilts at an angle α to the longitudinal axis C from the distal side toward a proximal side, and a second extending surface **62** tilts at an angle β to the longitudinal axis C from the proximal side toward the distal side. The angles α and β are the same in the certain example. Consequently, the first and second extending surfaces **61** and **62** are parallel to each other. It is to be noted that in the certain example, each of the angles α and β is 7.5°.

[0119] A first continuous surface **71** of the treatment portion **33** which is continuous with the first extending surface **61** of this embodiment also intersects the longitudinal axis C due to the bend extending portion **32** bent to the second intersecting direction P2 side on the distal side of the narrowing portion **31**. Here is described an example where the first continuous surface **71** intersects the longitudinal axis C, but the first continuous surface may only approach the longitudinal axis C from the proximal side toward the distal side due to the bend extending portion **32** on the distal side of the narrowing portion **31**.

[0120] Furthermore, a cutting region **34** of the treatment portion **33** is disposed on the second intersecting direction P2 side of the longitudinal axis C due to the bend extending portion **32** in the same manner as described in the first and second embodiments.

[0121] A second continuous surface **72** is formed on the distal side of the second extending surface **62**. A boundary position E9 is formed between a distal end of the second extending surface **62** and the second continuous surface **72**. Here, in the second continuous surface **72**, a first flat portion **72a**, a curved portion **72b** and a second flat portion **72c** are continuous from the proximal side toward the distal side.

[0122] The first flat portion **72a** forms an edge at the boundary position E9 between the distal end of the second extending surface **62** and the second continuous surface. The distal side of the first flat portion **72a** is disposed closer to the longitudinal axis C than the boundary position E9. In the curved portion **72b**, the distal side of the first flat portion **72a** is disposed away from the longitudinal axis C, from the proximal side toward the distal side. The curved portion **72b** is formed to have a radius Rp. On the distal side of the curved portion **72b**, the second flat portion **72c** is formed continuously with the curved portion **72b**. In the certain example, the radius Rp is 0.5 mm.

[0123] On the distal side of the second flat portion **72c**, a flat portion **75** is formed to approach the longitudinal axis C from the proximal side toward the distal side. The cutting region **34** is formed into an edge between the second flat portion **72c** and the flat portion **75**. In other words, according to this embodiment, a spherical cutting region **34** (see FIG. 3) described in the first and second embodiments is not used.

[0124] It is preferable that an angle θ between the second flat portion **72c** and the flat portion **75** is smaller than 90°. It is preferable that the cutting region **34** extends in a direction perpendicular to the longitudinal axis C and extends in parallel with a width direction.

[0125] It is to be noted that here, the cutting region **34** is present at a position to come in contact with the second extending surface **62**, when the second extending surface is a virtually extending plane. In other words, at least a part of the cutting region **34** is present on the virtually extending plane of the second extending surface **62**.

[0126] A height H1 of the cutting region **34** to the first flat portion **72a** is, for example, 0.7 mm. A height H2 (a

dimension Lk) of the cutting region 34 to a distal end Ed of the treatment portion 33 along the longitudinal axis C is, for example, 1 mm. An angle ϵ formed between the first flat portion 72a and the second flat portion 72c is 900 in the certain example. An angle ζ formed between the second flat portion 72c and the first continuous surface 71 is 72.5° in the certain example. An angle η formed between the first continuous surface 71 and the flat portion 75 is 30° in the certain example.

[0127] It is to be noted that in the certain example, a dimension La from the distal end Ed of the treatment portion 33 of the ultrasonic probe 8 to a boundary position E1 between a probe main body 15 and the narrowing portion 31 on a first narrowing outer surface 41 side and a second narrowing outer surface 42 side in a direction along the longitudinal axis C (a longitudinal direction) is 32 mm. A dimension Lb is 25 mm, a dimension Lc is 18.5 mm, and a dimension Ld is 17.5 mm. Each of dimensions Le and Lf is 15 mm. Here, a distance Lh is 7 mm and smaller than a distance Lg. A distance Li from the distal end Ed of the treatment portion 33 to an edge of a proximal portion of the cutting region 34 is not prescribed. A distance Lj is 1.7 mm.

