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NISHINA et al.

(54) **ULTRASOUND-GUIDED ABLATION METHOD AND ULTRASOUND-GUIDED ABLATION SYSTEM**

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A61B 8/00 (2006.01)

(52) **U.S. Cl.** **600/439**

(57) **ABSTRACT**

An ultrasound-guided ablation method captures an objective area to be ablated in an ultrasound scan area of an ultrasound transducer and delineates the objective area on an ultrasound image; specifies an ablation target area to display the ablation target area with a margin necessary for ablating the objective area on the ultrasound image processed by an ultrasound observation device and displayed on a display device; ablates, by an ablation device, the ablation target area displayed on the ultrasound image; and checks, on the ultrasound image, that an ablated area ablated by the ablation device has reached the ablation target area displayed on the ultrasound image.

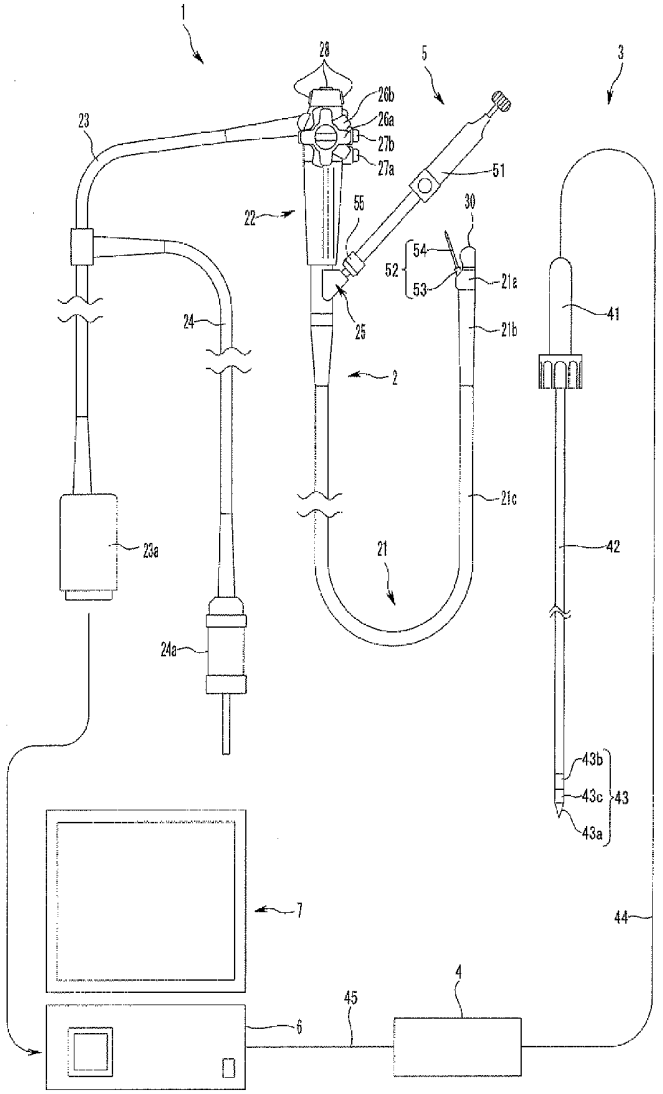

FIG. 1

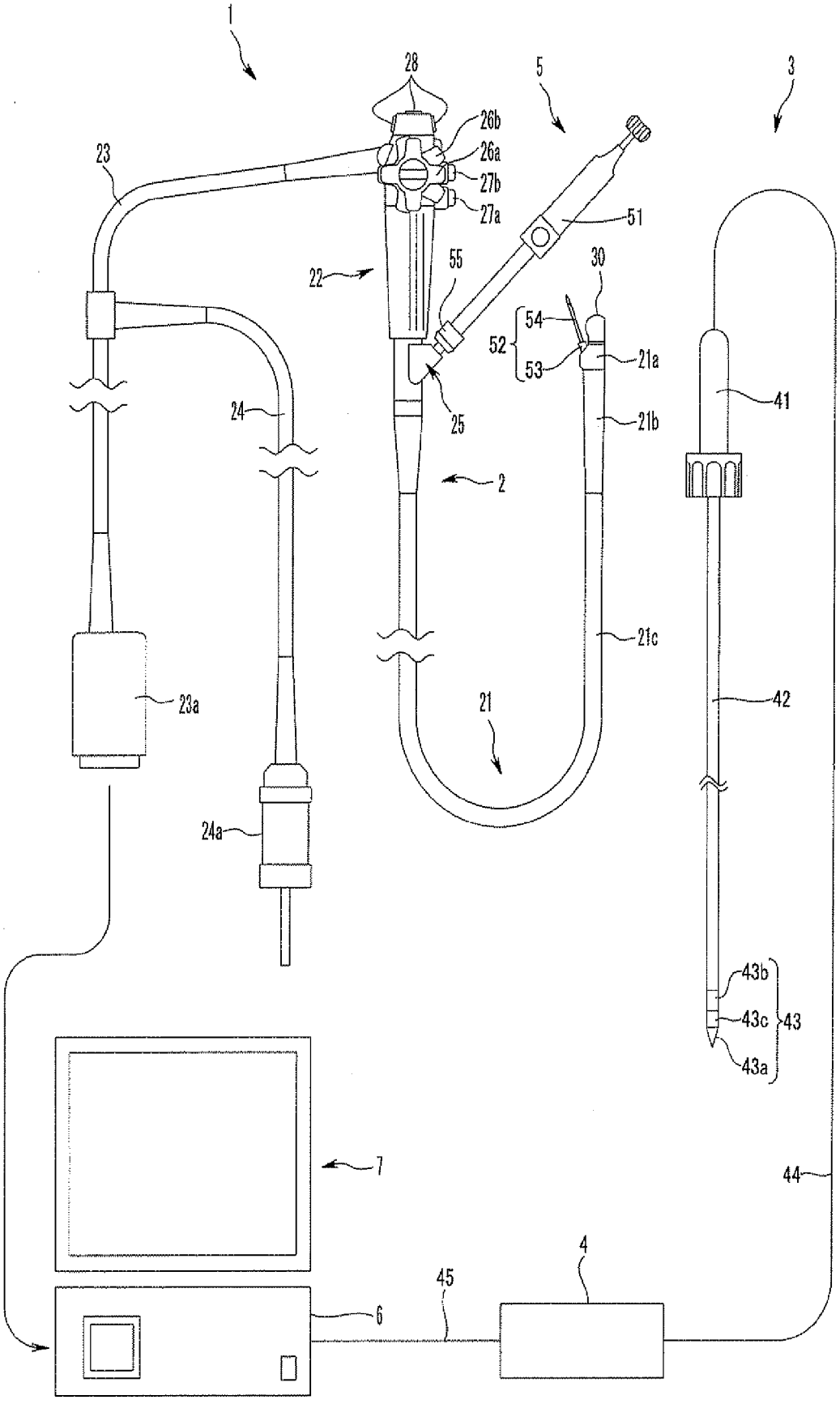
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FIG.2

