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(54) ULTRASONIC PROBE FOR OPERATION UNDER MICROSCOPE

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(30) **Foreign Application Priority Data**

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Publication Classification

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(52) **U.S. Cl.** **600/2**

(57) **ABSTRACT**

An ultrasonic probe for microscopic operations in accordance with the present invention consists mainly of an ultrasonic probe body, an elongated tubular member, and a bent handle member. The ultrasonic probe body has a transducer assembly attached to the distal end of a soft elongated tube that is extended from a connector to be coupled to an ultrasonic observation apparatus, and has a coupler mounted on the tube thereof. The transducer assembly and tube are passed through the elongated tubular member. The handle member is attached to the proximal end of the tubular member and includes a coupling mechanism for use in coupling the coupler to the handle member so that the coupler can be uncoupled freely.

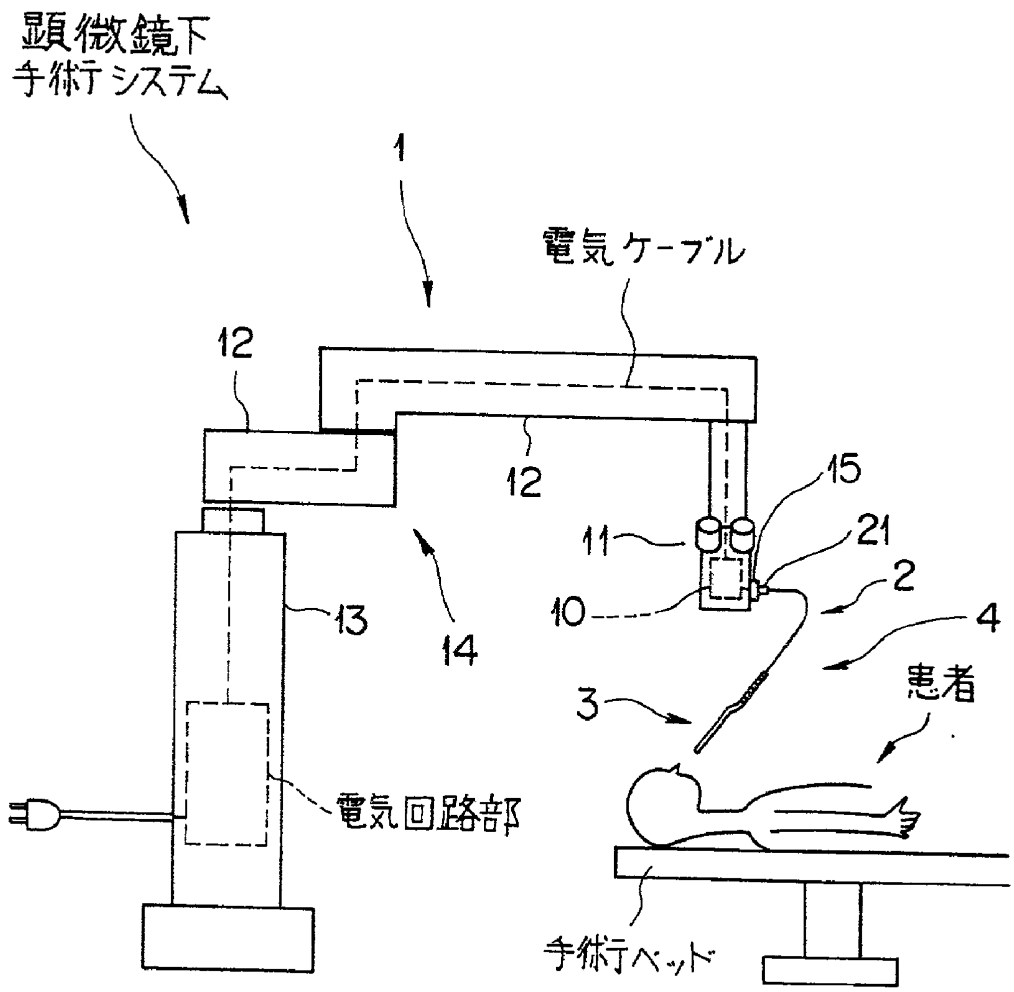
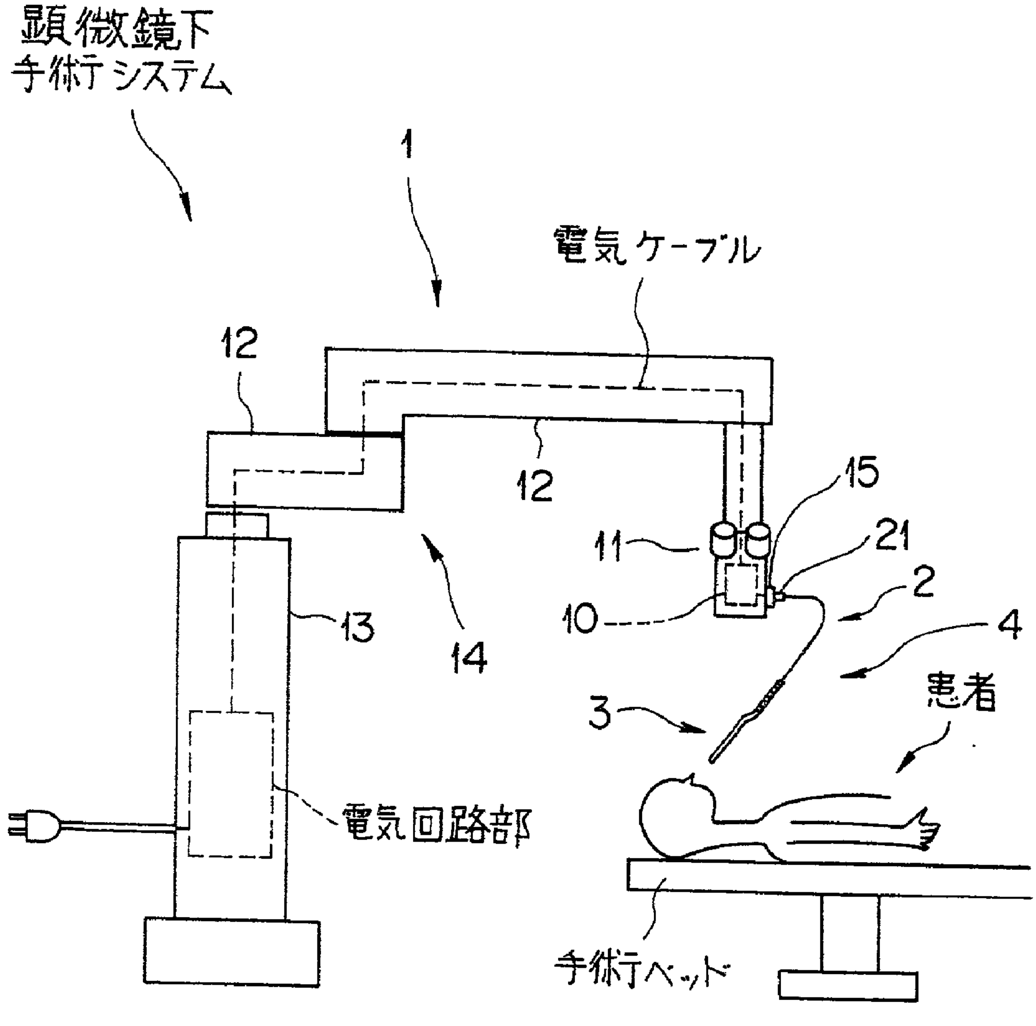


FIG. 1


顕微鏡下
手術システム
1
電気ケーブル
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15
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21
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10
4
13
14
3
患者
電気回路部
手術ベッド