[0128] Although not shown in the drawing, each of radii Rc, Rd, Re and Rf of curved surfaces 55, 56, 57 and 58 of a transverse cross section in the bend extending portion 32 formed similarly to FIG. 5 is 0.5 mm. Each of radii Rk and R1 is 0.5 mm.

[0129] Here is described a shape of a range (a range shown with a broken line B2 in FIG. 18) of the second narrowing outer surface 42, the second relay surface 52 and the second extending surface 62 on the second intersecting direction P2 side in the ultrasonic probe 8. In the second narrowing outer surface 42 of the narrowing portion 31, a distance (a first distance) D1 on the second intersecting direction P2 side which is perpendicular to the straight longitudinal axis C increases from the distal side toward the proximal side along the longitudinal axis C. In a region between a distal end of the second relay surface 52 of the narrowing portion 31 (a boundary position E8) and a proximal end thereof (a boundary position E4), the distance (a second distance) D2 to the longitudinal axis C is smaller than the distance D1 and uniform. The distance D2 to the longitudinal axis C is also uniform at a distal end of the second narrowing outer surface 42 (the boundary position E4) and a proximal end of the second extending surface 62 (the boundary position E8). In the second extending surface 62 of the bend extending portion 32, a distance D3 (>D2) to the longitudinal axis C on the second intersecting direction P2 side increases toward the distal side. Furthermore, the distance Lj between the longitudinal axis C and the cutting region 34 is larger than the distance D3 at any position. Consequently, as described above, the cutting region 34 is provided at a position more away from the longitudinal axis C than the bend extending portion 32 in the second intersecting direction P2. Therefore, according to the ultrasonic probe 8 of this embodiment, in the state where the cutting region 34 is in contact with a treatment target Ap, it is easy to form a gap (space) G (see FIG. 9A and FIG. 10A) between a tissue or the like adjacent to the proximal side of the cutting region 34 and each of the second relay surface 52 and the second extending surface 62. The gap G can contribute to inhibition of interference with the tissue or the like adjacent to the proximal side of the cutting region 34.

[0130] The probe 8 of this embodiment is likely to form the gap (space) G (see FIG. 9A and FIG. 10A) especially between the second relay surface 52 and the tissue or the like other than the treatment target during a treatment. Consequently, in the same manner as described in the first embodiment, the interference with the tissue or the like other than the treatment target is inhibited by use of the probe 8 of this embodiment. Consequently, the ultrasonic probe 8 is hard to come in contact with a position of the treatment target Ap excluding an area in contact with the cutting region 34, and hence unintended cutting by ultrasonic vibration can be inhibited. Thus, also in a narrow space S, the cutting region 34 that is a blade region appropriately comes in contact with the treatment target Ap, and a treatment performance in the treatment of cutting the treatment target Ap is acquired.

[0131] Also in this embodiment, similarly to the first and second embodiments, the gap (space) G formed by the second extending surface 62 of the bend extending portion 32 and the second relay surface 52 of the narrowing portion 31 is formed on the proximal side of the cutting region 34. Consequently, when the cutting region 34 of the treatment portion 33 is brought into contact with the affected part Ap from an opening So of the narrow space S of a joint cavity on the left side of FIG. 9A, a position in the vicinity of the opening So of the narrow space S of the joint cavity is hard to interfere with the second extending surface 62. Furthermore, as shown in FIG. 10A, also when the cutting region 34 of the treatment portion 33 is brought into contact with the affected part Ap at a position inner than the position shown in FIG. 9A from the opening So of the narrow space S of the joint cavity on the left side of FIG. 10A, the position in the vicinity of the opening So of the narrow space S of the joint cavity is hard to interfere with the narrowing portion 31.