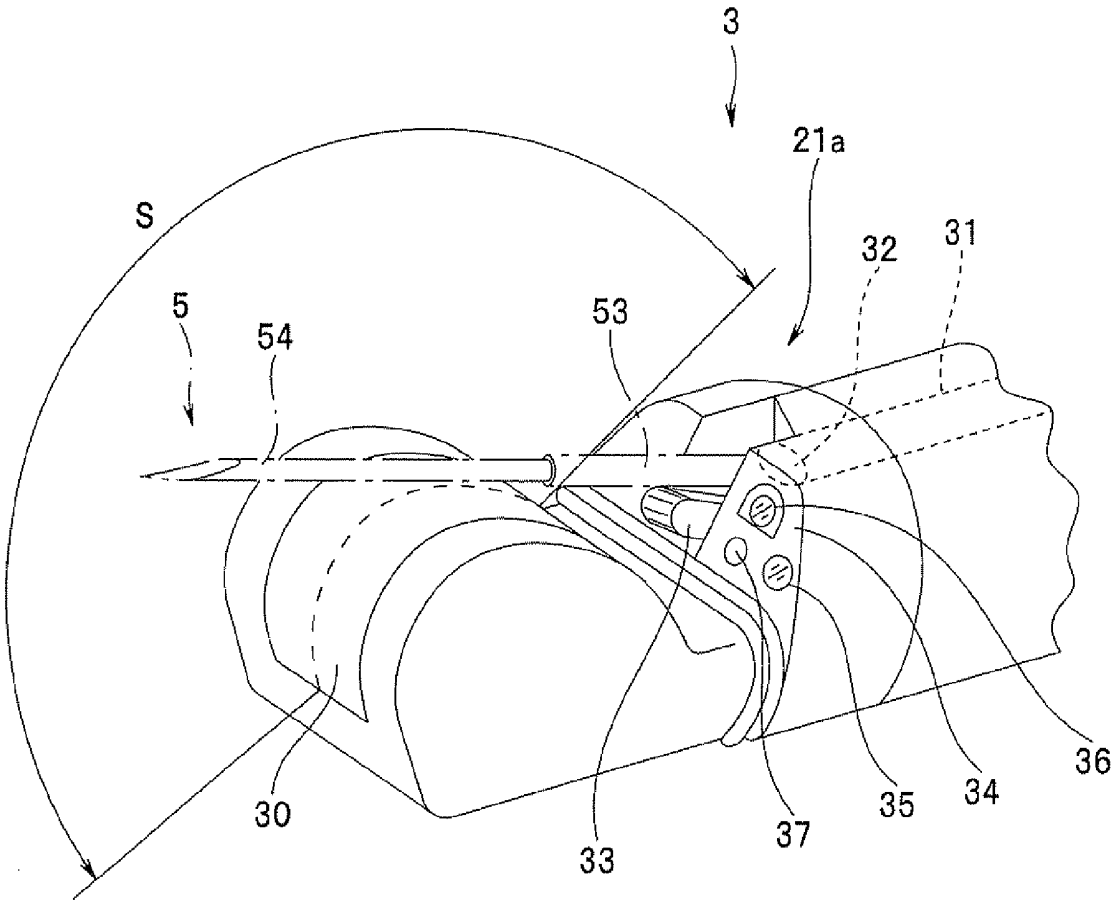


FIG. 3

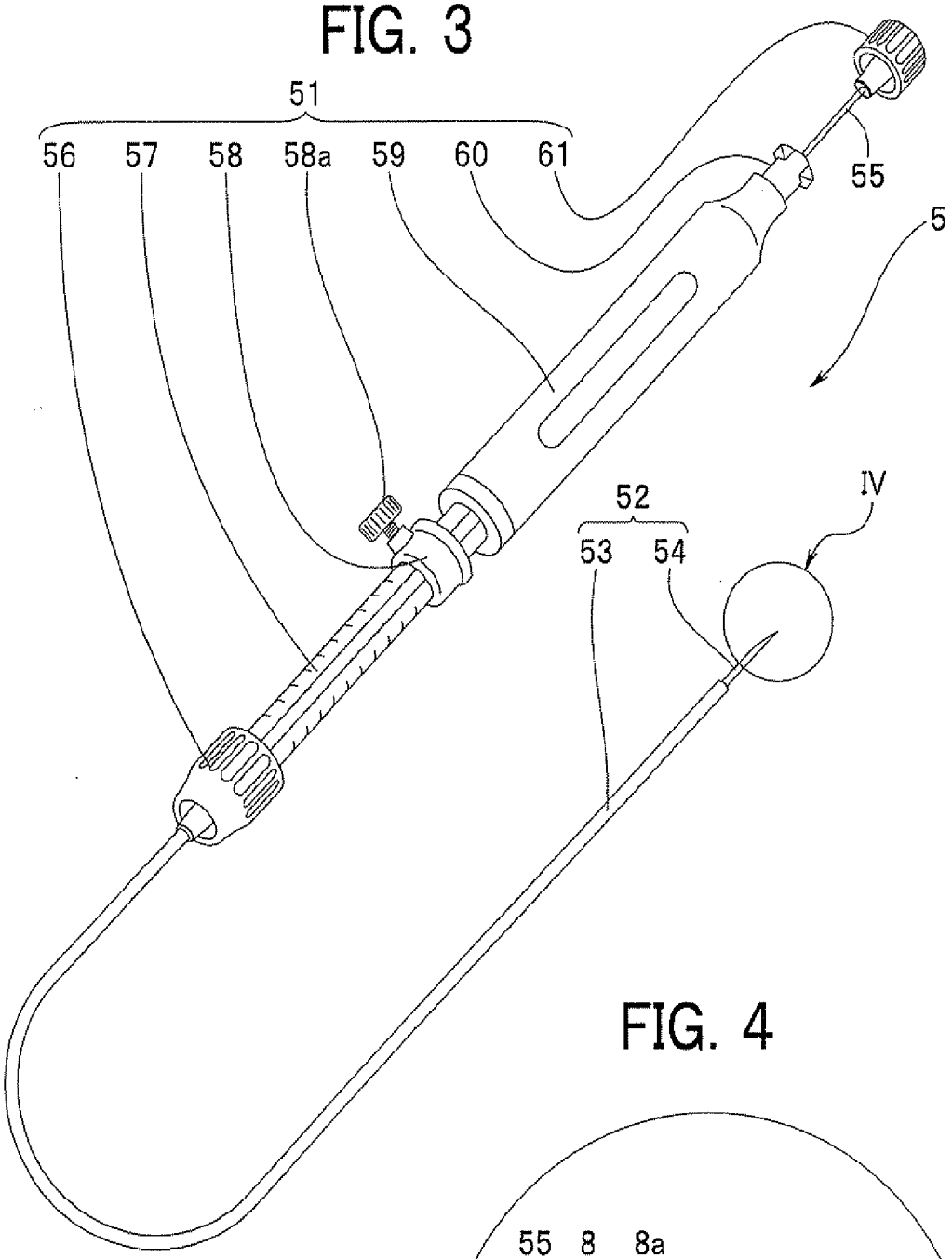


FIG. 4

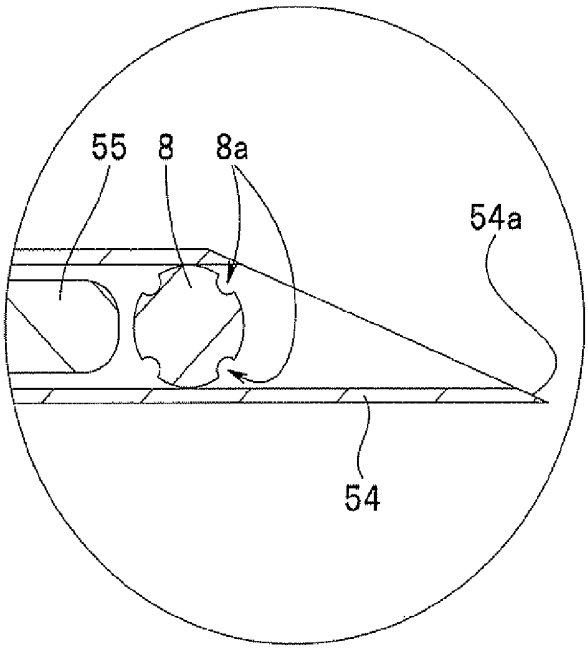


FIG. 5

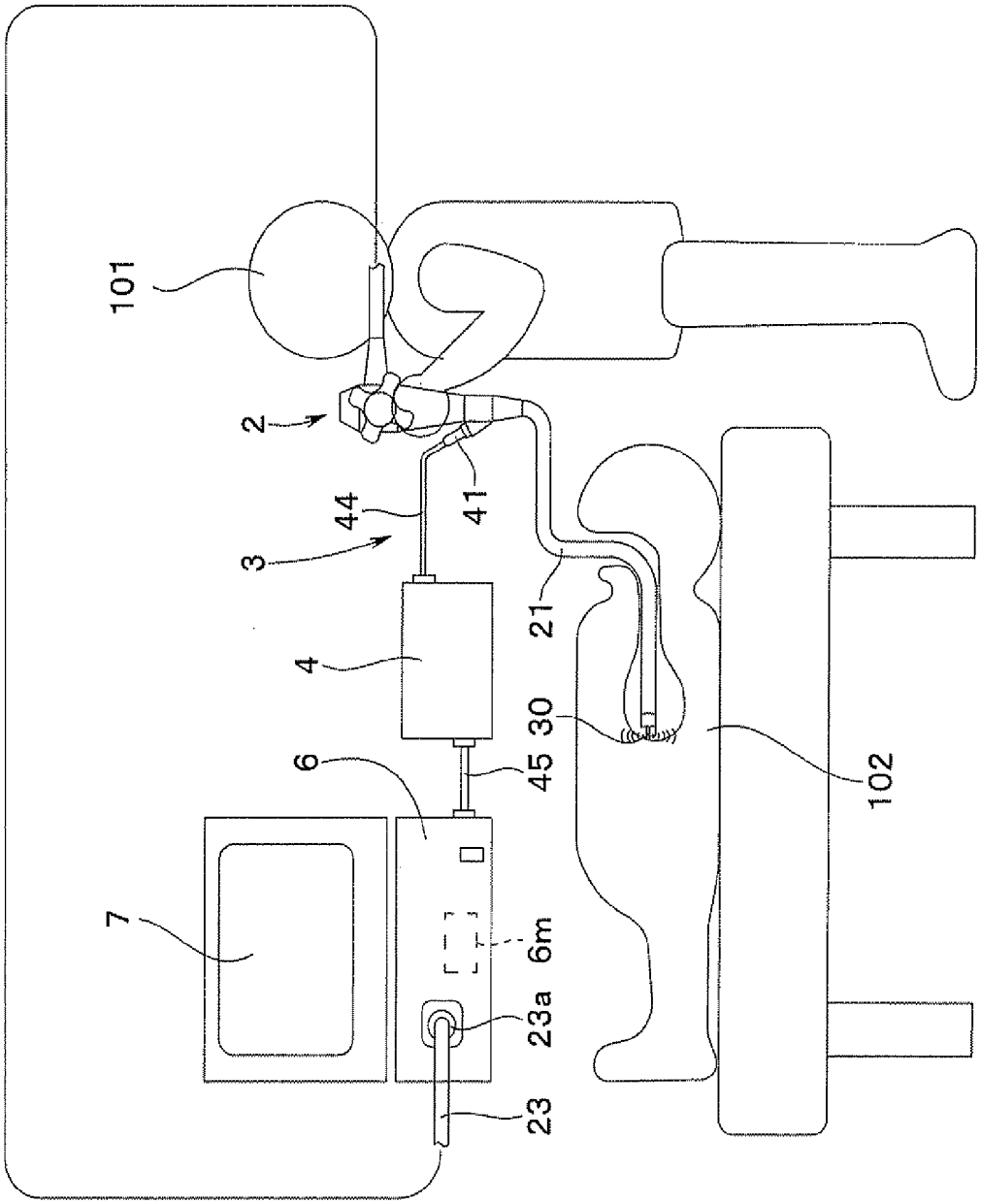


FIG. 6

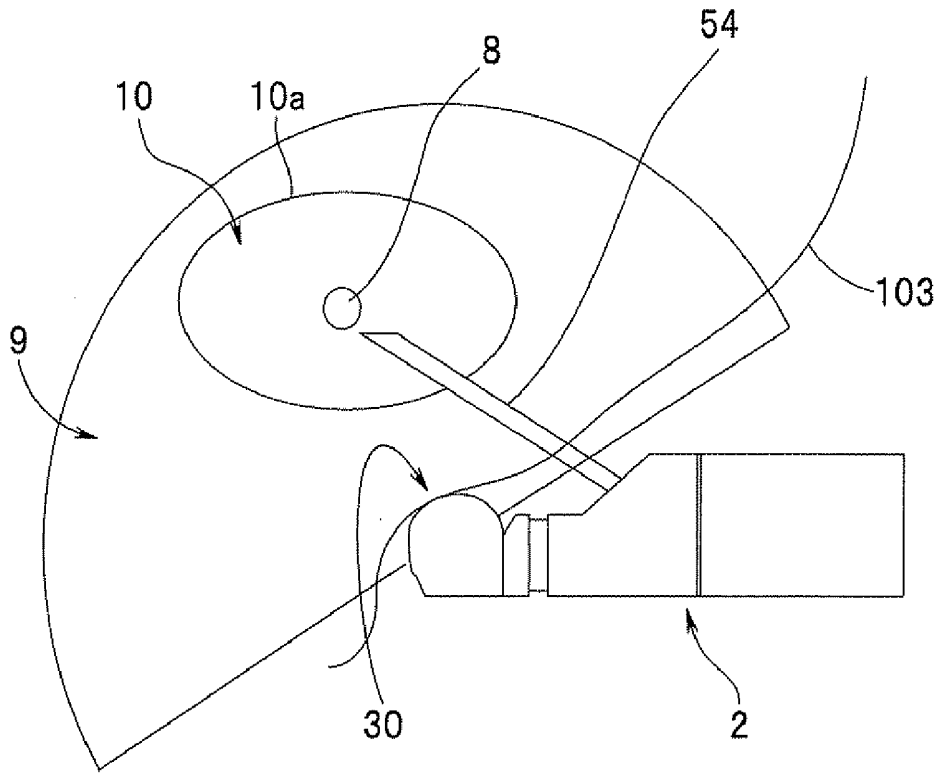


FIG. 7

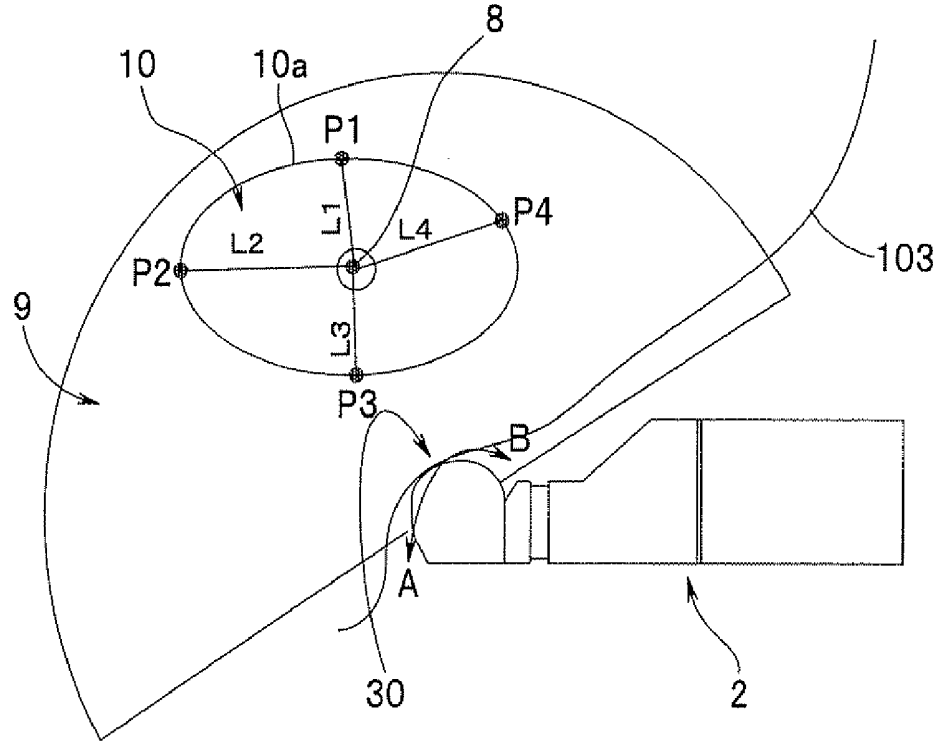
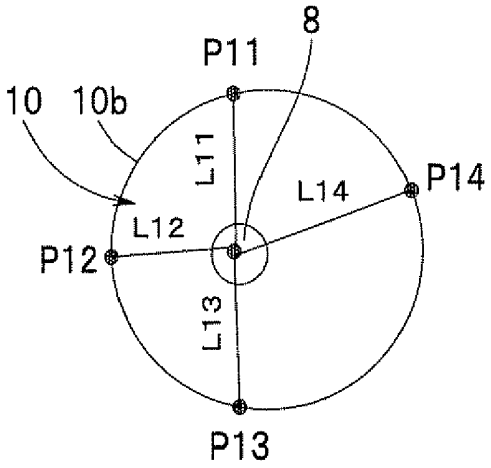


FIG. 8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P11
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FIG. 9

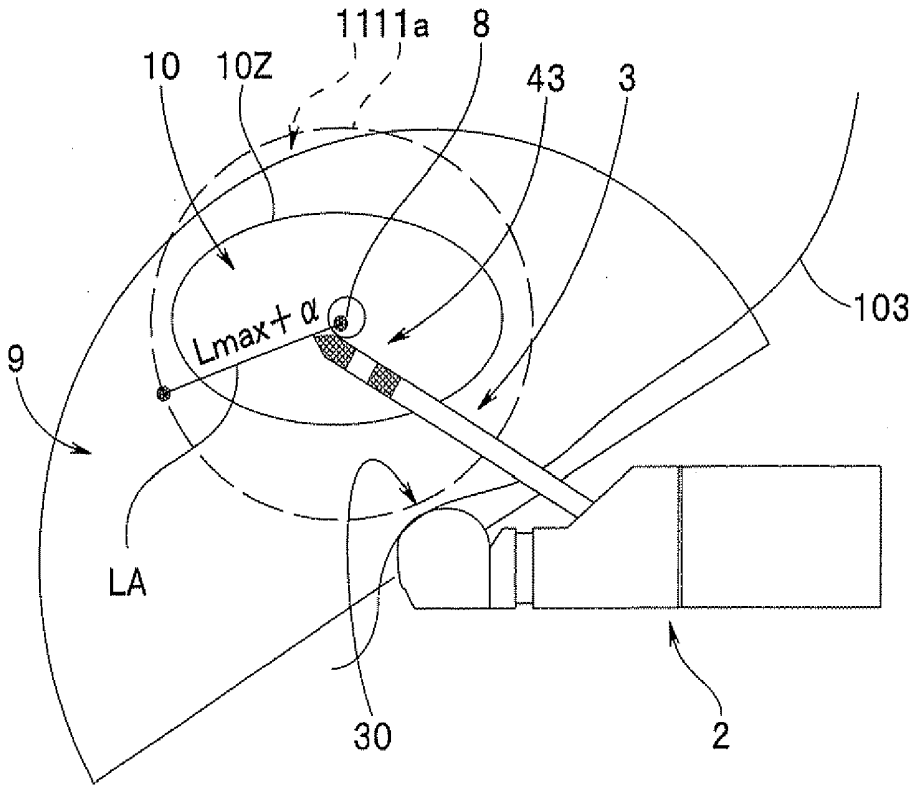
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FIG. 10