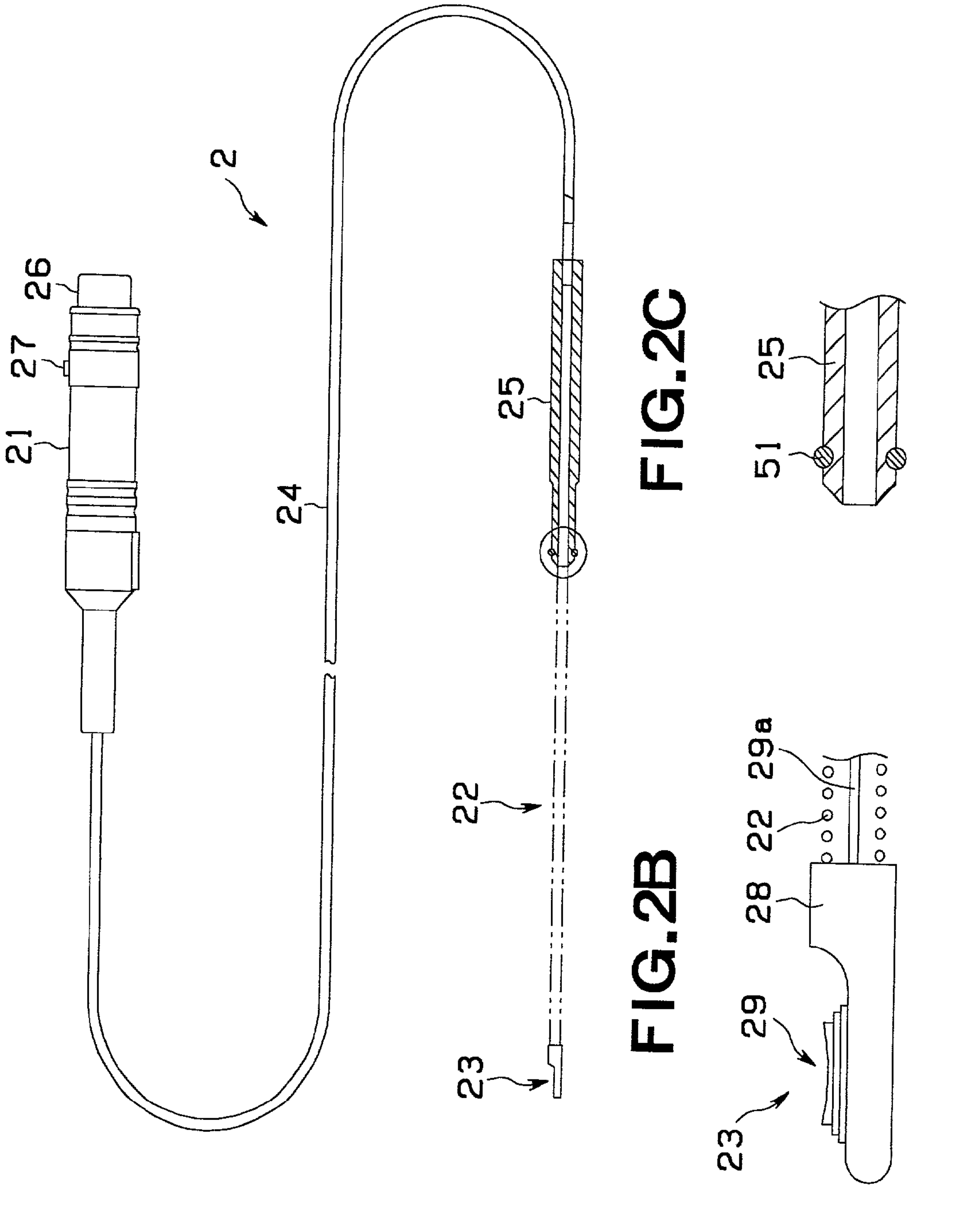


FIG.2A

FIG.2B

FIG.2C

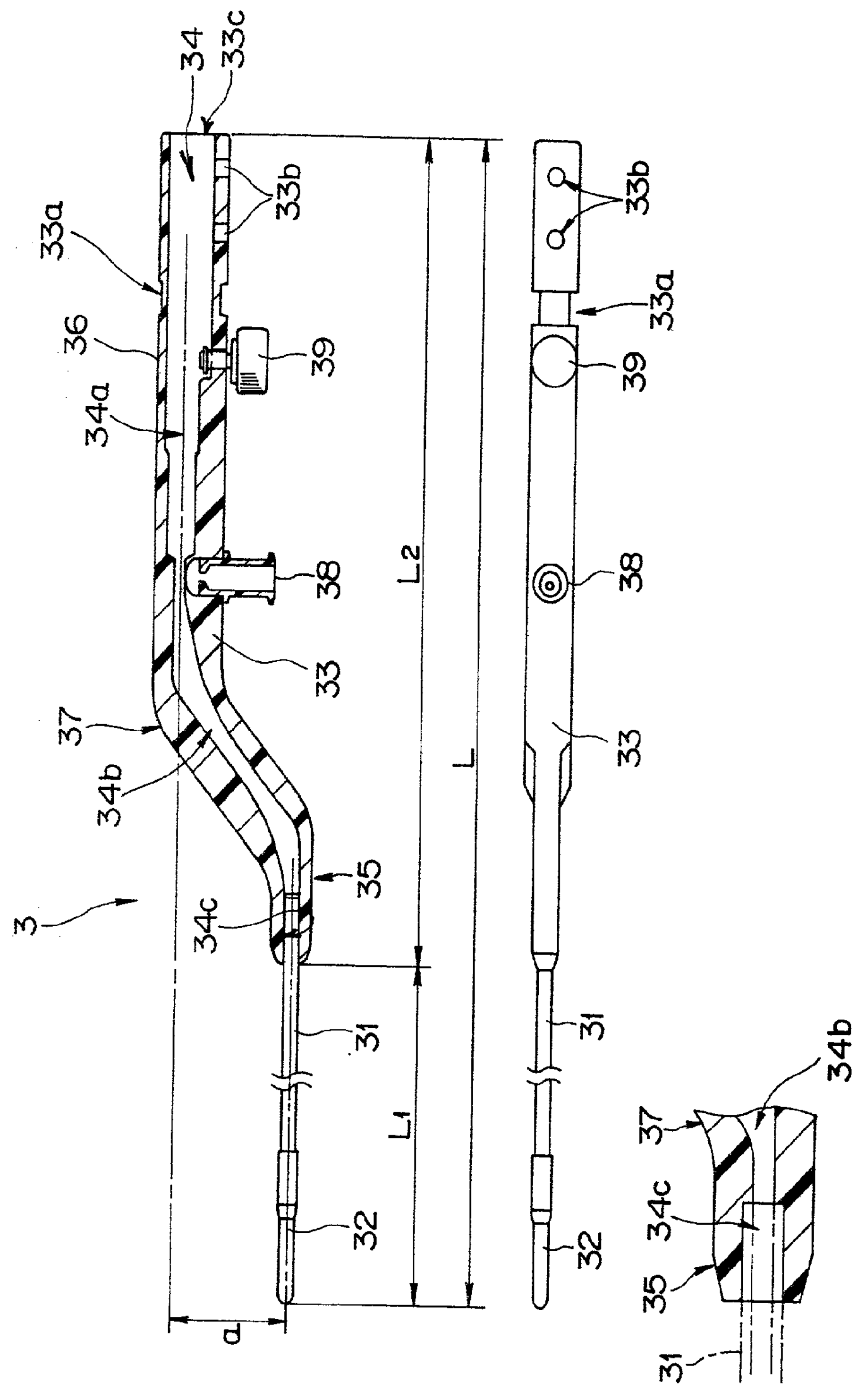


FIG.3B

FIG.4A

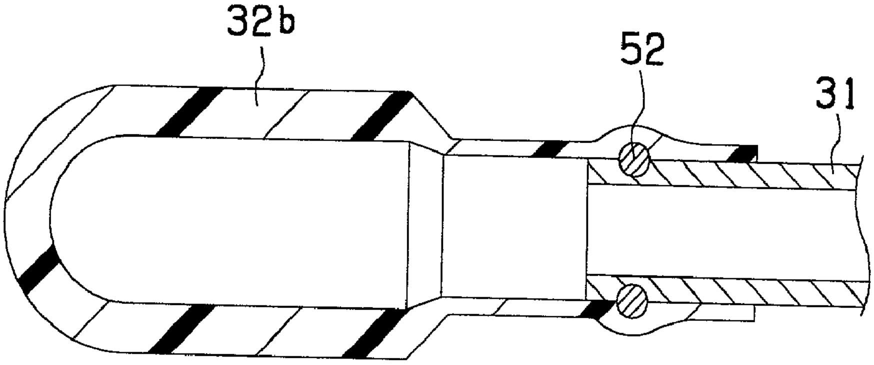


FIG.4B

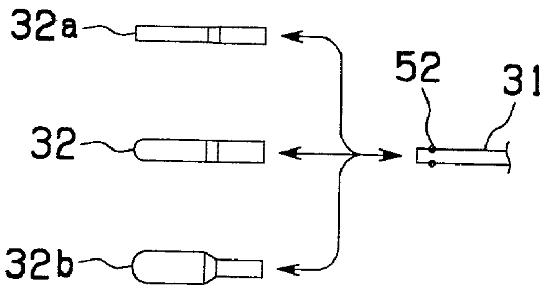


FIG.4C

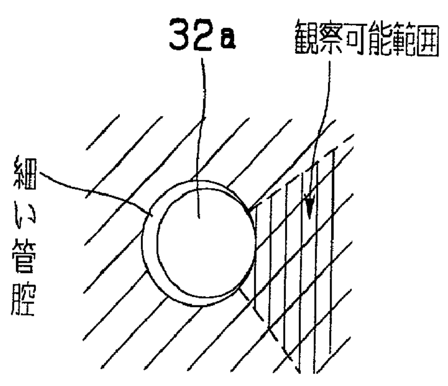


FIG.4D

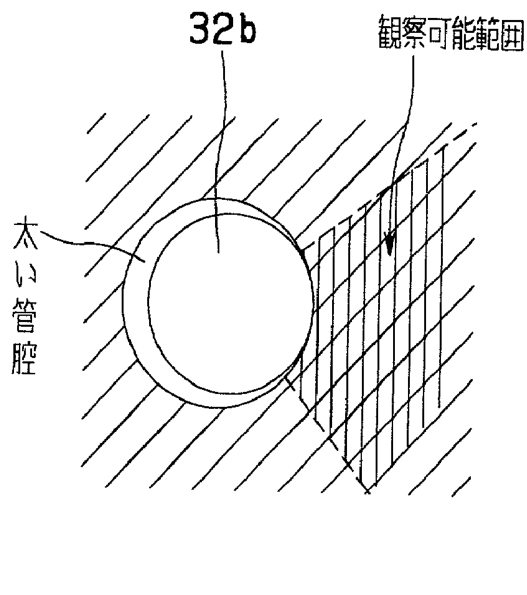


FIG.5B

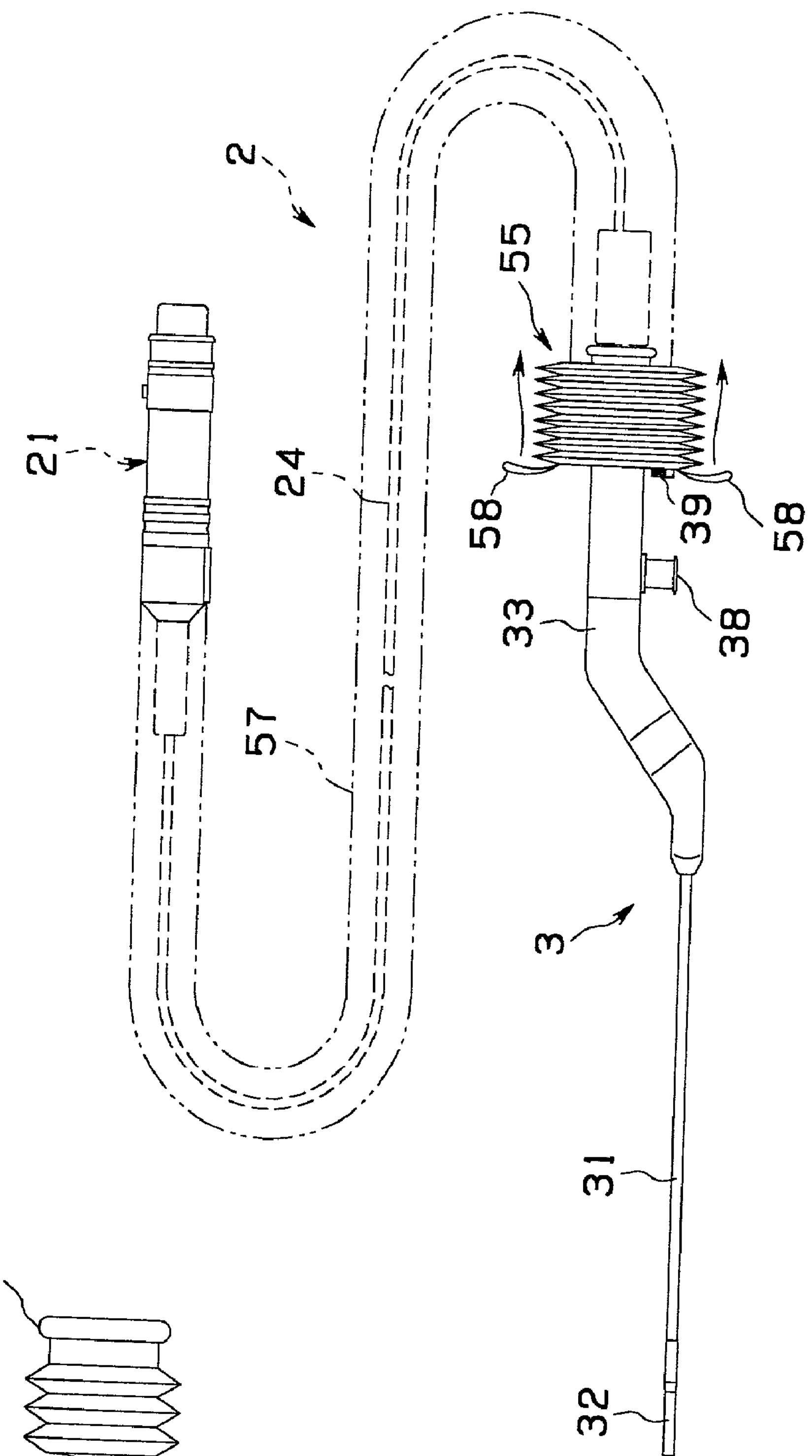


FIG.5A

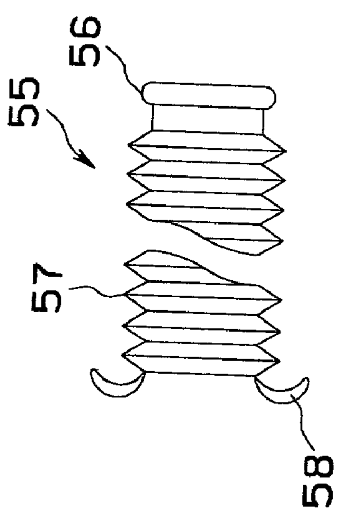


FIG.6

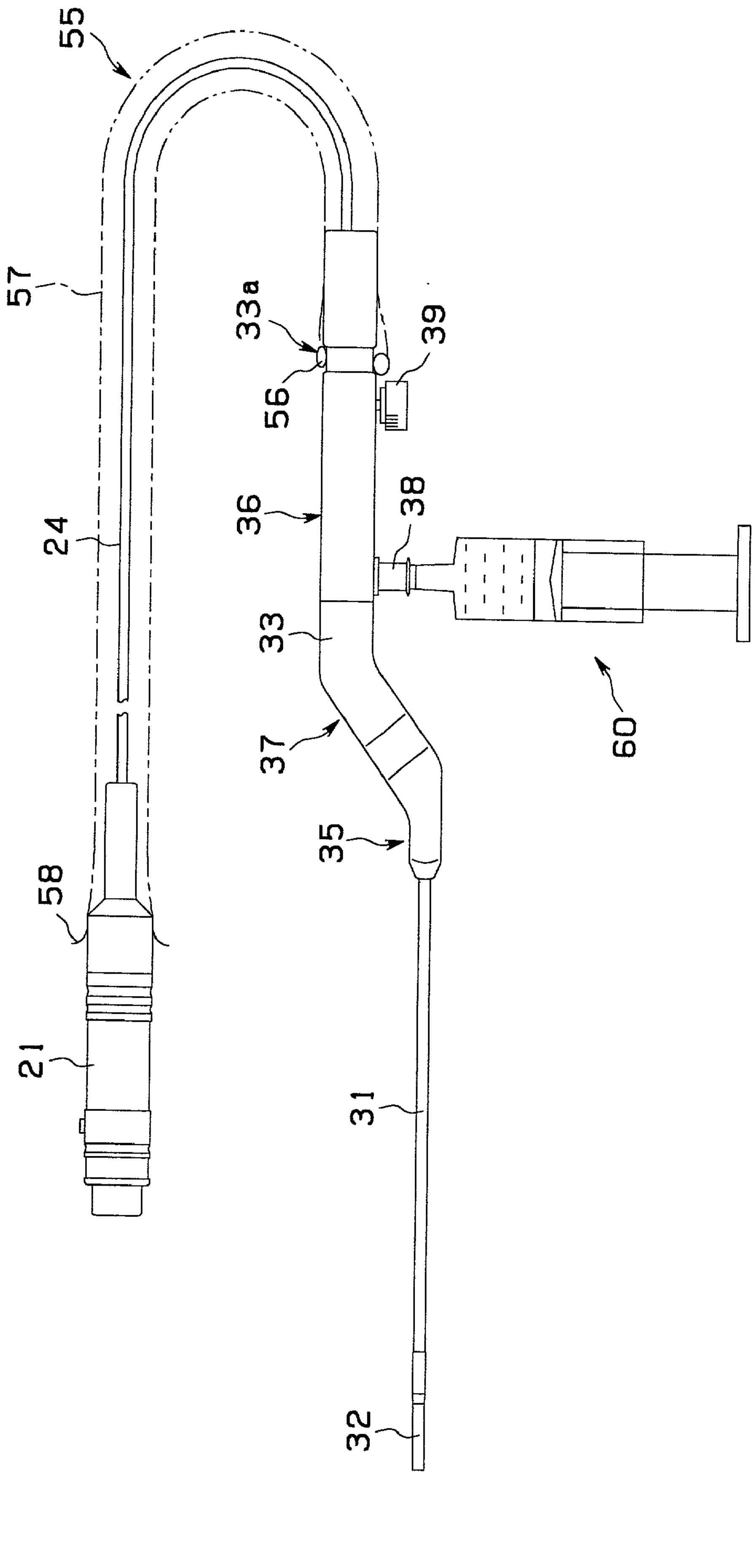


FIG. 7

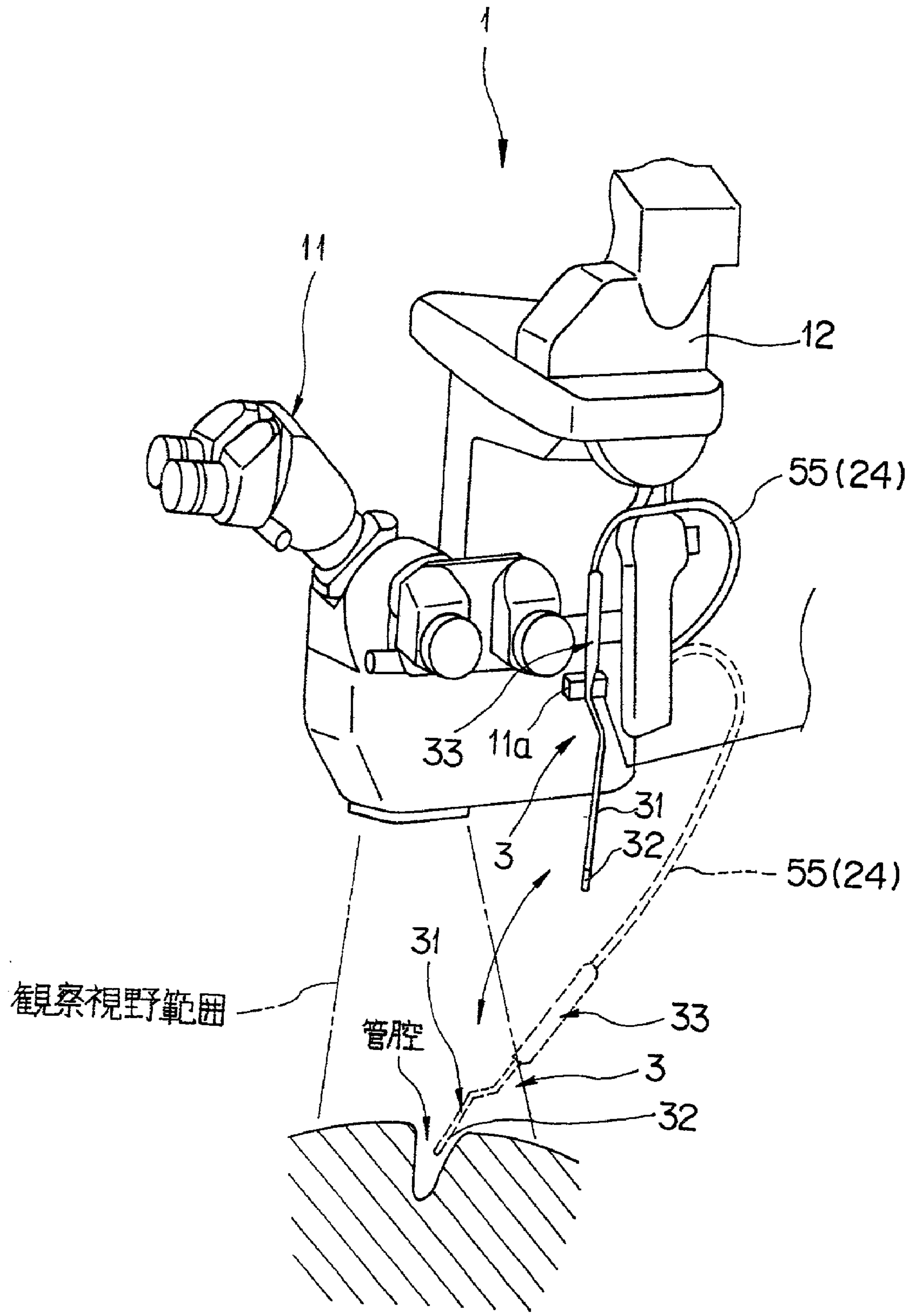


FIG.8A

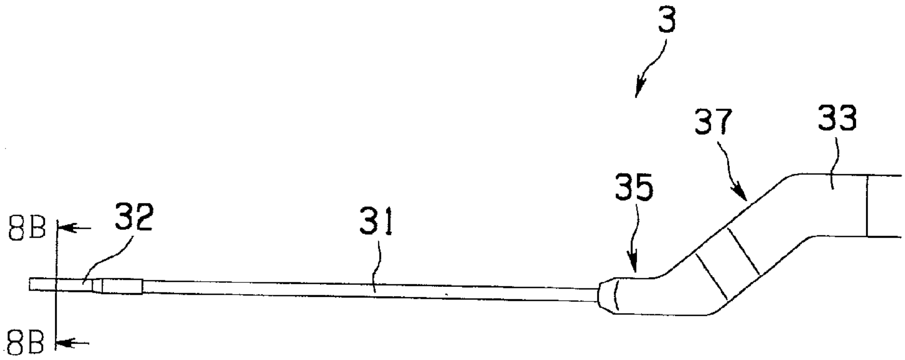


FIG.8B

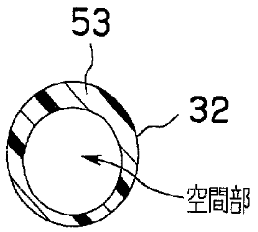


FIG.8C

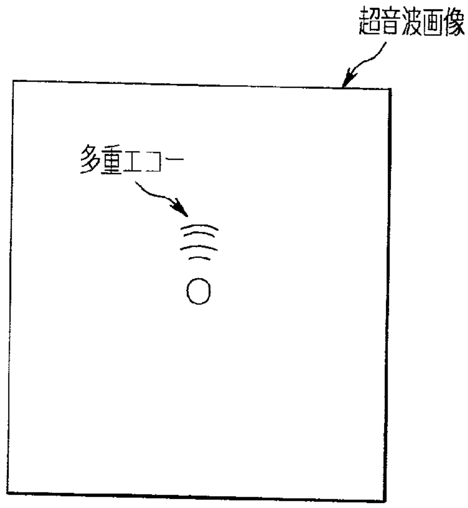


FIG.9

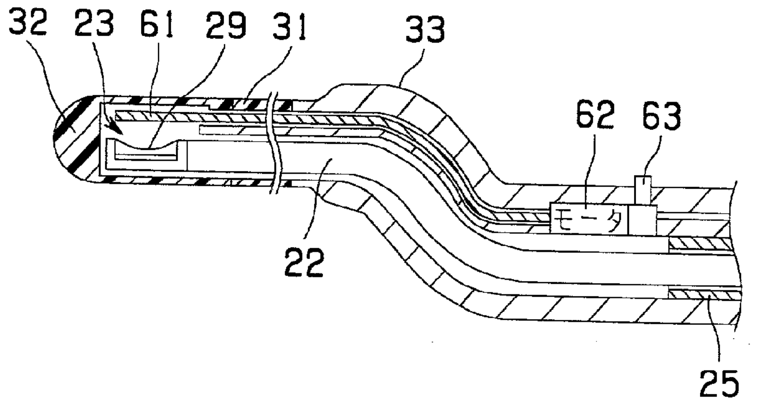


FIG.10A

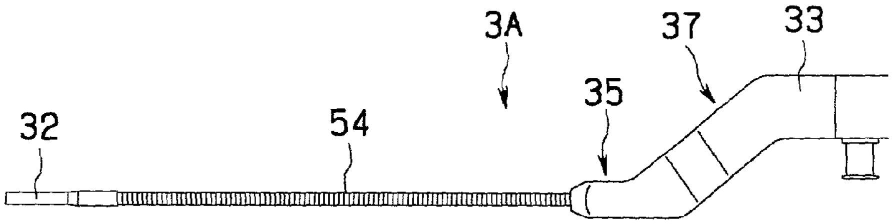


FIG.10B

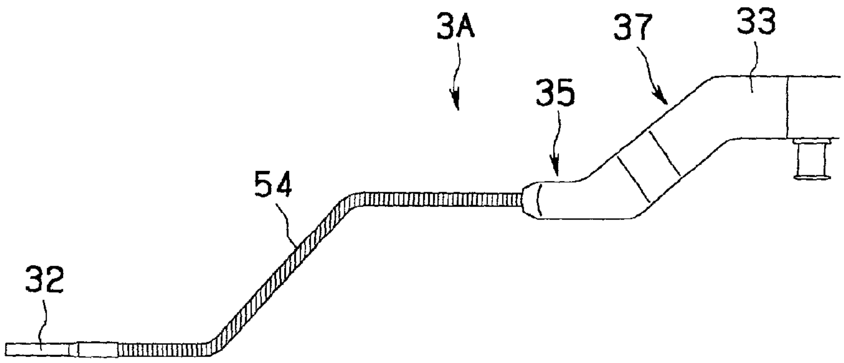


FIG.10C

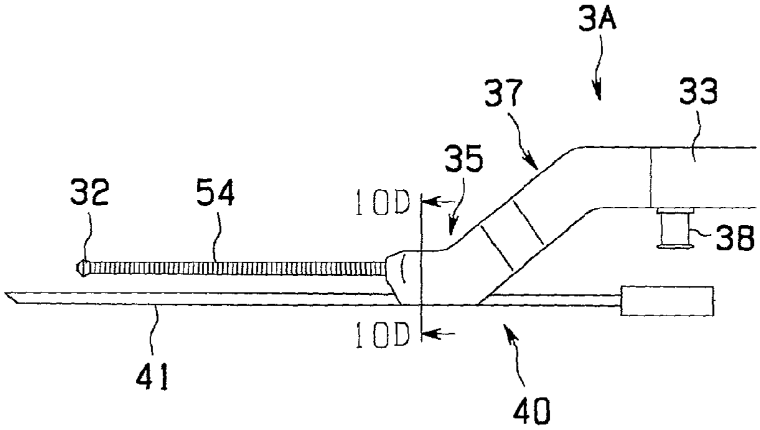


FIG.10D

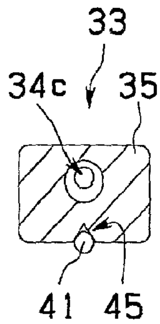


FIG.10E

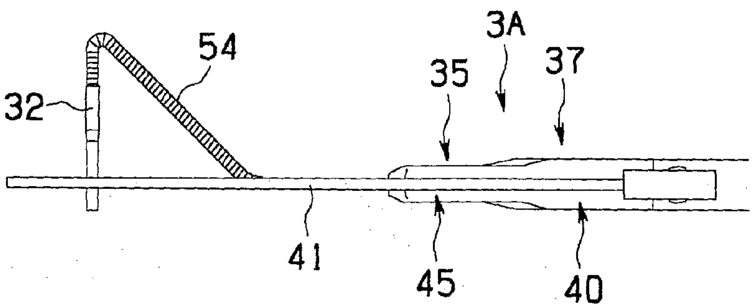


FIG.11A

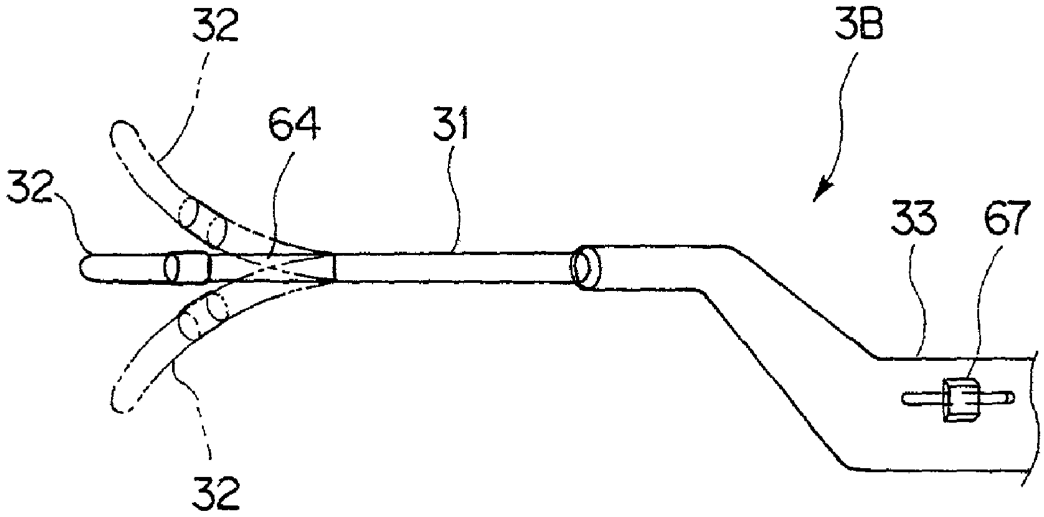


FIG.11B

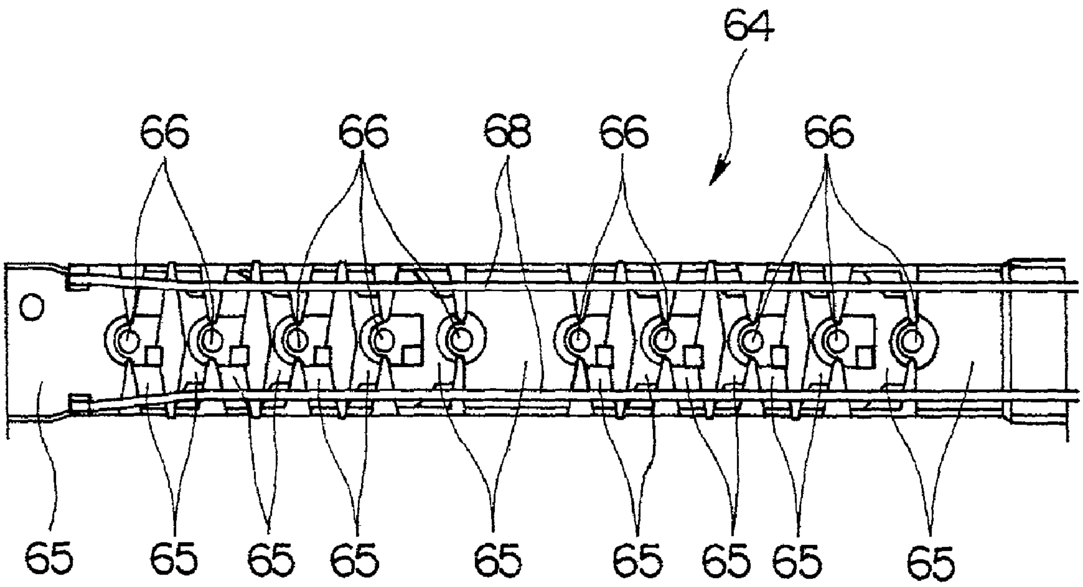
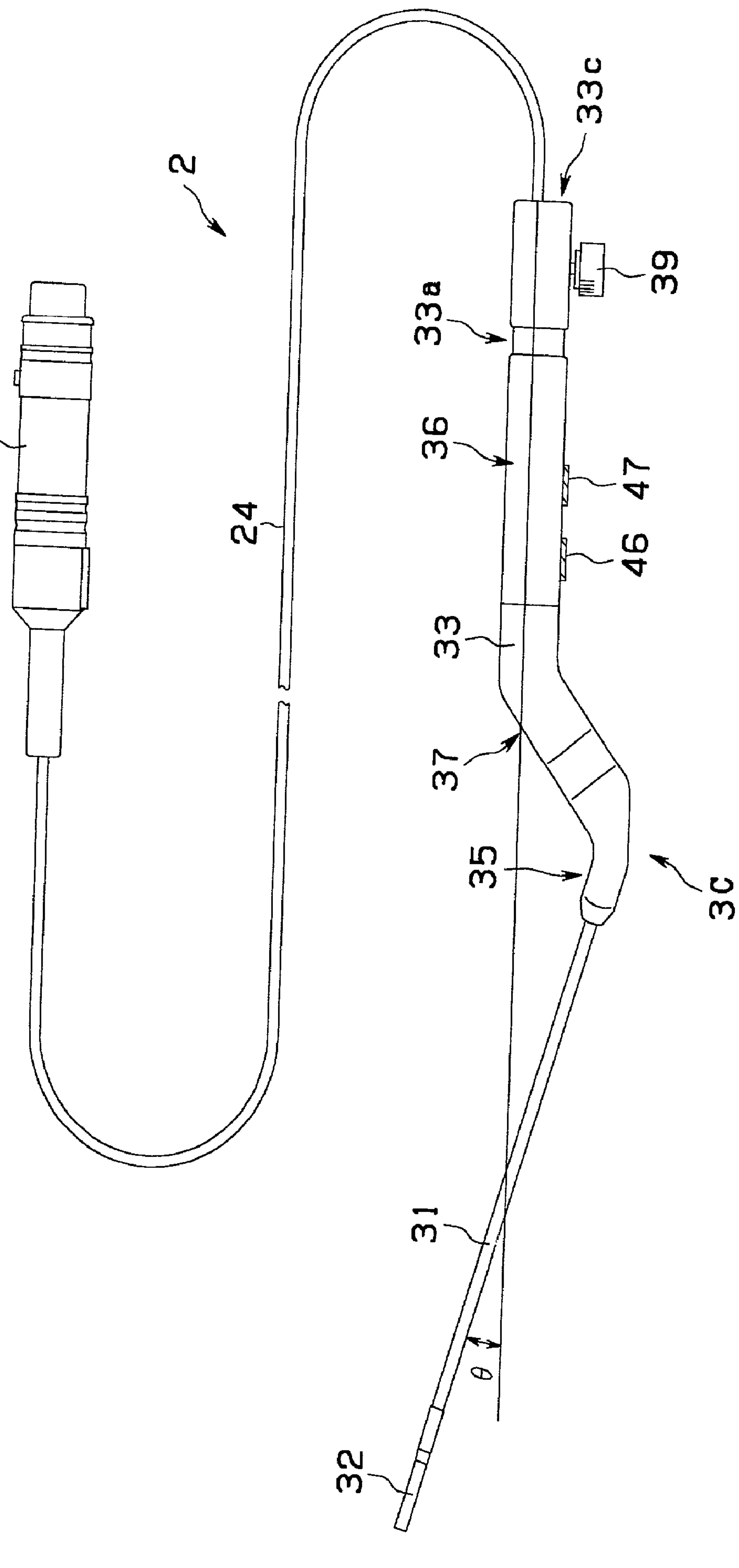