[0132] Consequently, in the ultrasonic probe 8 according to the present embodiment, the bend extending portion 32 is provided on the distal side of the narrowing portion 31. The bend extending portion 32 extends in a state of bending to the second intersecting direction P2 side of the longitudinal axis C. Furthermore, in the bend extending portion 32, the cutting region 34 is formed toward the second intersecting direction P2 side. Due to the above-mentioned constitution, a region of the ultrasonic probe 8 excluding the cutting region 34 is prevented from interfering with the tissue or the like other than the treatment target Ap (e.g., an area other than the affected part Ap in a bone Ba) also in the narrow space S of the joint cavity in which an angle range of an approach angle to the treatment target Ap is limited to a small range. Consequently, the position of the treatment target Ap excluding an area in contact with the cutting region 34 is hard to come in contact with the ultrasonic probe 8, and hence unintended cutting by the ultrasonic vibration can be inhibited. In consequence, also in the narrow space S, the cutting region 34 that is the blade region appropriately comes in contact with the treatment target Ap, and the treatment performance in the treatment of cutting the treatment target Ap is acquired.

[0133] Furthermore, in the present embodiment, as shown in FIG. 21, the narrowing portion 31, the bend extending portion 32 and the treatment portion 33 are arranged in a range inner than a minimum inner diameter ϕ_0 of a sheath 7 in projection from the distal side. Consequently, in the narrow space S of the joint cavity, the region other than the cutting region 34 in the ultrasonic probe 8 is further effec-

tively prevented from interfering with the tissue or the like other than the treatment target Ap. Consequently, in the narrow space S, the cutting region 34 that is the blade region further appropriately comes in contact with the treatment target Ap.

[0134] The present embodiment has a constitution where the narrowing portion 31, the bend extending portion 32 and the treatment portion 33 are arranged in the range inner than the minimum inner diameter ϕ_0 of the sheath 7. Consequently, it is easy to insert the ultrasonic probe 8 through the sheath 7. In consequence, time and labor in assembling an ultrasonic treatment instrument 2 are decreased.

[0135] FIG. 21 is a view of the sheath 7 and the ultrasonic probe 8 which are seen from the distal side. The minimum inner diameter ϕ_0 of the sheath 7 shown in FIG. 21 is larger than an outer diameter ϕ_a of the ultrasonic probe 8 at the boundary position E1 between the probe main body 15 and the narrowing portion 31. In an example where the outer diameter ϕ_a is 4.9 mm, the minimum inner diameter ϕ_0 of the sheath 7 is, for example, 5 mm. In the projection seen from the distal side, the treatment portion 33, the bend extending portion 32 and the narrowing portion 31 are arranged in the range inner than the minimum inner diameter ϕ_0 of the sheath 7.

[0136] The treatment portion 33 of the ultrasonic probe 8 is not limited to the example shown in FIG. 21, and it is also preferable that the treatment portion is formed as in a modification shown in FIG. 22.

[0137] FIG. 22 shows a state where in the projection seen from the distal side of the longitudinal axis C, the narrowing portion 31, the bend extending portion 32 and the treatment portion 33 are arranged in a range inner than the outer diameter ϕ_a of the ultrasonic probe 8 at the boundary position E1. Furthermore, the narrowing portion 31, the bend extending portion 32 and the treatment portion 33 are capable of performing the treatment as described in the first embodiment, even in the state where the portions are arranged in the range inner than the outer diameter ϕ_a of the ultrasonic probe 8 at the boundary position E1 as shown in FIG. 22. Therefore, as long as the portions are arranged in a range inner than the inner diameter ϕ_0 of the sheath 7, the treatment portion 33 may have a size to be in contact with the outer diameter ϕ_a of the ultrasonic probe 8.