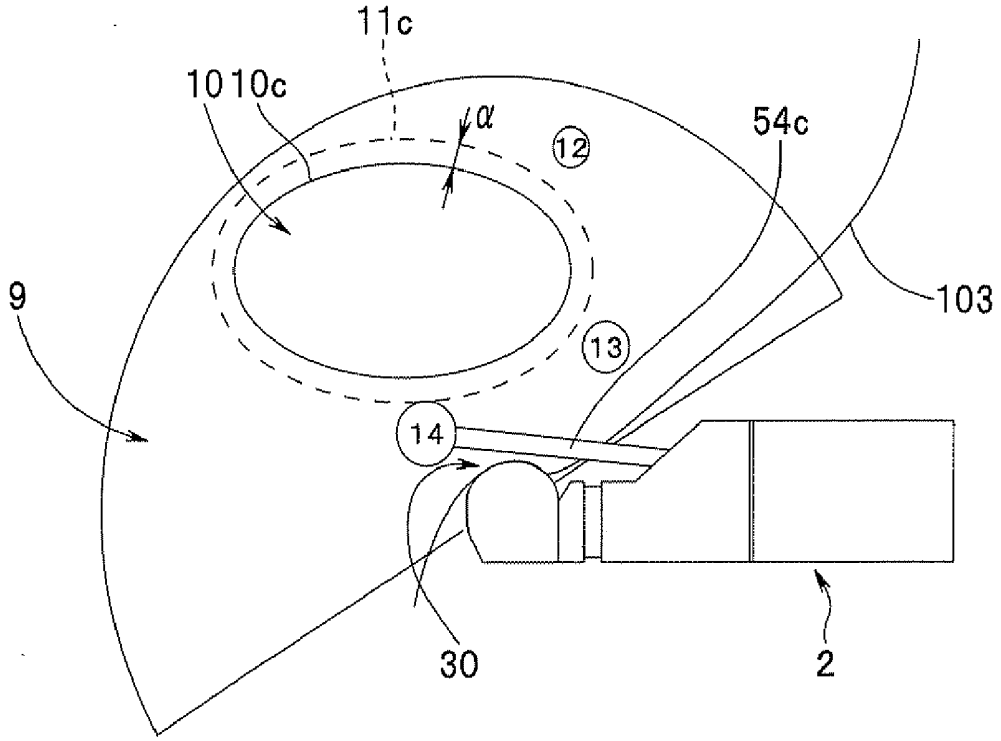
11c
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FIG. 11

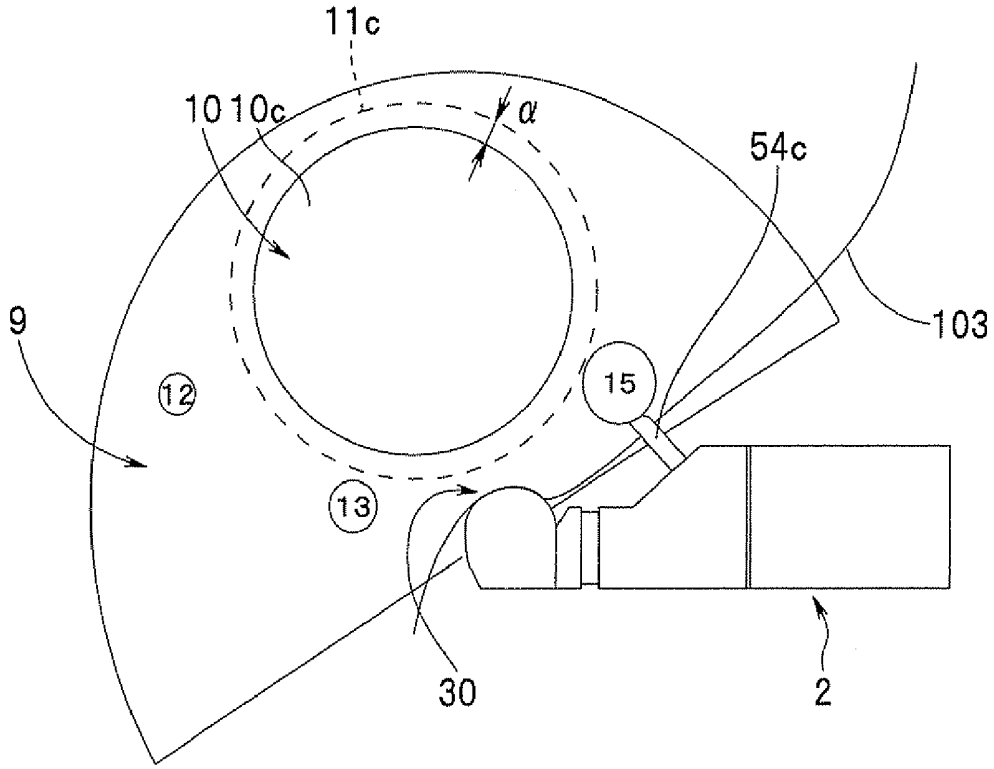
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FIG. 12