FIG.12



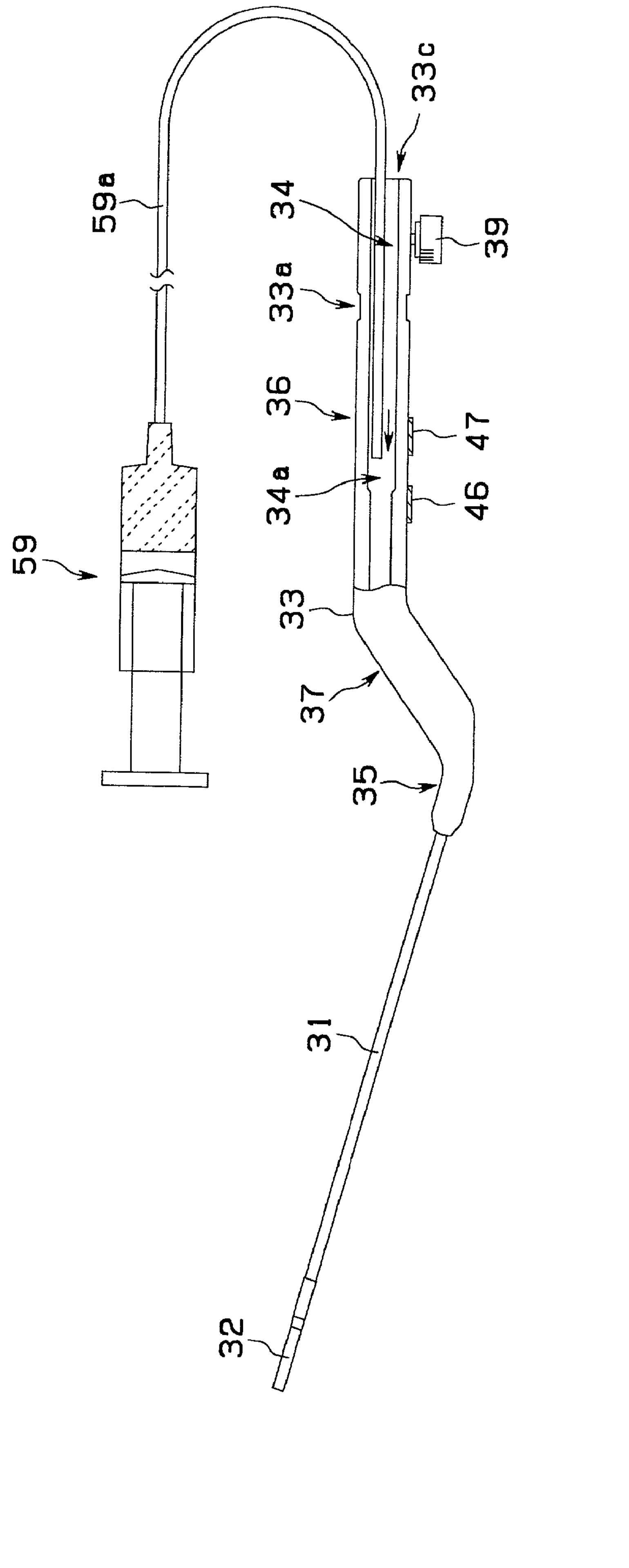


FIG.13

FIG. 14A

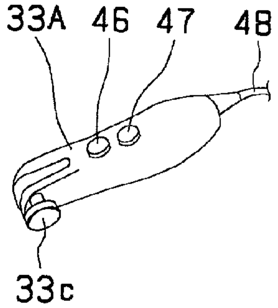


FIG. 14B

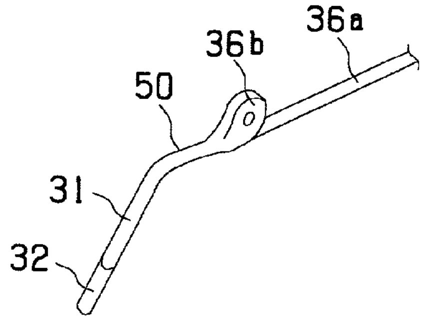


FIG. 14C

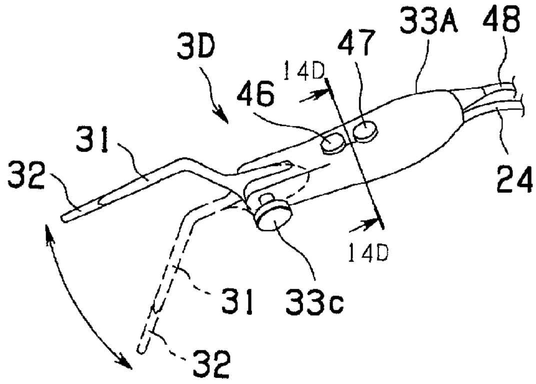


FIG. 14D

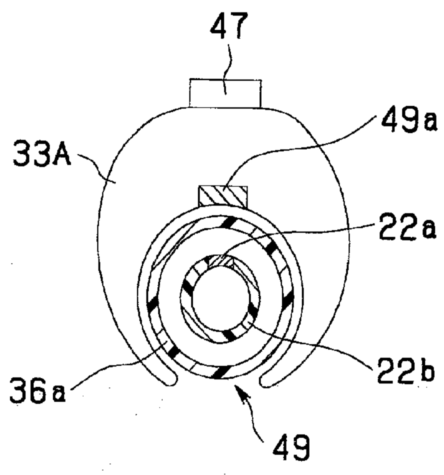


FIG. 14E

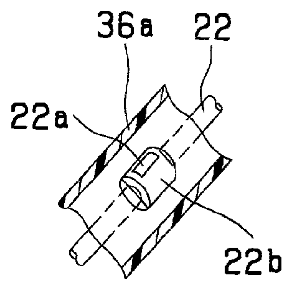


FIG. 15

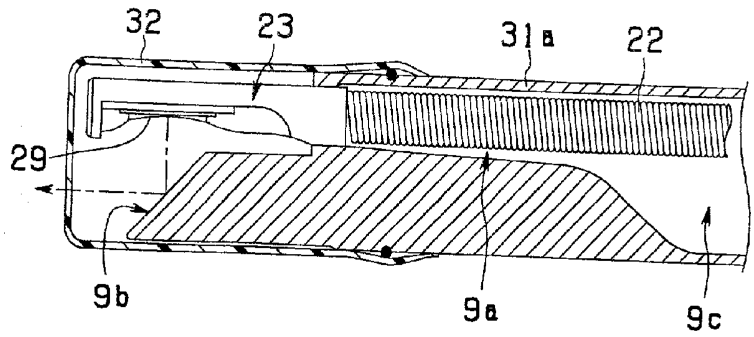


FIG. 16

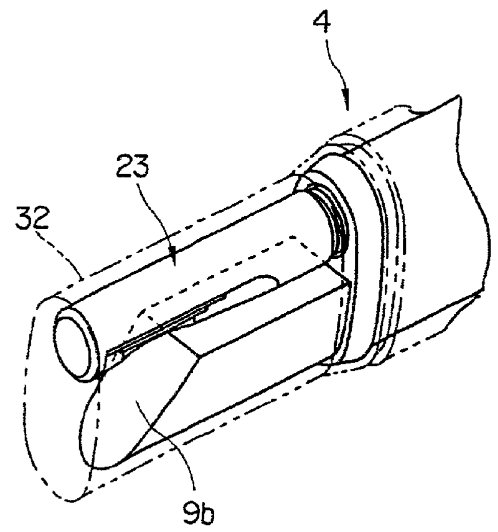


FIG. 17

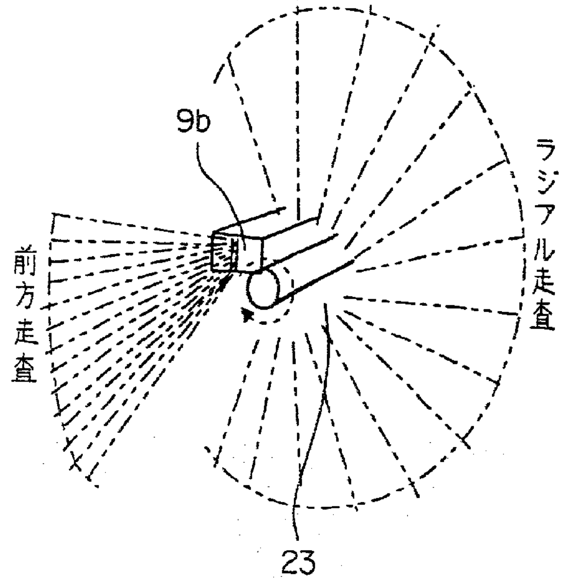


FIG. 18

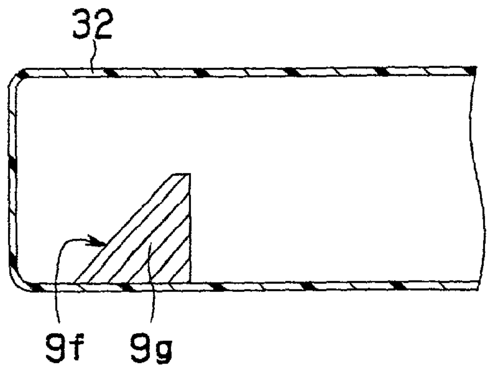


FIG. 19

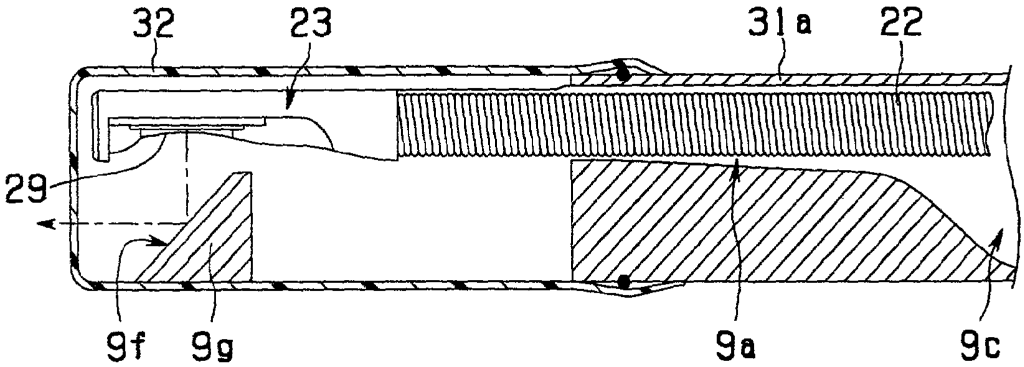


FIG. 20

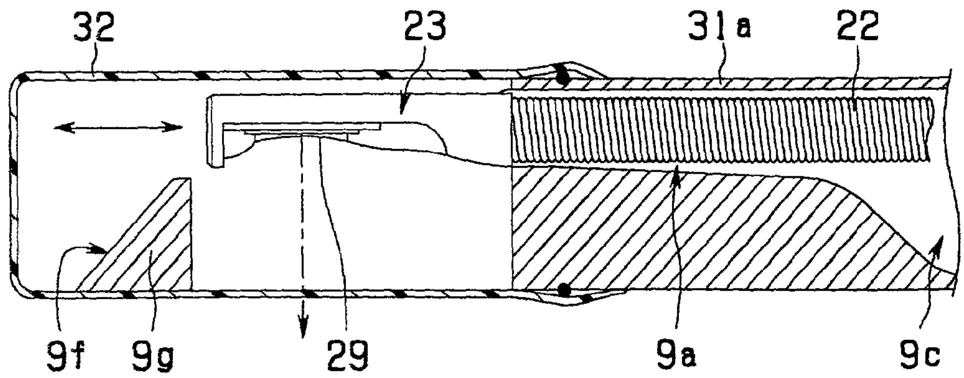


FIG.21

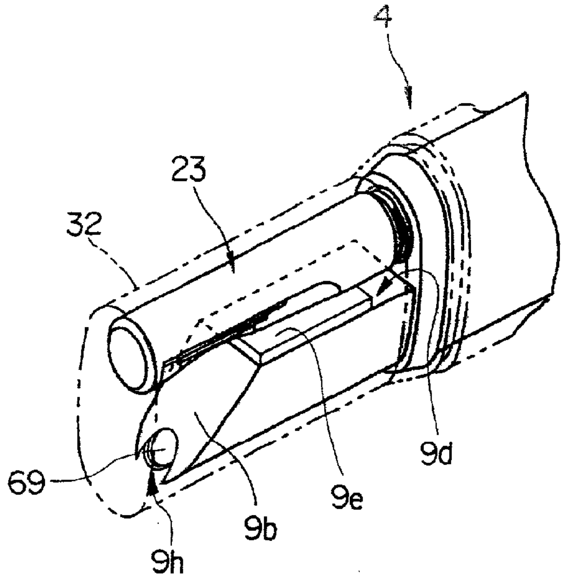


FIG.22

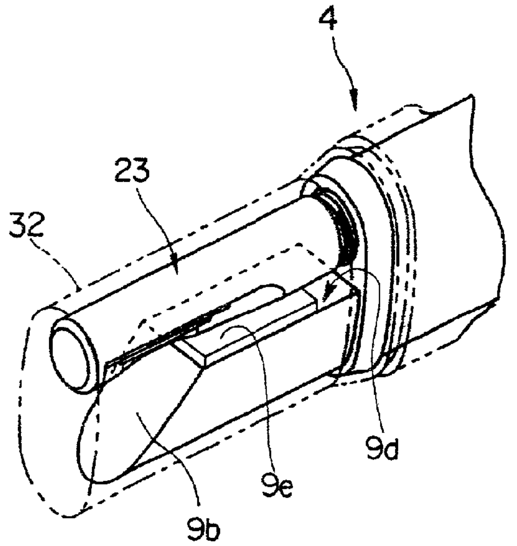


FIG.23

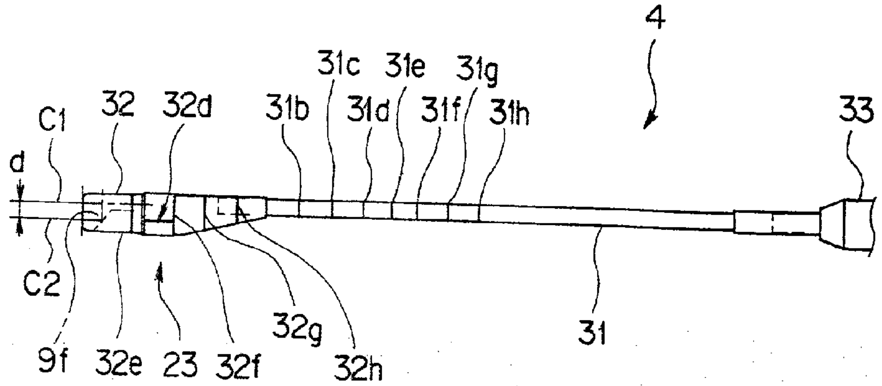


FIG.24C

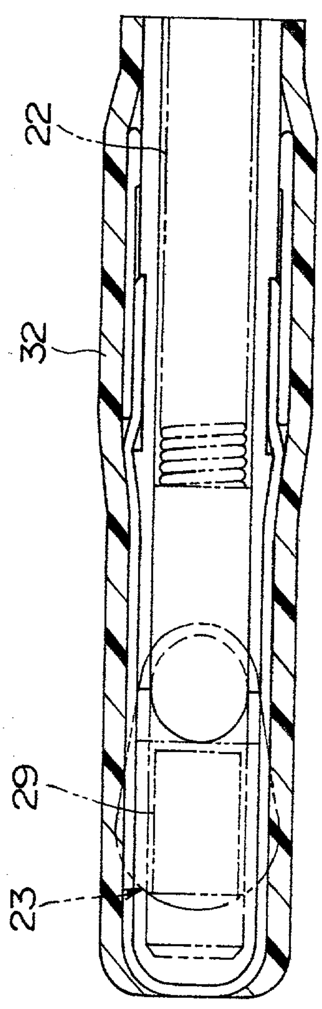


FIG.24B

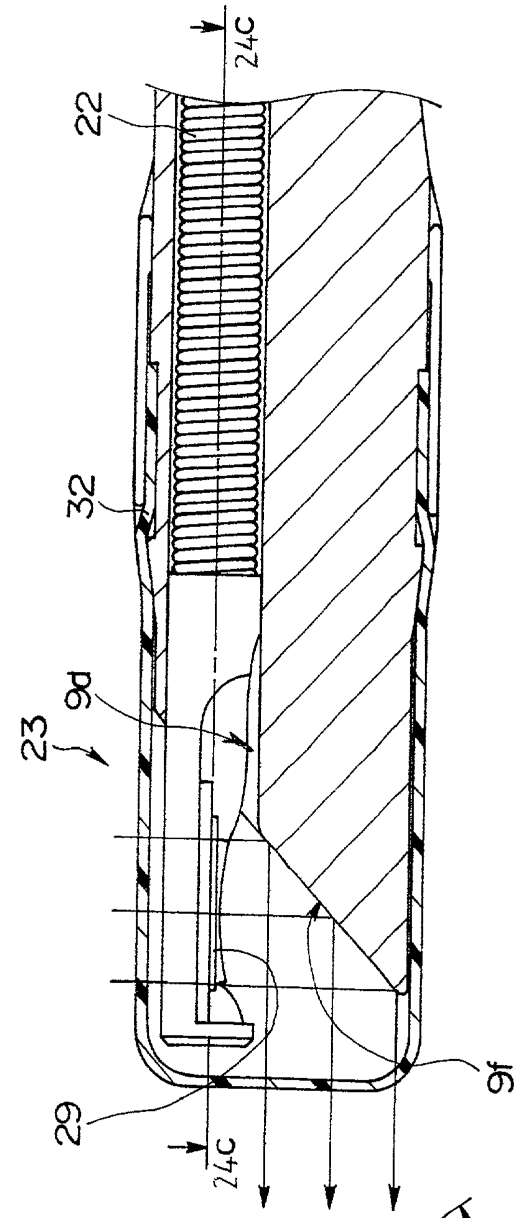


FIG.24A

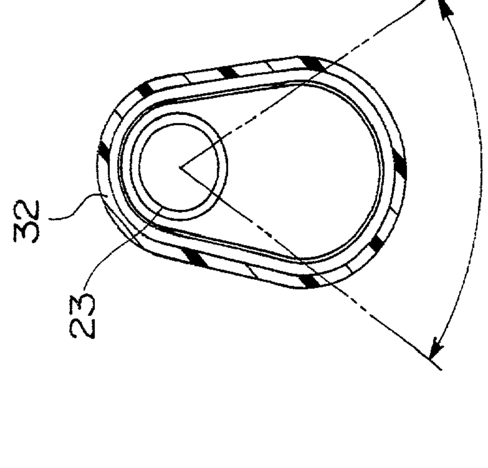


FIG.25

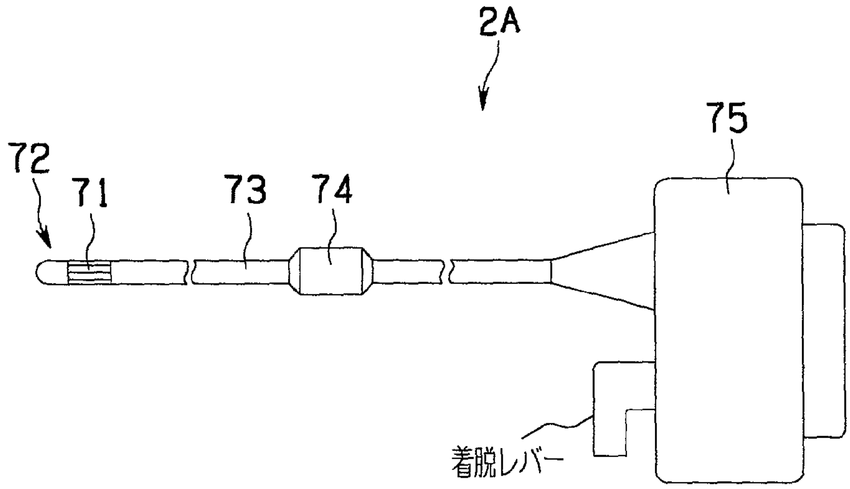


FIG.26A

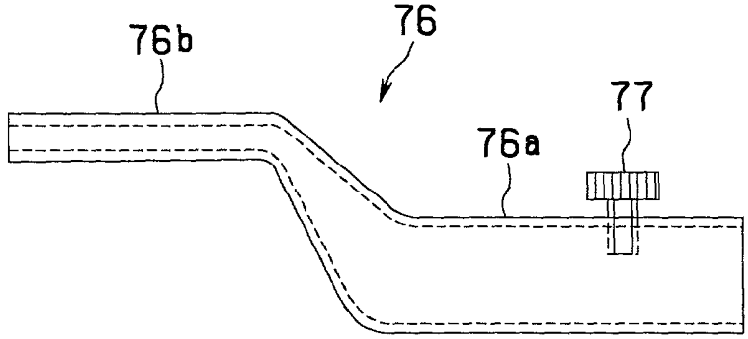


FIG.26B

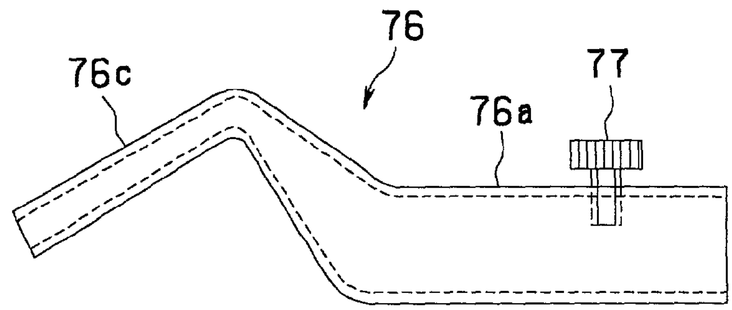


FIG.27

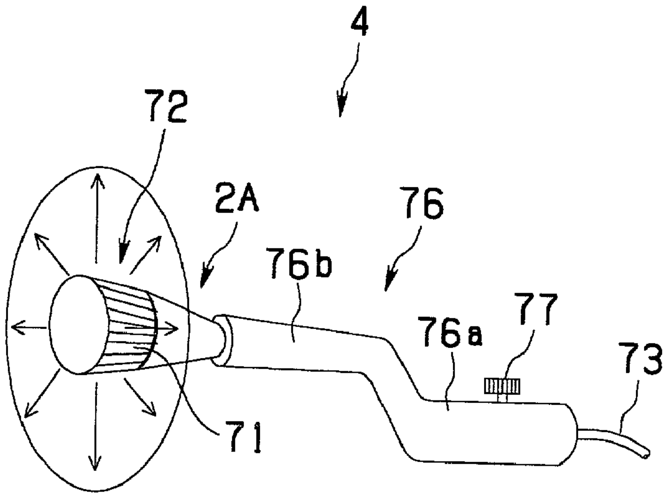


FIG.28

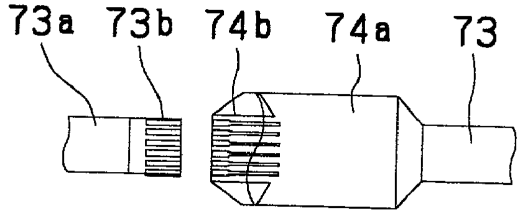


FIG.29A

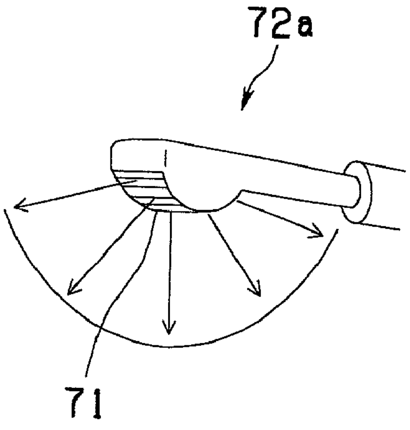


FIG.29B

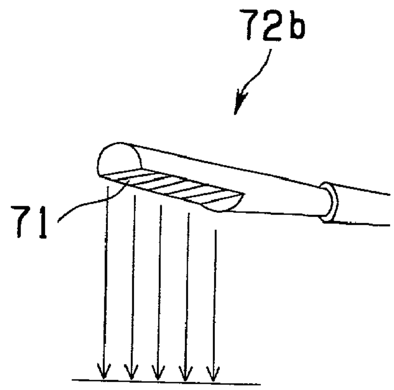


FIG.30A

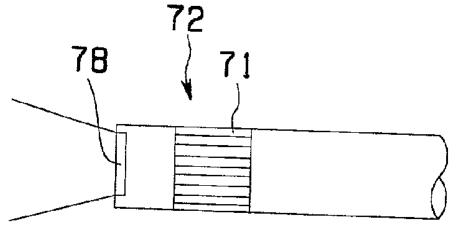


FIG.30B

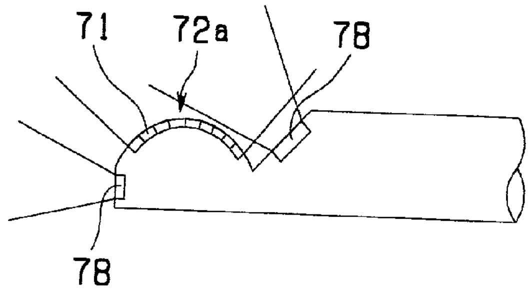


FIG.30C

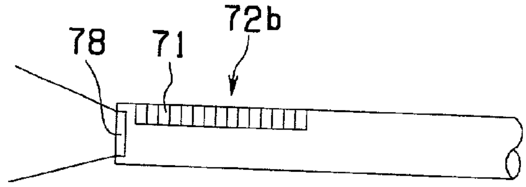


FIG.31A

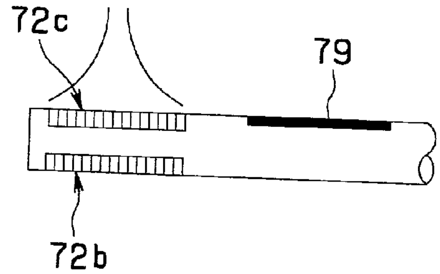


FIG.31B

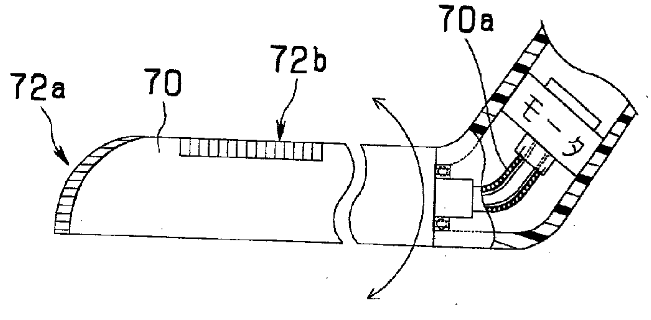


FIG.32

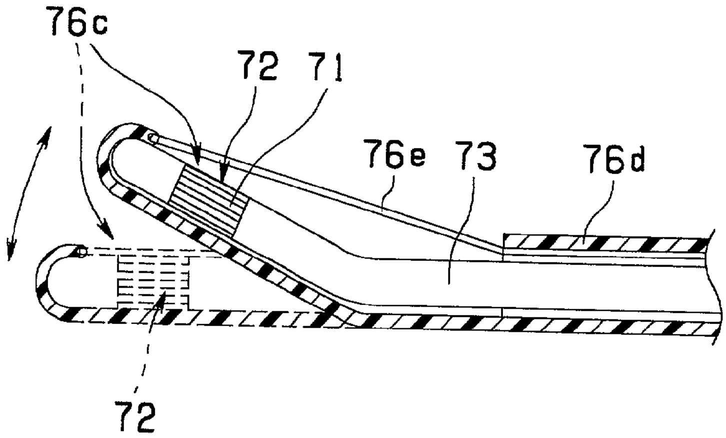


FIG.33

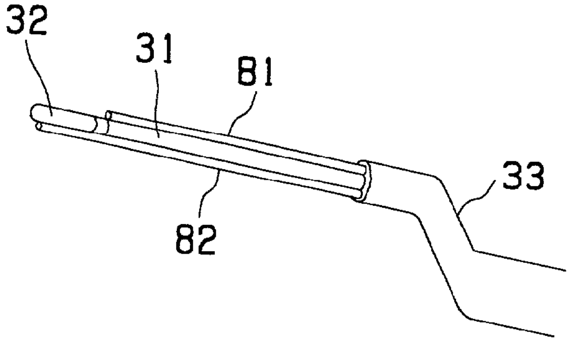


FIG.34

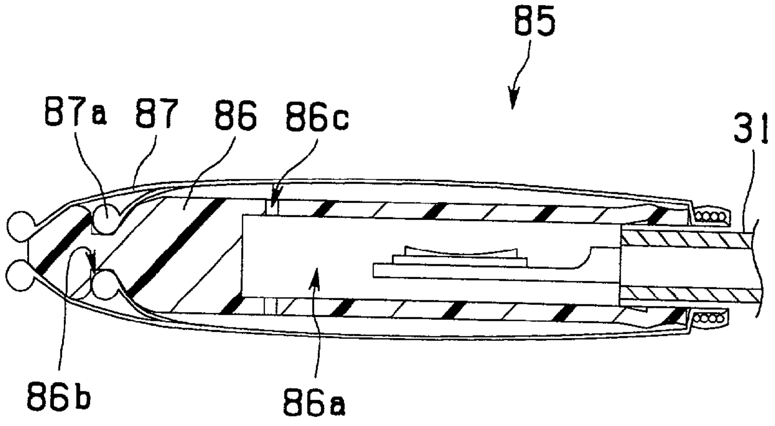


FIG.35A

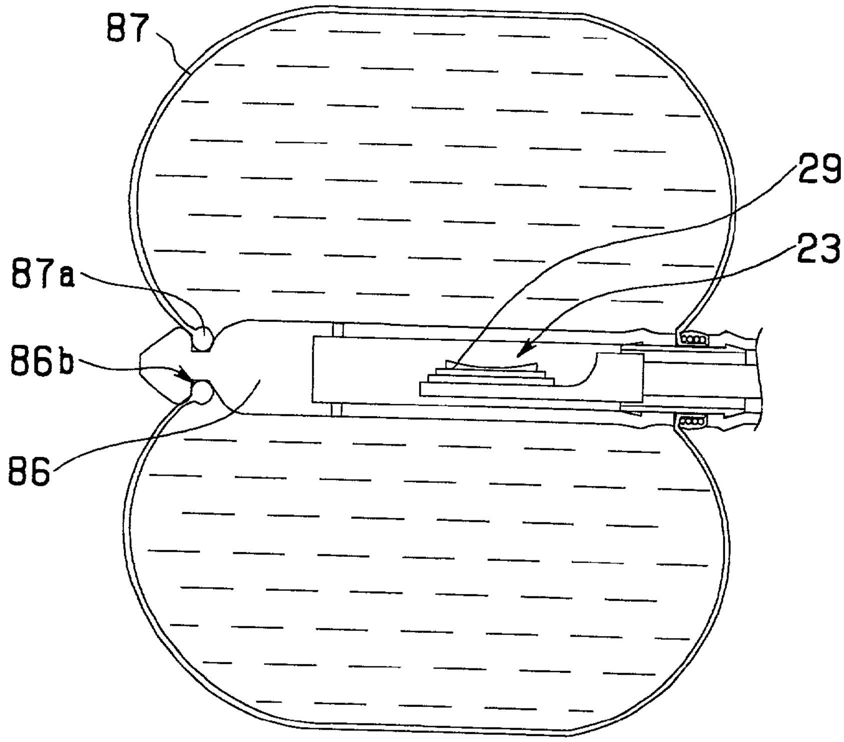


FIG.35B

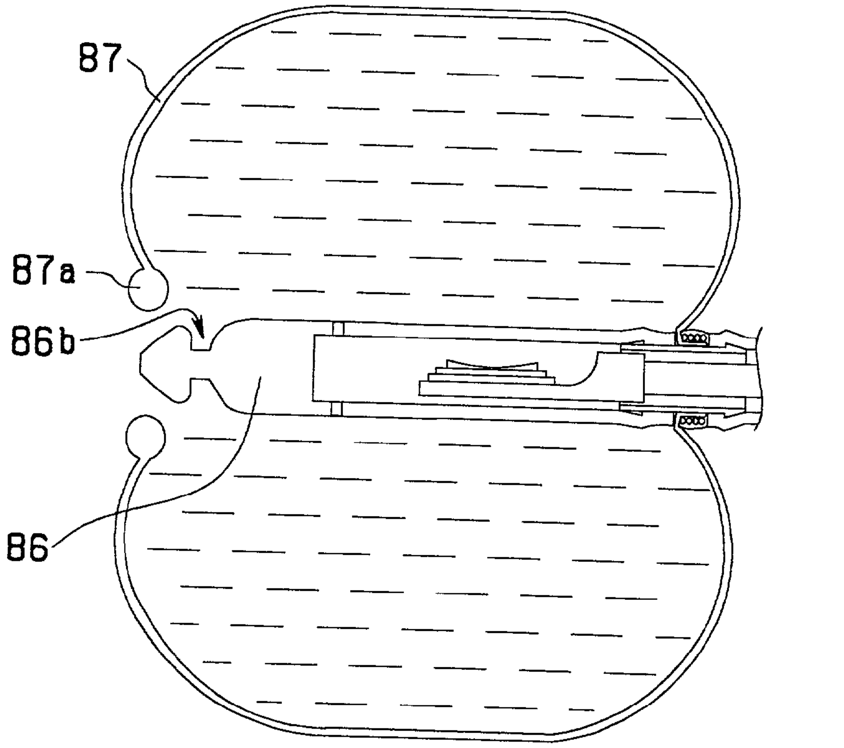


FIG.36

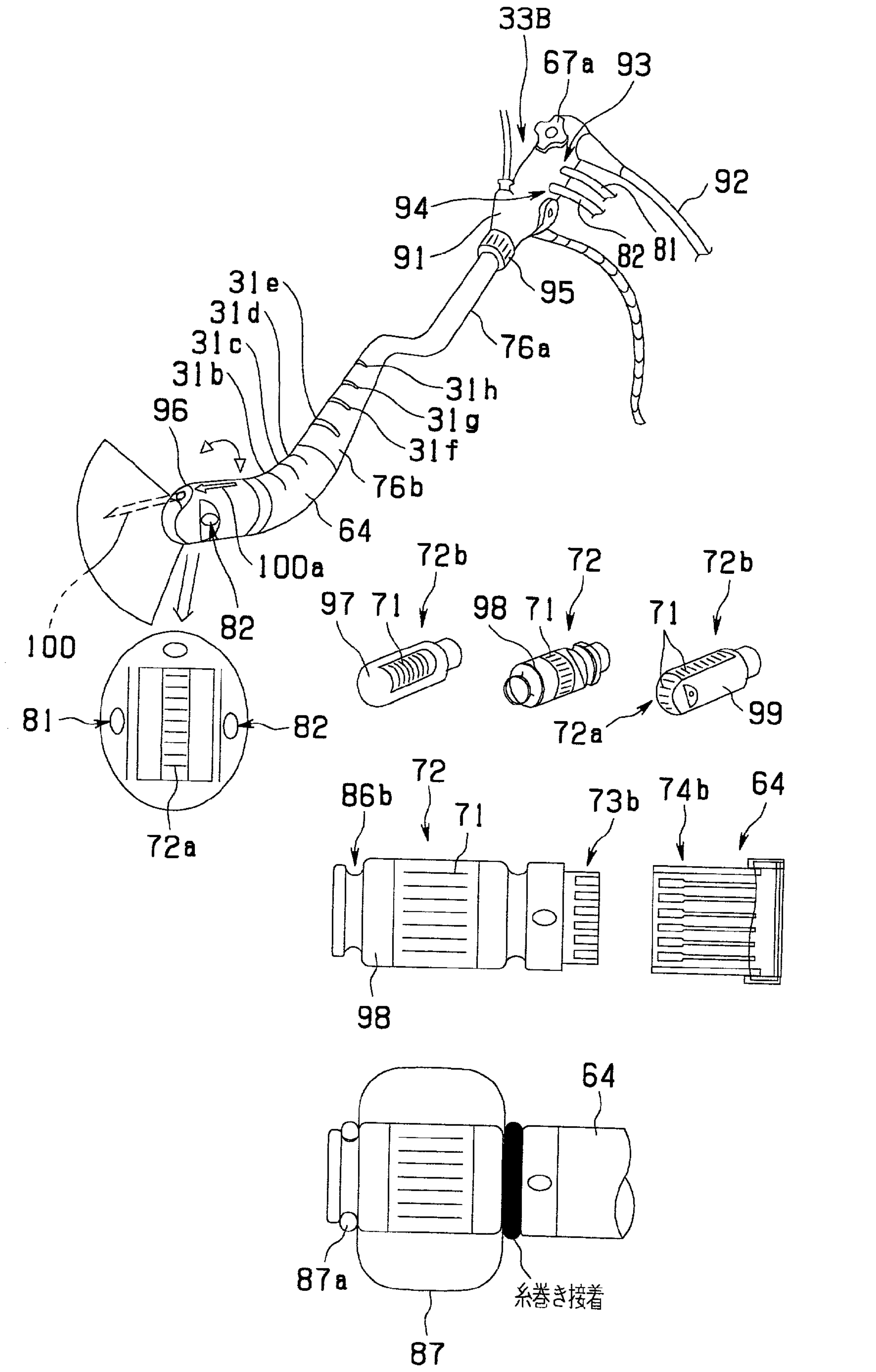

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FIG.37

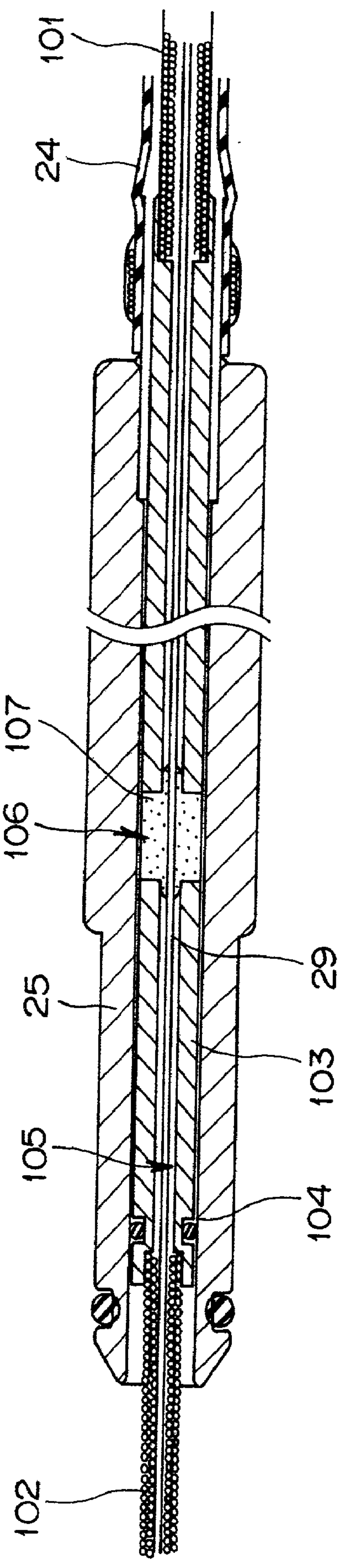


FIG.38

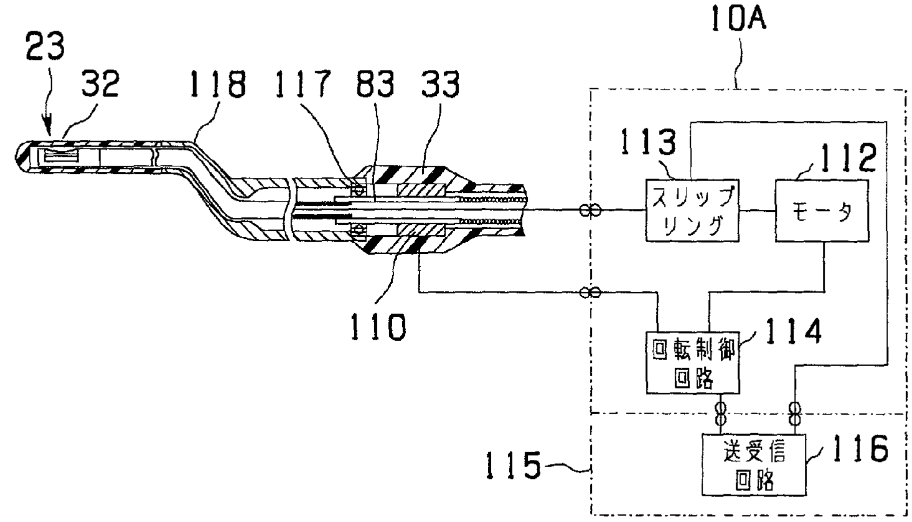


FIG.39A

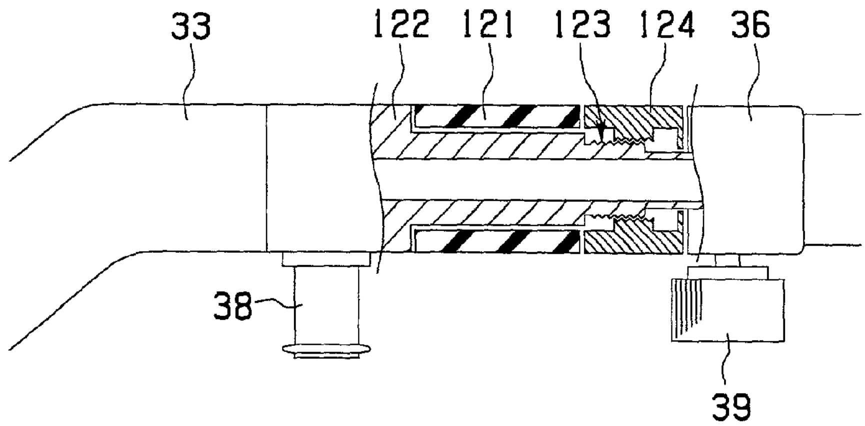


FIG.39B

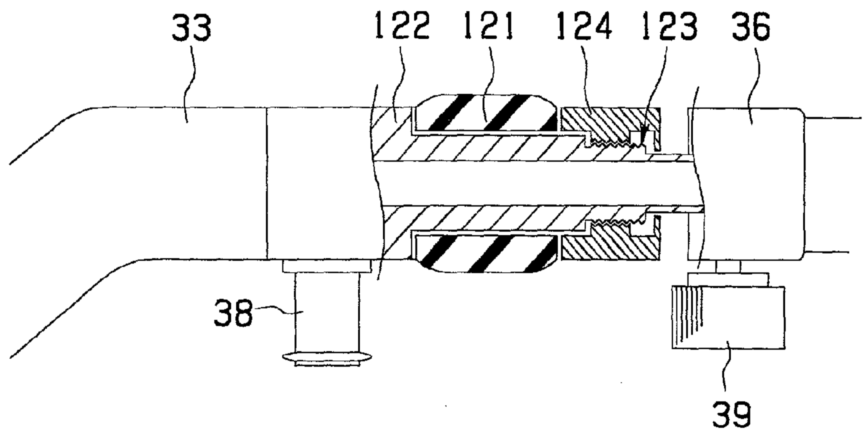


FIG.40A

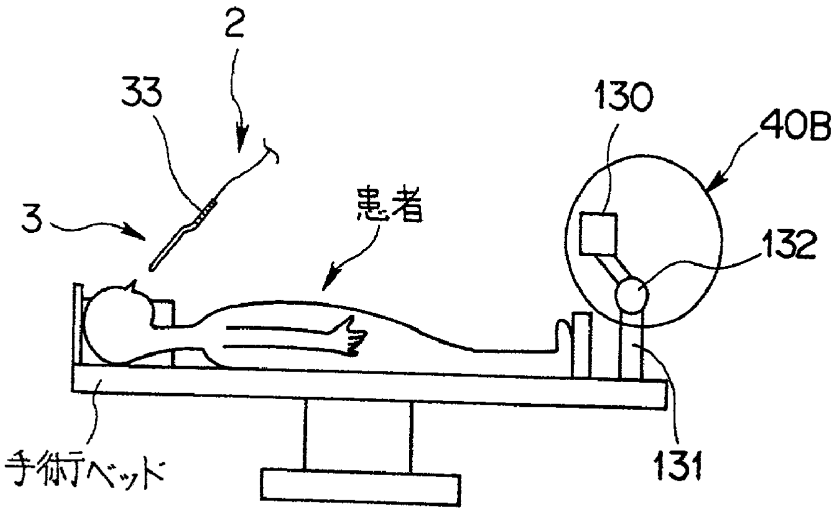


FIG.40B

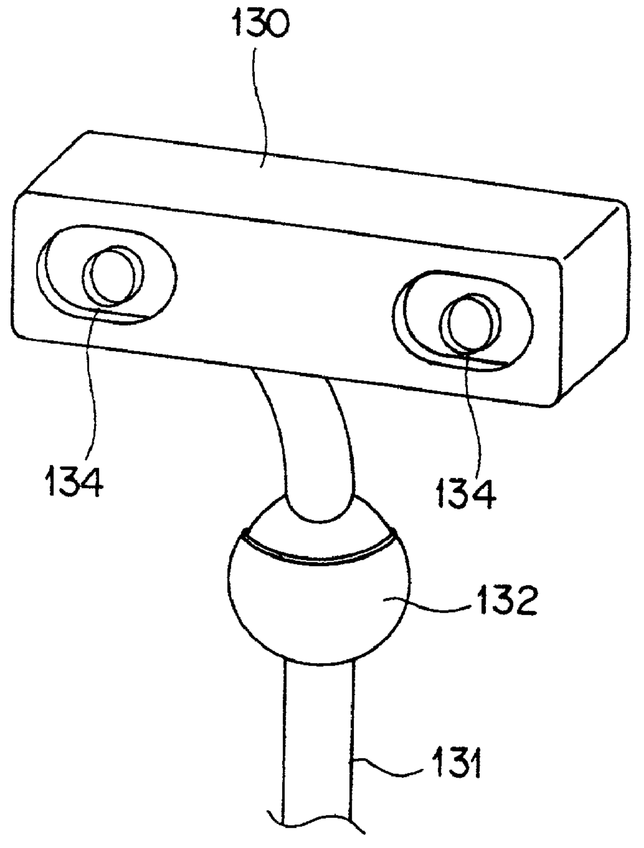


FIG.41

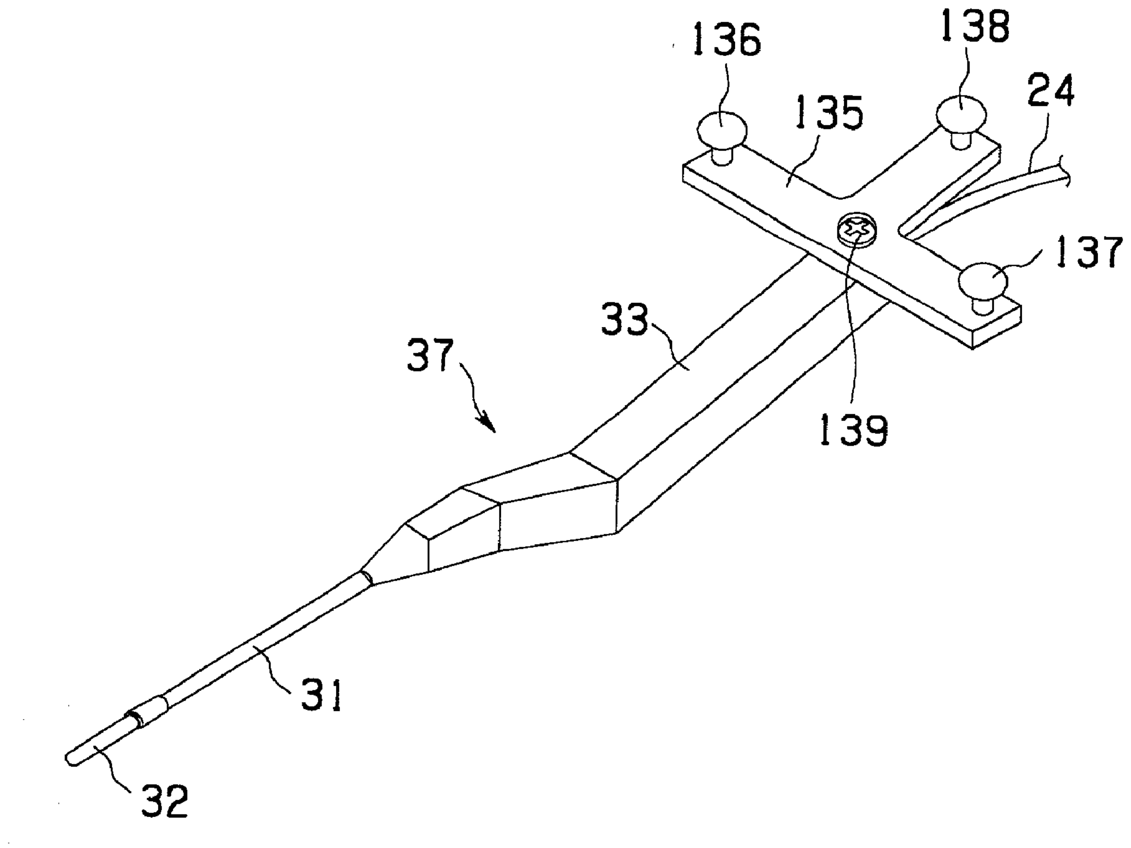


FIG.42

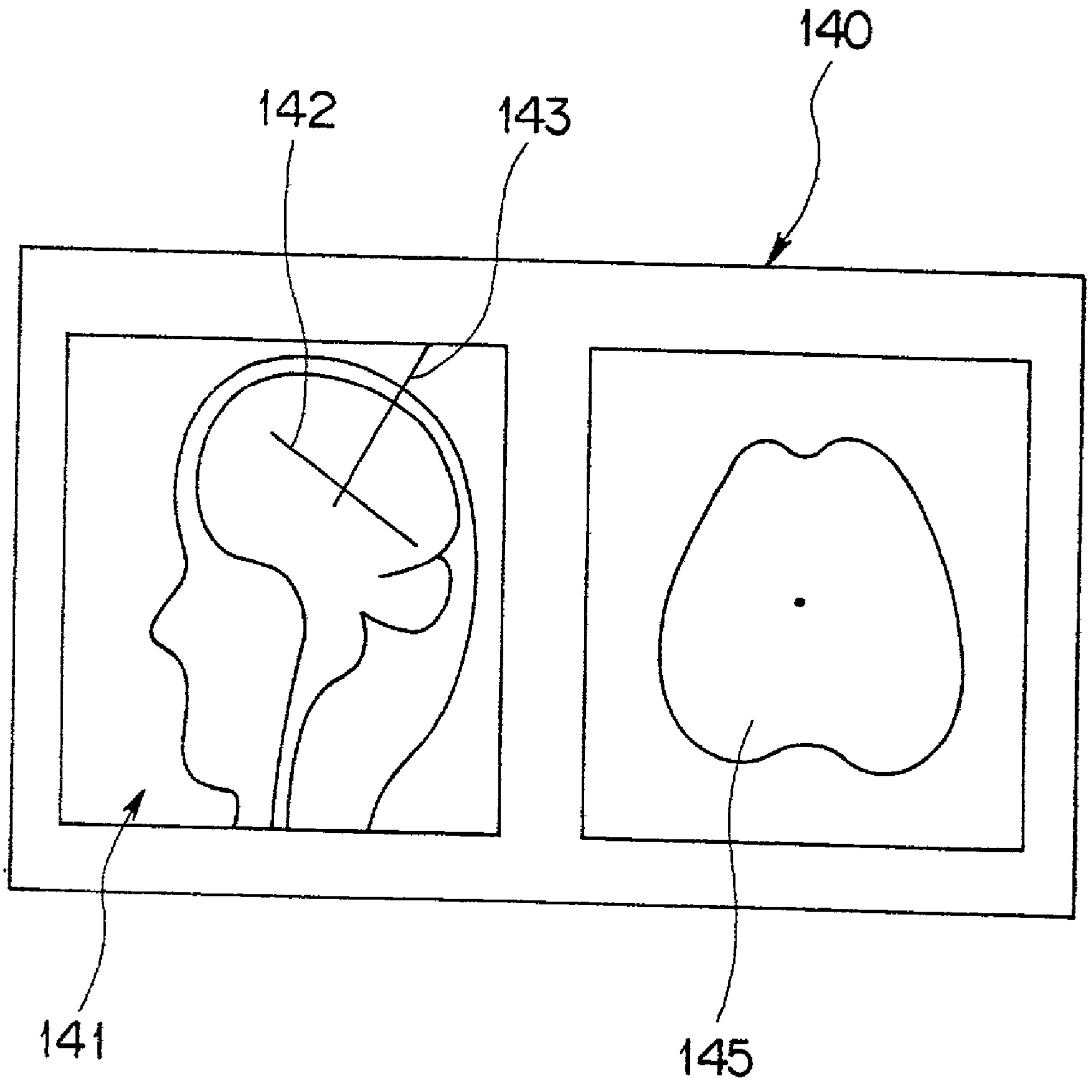


FIG. 43A

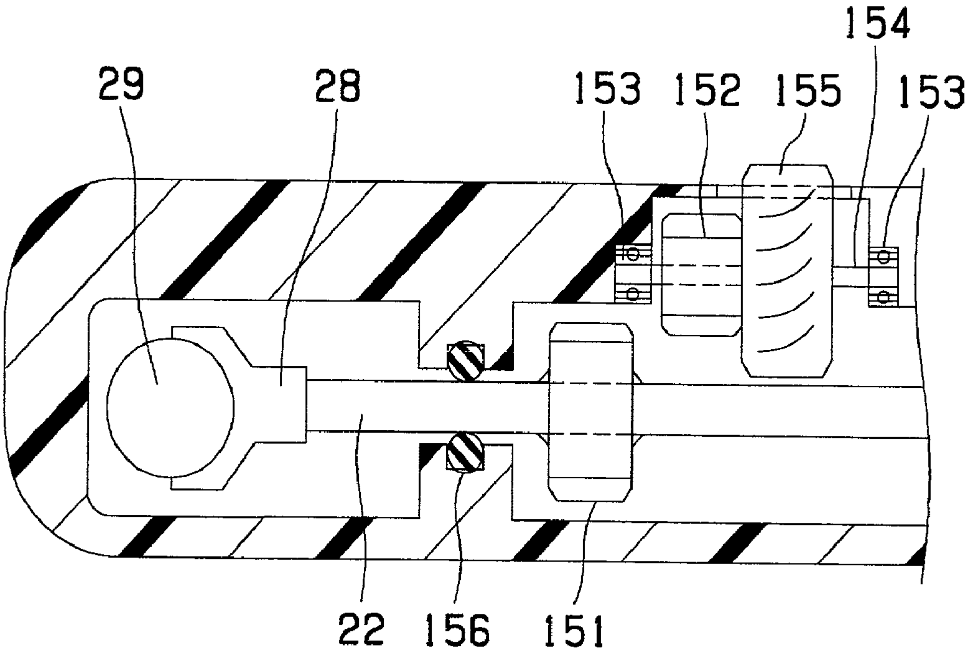
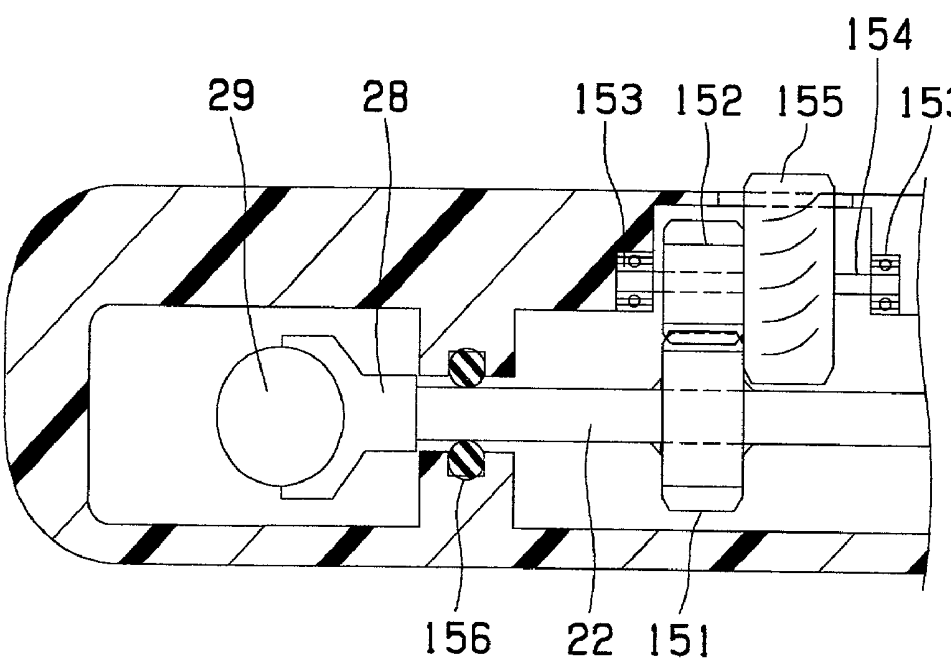


FIG. 43B



ULTRASONIC PROBE FOR OPERATION UNDER MICROSCOPE

[0001] This application claims benefit of Japanese Application No. Hei 11-349433 filed in Japan on Dec. 8, 1999 and 2000-354846 filed in Japan on November 21 the contents of which are incorporated these references.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an ultrasonic probe for microscopic operations that is used under microscopic observation.

[0004] 2. Description of the Related Art

[0005] In recent years, a surgery system composed of an observation/imaging apparatus and a surgical apparatus that are combined based on a region to be operated or a surgical procedure has been used in the field of medicine.

[0006] The observation/imaging apparatus includes an endoscope, a laparoscope (optical instrument), and a surgical microscope. The endoscope has a soft insertion unit inserted into a body cavity through the oral cavity or anus. The laparoscope (optical instrument) has a rigid insertion unit indwelled in the abdominal cavity using a trocar for piercing the wall of the abdominal cavity. The surgical microscope enables observation of fine nerves or vessels under magnification.

[0007] An example of medical systems is a microscopic surgery system that is a type of medical system for enabling observation of fine nerves or vessels under magnification and helping perform surgery under microscopic observation. The microscopic surgery system is employed in the field of neurosurgery. In the microscopic surgery system, a handpiece or the like is manipulated for treatment while a region concerned is observed under magnification through an eyepiece unit of a surgical microscope.

[0008] For example, when the microscopic surgery system is used to perform cerebral surgery, the surgery is performed under optical observation. It is therefore impossible to observe a deeper part of a region than an observed surface thereof during the surgery. For this reason, magnetic resonance imaging (hereinafter MRI) or computed tomography (hereinafter CT) is performed in order to produce tomographic images of the region to be treated prior to surgery.

[0009] However, even when the tomographic images depicting the region to be treated and its surroundings are produced in advance, a disadvantage of a brain shift occurs due to craniotomy. The brain shift is a phenomenon that the actual position of the brain having undergone craniotomy is different from the position thereof detected in a diagnostic image produced through CT or MRI before surgery. Moreover, some surgeons want to check a deeper part of a region than the observed surface thereof during surgery. Therefore, a ultrasonic probe for cerebral surgery or craniotomy (hereinafter, a cerebral surgery probe) or a catheter type ultrasonic probe that has a small diameter and can radiate high-frequency ultrasonic waves and offer a high resolution and high image quality is often used in combination with a surgery system during surgery.

[0010] However, when the cerebral surgery probe is used under microscopic observation, the distal part of the probe is so large in diameter that it blocks a field of view given by a microscope. For preventing the cerebral surgery probe from blocking the field of view, the cerebral surgery probe is located away from a lesion in a region to be observed, and the lesion is scanned ultrasonically. At this time, since a far point is observed, the frequency of ultrasonic waves is set to a lower value. This leads to disadvantages of a lower resolution and degraded image quality.

[0011] On the other hand, assume that the catheter type ultrasonic probe is located near a lesion under microscopic observation in order to produce high-quality images for the purpose of observation of the lesion. Since the ultrasonic probe is so soft that its maneuverability is poor, it is hard to locate the ultrasonic probe at a predetermined position under microscopic observation for the purpose of producing a desired view image.