Fourth Embodiment

[0138] Next, a fourth embodiment will be described with reference to FIG. 23 to FIG. 26. This embodiment is a modification of the first to third embodiments, the same members or members having the same functions as in the members described in the first to third embodiments are denoted with the same signs to the utmost, and detailed description is omitted. This embodiment is especially a modification of the third embodiment.

[0139] As shown in FIG. 25, the flat portion 75 described in the third embodiment has a first flat portion 75a adjacent to a cutting region 34, and a second flat portion 75b adjacent to the first flat portion 75a on a side close to a distal end Ed of a treatment portion 33 due to a curved surface 72b having a radius Rp.

[0140] As shown in FIG. 23 and FIG. 25, in this embodiment, at least a part of the cutting region 34 is present at a position far from a longitudinal axis C to a virtually extending plane of a second extending surface 62. Consequently, in the cutting region 34, when the first extending surface 62

virtually extends, the plane intersects a second flat portion 72c adjacent to a proximal side of the cutting region 34 and intersects at least one of the first and second flat portions 75a and 75b which are adjacent to a distal side of the cutting region 34. In other words, the cutting region 34 projects from the virtually extending plane of the first extending surface 62 to a second intersecting direction P2 side. Thus, differently from the example of the third embodiment, a projecting length of the cutting region 34 from the second extending surface 62 may be adjusted.

[0141] It is to be noted that a distance between a first relay surface 51 and a second relay surface 52, i.e., a thickness T of a distal portion of a narrowing portion 31 is 1.7 mm in a certain example. In this case, a distance between the longitudinal axis C and the first relay surface 51 is 0.75 mm, and a distance D2 between the longitudinal axis C and the second relay surface 52 is 0.95 mm. Consequently, a center of gravity of the distal portion of the narrowing portion 31 shifts to the second intersecting direction P2 side of the longitudinal axis C in the same manner as in the third embodiment.

[0142] It is to be noted that each of radii Rc, Rd, Re and Rf is 0.5 mm, each of radii Rk, R11, R12, Rm and Rn is 0.5 mm, and a radius Rp is 0.5 mm.

[0143] Furthermore, as one example, a dimension La is 32 mm, a dimension Lb is 25 mm, a dimension Lc is 18 mm, a dimension Ld is 19 mm, and each of dimensions Le and Lf is 15 mm. A distance Lh is 7 mm. A height H1 is 0.9 mm, a distance Lk (=a height H2) is 1 mm, and a height H3 is 1.4 mm. Furthermore, a thickness T1 between a distal end of a first continuous surface 71 of the treatment portion 33 and the cutting region 34 is 1.6 mm, and a width W is 2.8 mm.

[0144] An angle η_1 is determined by a first extending surface 61 and the first continuous surface 71 which are directed to a first intersecting direction P1 side and the first flat portion 75a adjacent to the distal side of the cutting region 34. An angle η_2 is determined by the first extending surface 61, the first continuous surface 71, and the second flat portion 75b adjacent to the distal side of the first flat portion 75a. In the certain example, the angle η_1 is 250 and the angle η_2 is 45°. It is to be noted that in the certain example, each of angles α and β is 50, an angle ϵ is 80°, and an angle ζ is 85°. Thus, differently from the third embodiment, an angle of a bend extending portion 32 may be adjusted. The above-mentioned protruding length and angles α and β are adjusted, so that the treatment portion 33 suitable for a joint of a treatment target can be formed.