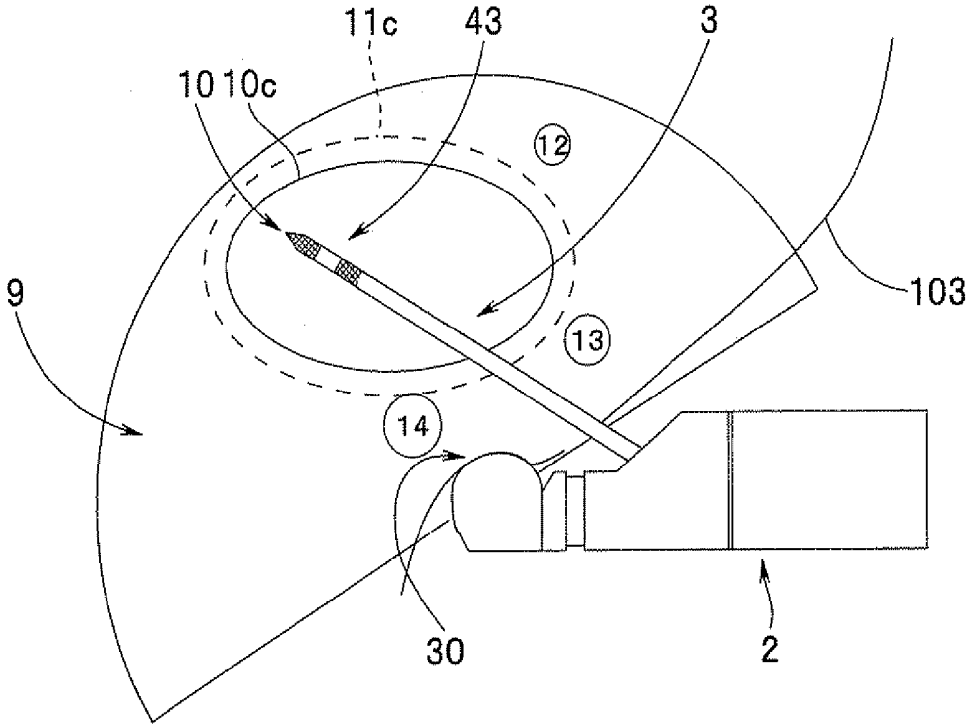


FIG. 13

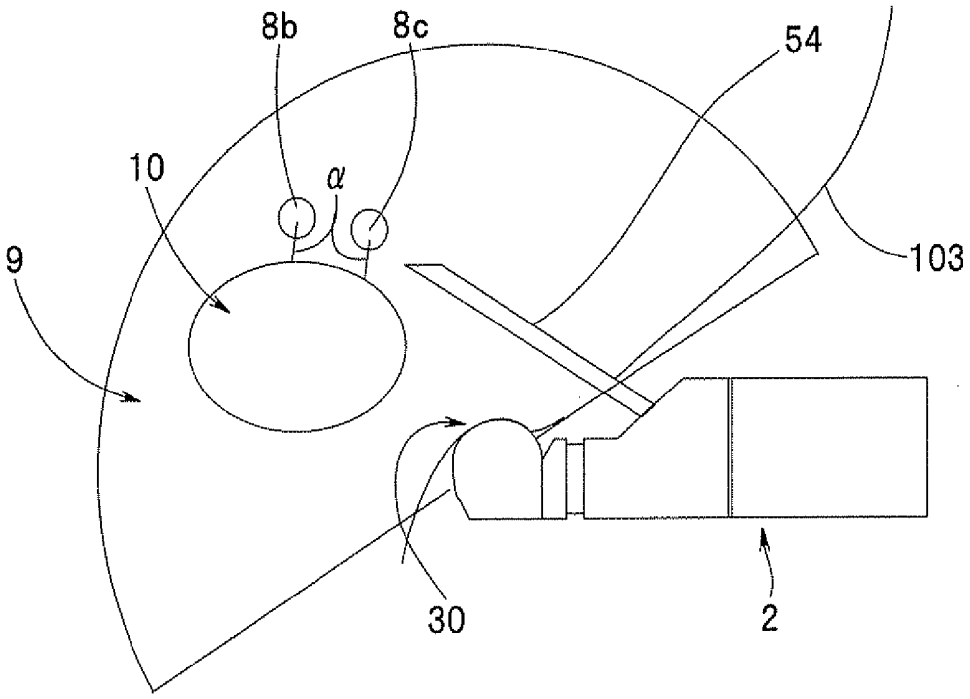


FIG. 14

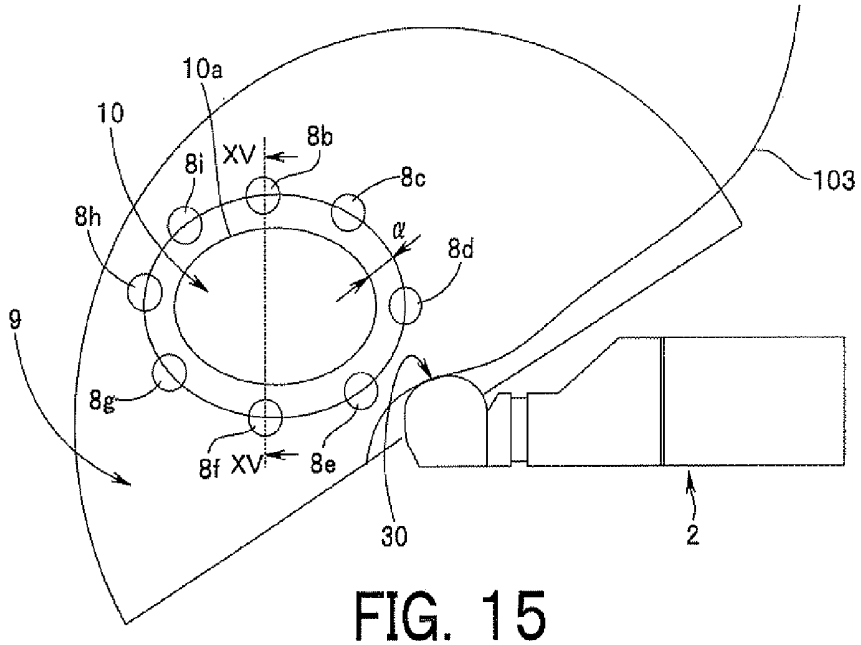


FIG. 15

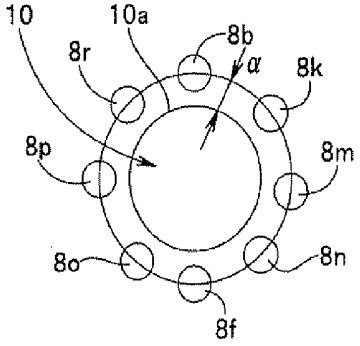


FIG. 16A

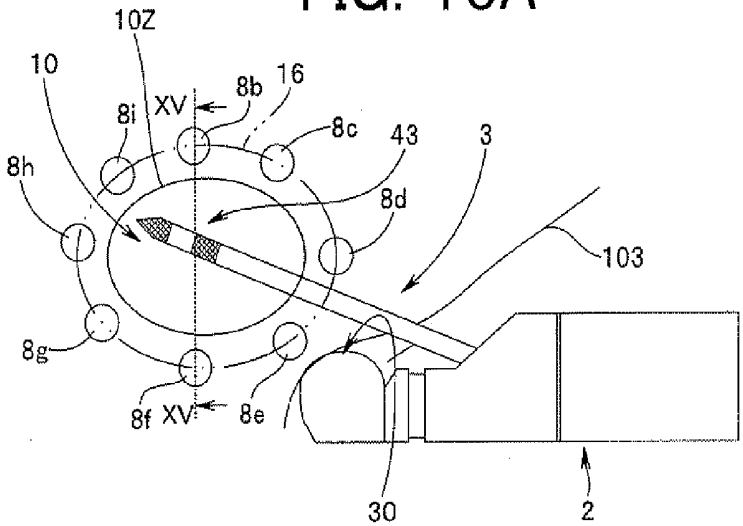


FIG. 16B

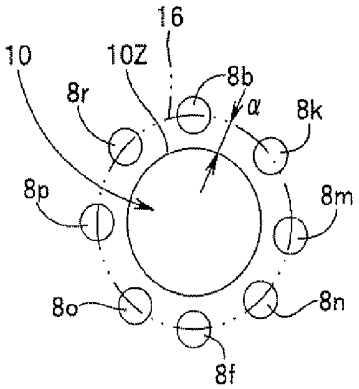
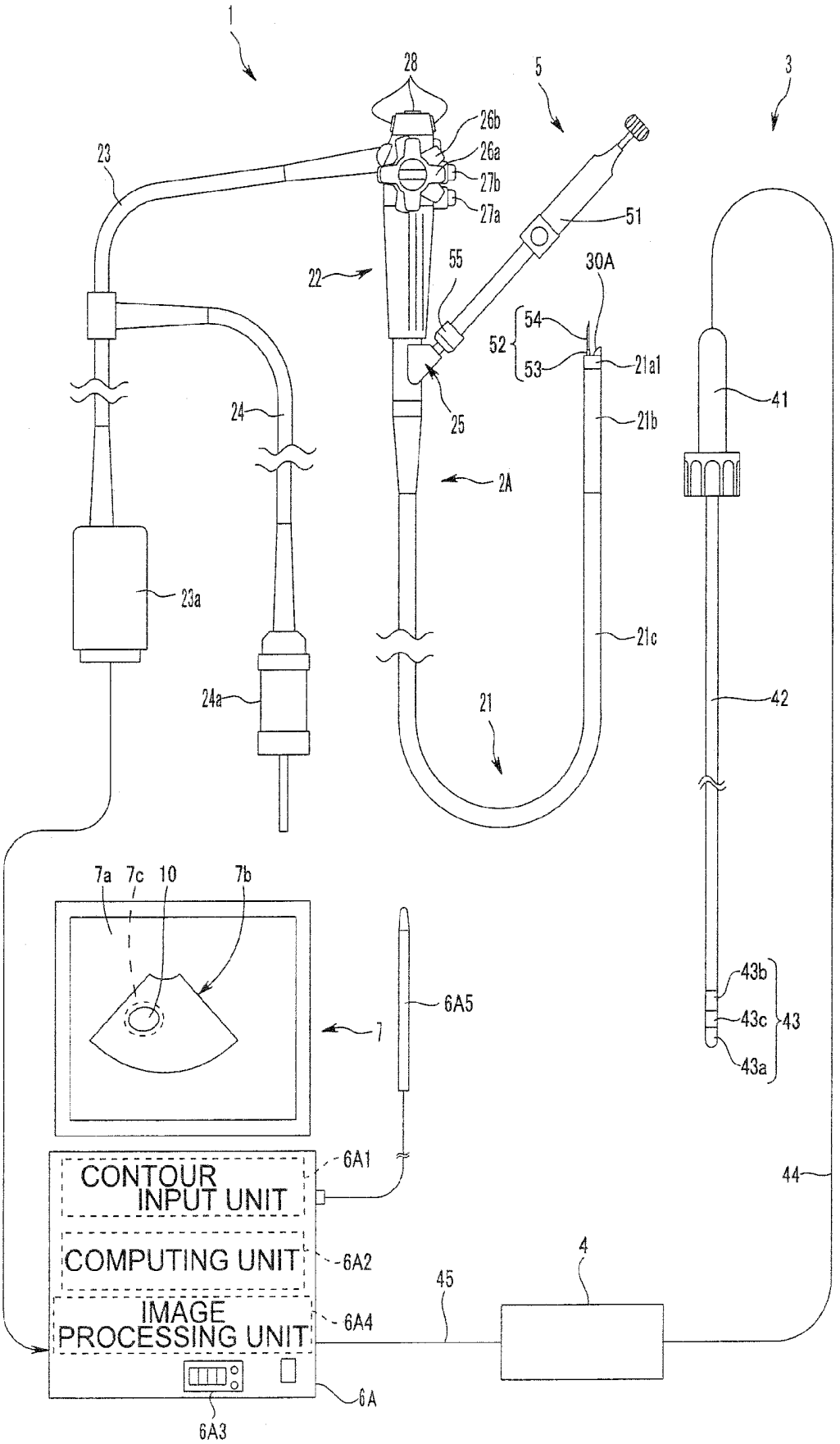


FIG. 17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6A5
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COMPUTING UNIT
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IMAGE PROCESSING UNIT
6A4
6A
6A3

FIG. 18

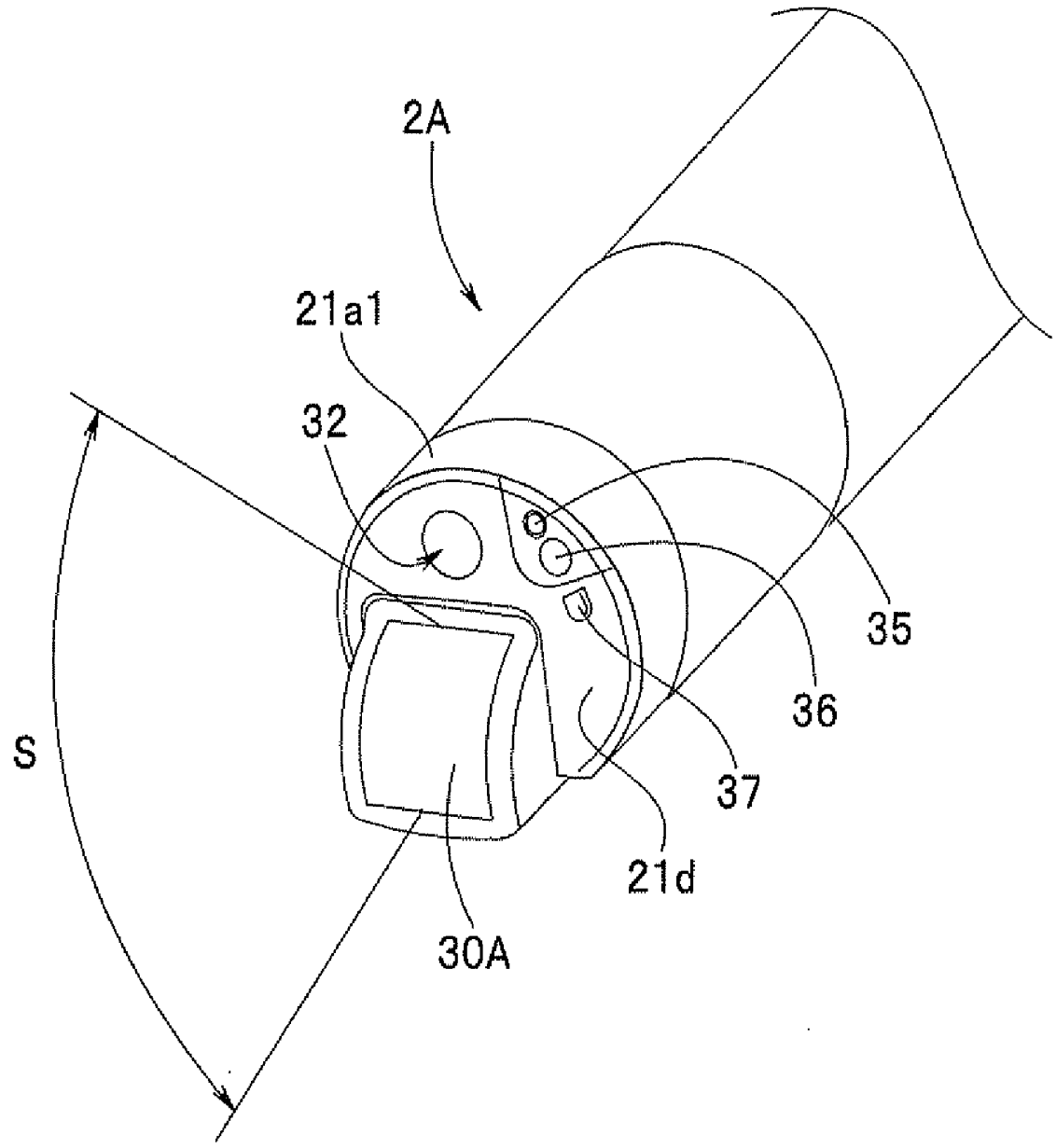
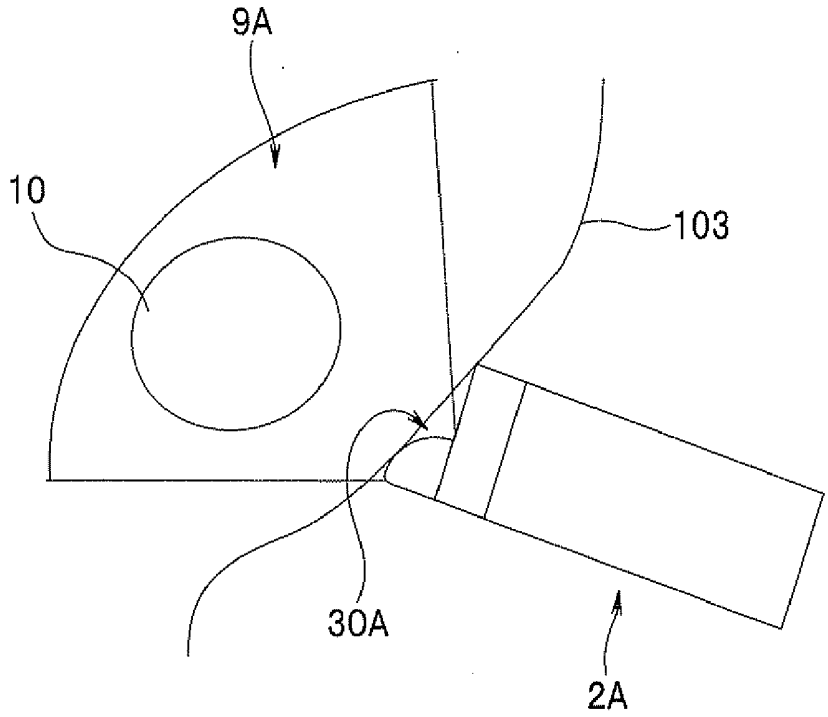


FIG.19



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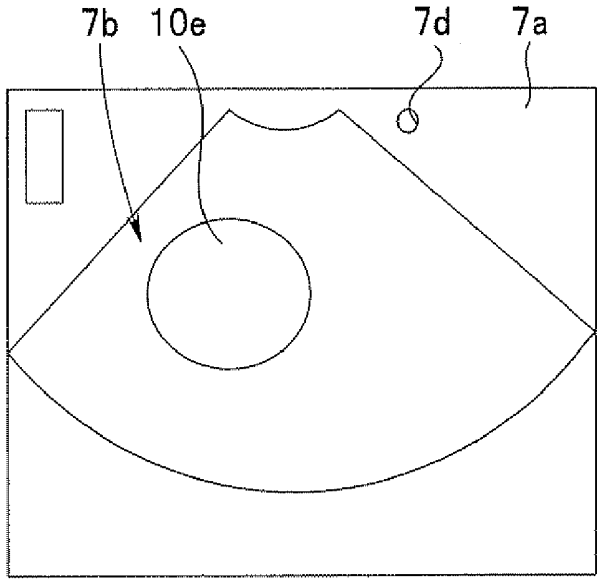


FIG.21

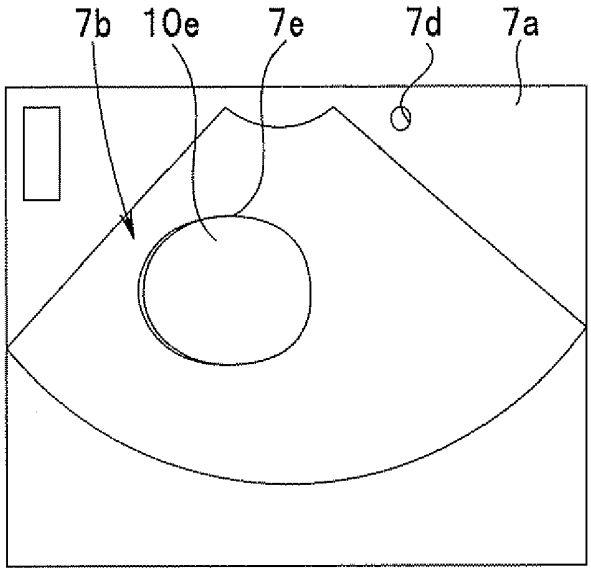
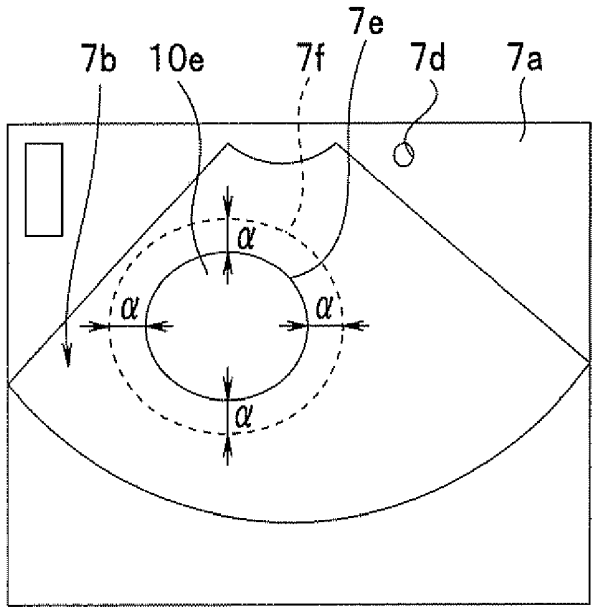