[0012] Moreover, the ultrasonic probe that is a device employed in surgery must be sterilized prior to use. The ultrasonic probe must therefore be disposable or must be able to be autoclaved, or anyhow, sterilized.

SUMMARY OF THE INVENTION

[0013] Accordingly, an object of the present invention is to provide an ultrasonic probe for microscopic operations capable of being sterilized and being manipulated excellently under microscopic observation.

[0014] Another object of the present invention is to provide an ultrasonic probe for microscopic operations capable of producing ultrasonic images that are very helpful in observing a lesion.

[0015] Briefly, according to the present invention, there is provided an ultrasonic probe for microscopic operations comprising an ultrasonic probe body, an elongated tubular member, and a bent handle member. The ultrasonic probe body has a transducer assembly attached to the distal end of a soft elongated tube that is extended from a connector to be coupled to an ultrasonic observation apparatus. The ultrasonic probe body has a coupler mounted on the tube. The transducer assembly and tube are passed through the elongated tubular member. The bent handle member is attached to the proximal end of the tubular member and has a coupling mechanism for use in coupling the coupler to the handle member so that the coupler can be uncoupled freely.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] **FIG. 1** to **FIG. 9** are concerned with the first embodiment of the present invention;

[0017] **FIG. 1** is an explanatory diagram schematically showing the configuration of a microscopic surgery system;

[0018] **FIG. 2A** to **FIG. 2C** are explanatory diagrams showing the components of an ultrasonic probe body;

[0019] **FIG. 2A** shows the ultrasonic probe body;

[0020] **FIG. 2B** is an explanatory diagram showing the components of a transducer assembly;

[0021] **FIG. 2C** is an explanatory diagram showing the structure of the distal part of a stepped base;

[0022] **FIG. 3A** and **FIG. 3B** are explanatory diagrams showing the components of an observation body;

[0023] **FIG. 3A** is a sectional view and bottom view for explaining the structure and components of the observation body;

[0024] **FIG. 3B** is an explanatory diagram showing a pipe placement hole in a pipe placement portion;

[0025] **FIG. 4A** to **FIG. 4D** are explanatory diagrams concerning the relationship between distal caps and a linkage pipe;

[0026] **FIG. 4A** shows an example of a structure enabling the distal cap to be freely detachably attached to the linkage pipe;

[0027] **FIG. 4B** shows distal caps capable of being freely detachably attached to the linkage pipe;

[0028] **FIG. 4C** shows an observed state of a region with a distal cap, which suits for a thin lumen, attached to the linkage pipe;

[0029] **FIG. 4D** shows an observed state of a region with a distal cap, which suits for a thick lumen, attached to the linkage pipe;

[0030] **FIG.** 5A and **FIG. 5B** are explanatory diagrams showing a sterilization cover;

[0031] **FIG. 5A** is an explanatory diagram showing the components of the sterilization cover;

[0032] **FIG. 5B** is an explanatory diagram concerning the operation of the sterilization cover;

[0033] **FIG. 6** is an explanatory diagram showing an ultrasonic probe for microscopic operations;

[0034] **FIG. 7** is an explanatory diagram showing an examined state of a region;

[0035] **FIG. 8A** to **FIG. 8C** are explanatory diagrams showing a variant of an ultrasound transmissive cap;

[0036] **FIG. 8A** shows an observation body;

[0037] **FIG. 8B** is an **8**B-8B sectional view of the ultrasonic probe body shown in **FIG. 8A**;

[0038] **FIG. 8C** shows an ultrasonic image displayed on a screen of a monitor;

[0039] **FIG. 9** is an explanatory diagram showing an example of the structure of an ultrasonic probe for microscopic operations capable of being easily oriented in any direction;

[0040] **FIG. 10A** to **FIG. 11B** are concerned with the second embodiment of the present invention;

[0041] **FIG. 10A** to **FIG. 10E** are explanatory diagrams showing another example of an observation body;

[0042] **FIG. 10A** shows a practical structure of an observation body;

[0043] **FIG. 10B** is an explanatory diagram concerning the operation of the observation body;

[0044] **FIG. 10C** is an explanatory diagram showing an example of application of the observation body;

[0045] **FIG. 10D** is a **10**D-**10D** sectional view of the observation body shown in **FIG. 10C**;

[0046] **FIG. 10E** is an explanatory diagram concerning the operation of the observation body shown in **FIG. 10C**;

[0047] **FIG. 11**A and **FIG. 11B** are explanatory diagrams showing an example of application of the observation body shown in **FIG. 10A** to **FIG. 10E**;

[0048] **FIG. 11A** is an explanatory diagram showing the observation body having a bending member;

[0049] **FIG. 11B** is an explanatory diagram showing an example of the structure of the bending member;

[0050] **FIG. 12** and **FIG. 13** are concerned with the third embodiment of the present invention;

[0051] **FIG. 12** is an explanatory diagram showing the components of a microscopic probe having a differently structured observation body;

[0052] **FIG. 13** is an explanatory diagram concerning the operation of the microscopic probe;

[0053] **FIG. 14A** to **FIG. 14E** are explanatory diagrams showing an example of application of the observation probe body shown in **FIG. 12**;

[0054] **FIG. 14A** is an explanatory diagram showing a handle member;

[0055] **FIG. 14B** is an explanatory diagram showing a probe passage member;

[0056] **FIG. 14C** is an explanatory diagram showing the observation probe body;

[0057] **FIG. 14D** is a sectional view of the observation probe body;

[0058] **FIG. 14E** is an explanatory diagram showing the structure of a flexible shaft placed in a base placement portion;

[0059] **FIG. 15** to **FIG. 17** are concerned with the fourth embodiment of the present invention;

[0060] **FIG. 15** is an explanatory diagram showing the structure of the distal part of a microscopic probe;

[0061] **FIG. 16** is a perspective view showing the distal part of the microscopic probe;

[0062] **FIG. 17** is an explanatory diagram showing a range scanned with the microscopic probe;

[0063] **FIG. 18** is an explanatory diagram showing another example of the structure of a distal cap;