[0145] Here is described a shape of a range (a range shown with a broken line B2 in FIG. 23) of a second narrowing outer surface 42, the second relay surface 52 and the second extending surface 62 on the second intersecting direction P2 side in the ultrasonic probe 8. In the second narrowing outer surface 42 of the narrowing portion 31, a distance (a first distance) D1 on the second intersecting direction P2 side which is perpendicular to the straight longitudinal axis C increases from the distal side toward the proximal side along the longitudinal axis C. In a region between a distal end of the second relay surface 52 of the narrowing portion 31 (a boundary position E8) and a proximal end thereof (a boundary position E4), the distance (a second distance) D2 to the longitudinal axis C is smaller than the distance D1 and uniform. The distance D2 to the longitudinal axis C is also uniform at a distal end of the second narrowing outer surface 42 (the boundary position E4) and a proximal end of the

second extending surface 62 (the boundary position E8). In the second extending surface 62 of the bend extending portion 32, a distance D3 (>D2) to the longitudinal axis C on the second intersecting direction P2 side increases toward the distal side. Furthermore, a distance Lj between the longitudinal axis C and the cutting region 34 is larger than the distance D3 at any position, though an example of a specific numeric value is omitted. Consequently, as described above, the cutting region 34 is provided at a position more away from the longitudinal axis C than the bend extending portion 32 in the second intersecting direction P2. Therefore, according to the ultrasonic probe 8 of this embodiment, in the state where the cutting region 34 is in contact with a treatment target Ap, it is easy to form a gap (space) G (see FIG. 9A and FIG. 10A) between a tissue or the like adjacent to the proximal side of the cutting region 34 and each of the second relay surface 52 and the second extending surface 62. The gap G can contribute to inhibition of interference with the tissue or the like adjacent to the proximal side of the cutting region 34.

[0146] FIG. 26 is a view of a sheath 7 and the ultrasonic probe 8 which are seen from the distal side. A minimum inner diameter ϕ_0 of the sheath 7 shown in FIG. 26 is larger than an outer diameter ϕ_a of the ultrasonic probe 8 at a boundary position E1 between a probe main body 15 and the narrowing portion 31. In an example where the outer diameter ϕ_a is 3.8 mm, the minimum inner diameter ϕ_0 of the sheath 7 is, for example, 4 mm. In projection seen from the distal side, the treatment portion 33, the bend extending portion 32 and the narrowing portion 31 are arranged in a range inner than the minimum inner diameter ϕ_0 of the sheath 7.

[0147] Although not shown in the drawing, it is also preferable that in the projection seen from the distal side, the treatment portion 33, the bend extending portion 32 and the narrowing portion 31 are arranged in a range inner than the outer diameter ϕ_a of the ultrasonic probe 8 at the boundary position E1.

[0148] Also when the ultrasonic probe 8 is formed in this way, the ultrasonic probe is usable in the same manner as described in the third embodiment.

Fifth Embodiment

[0149] Next, a fifth embodiment will be described with reference to FIG. 27 to FIG. 30. This embodiment is a modification of the first to fourth embodiments, the same members or members having the same functions as in the members described in the first to fourth embodiments are denoted with the same signs to the utmost, and detailed description is omitted. This embodiment is especially a modification of the third embodiment.

[0150] Here, a position in the vicinity of a distal portion of a narrowing portion 31 shifts. In other words, a dimension Ld is longer than a dimension Lc. In a certain example, the dimension Lc is 13 mm and the dimension Ld is 14.5 mm. Consequently, boundary positions E3 and E4 shift forward and backward along a longitudinal axis C. In particular, the boundary position E3 of a first narrowing outer surface 41 is disposed closer to a proximal side than the boundary position E4 of a second narrowing outer surface 42. Furthermore, a dimension between a first relay surface 51 and the longitudinal axis C is larger than a dimension D2 between a second relay surface 52 and the longitudinal axis C. A distance between the first relay surface 51 and the second

relay surface 52, i.e., a thickness T of the distal portion of the narrowing portion 31 is 1.75 mm in the certain example. In this case, a distance between the longitudinal axis C and the first relay surface 51 is 1.25 mm and the distance D2 between the longitudinal axis C and the second relay surface 52 is 0.5 mm. Consequently, a center of gravity of the distal portion of the narrowing portion 31 shifts to a first intersecting direction P1 side of the longitudinal axis C.