FIG.22



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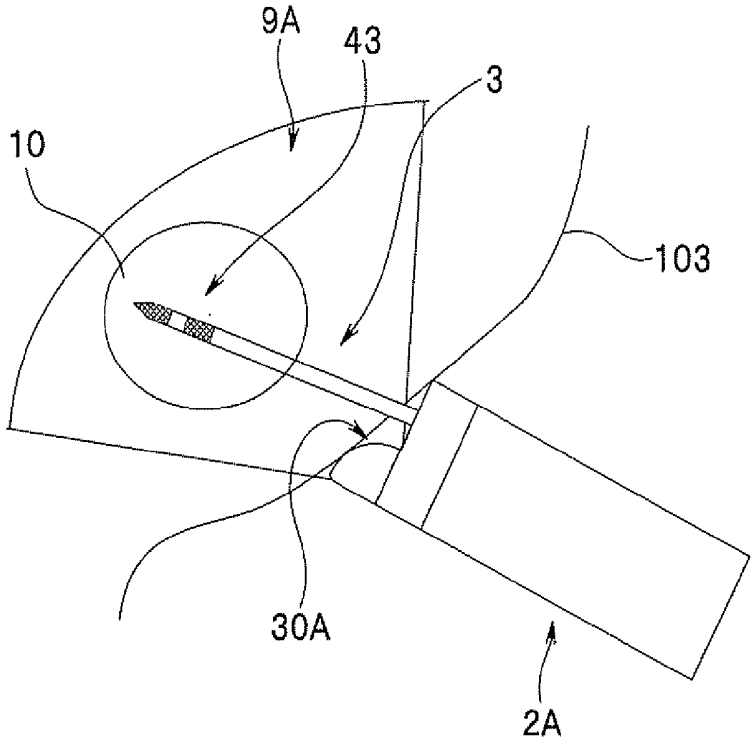