[0064] **FIG. 19** is an explanatory diagram showing the position of the probe for producing a forward image and a radial image;

[0065] **FIG. 20** is an explanatory diagram showing the position of the probe for producing a radial image that represents the whole range of 360°;

[0066] **FIG. 21** is an explanatory diagram showing another example of the structure of an ultrasonic probe for microscopic operations;

[0067] **FIG. 22** to **FIG. 24** are concerned with an example of application of the fourth embodiment;

[0068] **FIG. 22** is an explanatory diagram showing an example of a structure for minimizing an artifact;

[0069] **FIG. 23** shows the appearance of the microscopic probe;

[0070] **FIG. 24A** to **FIG. 34C** are explanatory diagrams showing another example of the structure for minimizing an artifact;

[0071] **FIG. 24A** is a front view of a reflecting mirror surface;

[0072] **FIG. 24B** is a side view of the reflecting mirror surface;

[0073] **FIG. 24C** is a 24C-24C sectional view of the reflecting mirror surface shown in **FIG. 24B**;

[0074] **FIG. 25** to **FIG. 29B** are concerned with the fifth embodiment of the present invention;

[0075] **FIG. 25** is an explanatory diagram showing another example of the components of an ultrasonic probe body;

[0076] **FIG. 26**A and **FIG. 26B** are explanatory diagrams showing an observation body suitable for the ultrasonic probe body;

[0077] **FIG. 26A** shows the ultrasonic probe body having a pipe portion thereof extended substantially parallel to the centerline (axis) of an uneven linkage portion;

[0078] **FIG. 26B** shows the ultrasonic probe body having a pipe portion thereof bent relative to the centerline (axis) of an uneven linkage portion;

[0079] **FIG. 27** is an explanatory diagram showing the components of a microscopic probe;

[0080] **FIG. 28** is an explanatory diagram showing another example of a locking base;

[0081] **FIG. 29**A and **FIG. 29B** are explanatory diagrams showing another examples of a transducer assembly;

[0082] **FIG. 29A** shows a transducer assembly having transducer elements arranged in a convex form;

[0083] **FIG. 29B** shows a transducer assembly having transducer elements arranged in a linear form;

[0084] **FIG. 30A** to **FIG. 30C** are explanatory diagram showing another examples of a structure included in an electronic ultrasonic probe for microscopic operations;

[0085] **FIG. 30A** is an explanatory diagram showing a structure having an observation optical system incorporated in a radial scanning type transducer assembly;

[0086] **FIG. 30B** is an explanatory diagram showing a structure having an observation optical system incorporated in a convex scanning type transducer assembly;

[0087] **FIG. 30C** is an explanatory diagram showing a structure having an observation optical system incorporated in a linear scanning type transducer assembly;

[0088] **FIG. 31**A and **FIG. 31B** are explanatory diagrams showing another example of a structure included in the electronic ultrasonic probe for microscopic operations;

[0089] **FIG. 31A** is an explanatory diagram showing a structure having a treatment transducer incorporated in addition to an observation transducer;

[0090] **FIG. 31B** is an explanatory diagram showing a structure for producing a three-dimensional ultrasonic view image;

[0091] **FIG. 32** is an explanatory diagram showing an example of application of an observation body included in the electronic ultrasonic probe for microscopic operations;

[0092] **FIG. 33** is an explanatory diagram showing an example of a structure for improving the performance of the observation body enabling observation;

[0093] **FIG. 34** and **FIG. 35** are explanatory diagrams showing an example of a structure included in an ultrasonic probe for microscopic operations having a balloon;

[0094] **FIG. 34** is an explanatory diagram showing a structure having a balloon attached to an observation body;

[0095] **FIG. 35**A and **FIG. 35B** are explanatory diagrams concerning the operation of the balloon;

[0096] **FIG. 35A** shows a dilated balloon;

[0097] **FIG. 35B** shows the balloon whose internal pressure has risen to discharge an ultrasound propagating medium to outside;

[0098] **FIG. 36** is an explanatory diagram showing an example of the components of an electronic microscopic probe;

[0099] **FIG. 37** shows an example of the structure of a flexible shaft;

[0100] **FIG. 38** is an explanatory diagram showing an example of a configuration for improving the performance of a mechanical ultrasonic probe for microscopic operations enabling observation;

[0101] **FIG. 39**A and **FIG. 39B** are explanatory diagrams showing a handle member including a hand-held portion whose diameter can be varied depending on the size of an operator's hand;

[0102] **FIG. 39A** is an explanatory diagram showing the structure of a base placement portion having an elastic member mounted therein;

[0103] **FIG. 39B** is an explanatory diagram concerning the operation of the base placement portion having the elastic member mounted therein;

[0104] **FIG. 40A** to **FIG. 42** are explanatory diagrams showing an example of a configuration for improving the performance of an electronic ultrasonic probe for microscopic operations enabling observation;

[0105] **FIG. 40**A and **FIG. 40B** are explanatory diagrams showing the relationship between a handle member and a navigation body head;

[0106] **FIG. 40A** shows the navigation body head mounted on an operating table;

[0107] **FIG. 40B** shows the navigation body head;

[0108] **FIG. 41** is an explanatory diagram showing a maker member attached to an observation body;

[0109] **FIG. 42** is an explanatory diagram showing an example of a view image displayed on the screen of a monitor;

[0110] **FIG. 43**A and **FIG. 43B** are explanatory diagrams showing an example of a structure included in an ultrasonic probe for microscopic operations having a therapeutic transducer assembly;

[0111] **FIG. 43A** is an explanatory diagram showing an example of a structure including a cutter; and

[0112] **FIG. 43B** is an explanatory diagram showing the structure whose cutter is driven to rotate.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0113] Embodiments of the present invention will be described with reference to the drawings below.