[0151] As shown in FIG. 29, a treatment portion 33 shifts to a second intersecting direction P2 side. Thus, the distal portion of the narrowing portion 31 shifts to the first intersecting direction P1 side, whereby balance between the first intersecting direction P1 and the second intersecting direction P2 of a bend extending portion 32 and the treatment portion 33 is taken. Therefore, in an ultrasonic probe 8 according to the present embodiment, there is inhibited transverse vibration (improper vibration) in a vibrating direction substantially parallel to the first intersecting direction P1 and the second intersecting direction P2.

[0152] Here is described a shape of a range (a range shown with a broken line B2 in FIG. 27) of the second narrowing outer surface 42, the second relay surface 52 and a second extending surface 62 on the second intersecting direction P2 side in the ultrasonic probe 8. In the second narrowing outer surface 42 of the narrowing portion 31, a distance (a first distance) D1 on the second intersecting direction P2 side which is perpendicular to the straight longitudinal axis C increases from the distal side toward the proximal side along the longitudinal axis C. In a region between a distal end of the second relay surface 52 of the narrowing portion 31 (a boundary position E8) and a proximal end thereof (the boundary position E4), the distance (a second distance) D2 to the longitudinal axis C is smaller than a distance D1 and uniform. The distance D2 to the longitudinal axis C is also uniform at a distal end of the second narrowing outer surface 42 (the boundary position E4) and a proximal end of the second extending surface 62 (the boundary position E8). In the second extending surface 62 of the bend extending portion 32, a distance D3 (>D2) to the longitudinal axis C on the second intersecting direction P2 side increases toward the distal side. Furthermore, a distance Lj between the longitudinal axis C and a cutting region 34 is larger than the distance D3 at any position, though an example of a specific numeric value is omitted. Consequently, as described above, the cutting region 34 is provided at a position more away from the longitudinal axis C than the bend extending portion 32 in the second intersecting direction P2. Therefore, according to the ultrasonic probe 8 of this embodiment, in the state where the cutting region 34 is in contact with a treatment target Ap, it is easy to form a gap (space) G (see FIG. 9A and FIG. 10A) between a tissue or the like adjacent to the proximal side of the cutting region 34 and each of the second relay surface 52 and the second extending surface 62. The gap G can contribute to inhibition of interference with the tissue or the like adjacent to the proximal side of the cutting region 34.

[0153] It is to be noted that as one example, each of radii R_c , R_d , R_e and R_f is 0.5 mm. Here, in the same manner as described in the second embodiment, suitable radii R_{i1} , R_{i2} , R_{j1} and R_{j2} are prescribed. Furthermore, a radius R_k is 0.5 mm, a radius R_{11} is 1 mm, a radius R_{12} is 0.4 mm, each of radii R_m and R_n is 1 mm, and a radius R_p is 0.5 mm.

[0154] The dimension Lb prescribed in the third and fourth embodiments is not prescribed here. This is because in the present embodiment, a distance from the longitudinal axis C to an outer surface directed in a width direction W is uniform from a distal end of a supported portion 25 to the bend extending portion 32. Furthermore, dimensions Le and Lf are not prescribed similarly. As one example, a dimension La is 29.2 mm, the dimension Lc is 13 mm, and the dimension Ld is 14.5 mm. Each of distances Lg and Lh is 8.5 mm. A distance Li is 5.5 mm. A height H1 is 0.7 mm, and a distance Lk (=a height H2) is 1 mm. A thickness T1 between a distal end of a first continuous surface 71 of the treatment portion 33 and the cutting region 34 is 1.7 mm, and a width W of the treatment portion 33 is 5.5 mm.

[0155] In the certain example, each of angles α and β is 10°, an angle ϵ is 90°, an angle η_1 is 30°, and an angle η_2 is 50°.