FIG.24

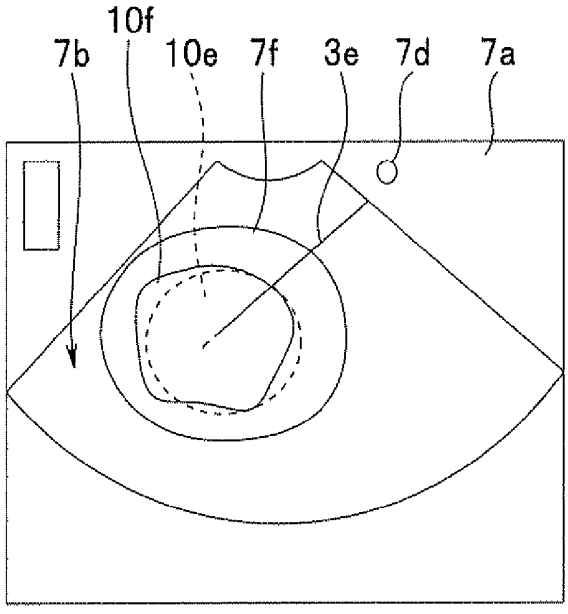


FIG. 25

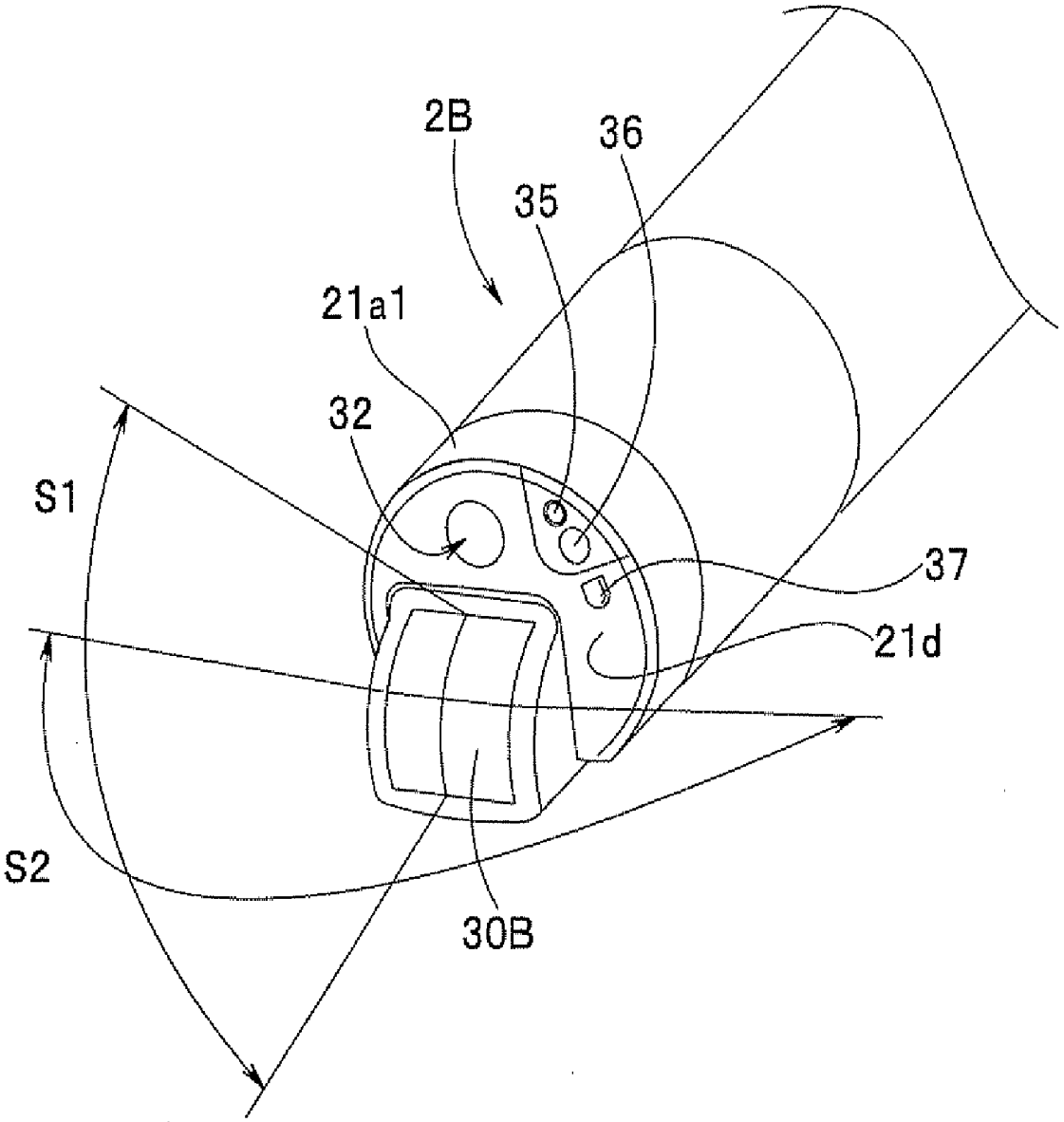


FIG.26

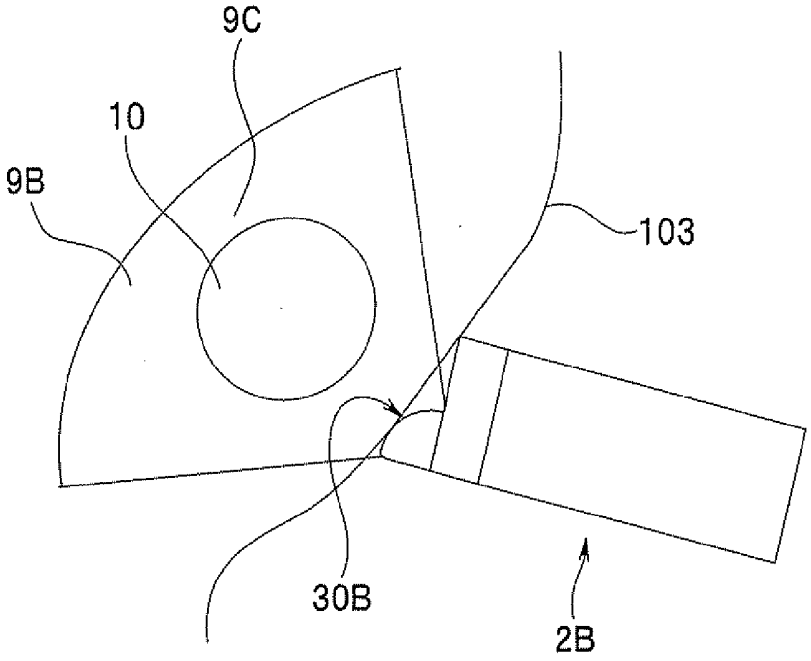


FIG.27

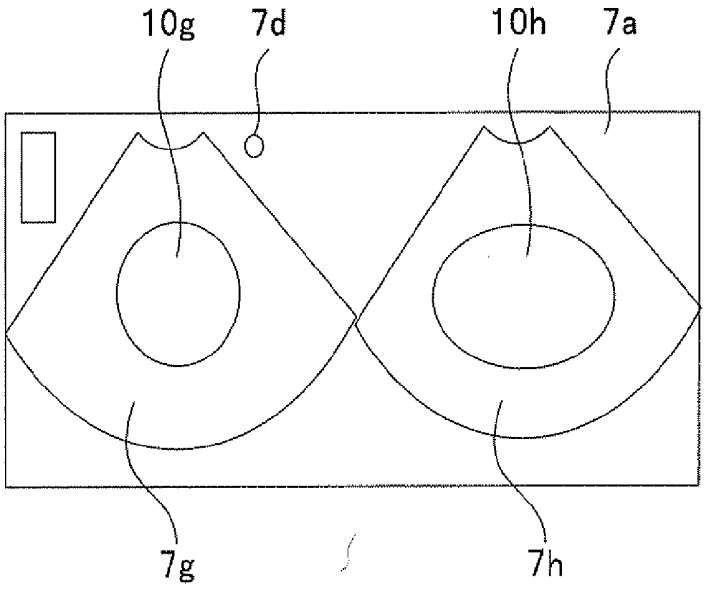


FIG.28

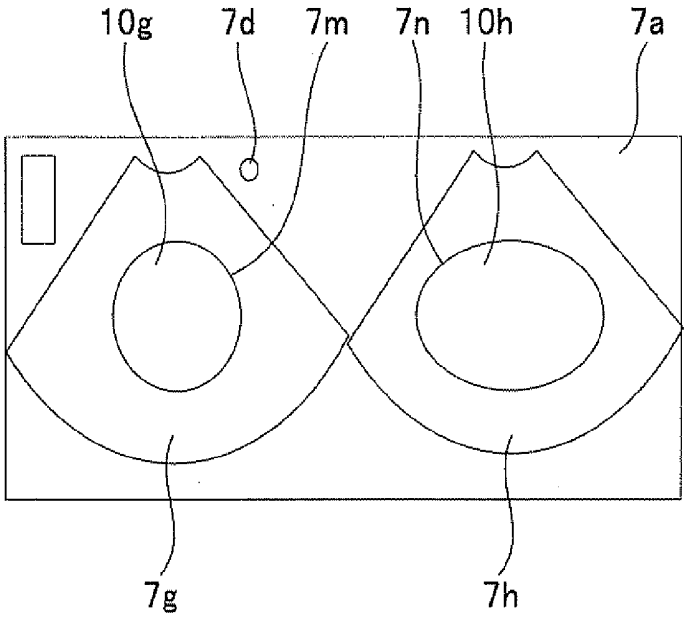


FIG.29

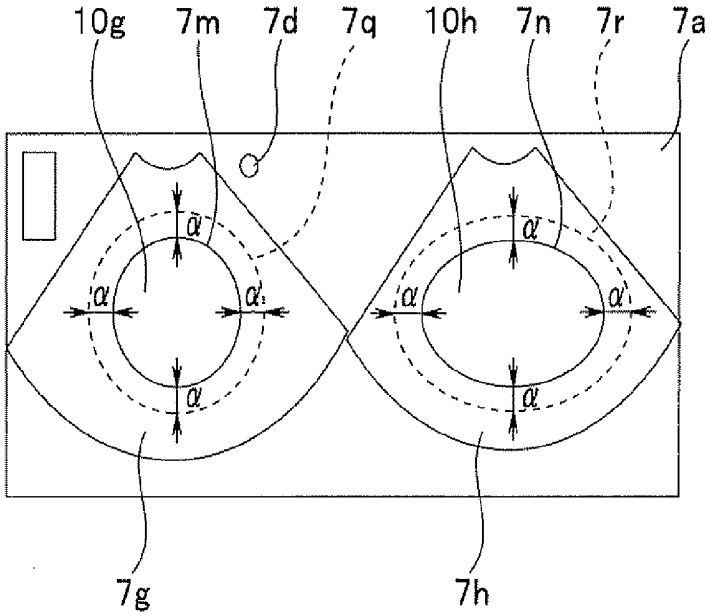


FIG.30

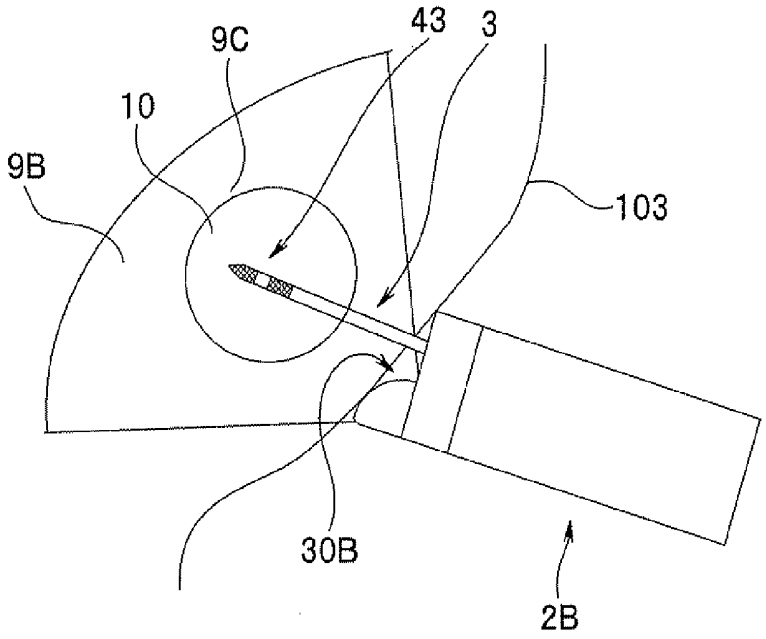


FIG.31

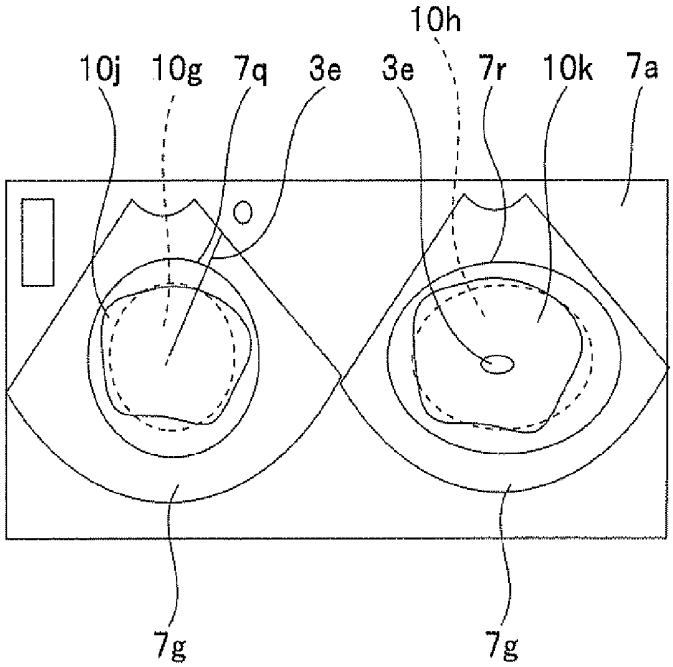


FIG.32

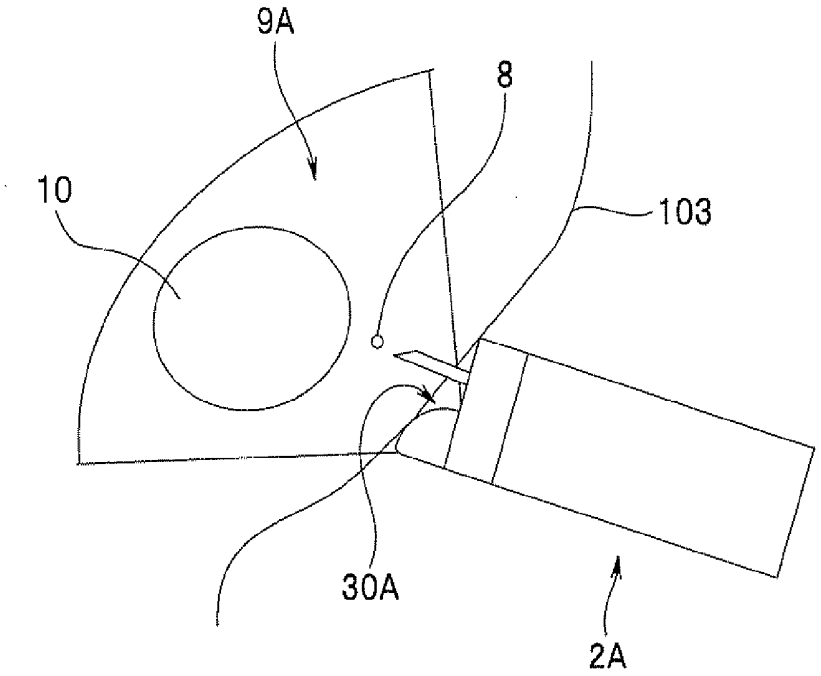


FIG.33

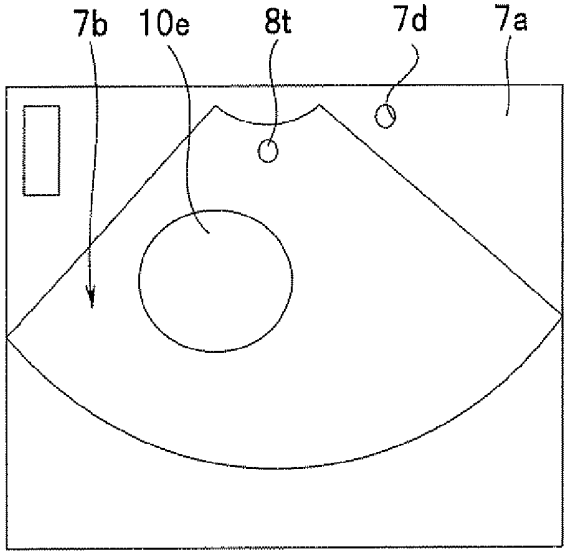