[0114] Referring to **FIG. 1** to **FIG. 9**, the first embodiment of the present invention will be described below.

[0115] A surgery system in accordance with the present embodiment shown in **FIG. 1** is a microscopic surgery system consisting mainly of a surgical microscope **1** used to observe a region to be treated and various apparatuses used to treat or examine the region to be treated. The surgical apparatuses include surgical appliances such as clamp forceps and a knife, various surgical devices such as a motor-driven cautery, an ultrasonic knife, and an electric cautery, and an observation device such as an ultrasonic probe.

[0116] The surgical microscope **1** consists mainly of a microscope eyepiece unit **11** (hereinafter, an eyepiece unit) and an arm stand **14**. The eyepiece unit **11** enables observation under magnification of a region to be treated of a patient lying down on an operating table, and is disposed freely to lie near the patient. The arm stand **14** consists of a support arm **12** and a support **13** and enables three-dimensional movement and tilting of the eyepiece unit **11**.

[0117] A motor and a probe drive unit **10** are incorporated in the arm stand **14**. The motor is used to drive and rotate a housing, which will be describe later, included in an ultrasonic probe for microscopic operations (hereinafter, a microscopic probe) **4** composed of an ultrasonic probe body **2** and an observation body **3**. The probe drive unit **10** includes an ultrasound originating/receiving circuit and drives an ultrasonic transducer, which will be described later, held in the housing.

[0118] Moreover, an electric probe joint (hereinafter, a probe joint) **15** is formed on the wall of the arm stand **14** near the eyepiece unit **11**. A connector **21** of the ultrasonic probe body **2** included in the microscopic probe **4** is coupled to the probe joint **15** so that the connector **21** can be uncoupled freely. When the connector **21** is coupled to the probe joint **15**, the microscopic probe **4** and probe drive unit **10** are mechanically and electrically connected to each other.

[0119] Aside from the probe joint **15**, a plurality of electric joints through which power is fed to various surgical apparatuses and a sterilized probe holder **11***a* in **FIG. 7** can be freely detachably attached to the arm stand **14**. A handle member **33** in **FIG. 3** of the microscopic probe **4** is mounted in the probe holder **11***a* so that it can be dismounted freely.

[0120] An electric circuit serving as a voltage transformer is incorporated in the support **13**. The electric circuit is electrically connected to the electric joints over electric cables.

[0121] Referring to the drawings, the components of the microscopic probe **4** will be described by taking a practical example.

[0122] To begin with, the ultrasonic probe body **2** will be described with reference to **FIG. 2A** to **FIG. 2C**.

[0123] The ultrasonic probe body **2** shown in **FIG. 2A** consists mainly of the connector **21**, an elongated flexible shaft **22**, a transducer assembly **23**, a soft tube member **24**, and a stepped base **25**. The connector **21** is mechanically and electrically attached to the probe drive unit **10**. The flexible shaft **22** conveys driving torque exerted by the motor, which is not shown, incorporated in the probe drive unit **10** through the connector **21**. The transducer assembly **23** is located at the distal end of the flexible shaft **22**. The tube member **24** has a proximal end thereof locked in the connector **21** and shields the proximal half of the flexible shaft **22**. The stepped base **25** that is a base member is fixed to the distal end of the tube member **24** and realized with, for example, a metallic pipe. The stepped base **25** serves as a coupler for coupling the ultrasonic probe body to the observation body **3**.

[0124] The connector **21** has a linkage cylinder **26** and a pin **27**. The linkage cylinder **26** serves as a conveyor for conveying driving force exerted by the probe drive unit **10** to the flexible shaft **22**. The pin **27** is used to hold the connector **21**. The flexible shaft **22** is enclosed in the tube member **24** so that it can be rotated freely.

[0125] As shown in **FIG. 2**B, the transducer assembly **23** located at the distal end of the flexible shaft **22** consists of a housing **28** fixed to the tip of the flexible shaft **22** and an ultrasonic transducer **29** held in the housing **28**. A signal line **29***a* lies through the flexible shaft **22**. The ultrasonic transducer **29** is electrically connected to an ultrasound originating/receiving circuit or the like incorporated in the probe drive unit **10** over the signal line **29***a*. In short, the microscopic probe **4** in accordance with the present embodiment is designed to scan a plane orthogonal to a direction of insertion of the probe so as to produce a so-called radial image.

[0126] As shown in **FIG. 2**C, an O ring **51** is mounted on the distal part of the stepped base **25** in order to seal a base placement hollow, which will be described later, in a watertight manner.

[0127] Next, the observation body **3** will be described with reference to **FIG. 3**.

[0128] As shown in **FIG. 3**A, the observation body **3** consists mainly of a straight pipe **31**, an ultrasound transmissive cap (which may be referred to as a distal cap) **32**, and a handle member **33**. The straight pipe **31** is an elongated straight linkage pipe realized with, for example, a hard resin member. The distal cap **32** is realized with a resin member made of polyethylene or polymethyl pentane that transmits ultrasonic waves. The distal cap **32** has a space in which the housing **28** attached to the distal end of the straight pipe **31** is placed. The handle member **33** is located at the proximal end of the straight pipe **31**, bent, and realized with, for example, a bent transparent resin member. The handle member **33** has a penetrating hollow **34** through which the housing **28** and flexible shaft **22** included in the ultrasound probe body **2** are passed.

[0129] The distal cap **32** is fixed to the straight pipe **31** as an integral part of the straight pipe **31** through bonding or bobbin winding bonding. Otherwise, an elastic member **52** such as an O ring is mounted on the periphery of the distal part of the straight pipe **31**, and the distal part of the straight pipe **31** is enclosed in the proximal part of the distal cap **32**. Thus, the distal cap **32** is freely detachably attached to the straight pipe **31** while having the space thereof sealed in a watertight manner.

[**0130**] As shown in **FIG. 4**B, distal caps having mutually different outer diameters can be selectively attached to the end of the straight pipe **31**. For example, the distal cap **32** that is short, a thin distal cap **32***a* fit for a region to be observed having a small-diameter lumen, and a thick distal cap **32***b* fit for a region to be observed having a large-diameter lumen can be selectively attached to the end of the straight pipe **31**.

[**0131**] As shown in **FIG. 4**C and **FIG. 4**D, the distal caps **32**, **32***a,* and **32***b* can be used selectively according to the size of a lumen of a region to be observed. Consequently, a clearance created in a lumen around the distal cap **32**, **32***a,* or **32***b* is minimized to prevent the distal cap **32**, **32***a,* or **32***b* from vibrating during observation. Eventually, excellent ultrasonic view images can be produced.

[**0132**] The bent handle member **33** shown in **FIG. 3A** consists of a pipe placement portion **35**, a base placement portion **36**, and an uneven linkage portion **37**. The straight pipe **31** is placed in the pipe placement portion **35**. The stepped base **25** is placed in the base placement portion **36** that also serves as a hand-held portion. The uneven linkage portion **37** links the base placement portion **36** and pipe placement portion **35**.

[**0133**] The penetrating hollow **34** of the handle member **33** consists of a pipe placement hollow (see **FIG. 3B**) **34***c,* a base placement hollow **34***a,* and a sloping hollow **34***b* that are joined smoothly. The pipe placement hollow **34***c* is bored in the pipe placement portion **35**, and the proximal part of the straight pipe **31** is locked in the pipe placement hollow **34***c.* The base placement hollow **34***a* is bored in the base placement portion **36**, and the stepped base **25** is placed in the base placement hollow **34***a.* The sloping hollow **34***b* is bored in the uneven linkage portion **37**, and links the pipe placement hollow **34***c* and base placement hollow **34***a.*

[**0134**] The centerline (axis) of the pipe placement hollow **34***c* bored in the handle member **33** and the centerline (axis) of the base placement hollow **34***a* bored therein are made uneven.

[**0135**] With the straight pipe **31** locked in the pipe placement hollow **34***c,* the straight pipe **31** and base placement portion (hand-held portion) **36** of the handle member **33** are uneven with a distance a between them.

[**0136**] The length and weight of the observation body **3** will be described below.

[**0137**] When the surgical microscope **1** is used to perform surgery, a distance from an objective to a region to be observed (referred to as a working length) is about 300 mm. The overall length L of the observation body **3** employed in the present embodiment is made smaller than the working length.

[**0138**] Specifically, according to the present embodiment, a distance L1 from the distal end of the handle member **33** to the distal end of the distal cap **32** fixed to the hard pipe **31** is set to 120 mm. Moreover, the length L2 of the handle member **33** is set to 130 mm. The overall length L of the observation body **3** is therefore 250 mm. The magnitude of unevenness between the straight pipe **31** and the base placement portion **36** of the handle member **33**, that is, the distance a is set to 20 mm.

[**0139**] On the other hand, the weight of the observation body **3** is set to a range from 50 g to 10 g in consideration of an incident that part of the distal cap **32** may touch a lesion and a weight balance. Namely, when the observation body **3** has an adequate weight, even if such an incident should occur, the incident will be accurately communicated to an operator. Moreover, the weight of the observation body **3** must be balanced with the weights of the other components in terms of maneuverability.

[**0140**] Moreover, reference numeral **38** denotes a fluid injection portion **38**. An ultrasound propagating medium is injected into the space in the distal cap **32** through the fluid injection port **38** by way of the sloping hollow **34***b,* pipe placement hollow **34***c,* and the hollow of the straight pipe **31**. The ultrasound propagating medium is a fluid whose acoustic impedance is close to that of a living body, for example, deaerated water, physiological saline, sterilized water, or ultrasonic jelly. Reference numeral **39** denotes a body locking screw that is a locking member for locking and holding the stepped base **25** placed in the base placement hollow **34***a.*

[**0141**] The inner diameter of the base placement hollow **34***a* is determined so that an O ring **51** mounted on the distal part of the stepped base **25** will come into close contact with the wall of the base placement hollow **34***a* to seal the base placement hollow **34***a* in a watertight manner. At the same time, the stepped base **25** must be able to slide within the base placement hollow **34***a* for placement. Consequently, an ultrasound propagating medium injected through the fluid injection port **38** is prevented from flowing out to an operator's hand through a proximal opening **33***c* of the base placement portion **36** after passing through a clearance between the wall of the base placement hollow **34***a* and the periphery of the stepped base **25**.

[**0142**] Moreover, a peripheral groove **33***a* and a sensor mount **33***b* are formed on the periphery of the proximal part of the base placement portion **36** of the handle member **33**. The distal end of a sterilization cover (see **FIG. 5A**) to be described later is fitted in the peripheral groove **33***a.* A position-of-probe body checking sensor, for example, the one **135** shown in **FIG. 41** and described later is mounted on the sensor mount **33***b.* Owing to the position checking sensor, an indication of the position of the probe can be seen together with an ultrasonic image within the field of view of the microscope.

[**0143**] As shown in **FIG. 5**A, the sterilization cover **55** is elongated and realized with a soft member. The sterilization cover **55** consists of an elastic stationary part **56**, a contractile and expandable bellows **37**, and a knob **58**. The elastic stationary part **56** is shaped substantially like an O ring and fitted in the peripheral groove **33***a.* The knob **58** is held to stretch the pleated bellows **57**.

[**0144**] As shown in **FIG. 5**B, the sterilized sterilization cover **55** is attached to the handle member **33** with the elastic stationary part **56** thereof fitted in the peripheral groove **33***a.*

At this time, the bellows **57** is pleated and the knob **58** is facing the distal cap **32**. In this state, the ultrasonic probe body **2** is placed in the handle member **33** as indicated with dashed lines. The knob **58** of the sterilization cover **55** is pulled in a direction of an arrow. Consequently, the bellows **57** is turned inside out, and the inner surface of the bellows **57** becomes the outer surface thereof. The bellows **57** thus shields the tube member **24** as indicated with alternate long and two short dashes lines.

[**0145**] In other words, when the microscopic probe **4** is in use, a portion of the ultrasonic probe body **2** from the distal end thereof at which the transducer assembly **23** is located to the middle point of the tube member **24** is placed in the observation body **3**. A portion of the tube member **24** from the middle point thereof to the proximal end thereof is sheathed with the bellows **57** of the sterilization cover **55**.

[**0146**] Consequently, the ultrasonic probe body **2** need not be sterilized or cleaned at every completion of surgery. Even when the ultrasonic probe body **2** is used once, once the sterilized observation body **3** having the sterilization cover **55** attached thereto is mounted on the ultrasonic probe body **2**, the microscopic probe **4** can be used in a sterilized state.

[**0147**] According to the present embodiment, the straight pipe **31**, distal cap **32**, and handle member **33** are sterilizable and disposable. This means that the observation body **3** is of a disposable type.

[**0148**] The handle member **33** and straight pipe **31** may be formed as a united body using a resin member. Moreover, the distal cap **32** may be detachable from the straight pipe **31**. This leads to drastic improvement of the efficiency in cleaning or sterilizing the hollows of the straight pipe **31** and handle member **33** after use. When this structure is adopted, the handle member **33** and straight pipe **31** may be designed to be of a reusable type and resistive to autoclaving.

[**0149**] The operations of the microscopic probe **4** having the foregoing components will be described below.

[**0150**] As shown in **FIG. 6**, the ultrasonic probe body **2** and observation body **3** are joined as a united body to construct the microscopic probe **4**.

[**0151**] At this time, first, the housing **28** fixed to the distal end of the flexible shaft **22** included in the ultrasonic probe body **2** is inserted through the proximal opening **33***c* of the handle member **33**. The housing **28** is then passed through the penetrating hollow **34** and the hollow of the straight pipe **31**, and routed to the space in the distal cap **32**. The penetrating hollow **34** is composed of the base placement hollow **34***a*, sloping hollow **34***b*, and pipe placement hollow **34***c*. In this state, the stepped base **24** is placed in the base placement hollow **34**.

[**0152**] As mentioned above, the handle member **33** is realized with a transparent resin member. The passage of the housing **28** through the base placement hollow **34***a*, sloping hollow **34***b*, and pipe placement hollow **34***c* can be visually checked. An amount of force to be exerted for insertion or a direction of insertion can be adjusted properly. The housing **28** can be advanced smoothly and routed readily but will not be abutted on the wall of the penetrating hollow **34** with strong force.

[**0153**] Thereafter, the stepped base **25** inserted into the base placement hollow **34***a* is thrust forward against constraining force exerted by the O ring **51**. When the ultrasonic transducer **29** reaches a predetermined position in the space of the distal cap **32**, the body locking screw **39** is tightened to abut on the stepped base **25**. Consequently, the stepped base **25** is fixed to the handle member **33**. The ultrasonic probe body **2** and observation body **3** are thus joined as a united body to construct the microscopic probe **4**.

[**0154**] Thereafter, the knob **58** of the sterilization cover **55** sterilized and fitted in the peripheral groove **33***a* is pulled forwards in order to sheath the tube member **24** with the bellows **57** as indicated with dot-dash lines.

[**0155**] Thereafter, an injector **59** to which deaerated water is poured halfway is coupled to the fluid injection port **38**. The penetrating hollow **34**, the hollow of the straight pipe **31**, and the space in the distal cap **32** are deaerated. After air in the observation body **3** is fully deaerated, the deaerated water is injected into the penetrating hollow **34** using the injector **59**.

[**0156**] If the deaerated water does not flow into the space in the distal cap **32**, the distal cap **32** is swung several times. This causes the deaerated water to flow into the distal cap **32** due to the operation of centrifugal force.

[**0157**] An operator places the distal cap **32** of the microscopic probe **4** indicated with dashed lines in **FIG. 7** at a predetermined position within a lumen located within an observable range or the field of view of the eyepiece unit **11** of the surgical microscope **1**. As illustrated, the microscopic probe **4** is held in the probe holder **11***a* with the distal cap **32** thereof oriented vertically downwards. The distal cap **32** is used while always being oriented vertically downwards during examination. Therefore, once water flows into the space in the distal cap **32**, no bubble will occur in the distal cap **32** during examination.

[**0158**] After examination is completed, the body locking screw **39** is loosened, and the stepped base **25** is removed from the handle member **33**. The flexible shaft **22** of the ultrasonic probe body **2** and the transducer assembly **23** thereof are pulled out of the observation body **3**. The used observation body **3** is disposed of, and the sterilized observation body **3** is mounted on the ultrasonic probe body **2**. Preparations are then made for a subsequent examination.

[**0159**] As mentioned above, the handle member included in the observation body is realized with a hard member and bent. The centerline (axis) of the pile placement hollow bored in the handle member and the centerline (axis) of the base placement hollow bored therein are made uneven. Therefore, when the linkage pipe is locked in the pipe placement hollow, the distal cap fixed to the distal end of the linkage pipe and the base placement portion of the handle member are held uneven by a predetermined distance. Consequently, the distal cap or ultrasound transmissive cap enclosing the transducer assembly of the microscopic probe can be readily located at a position optimal for an intended region. At this time, the field of view defined by the eyepiece unit of the surgical microscope will not be blocked.

[**0160**] Consequently, the ultrasound transmissive cap enclosing the transducer assembly can be located at a position optimal for an intended region whenever an operator desires it. An ultrasonic image enjoying a high resolution can be produced instantaneously.

[0161] Incidentally, according to the present embodiment, the ultrasonic probe body and the observation body are separate bodies. Alternatively, they may be constructed as a united body. Nevertheless, their fundamental functions are drawn out.

[0162] Moreover, the housing **28** enclosed in the distal cap **32** of the observation body **3** is rotated with rotation of the flexible shaft **22**. Specifically, driving torque exerted by the motor included in the probe drive unit **10** incorporated in the arm stand **14** of the surgical microscope **1** is conveyed over the flexible shaft **22** to rotate the housing **28**. It is therefore hard to accurately detect the position of the rotating housing **28** and to grasp a positional relationship at the sight of an ultrasonic image displayed on the screen of a monitor.

[0163] A structure described below is adopted so that the position of the rotating transducer assembly **23** can be detected in order to display an ultrasonic image, which helps readily grasp a positional relationship, on the screen of the monitor.

[0164] As shown in **FIG. 8**A and **FIG. 8**B, the thickness of the distal cap **32** may not be uniform but part of the distal cap **32** may be formed as a thick part **53**. Alternatively, the center point on the inner diameter of the cap may not be aligned with the center point on the outer diameter thereof. The distal cap **32** may thus be structured to have a non-uniform thickness.

[0165] When the transducer assembly **23** is rotated within the distal cap **32**, multiple echoes are detected through the thick part of the distal cap **32**. Namely, multiple echoes are depicted as shown in **FIG. 8C** on an ultrasonic image.

[0166] A direction-of-rotation correcting means and an ultrasound originating/receiving circuit are included in the probe drive unit **10** so that a direction from which multiple echoes are returned will always remain constant (from above in the drawing). When the distal cap **32** is attached to the straight pipe **31** of the observation body **3**, the thick part **53** is oriented in a specific direction, for example, oriented towards the uneven linkage portion **37**.

[0167] Consequently, as shown in **FIG. 8**C, multiple echoes are visualized on the screen of the monitor so that they will be seen returned from above all the time. This helps an operator observe a lesion while readily grasping the positional relationship between components of the handle member **33** and the positional relationship between things depicted in an ultrasonic image.

[0168] The distal cap is structured in order to utilize multiple echoes. Therefore, an error in the position of the distal cap a direction of rotation thereof caused by the flexible shaft can be corrected and an image can be oriented in a desired direction easily.

[0169] As shown in **FIG. 9, a** reflector **61** may be included so that it can be freely thrust or sunk relative to the radiating surface of the ultrasonic transducer **29**. The reflector **61** is located in front of the radiating surface of the ultrasonic transducer **29** when needed. Thus, an ultrasonic image of the reflector **61** is displayed on the screen of the monitor. This helps orient the distal cap. As a means for advancing or withdrawing the reflector **61**, an advancing/withdrawing mechanism may be constructed with a linear motor **62** and a switch **63**, which is manipulated, located as shown in **FIG. 9**. Otherwise, the reflector **61** may be moved manually.

[0170] Referring to **FIG. 10A** to **FIG. 11**B, the second embodiment of the present invention will be described below.

[0171] As shown in **FIG. 10**A, according to the present embodiment, a bellows pipe **54** hollowed and freely bent and held bent as shown in **FIG. 10B** is substituted for the straight pipe **31** that is straight and links the distal cap **32** and handle member **33**. The bellows pipe **54** is used as a linkage pipe, thus constructing an observation body **3**A. The other components are identical to those of the first embodiment. The same reference numerals are assigned to the identical components, and the description of the components is omitted.

[0172] The bellows pipe **54** of the observation body **3**A is initially shaped straight as shown in **FIG. 10A**. In this state, the transducer assembly **23** and flexible shaft **22** of the ultrasonic probe body **2** are inserted into the observation body **3**A. After the transducer assembly **23** and flexible shaft **22** are placed at their predetermined positions, the observation body **3**A and ultrasonic probe body **2** are joined as a united body using the body locking screw **39** in order to construct the microscopic probe **4**. An ultrasound propagating medium is injected using the injector **59**. Thereafter, the bellows pipe **54** is, as shown in **FIG. 10**B, bent according to the shape of a lumen of a region having a lesion.

[0173] As mentioned above, the linkage pipe of the observation body is realized with the bellows pipe capable of being bent and held bent. The bent state of the bellows pipe can be varied depending on the shape of a lumen of a region having a lesion. Consequently, ultrasonic images representing the areas in the region located in various angular directions can be produced. The other operations and advantages are identical to those of the first embodiment.