[0156] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

1-11. (canceled)

12. An ultrasonic probe for arthroscopic surgery which is for use in an operation of a joint and which is configured to transmit ultrasonic vibration from a proximal side to a distal side thereof, the ultrasonic probe comprising:

a probe main body which extends from the proximal side to the distal side along a linear longitudinal axis and to which an ultrasonic transducer to generate the ultrasonic vibration is connected to the proximal side;

a bend extending portion which is provided on the distal side of the probe main body and which extends to bend to a side of a second intersecting direction of the probe main body, when a certain direction intersecting the longitudinal axis is a first intersecting direction and a direction opposite to the first intersecting direction is the second intersecting direction; and

a treatment portion which is provided on the distal side of the bend extending portion and which is configured to treat a treatment target,

wherein the bend extending portion includes:

a first extending surface directed to a side of the first intersecting direction;

a second extending surface directed to a side of the second intersecting direction;

a third extending surface directed to a side of a first width direction, when two directions intersecting the longitudinal axis and being vertical to the first intersecting direction and the second intersecting direction are defined as the first width direction and a second width direction; and

a fourth extending surface directed to a side of the second width direction, and

the treatment portion includes:

a first continuous surface continuous with the first extending surface;

a second continuous surface which is continuous with the second extending surface and in which grooves to cut the treatment target are formed;

a first extending end face which is continuous with the third extending surface and in which first concave portions to cut the treatment target are formed; and a second extending end face which is continuous with the fourth extending surface and in which second concave portions to cut the treatment target are formed.

13. The ultrasonic probe of claim 12, further comprising a narrowing portion between the probe main body and the bend extending portion,

wherein the narrowing portion includes:

a first narrowing outer surface which is directed to a side of the first intersecting direction and in which a first distance from the longitudinal axis in the first intersecting direction decreases from the proximal side toward the distal side;

a first relay surface which is directed to the first intersecting direction side, continuous with a region between the first narrowing outer surface and the first extending surface in a direction along the longitudinal axis, and extends in parallel with the longitudinal axis;

a second narrowing outer surface which is directed to the second intersecting direction side and in which a second distance from the longitudinal axis in the second intersecting direction decreases from the proximal side toward the distal side; and

a second relay surface which is directed to a side of the second intersecting direction, continuous with a region between the second narrowing outer surface and the second extending surface in the direction along the longitudinal axis, and extends in parallel with the longitudinal axis.

14. The ultrasonic probe of claim 13, wherein a boundary position between the first narrowing outer surface and the first relay surface and a boundary position between the second narrowing outer surface and the second relay surface are mutually different positions along the longitudinal axis.

15. The ultrasonic probe of claim 14, wherein the boundary position between the first narrowing outer surface and the first relay surface is positioned closer to the proximal side in the direction along the longitudinal axis than the boundary position between the second narrowing outer surface and the second relay surface.

16. The ultrasonic probe of claim 13, wherein:

a boundary position between the probe main body and the first narrowing outer surface is positioned closer to the proximal side in the direction along the longitudinal axis than a boundary position between the probe main body and the second narrowing outer surface, and

the boundary position between the first narrowing outer surface and the first relay surface is positioned closer to the distal side in the direction along the longitudinal axis than the boundary position between the second narrowing outer surface and the second relay surface.

17. The ultrasonic probe of claim 12, wherein the grooves are continuous with the first concave portions and the second concave portions.

18. A vibrating body unit comprising:

the ultrasonic probe according to claim 12; and
an ultrasonic transducer connected to the ultrasonic probe.

专利名称(译)	用于关节镜手术的超声探头和超声探头单元		
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[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		
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摘要(译)

一种用于关节镜手术的超声波探头，包括：弯曲延伸部分，其设置在探头主体的远侧并且当与纵向交叉的特定方向延伸以弯曲到探头主体的第二交叉方向的一侧时轴是第一交叉方向，与第一交叉方向相反的方向是第二交叉方向;治疗部分设置在弯曲延伸部分的远端侧，并且被配置为治疗治疗目标。