FIG.34

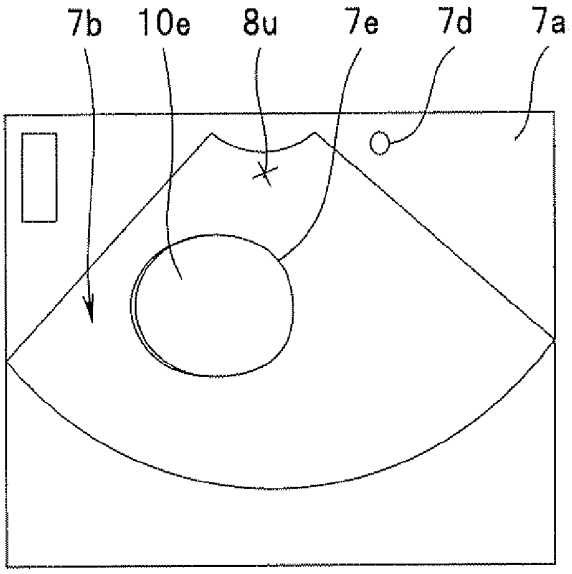


FIG.35

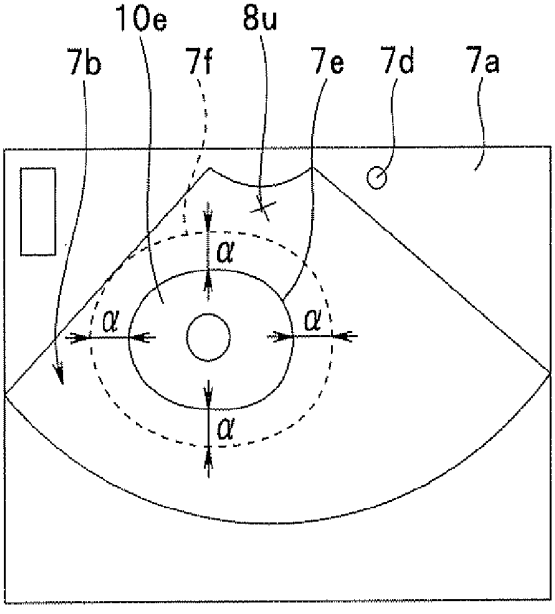


FIG.36

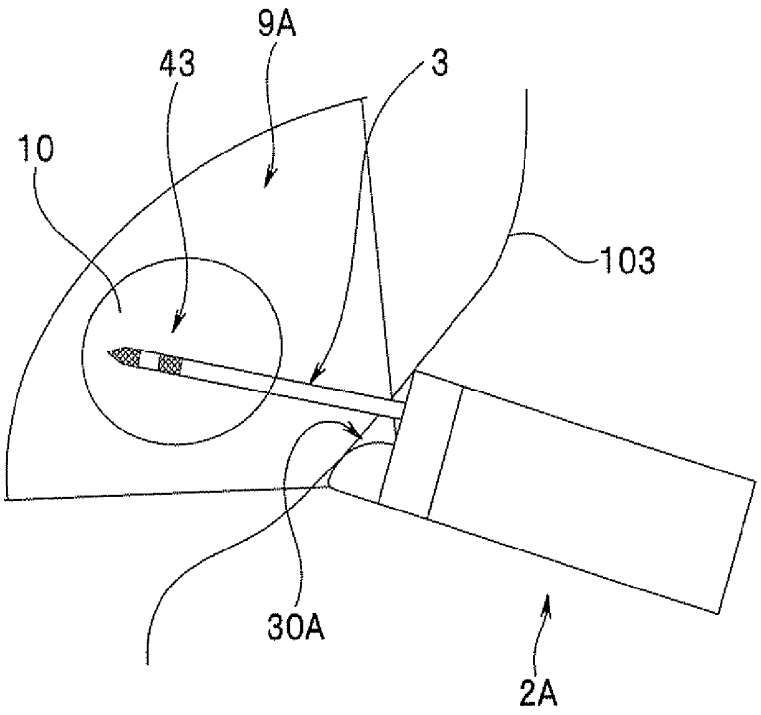


FIG.37

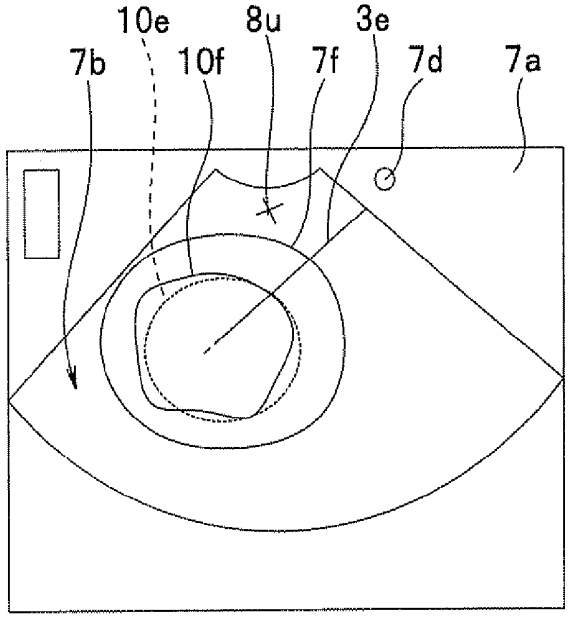


FIG. 38

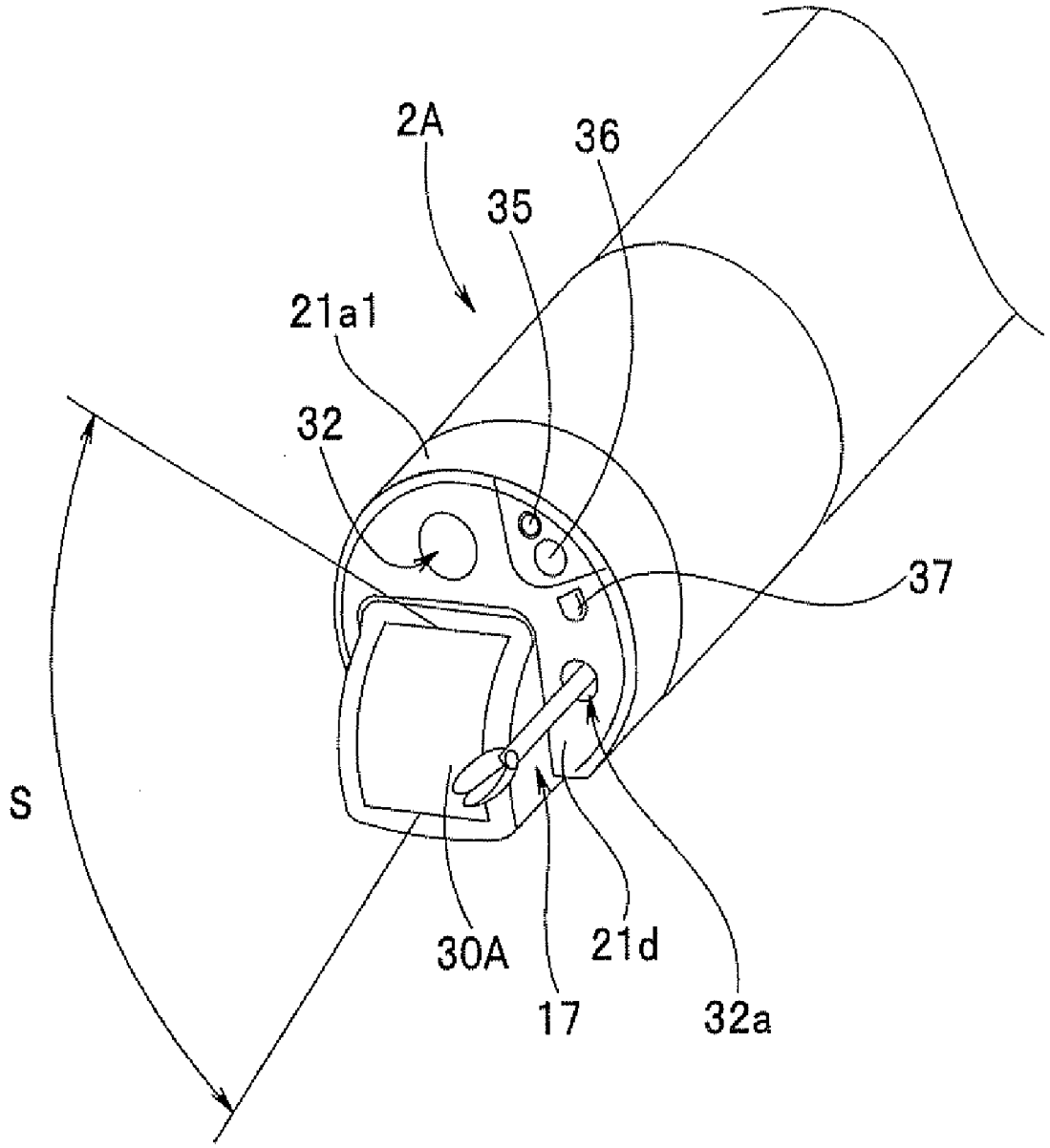
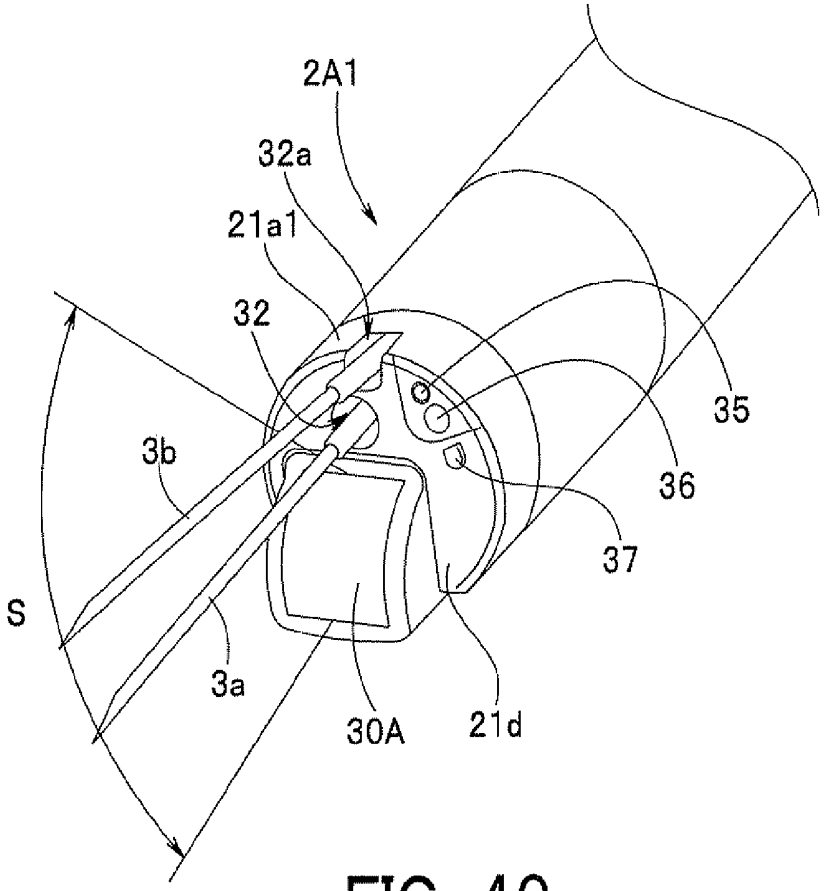


FIG. 39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21d

FIG. 40

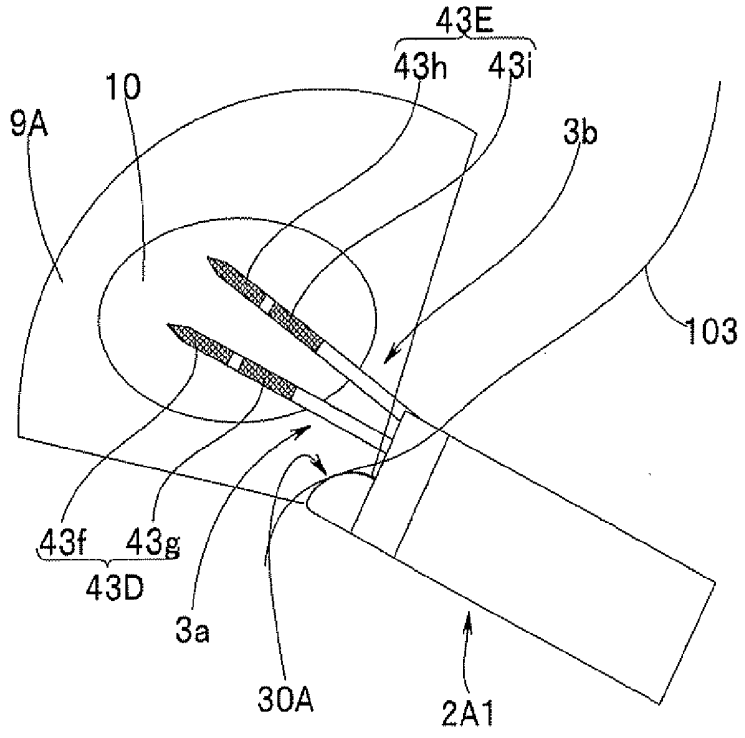
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FIG. 41A