[0174] The bellows pipe **54** structured as shown in **FIG. 10C** may be bent as shown in **FIG. 10E** so that the distal cap **32** will be located orthogonally to a direction of insertion. In this case, the orientation of the distal cap **32** is adjusted so that an ultrasonic image representing an area in a region located in the direction of an extension of the inserted microscopic probe. A needle groove **45** in which a needle portion **41** of a puncturing needle **40** is put is bored in the pipe placement portion **35** of the handle member **33** so that the needle groove **45** will extend in the direction of insertion. The needle portion **41** of the puncturing needle **40** is shot under ultrasonic guidance in order to inject an agent into a lesion or collect the tissue of a lesion.

[0175] As mentioned above, when the linkage pipe of the observation body is realized with the bellows pipe capable of being bent freely and held bent, a lesion can be punctured safely under ultrasonic guidance.

[0176] A bending member **64** structured as shown in **FIG. 11**B and angled vertically as indicated with dashed lines in **FIG. 11**A and laterally alike may be substituted for the straight pipe **31** or may be formed as part of the straight pipe **31**. An observation body **3**B having the bending member **64** may be constructed. The bending member **64** is composed of a plurality of bending pieces **65** which are concatenated using rivets **66** so that the bending pieces can turn freely. Angling wires **68** to be hauled by manipulating a sliding angling lever **67** formed at a predetermined position are coupled to the distal bending piece **65**.

[0177] Consequently, the angling lever **67** is manipulated in order to angle the bending member **64** in line with the shape of a lumen of a region having a lesion. Thus, ultrasonic images representing the areas in the region located in various directions can be produced. The bending member **64** has the concatenated bending pieces **65** sheathed with a rubber bending tube that is not shown.

[0178] Referring to **FIG. 12** and **FIG. 13**, the third embodiment of the present invention will be described below.

[0179] As shown in **FIG. 12**, an observation body **3**C employed in the present embodiment does not include the fluid injection port **38** that is formed on the lateral surface of the handle member **33** employed in the first and second embodiments. The proximal opening **33***c* of the handle member **33** is also used as the fluid injection port. Moreover, the body locking screw **39** is located proximally beyond the peripheral groove **33***a* in which the distal part of the sterilization cover **55** is fitted.

[0180] Furthermore, a remote switch **46** used to freeze an ultrasonic image and a remote switch **47** used to give control to print out an ultrasonic image are bared on the lateral surface of the handle member **33** included in the observation body **3**C.

[0181] The handle member **33** included in the observation body **3**C is realized with a hard member, and bent so that the centerline (axis) of the straight pipe **31** and the centerline of the base placement portion (hand-held portion) **36** will meet at an angle θ. The distal cap **32** fixed to the distal end of the straight pipe **31** and the base placement portion **36** of the handle member **33** are made uneven.

[0182] A magnitude of unevenness of the handle member **33** is determined for each operator in consideration of a balance of the handle member held by an operator, maneuverability thereof, and a field of view ensured by the microscope. Besides, excellent maneuverability must be offered without the sacrifice of the basic function of the handle member. Incidentally, the sterilization cover is not shown for a clear understanding of the structure of the observation body.

[0183] According to the present embodiment, for injecting deaerated water into the space in the distal cap **32**, a small-diameter tube **59***a* coupled to the injector **59** is, as shown in **FIG. 13**, placed in the penetrating hollow **34**. The injector **59** has deaerated water poured thereinto.

[0184] The small-diameter tube **59***a* of the injector **59** is passed through the penetrating hollow **34**, and the tip of the small-diameter tube **59***a* is routed to the space in the distal cap **32**. The deaerated water is then injected. An amount of injected deaerated water is determined to be a bit smaller than the volume of the space in the observation body **3**C.

[0185] After the injection of the deaerated water is completed, the transducer assembly **23** and flexible shaft **22** of the ultrasonic probe body **2** are moistened with water and then inserted into the penetrating hollow **34** through the proximal opening **33***c* of the handle member **33**. Since the flexible shaft **22** is moistened with water, air hardly enters the deaerated water injected into the space within the observation body **3**C.

[0186] After the flexible shaft **22** is inserted, the stepped base **25** placed in the base placement hollow **34***a* is thrust against constraining force exerted by the O ring **51**. When the stepped base **25** reaches a predetermined position, the body locking screw **39** is tightened. Eventually, the ultrasonic probe body **2** and observation body **3**C are joined as a united body to construct the microscopic probe **4**. The other components are identical to those of the aforesaid embodiments. The same reference numerals are assigned to the identical components, and the description of the components is omitted.

[0187] As mentioned above, the fluid injection portion is excluded from the handle member. The remote switches used to instruct various movements are included in the handle member. This leads to drastically improved maneuverability. The other operations and advantages are identical to those of the aforesaid embodiments.

[0188] Referring to **FIG. 14A** to **FIG. 14**E, an example of application of the observation body shown in **FIG. 12** and **FIG. 13** will be described below.

[0189] As shown in **FIG. 14**C, an observation body **3**D consists of a handle member **33**A shown in **FIG. 14A and a** probe passage member **50** freely detachably attached to the handle member **33**A as shown in **FIG. 14**B. The probe passage member **50** is attached to the handle member **33**A as an integral part of the handle member.

[0190] As shown in **FIG. 14**A, the handle member **33**A has an adjustment knob **33***c* serving as an attachment mechanism for holding the probe passage member **50** so that the probe passage member can be detached freely and also serving as an angle adjustment mechanism to be described later. Moreover, the remote switches **46** and **47** are bared on the lateral surface of the handle member **33**A. An electric cable **48** is extended from the proximal end of the handle member **33**A. Signal lines extended from the remote switches **46** and **47** are contained in the electric cable **48**.

[0191] On the other hand, as shown in **FIG. 14**B, the probe passage member **50** consists of the straight pipe **31**, the distal cap **32**, and a base placement portion **36***a* having an attachment **36***b*.

[0192] The adjustment knob **33***c* is tightened with the attachment **36***b* located at a predetermined position in the handle member **33**A. Consequently, the direction of extension of the straight pipe **31** extending from the handle member **33**A can be changed to a direction indicated with a solid line in **FIG. 14**C or a direction indicated with a dashed line therein. In other words, an angle at which the longitudinal axis of the handle member **33**A and the longitudinal axis of the straight pipe **31** meets can be set to an operator's desired value.

[0193] As shown in **FIG. 14**D, the handle member **33**A has a placement concave part **49** in which the base placement portion **36** is fitted. A Hall-effect device **49***a* for sensing magnetic field strength is located at a predetermined position in the wall of the placement concave part **49**. A sensing member **22***b* having a magnet **22***a* to be sensed by the Hall-effect device **49***a* is, as shown in **FIG. 14**E, located at a predetermined position in the flexible shaft **22** passed through the base placement portion **36***a*.

[0194] Consequently, the Hall-effect device **49***a* senses the magnet **22***a* included in the sensing member **22***b* mounted in the flexible shaft **22**. As described in conjunction with **FIG. 8**C, the orientation of the handle member **33**A is corrected so that the orientation of the magnet **22***a* sensed by the Hall-effect device **49***a* will remain constant (lie above in the drawings) all the time. An ultrasonic image is thus displayed on the screen. This helps an operator view the ultrasonic image while grasping the positional relationship between components of the handle member **33**A and the positional relationship between things depicted in an ultrasonic image.

[**0195**] Referring to **FIG. 15** to **FIG. 17**, the fourth embodiment of the present invention will be described below.

[**0196**] According to the first to third embodiments, the direction of scanning performed by the ultrasonic transducer **29** included in the microscopic probe **4** is orthogonal to the direction of insertion of the microscopic probe **4**, and includes all directions within 360°. Thus, the microscopic probe produces a radial image. In contrast, according to the present embodiment, a microscopic probe is designed to produce both an image representing an area in a region located in a forward direction of insertion and a radial image.

[**0197**] As shown in **FIG. 15** and **FIG. 16**, according to the present embodiment, a mirror-inclusive pipe **31***a* having, for example, a metallic ultrasound reflecting mirror included therein as a distal projection is substituted for the straight pipe **31** to which the distal cap **32** is fixed.

[**0198**] As shown in **FIG. 15**, the mirror-inclusive pipe **31***a* consists of a shaft placement hollow **9***a,* a reflecting mirror surface **9***b,* and a passage hole **9***c*. The flexible shaft **22** is passed through the shaft placement hollow **9***a*. The reflecting mirror surface **9***b* that is an distal surface of the projection formed in the shaft placement hollow **9***a* is inclined substantially 45° and opposed to the ultrasonic transducer **29**. The transducer assembly **23** of the ultrasonic probe body **2** is passed through the passage hole **9***c* that serves as an escape recess intended to reduce the weight of the pipe **31***a*.

[**0199**] As shown in **FIG. 15** and **FIG. 16**, the transducer assembly **23** is passed through the passage hole **9***c* and shaft placement hollow **9***a,* and routed to a predetermined position. Consequently, the reflecting mirror surface **9***b* is opposed to the ultrasonic transducer **29** of the transducer assembly **23**.

[**0200**] When the rotating ultrasonic transducer **29** radiates ultrasonic waves in all directions within 360° as shown in **FIG. 17**, part of the radiated ultrasonic waves is reflected from the reflecting mirror surface **9***b* and propagated forwards.

[**0201**] In other words, according to the present embodiment, the ultrasonic transducer **29** included in the transducer assembly **23** radiates ultrasonic waves in all directions within 360°. Ultrasonic waves reflected from the reflecting mirror surface **9***b* are used to scan an area in a region located forwards. Ultrasonic waves not reflected from the reflecting mirror surface **9***b* but radiated in radial directions are used to scan areas in the region located in the radial directions. This results in both a forward image and a radial image.

[**0202**] Since the distal projection is included to provide the reflecting mirror surface **9***b,* part of the radial image is missing.

[**0203**] As mentioned above, the mirror-inclusive pipe has the reflecting mirror surface, which is inclined substantially 45° and opposed to the ultrasonic transducer, formed in the distal part thereof. The ultrasonic transducer radiates ultrasonic waves in all directions within 360°. Both a forward image produced with ultrasonic waves reflected from the reflecting mirror surface and a radial image produced with ultrasonic waves radiated in radial directions can be produced to facilitate observation of a lesion and treatment thereof.

[**0204**] As shown in **FIG. 18**, an ultrasound reflecting mirror member **9***g* may be substituted for the reflecting mirror surface of the projection. The ultrasound reflecting mirror member **9***g* serves as an ultrasonic reflecting mirror having a reflecting mirror surface **9***f* inclined substantially 45°, and is formed in the distal part of the distal cap **32**.

[**0205**] When the transducer assembly **23** is, as shown in **FIG. 19**, placed at a predetermined position in the distal part of the distal cap **32**, the ultrasonic transducer **29** is opposed to the reflecting mirror surface **9***f* of the ultrasound reflecting mirror member **9***g*. This results in, as mentioned above, both a forward image produced with ultrasonic waves reflected from the reflecting mirror surface **9***f* and a radial image produced with ultrasonic waves radiated in radial directions.

[**0206**] The ultrasonic transducer **29** may be, as shown in **FIG. 20**, placed at a predetermined position in the proximal part of the distal cap **32**. At this position, the ultrasonic transducer **29** is not opposed to the reflecting mirror surface **9***d*. This results in a perfectly radial image representing areas in a region located in all directions within 360°.

[**0207**] As mentioned above, an operator advances or withdraws the ultrasonic transducer in the direction of insertion so as to set the ultrasonic transducer at a proper position. Consequently, both a forward image and a radial image are produced to facilitate observation of a lesion and treatment thereof. Otherwise, a radial image representing areas in a region located in all directions within 360° can be produced in order to selectively observe and treat a lesion.

[**0208**] As shown in **FIG. 21, a** groove **9***h* may be formed to open as part of the reflecting mirror surface **9***d*. In this case, an observation optical system **69** including an image guide fiber is fitted in the groove **9***h*. Consequently, an optical image of a region to be observed which is formed by the observation optical system **69** can be viewed in addition to an image formed in the field of view of the microscope. A position to which the distal cap is inserted can therefore be checked accurately.

[**0209**] Referring to **FIG. 22** to **FIG. 24**C, an example of application of the fourth embodiment will be described below.

[**0210**] As shown in **FIG. 22, a** sound absorbing member **9***e* made of, for example, chloroprene rubber for absorbing ultrasonic waves is placed on a side surface **9***d* of the projection which communicates with the reflecting mirror surface **9***b* and extends near the ultrasonic transducer **29**. Consequently, the sound absorbing member **9***e* absorbs ultrasonic waves emitted from the ultrasonic transducer **29**. An artifact produced with ultrasonic waves reflected from the side surface **9***d* and propagated to the ultrasonic transducer **29** can be minimized. An excellent ultrasonic image can therefore be produced.

[0211] As shown in **FIG. 24**A, **FIG. 24**B, and **FIG. 24**C, the reflecting mirror surface **9***f* is opposed to the whole radiating surface of the ultrasonic transducer **29**. This is intended to prevent ultrasonic waves emitted from the ultrasonic transducer **29** from falling on the ultrasonic transducer **29** again after being reflected from the side surface **9***d*. Consequently, the side surface **9***d* is not opposed to the ultrasonic transducer **29**. Nevertheless, an excellent ultrasonic image can be produced with an artifact minimized. Moreover, the reflecting mirror surface **9***f* is formed to have the width thereof made wider towards the lower side thereof. The angle of view determining the size of a forward plane to be scanned becomes wider.

[0212] Since the sound absorbing member **9***e* is placed on the side surface **9***d* of the projection which communicates with the reflecting surface **9***f* and extends near the ultrasonic transducer **29**, ultrasonic waves reflected irregularly are absorbed. Eventually, an excellent ultrasonic image can be produced with an artifact minimized effectively.

[0213] In the aforesaid embodiment, the reflecting mirror surface **9***f* shaped to have the width thereof made wider towards the lower side thereof is formed to be opposed to the whole radiating surface of the ultrasonic transducer **29**. Consequently, as shown in **FIG. 23**, the centerline (axis) C1 of the flexible shaft **22** and the centerline (axis) C2 of a scanned plane located ahead of the reflecting mirror surface **9***f* are separated from each other by a distance d. For this reason, a forward scanned plane index **32***d* is marked at a predetermined position on the surface of the distal cap **32** enclosing the transducer assembly **23** so that the center point on the forward scanned plane can be identified at sight. Consequently, the centerline C2 passing through the forward scanned plane located ahead of the reflecting mirror surface **9***f* can be aligned with the center of an intended area in a lumen. The forward scanned plane index **32***d* is marked using, for example, a laser.

[0214] Furthermore, depth indices **32***e*, **32***f*, **32***g*, and **32***h* with which a user learns a length of insertion, by which the microscopic probe has been inserted, at sight are marked on the distal cap **32** using a laser. The depth indices **32***e*, **32***f*, **32***g*, and **32***h* enable an operator to grasp the length of insertion instantaneously while looking through the microscope.

[0215] Depth indices **31***b*, **31***c*, **31***d*, etc. may also be marked on the outer surface of the straight pipe **31** included in the microscopic probe **4**. This makes it possible to grasp a length of insertion, by which the microscopic probe **4** has been inserted, instantaneously while looking through the microscope.

[0216] Moreover, when the outer surface of the straight pipe **31** is made of a metal, the metallic outer surface is satin-finished. This is intended to prevent the surface of the pipe from glittering unnecessarily during use of the microscopic probe.

[0217] Referring to **FIG. 25** to **FIG. 31**B, the fifth embodiment of the present invention will be described below.

[0218] According to the aforesaid first to fourth embodiments, the transducer assembly **23** included in the microscopic probe **4** has the ultrasonic transducer **29** incorporated in the housing **28** thereof. The housing **28** is mechanically rotated using the flexible shaft **22** that conveys driving torque of the motor included in the probe drive unit **10**. According to the present embodiment, a plurality of transducer elements is, as shown in **FIG. 25**, arranged circumferentially regularly as the distal part of an ultrasonic probe body in order to construct a transducer assembly **62**. Thus, the present embodiment employs an electronic radial scanning type ultrasonic probe body **2**A in which the transducer elements **71** are electrically driven to rotate for scanning.

[0219] The ultrasonic probe body **2**A consists mainly of a transducer assembly **72**, a soft elongated signal cable **73**, a locking base **74**, and a connector **75**. The transducer assembly **72** has the plurality of transducer elements **71** arranged, for example, circumferentially regularly. The soft elongated signal cable **73** accommodates signal lines (not shown) extended from the transducer elements **71** constituting the transducer assembly **72**. The locking base **74** is located at the middle of the signal cable **73**, and has a body locking screw abutted thereon similarly to the stepped base **25**. The connector **75** is located at the proximal end of the signal cable **73**, and coupled to an ultrasound observation unit so that it can be uncoupled freely. The ultrasound observation unit includes an ultrasound transmission/reception circuit for driving the transducer elements **71** and transmitting or receiving ultrasonic waves. The connector **75** has an attachment/detachment lever.

[0220] On the other hand, an observation body **76** through which the ultrasonic probe body **2**A is passed has, as shown in **FIG. 26**A, an uneven linkage portion **76***a* and a pipe portion **76***b* joined as a united body. The pipe portion **76***b* has a distal end thereof left open, and is shaped straight and parallel to the centerline (axis) of the uneven linkage portion **76***a*. Otherwise, a pipe portion **76***c* that is bent with respect to the centerline (axis) of the uneven linkage portion **76***a*, and the uneven linkage portion **76***a* are joined to construct the observation body **2**A. A body locking screw **77** is located at a predetermined position of the uneven linkage portion **76***a*.

[0221] As shown in **FIG. 27**, the ultrasonic probe body **2**A is passed through the observation body **76**, and the body locking screw **77** is tightened to lock the locking base **74**. Consequently, the ultrasonic probe body **2**A and observation body **76** are joined with the transducer assembly **72** jutted out of the opening of the pipe portion **76***b* of the observation body **76**, thus constructing the electronic radial scanning type microscopic probe **4**.

[0222] As mentioned above, the ultrasonic probe body having the plurality of transducer elements arranged as the distal part thereof is placed at the predetermined position in the observation body having the distal end thereof left open, thus constructing the electronic microscopic probe. Consequently, the same operations and advantages as those provided by the aforesaid embodiments can be provided.

[0223] As shown in **FIG. 28**, the locking base **74** may be formed as a locking base-cum-cable connector **74***a* having an electrode pattern **74***b* drawn thereon. A transducer assembly-inclusive signal cable **73***a* has an electrode pattern **73***b* drawn on a proximal part thereof is electrically and mechanically attached to the distal part of the locking base **74** having the electrode pattern **74***b* drawn thereon. Only the transducer assembly-inclusive signal cable **73***a* having the transducer assembly **72** that does not resist the conditions for autoclaving, that is, high temperature and high humidity is designed to be disposable. This leads to an inexpensive ultrasonic probe body.

[0224] Moreover, the electronic transducer assembly **72** is not limited to the radial scanning technique. For example, as shown in **FIG. 29**A, the plurality of transducer elements **71** may be arranged radially in order to thus construct a convex scanning type transducer assembly **72***a* that scans a radial ultrasonically observable range. Otherwise, as shown in **FIG. 29**B, the plurality of transducer elements **71** may be lined in the direction of insertion in order to thus construct a linear scanning type transducer assembly **72***b* that scans an ultrasonically observable range extended in the direction of insertion. In this case, scan heads that are the transducer assemblies can be switched according to a purpose of use. This leads to improved efficiency in observation.

[0225] Furthermore, as shown in **FIG. 30**A, an observation optical system **78** including an image guide fiber may be included in the radial scanning type transducer assembly **72**. As shown in **FIG. 30**B, the observation optical system **78** may be included in the convex scanning type transducer assembly **72***a*. Moreover, as shown in **FIG. 30**C, the observation optical system **78** may be included in the linear scanning type transducer assembly **72***b*. In this case, in addition to an image formed in the field of view of the microscope, an optical image of a region to be observed formed by the observation optical system **78** can be viewed for checking a position to which the microscopic probe is inserted.

[0226] Moreover, in addition to the linear scanning type transducer assembly **72***b* having the transducer elements **71** lined, a therapeutic transducer assembly **72***c* having therapeutic transducer elements lined may be included as shown in **FIG. 31A**. The convex scanning type transducer assembly **72***a* and linear scanning type transducer assembly **72***b* may be included in a distal member **70** as shown in **FIG. 31B**. The distal member **70** may be rotated with driving torque exerted by a motor and conveyed over a flexible shaft **70***a*, whereby a three-dimensional ultrasonic view image may be produced. Incidentally, a mark **79** allows a user to visually identify the direction of an extension of the therapeutic transducer assembly **72***c*. Namely, the mark **79** informs a user of the direction of the therapeutic transducer assembly **72***c*.

[0227] As shown in **FIG. 32, a** flexible bending sheath member **76***d* that has a notch **76***c* in which the transducer assembly **72** is fitted may be formed as the distal part of the pipe portion **76***b*. Besides, an angling wire **76***e* is stretched over the notch **76***c*. The angling wire **76***e* is hauled in line with the shape of a lumen of a region having a lesion, whereby the bending sheath member **76***d* is bend from a straight state indicated with dashed lines to a bent state indicated with solid lines. Thus, ultrasonic images representing areas in the region located in various directions can be produced. Moreover, the pipe portion **76***b* having the notch **76***c* may be replaced with the bending member **64**. In this case, the bending member **64** can be bent in a desired direction by manipulating the angling wires **68**. Consequently, ultrasonic images representing areas in a region located in various directions can be produced. The other operations and advantages are identical to those of the aforesaid embodiments.

[0228] As described in conjunction with **FIG. 23**, the depth indices **32***e*, etc. and **32***h*, and **31***b*, etc. and **31***h* may be marked on the distal cap **32** and straight pipe **31**. This helps a user instantaneously grasp a length of insertion by which the microscopic probe has been inserted while looking through the microscope. Even in this case, if blood or the like is mixed in physiological saline injected into a lumen of a region to be observed during ultrasonic examination, it becomes hard to identify the distal end of the microscopic probe through the microscope. This may hinder observation.

[0229] For preventing the above incident, as shown **FIG. 33, a** fluid supply channel **81** and a suction channel **82** are laid in contact with the straight pipe **31**, bellows pipe **54**, or pipe portion **76***b* included in the observation body. Physiological saline is supplied through the fluid supply channel **81**. Physiological saline mixed with blood is sucked through the suction channel **82**. The distal end of one of the channels, for example, the suction channel **82** is located near the distal end of the distal cap **32**.

[0230] Consequently, if blood or the like is mixed in physiological saline, it becomes hard to form an image in the field of view of the microscope. In this case, the physiological saline mixed with blood is sucked through the suction channel **82** and discharged. At the same time, physiological saline is supplied through the fluid supply channel **81**. In other words, physiological saline is circulated in order to restore the transparency characteristic of physiological saline. Eventually, a view image can be observed through the microscope.

[0231] Moreover, the distal end of the suction channel **82** is located near the distal end of the distal cap **32**. Consequently, the distal end of the suction channel **82** is located ahead of the radiating surface of the ultrasonic transducer. An ultrasonic image of the suction channel **82** is therefore depicted in an ultrasonic image of an intended region. this helps orient the microscopic probe. Incidentally, the foregoing structure can be adapted irrespective of whether the transducer assembly is mechanically or electrically driven.

[0232] Moreover, in the aforesaid embodiments, physiological saline is injected into the lumen of a region to be observed in order to perform ultrasonic examination. The transducer assembly may be enclosed in a balloon that can be freely dilated or shrunken. Physiological saline is then supplied to the balloon, whereby the balloon is dilated. This causes the surface of the balloon to come into close contact with the wall of the lumen. The region is then observed ultrasonically.

[0233] A distal cap **86** has a space **86***a* and a distal groove **86***b*. The transducer assembly **23** is placed in the space **86***a*. The distal groove **86***b* has a predetermined shape and depth and serves as an engaging/locking portion in which part of a balloon **87** is locked so that it can be unlocked freely. Thus, a balloon assembly **85** is constructed as shown in **FIG. 34**. The balloon **87** can be freely dilated or shrunken, and can substantially entirely shield the periphery of the distal cap **86**. The balloon **87** is realized with a balloon member made of latex, Teflon rubber, or any other material that can transmit ultrasonic waves and can be freely stretched or contracted.

[0234] The balloon **87** has the proximal end thereof fixed to the periphery of the straight pipe **81** as an integral part of the straight pipe **31** through bobbin winding bonding. The distal part of the balloon **87** encloses the periphery of the distal cap **86** while partly being locked in the distal groove **86***b* with a balloon O ring **87***a*. The balloon O ring **87***a* is fitted in the distal groove **86***b* from the distal end of the distal cap **86** in order to seal a clearance around the periphery of the distal cap in a watertight manner. The balloon O ring **87***a* can be removed freely.

[0235] Moreover, one or a plurality of side holes **86***c* that links the space **86***a* and the outside of the distal cap **86** is bored in the lateral surface of the distal part of the distal cap **86**. Through the side holes **86***c*, an ultrasound propagating medium such as physiological saline is poured into the balloon **87**.

[0236] As shown in **FIG. 35**A, when the ultrasound propagating medium is injected, the ultrasound propagating medium once reserved in the space **87***a* passes through the side holes **86***c* and flows into the clearance between the balloon **87** and the periphery of the distal cap **86**. At this time, since the balloon O ring **87***a* is fitted in the distal groove **86***b*, the balloon **87** is dilated due to the ultrasound propagating medium flowing through the side holes **86***c*. The balloon **87** held dilated is brought into close contact with an intended region to be observed, and the ultrasonic transducer **29** is rotated. Thus, an ultrasonic view image of the intended region can be viewed.

[0237] If too much ultrasound propagating medium is injected to the balloon **87**, the internal pressure of the balloon **87** rises. This causes force to work on the balloon O ring **87***a* to press the balloon O ring **87***a* towards the distal end of the distal cap in the longitudinal direction. Therefore, before the balloon **87** is dilated so largely as to be ruptured, the balloon O ring **87***a* is, as shown in **FIG. 35**B, pushed out of the distal groove **86** towards the distal end of the distal cap and comes off. This causes the ultrasound propagating medium fed into the balloon **87** to flow out through the opening of the balloon **87**. At this time, since the proximal end of the balloon is fixed to the periphery of the straight pipe **31** as an integral part of the straight pipe **31** through bobbin winding bonding, the balloon **87** will therefore not fall. Incidentally, the transducer assembly is shown to be of a mechanically driven type. Alternatively, the transducer assembly may be of an electronically driven type.

[0238] When an attempt is made to realize an electronic microscopic probe having the aforesaid constituent features, the microscopic probe is preferably constructed as shown in **FIG. 36**.

[0239] Specifically, a handle member **33**B is configured to have a treatment appliance insertion port **91**, an angling knob **67***a*, a universal cord **92**, channel exits **93** and **94**, and a fixture **95**. The universal cord **92** accommodates signal lines and the flexible shaft. The fluid supply channel **81** and suction channel **82** are led out of the handle member through the channel exits **93** and **94**. The fixture **95** is used to fix the proximal end of the uneven linkage portion **76***a* so that the uneven linkage portion **76***a* can be unfixed freely. At this time, the universal cord **92**, the fluid supply channel **81**, the suction channel **82**, and a treatment appliance coming out of the treatment appliance insertion port **91** are laterally led out of the handle member in order to prevent them from hitting the microscope.

[0240] Thereafter, the bending member **64** is attached to the distal end of the pipe portion **76***b*. The indices **31***b*, **31***c*, **31***d*, etc. are marked on the outer surfaces of the bending member **64** and pipe portion **76***b*. Transducer assembly units **96**, **97**, **98**, and **99** of various scanning types are made available so that they can be freely attached or detached to or from the distal end of the bending member **64**. The transducer assembly units **96**, **97**, **98**, and **99** include the convex scanning type transducer assembly **72***a*, the linear scanning type transducer assembly **72***b*, the radial scanning type transducer assembly **72**, and a combination of the transducer assembly **72***a* and transducer assembly **72***b* respectively. At this time, the electrode patterns **73***b* and **74***b* are drawn on the transducer assemblies and the bending member respectively.

[0241] An opening through which a treatment appliance juts out may be bored in the transducer assembly units. In this case, a treatment appliance **100** inserted through the treatment appliance insertion port **91** can be led out of the transducer assembly unit as indicated with dashed lines. Moreover, the distal groove **86***b* in which the distal part of the balloon **87** is locked may be formed in the transducer assembly units. A mark **100***a* indicates a direction in which a treatment appliance should be introduced and also serves as a scanned plane index.

[0242] In the aforesaid embodiments, driving torque exerted by the motor included in the probe drive unit **10** is conveyed over the one elongated flexible shaft **22** in order to rotate the transducer assembly **23**. For conveying the driving torque exerted by the motor included in the probe drive unit **10** to the transducer assembly **23** on a stable basis, the flexible shaft must have a somewhat large diameter. However, for passing the microscopic probe through a very thin lumen, the flexible shaft must be small in diameter. For this reason, there is a demand for a thin flexible shaft structured to be able to convey driving force stably.

[0243] As shown in **FIG. 37**, according to the present embodiment, a flexible shaft for conveying driving force consists mainly of a first flexible shaft **101** and a second flexible shaft **102**.

[0244] Specifically, the first flexible shaft **101** having a large diameter and aiming to convey torque reliably is used to link the connector **21** and the proximal end of the stepped base **25**. The second flexible shaft **102** having a small diameter in line with the dimensions of the observation body **3** through which the second flexible shaft is passed is used to link the distal end of the stepped base **24** and the proximal end of the housing **28**. Within the stepped base **25**, the first flexible shaft **101** and second flexible shaft **102** are joined as a united body using a pipe-shaped relay shaft **103**.

[0245] Consequently, driving torque exerted by the motor that is not shown is conveyed to the housing **28** over the first flexible shaft **101**, relay shaft **103**, and second flexible shaft **102**.

[0246] An O ring **104** is attached to the distal end of the relay shaft **103** in order to seal in a watertight manner the clearance between the wall of the base and the periphery of the relay shaft. A side hole **106** communicating with a hollow **105** is bored substantially at the middle of the relay shaft **103**. An adhesive **87** is poured into the hollow **105** by way of the side hole **106**, whereby the signal line **29** is secured. At the same time, the hollow **105** is divided into a distal part and a proximal part.

[0247] As mentioned above, the two flexible shafts having different diameters are joined as a united body using the relay shaft, thus realizing a flexible shaft for conveying torque. Consequently, torque of a desired level can be conveyed efficiently over the flexible shafts having desired diameters. Although the flexible shaft having a small diameter is employed, the transducer assembly can be rotated stably.

[0248] Moreover, the adhesive is poured into the hollow of the relay shaft in order to divide the hollow into the distal and proximal parts. Consequently, filth can be reliably prevented from entering a flexible shaft. This leads to improved cleaning efficiency.

[0249] A typical probe drive unit consists mainly of a motor, an encoder serving as a detecting means, a slip ring serving as a signal transmitting means, and a rotation control circuit. A flexible shaft is coupled to the motor. An ultrasonic transducer serving as an ultrasound transmission/reception unit is rotated by way of the flexible shaft. For detecting the position of the rotating ultrasonic transducer, the encoder is attached to the motor for driving and rotating the ultrasonic transducer. The encoder is corrected so that the position detected by the encoder will agree with the actual position of the scanning transducer. Thus, an ultrasonic image is produced.

[0250] However, the aforesaid microscopic probe includes a flexible shaft having a small diameter. It is therefore hard to stably convey driving torque exerted by the motor to the ultrasonic transducer. An ultrasonic image highly precisely representing a region is hard to produce.

[0251] According to the present embodiment, as shown in FIG. **38**, a penetrating hollow-inclusive encoder **110** having a hollow through which the relay shaft **103** is passed is adopted and located at a predetermined position in the handle member **33**. The encoder **110** optically or magnetically detects the position of the rotating transducer and outputs a position-of-rotating transducer signal to a rotation control circuit **114** to be described later over a signal cable **111**.

[0252] A probe drive unit **10**A employed in the present embodiment consists of a motor **112**, a slip ring **113**, and the rotation control circuit **114** but does not include an encoder. A transmission/reception circuit **116** included in an ultrasonic observation apparatus **115** is connected to the probe drive unit **10**A.

[0253] Moreover, a bent pipe member **118** having a bearing **117**, which bears the relay shaft **103** so that the relay shaft **103** can rotate freely, is freely detachably attached to the handle member **33**.

[0254] As mentioned above, the penetrating hollow-inclusive encoder is included in the handle member. This results in the shortened distance between the ultrasonic transducer and the encoder. The position indicated with the position-of-rotating transducer signal output from the encoder agrees with the actual position of the transducer. Eventually, an ultrasonic image highly precisely representing a region can be produced.

[0255] Moreover, the pipe member is freely detachably attached to the handle member. Consequently, the pipe member to be inserted into a lumen of a region to be observed can be designed to be disposable.

[0256] Incidentally, in the microscopic surgery system, a feeling transmitted to an operator's hand is very important. An operator relies greatly on the feeling. However, the base placement portion **36** of the handle member **33** serving as a hand-held portion has a certain shape. Some operators may find the diameter of the hand-held portion unfit for their hands.

[0257] According to the present embodiment, as shown in **FIG. 39**A, an elastic member **121** is included in an armor of the base placement portion **36** also serving as a hand-held portion. The elastic member **121** is clamped by a main placement portion **122** and an adjustment knob **124** capable of sliding along a screw **123** threaded on the end of the main placement portion **122**.

[0258] As shown in **FIG. 39**B, when the adjustment knob **124** is screwed on, the elastic member **121** is crushed due to the adjustment knob **124** and main placement portion **122**. This causes the outer diameter of the elastic member **121** to expand. When the adjustment knob **124** is screwed off, the elastic member **121** is restored.

[0259] In other words, when the adjustment knob is screwed on or off relative to the main placement portion, the elastic member is dilated or shrunken. Thus, the diameter of the handle member can be made fit for an operator's hand. Consequently, firm holding of the hand-held portion is ensured and maneuverability is improved.

[0260] When a tomographic image of a region near a region to be treated is produced, if a brain shift derived from craniotomy is overcome, an ultrasonic image can be superposed on a diagnostic image preoperatively produced through CT or MRI. A structure required for this purpose will be described below.

[0261] As shown in **FIG. 40**A and **FIG. 40B, a** marker member having markers that will be described later is included in the handle member **33** of the observation body **3**. Moreover, a navigation body head (hereinafter a body head) having two cameras **134** that follows the marker member is installed at an end of an operating table, on which a patient lies down, near the patient's feet by way of an arm member **131**. The arm member **131** has a position adjustment mechanism **132** for adjusting the orientation of the body head **130**.

[0262] As shown in **FIG. 41, a** marker member **135** having a first marker **136**, a second marker **137**, and a third marker **138** arranged thereon is freely detachably attached to the proximal part of the handle member **33** using, for example, a locking screw **139**.

[0263] The markers **136**, **137**, and **138** that move along with the movement of the handle member **33** are followed by the cameras **134**. The coordinates representing the positions of the markers **136**, **137**, and **138** followed by the cameras **134** are arithmetically processed by a CPU included in a position measuring apparatus that is not shown. As shown in **FIG. 42, a** scanned plane index **142** and a probe index **143** are superimposed on a diagnostic image **141** produced by, for example, MRI and displayed on a screen **140** of a monitor. The scanned plane index **142** expresses the position of a scanned plane represented by an ultrasonic image and calculated through arithmetic operations performed by the CPU. The probe index **143** expresses the direction of insertion of the microscopic probe. An ultrasonic image **145** may be displayed adjacently to the diagnostic image. Consequently, the positional relationship between the ultrasonic probe and a region to be treated can be grasped accurately.

[**0264**] According to the present embodiment, an optical following system having the cameras mounted on the body head is used to measure the position of the handle member. The following system is not limited to the optical type system but may be of a magnetic type or an ultrasonic type.

[**0265**] Surgeons want to ultrasonically observe a lesion deeply located below the observed surface of a region during surgery and perform simple treatment.

[**0266**] According to the present embodiment, therefore, a first gear **151** is fixed to a predetermined point on the flexible shaft **22** that conveys driving torque to the housing **28** accommodating the ultrasonic transducer **29**. Moreover, a second gear **152** that meshes with the first gear **151** is fixed to a shaft member **154** supported by a pair of bearings **153**. A cutter **155** used to scrape and remove a tumor or the like is fixed together with the second gear **152** onto the shaft member **154**. Part of the cutter **155** is bared on the outer surface of the observation body.

[**0267**] As shown in **FIG. 43**B, for treating a lesion using the cutter **155**, the flexible shaft **22** is withdrawn proximally to cause the first gear **151** to mesh with the second gear **152**. The flexible shaft **22** is then rotated. Consequently, driving torque is conveyed to the second gear **152** via the first gear **151**. This causes the cutter **155** to rotate to achieve treatment.

[**0268**] Assume that the ultrasonic transducer **29** is rotated in order to perform ultrasonic examination and a tumor or the like is identified on the wall of a lumen. In this case, the flexible shaft **22** is withdrawn proximally by manipulating a specific component formed near an operator's hand in order to mesh the first gear with the second gear **152**. The flexible shaft **22** is then rotated. Consequently, the second gear **152** meshed with the first gear **151** is rotated, the shaft member **154** is rotated, and the cutter **155** is rotated. Eventually, the intended tumor or the like can be scraped.

[**0269**] Reference numeral **156** denotes an O ring for holding the flexible shaft **22** and sealing in a watertight manner a clearance around the periphery of the flexible shaft **22**.

[**0270**] According to the present invention, it is apparent that a wide range of different embodiments can be constructed based on the invention without a departure from the spirit and scope of the invention. This invention will be limited by the appended claims but not be restricted by any specific embodiments.

What is claimed is:

1. An ultrasonic probe for microscopic operations comprising:

an ultrasonic probe body having a transducer assembly attached to the distal end of a soft elongated tube that is extended from a connector to be coupled to an ultrasonic observation apparatus, and having a coupler mounted on the tube;

an elongated tubular member through which said transducer assembly and tube are passed, and a bent handle member attached to the proximal end of said tubular member and includes a coupling mechanism for use in coupling said coupler to the handle member so that said coupler can be uncoupled freely.

2. An ultrasonic probe for microscopic operations usable for cerebral surgery comprising:

an ultrasonic probe body having a transducer assembly attached to the distal end of a soft elongated tube that is extended from a connector to be coupled to an ultrasonic observation apparatus, and having a base member that serves as a coupler mounted on the middle of the tube; and

an observation body including a linkage pipe through which said transducer assembly and tube are passed, and a bent handle member that is attached to the proximal end of the linkage pipe and that has a base placement portion serving as a hand-held portion and including a coupling mechanism for use in coupling said base member to the handle member so that said base member can be uncoupled freely.

3. An ultrasonic probe for microscopic operations according to claim 2, wherein said transducer assembly is mechanically driven, and composed of an ultrasonic transducer, a housing that accommodates the ultrasonic transducer, a flexible shaft that has one end thereof coupled to the housing, has the other end coupled to said ultrasonic observation apparatus, and conveys driving torque, and a soft tube member with which the flexible shaft is sheathed.

4. An ultrasonic probe for microscopic operations according to claim 2, wherein: said transducer assembly is electronically driven, and composed of a plurality of transducer elements arranged regularly, and a signal cable having signal lines sheathed with a soft tube member; and the signal lines are extended from the plurality of transducer elements, coupled to said ultrasonic observation apparatus, and used to transmit or receive electric signals.

5. An ultrasonic probe for microscopic operations according to claim 3, wherein: said observation body includes a linkage pipe having an ultrasound transmissive cap, which has a space in which said housing fixed to the distal end of said flexible shaft is placed, attached to the distal end thereof; a pipe placement portion in which the proximal part of the linkage pipe is locked is formed as one end portion of said handle member; and a base placement portion which serves as a hand-held portion and in which said base member is placed is formed as the other end portion of said handle member.

6. An ultrasonic probe for microscopic operations according to claim 3, wherein: said observation body includes a linkage pipe having a distal opening through which said transducer assembly is jutted out; a pipe placement portion in which the proximal part of the linkage pipe is locked is formed as one end portion of said handle member; and a base placement portion which serves as a hand-held portion and in which said base member is placed is formed as the other end portion of said handle member.

7. An ultrasonic probe for microscopic operations according to claim 5, wherein: said observation body includes a pipe placement hollow which is bored in said pipe placement portion and in which the proximal part of said linkage pipe is locked, and a base placement hollow which is bored in said base placement portion and in which said base member is placed; said pipe placement hollow and said base placement hollow have such a positional relationship that the centerlines (axes) thereof are uneven, and are linked by a sloping hollow.

8. An ultrasonic probe for microscopic operations according to claim 6, wherein: said observation body includes a pipe placement hollow which is bored in said pipe placement portion and in which the proximal part of said linkage pipe is locked, and a base placement hollow which is bored in said base placement portion and in which said base member is placed; said pipe placement hollow and said base placement hollow have such a positional relationship that the centerlines (axes) thereof are uneven, and are linked by a sloping hollow.

9. An ultrasonic probe for microscopic operations according to claim 5, wherein said observation body includes a locking member used to lock said base member, which is placed in said base placement hollow, at a predetermined position so that said base member can be unlocked freely.

10. An ultrasonic probe for microscopic operations according to claim 6, wherein said observation body includes a locking member used to lock said base member, which is placed in said base placement hollow, at a predetermined position so that said base member can be unlocked freely.

11. An ultrasonic probe for microscopic operations according to claim 5, wherein at least said ultrasound transmissive cap and handle member are so transparent that their interiors can be discerned.

12. An ultrasonic probe for microscopic operations according to claim 5, wherein said ultrasound transmissive cap included in said observation body is freely detachably attached to said linkage pipe.

13. An ultrasonic probe for microscopic operations according to claim 12, wherein said ultrasound transmissive cap is shaped differently from another ultrasonic transmissive cap so that said ultrasound transmissive cap and another ultrasonic transmissive cap will match different regions to be observed.

14. An ultrasonic probe for microscopic operations according to claim 5, wherein said linkage pipe included in said observation body is a hard pipe shaped straight.

15. An ultrasonic probe for microscopic operations according to claim 6, wherein said linkage pipe included in said observation body is a hard pipe shaped straight.

16. An ultrasonic probe for microscopic operations according to claim 5, wherein said linkage pipe is a shape varying/maintaining pipe capable of being deformed freely and maintaining a changed shape.

17. An ultrasonic probe for microscopic operations according to claim 6, wherein said linkage pipe is a shape varying/maintaining pipe capable of being deformed freely and maintaining a changed shape.

18. An ultrasonic probe for microscopic operations according to claim 14, wherein said straight-shaped hard pipe lies substantially parallel to the centerline (axis) of said base placement portion.

19. An ultrasonic probe for microscopic operations according to claim 15, wherein said straight-shaped hard pipe lies substantially parallel to the centerline (axis) of said base placement portion.

20. An ultrasonic probe for microscopic operations according to claim 14, wherein said straight-shaped hard pipe and the centerline (axis) of said base placement portion meets at an angle θ.

21. An ultrasonic probe for microscopic operations according to claim 14, wherein said straight-shaped hard pipe and the centerline (axis) of said base placement portion meets at an angle θ.

22. An ultrasonic probe for microscopic operations according to claim 5, wherein the weight of said observation body ranges 10 g to 50 g.

23. An ultrasonic probe for microscopic operations according to claim 6, wherein the weight of said observation body ranges 10 g to 50 g.

24. An ultrasonic probe for microscopic operations according to claim 5, the overall length of said observation body ranges from 200 mm to 270 mm.

25. An ultrasonic probe for microscopic operations according to claim 6, the overall length of said observation body ranges from 200 mm to 270 mm.

26. An ultrasonic probe for microscopic operations according to claim 3, wherein said ultrasound transmissive cap has a reflecting mirror surface, which is inclined substantially 45° and realized with an ultrasonic mirror for reflecting ultrasonic waves, opposed to the lateral surface of said rotating ultrasonic transducer.

27. An ultrasonic probe for microscopic operations according to claim 2, wherein a fluid supply channel through which a fluid is supplied and a suction channel through which a fluid is sucked are included in said observation body.

28. An ultrasonic probe for microscopic operations according to claim 2, wherein depth indices used to notify a user of a length of insertion by which said ultrasonic probe has been inserted, and a scanned plane index used to notify a user of the position of a scanned forward plane are marked on said observation body.

29. An ultrasonic probe for microscopic operations according to claim 3, wherein a thick portion that helps orient a distal cap is formed as part of the distal cap linked to the distal end of said handle member.

30. An ultrasonic probe for microscopic operations according to claim 3, wherein a reflector that helps orient said transducer assembly is located in front of the radiating surface of said transducer assembly, or a fluid supply channel or a suction channel is extended to have the distal end thereof located near the distal end of said transducer assembly.

31. An ultrasonic probe for microscopic operations according to claim 4, wherein a reflector that helps orient said transducer assembly is located in front of the radiating surface of said transducer assembly, or a fluid supply channel or a suction channel is extended to have the distal end thereof located near the distal end of said transducer assembly.

32. An ultrasonic probe for microscopic operations according to claim 3, wherein said flexible shaft is composed of flexible shafts having different diameters, and one of the flexible shafts, that is, a small-diameter flexible shaft is passed through said observation body.

* * * * *

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摘要(译)

根据本发明的用于微观操作的超声探头主要包括超声探头主体，细长管状构件和弯曲手柄构件。超声波探头主体具有连接到软细长管的远端的换能器组件，该软细长管从连接器延伸以连接到超声波观察设备，并且具有安装在其管上的耦合器。换能器组件和管穿过细长管状构件。把手构件连接到管状构件的近端，并包括用于将联接器联接到把手构件的联接机构，使得联接器可以自由地脱开。