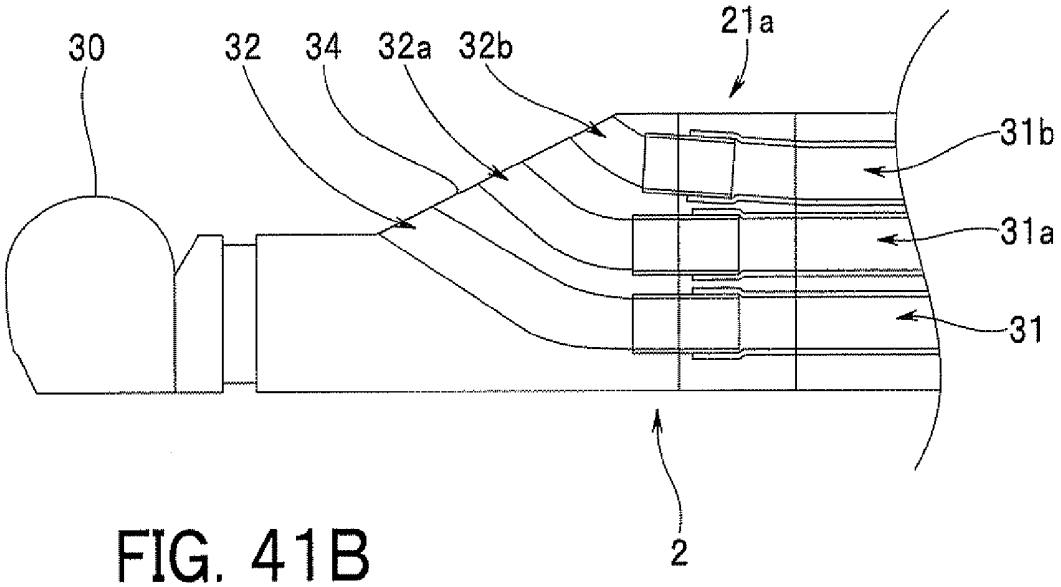


FIG. 41B

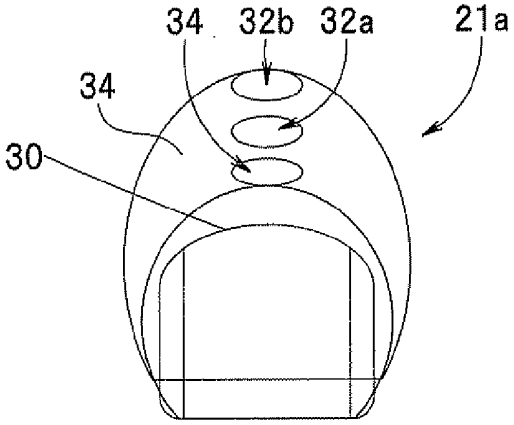


FIG. 42

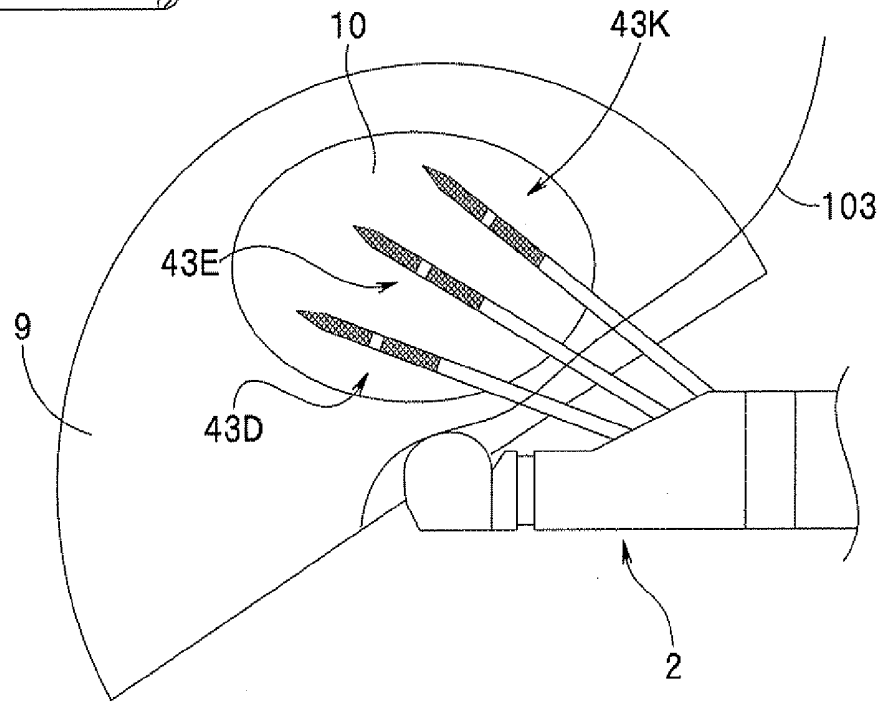


FIG. 43

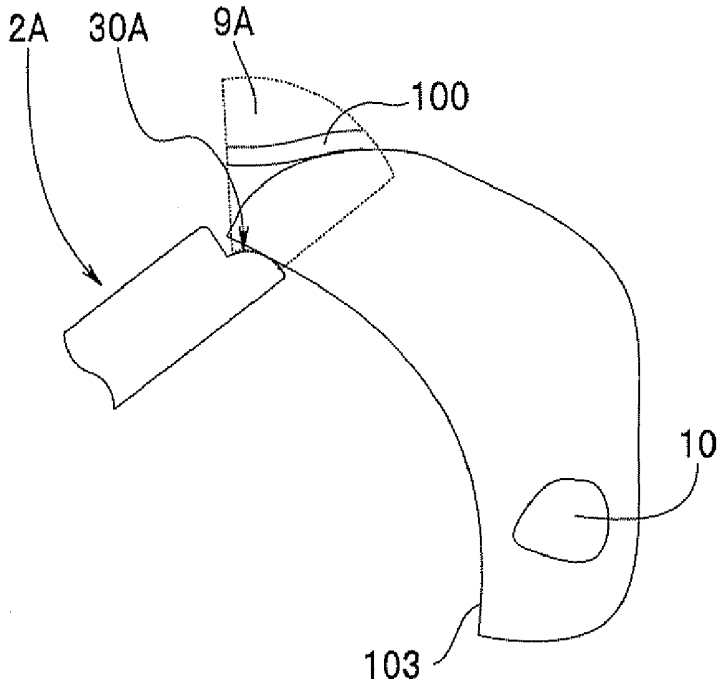


FIG. 44

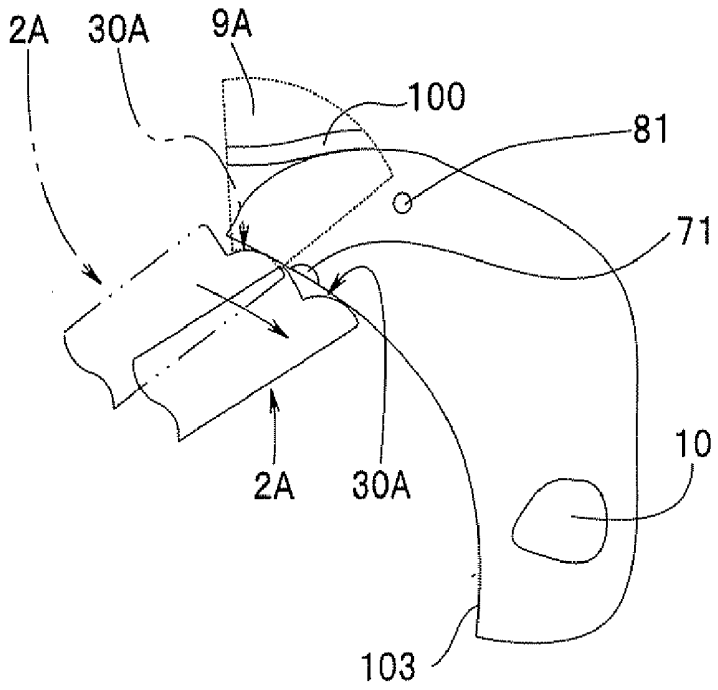
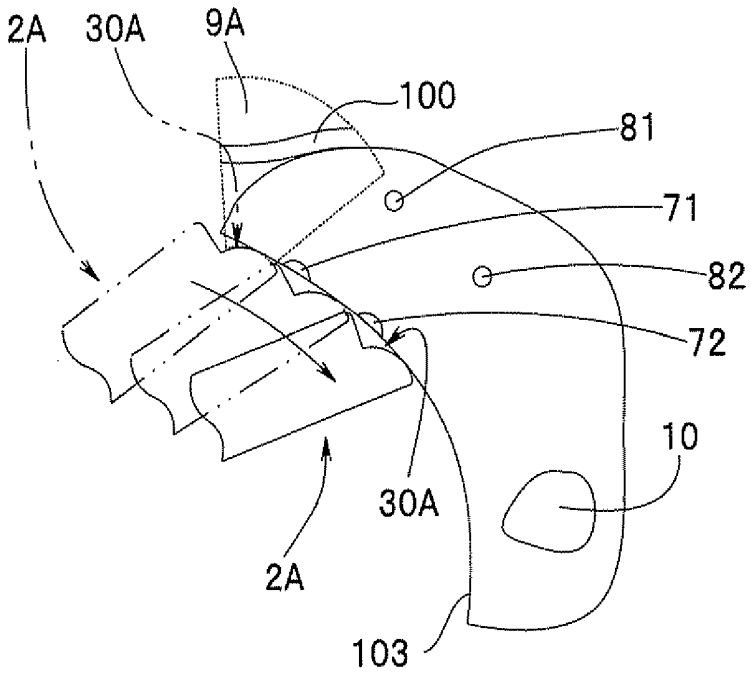


FIG. 45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2A
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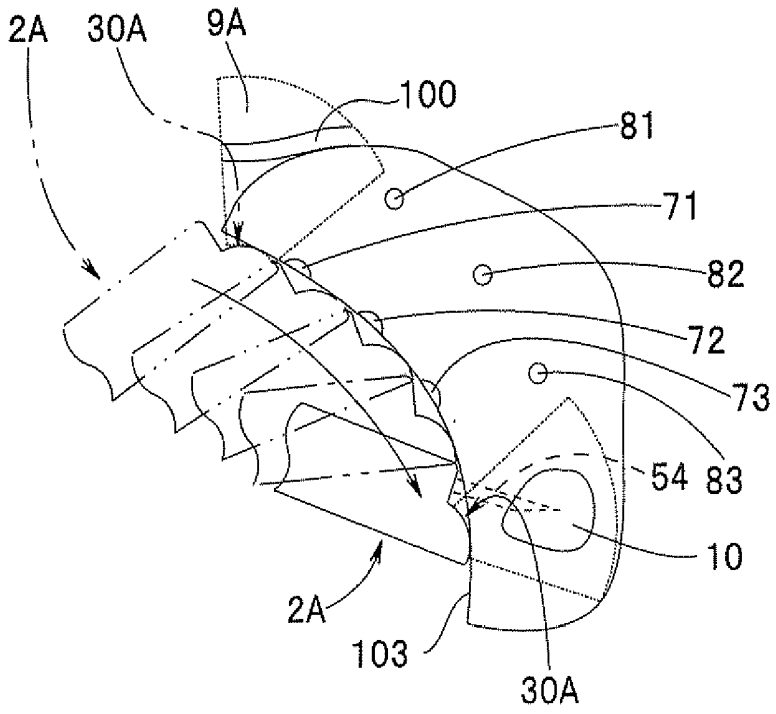
FIG. 46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103
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FIG. 47

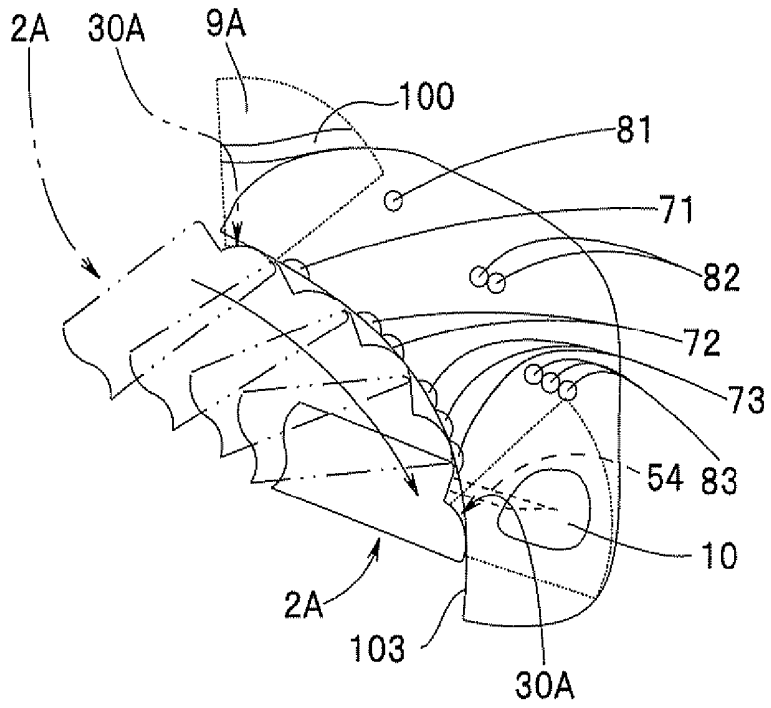
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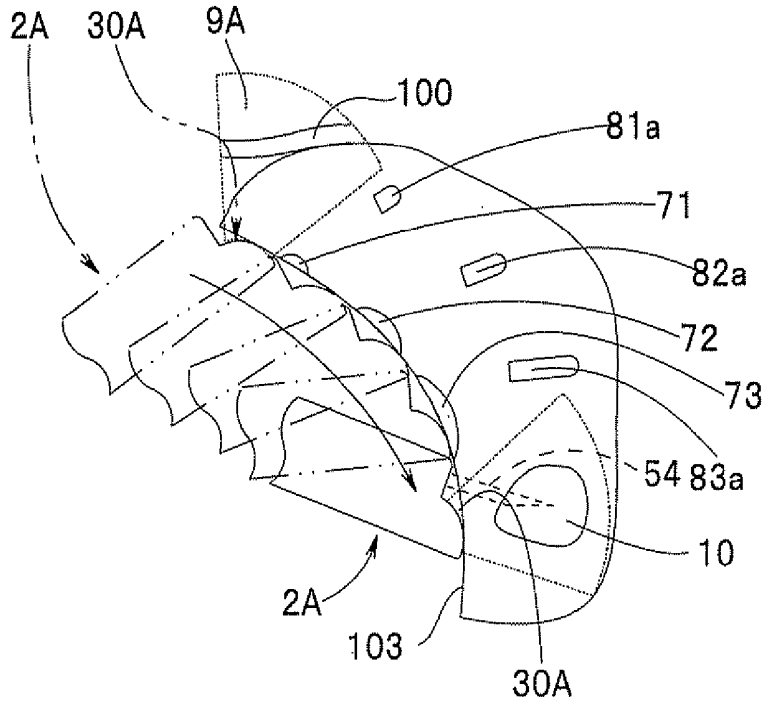
FIG. 48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10
2A
103
30A

FIG. 49

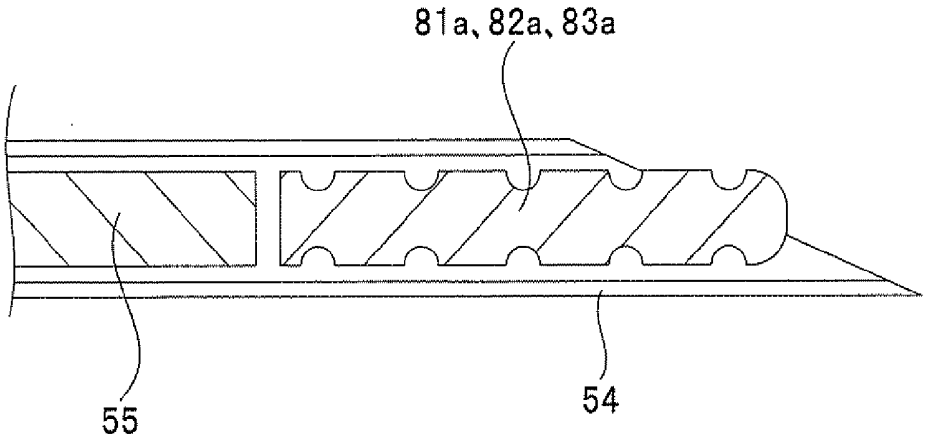


FIG. 50

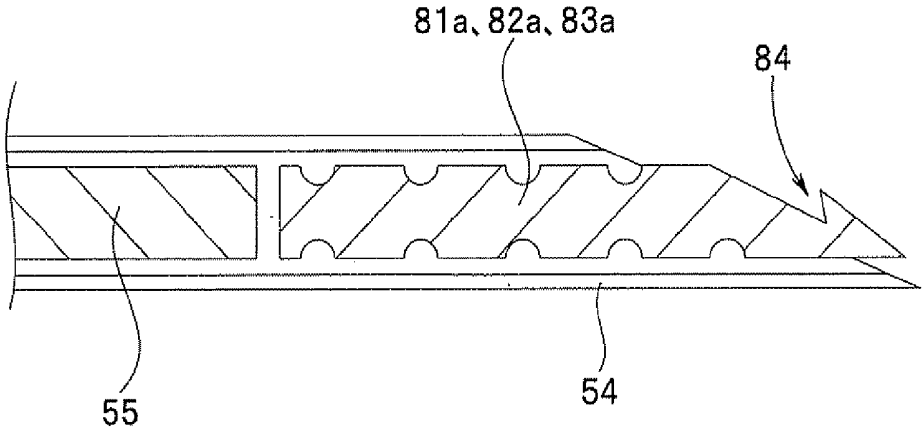


FIG. 51

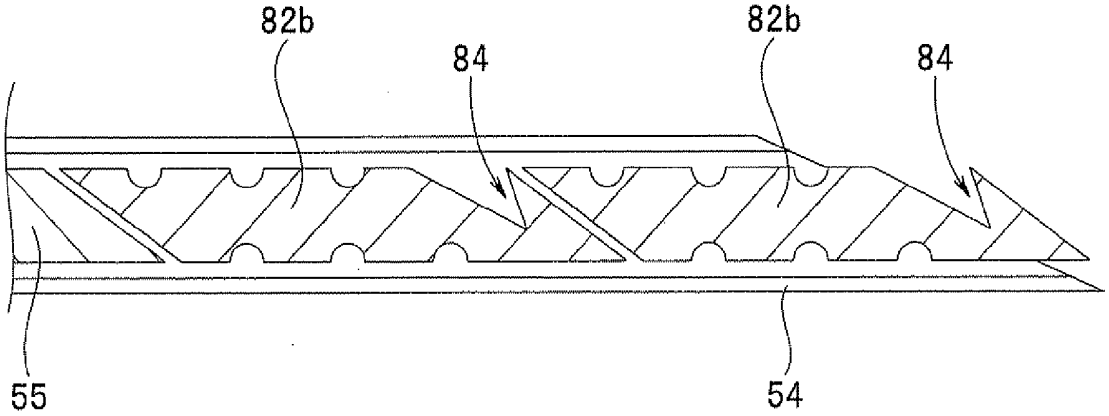


FIG. 52

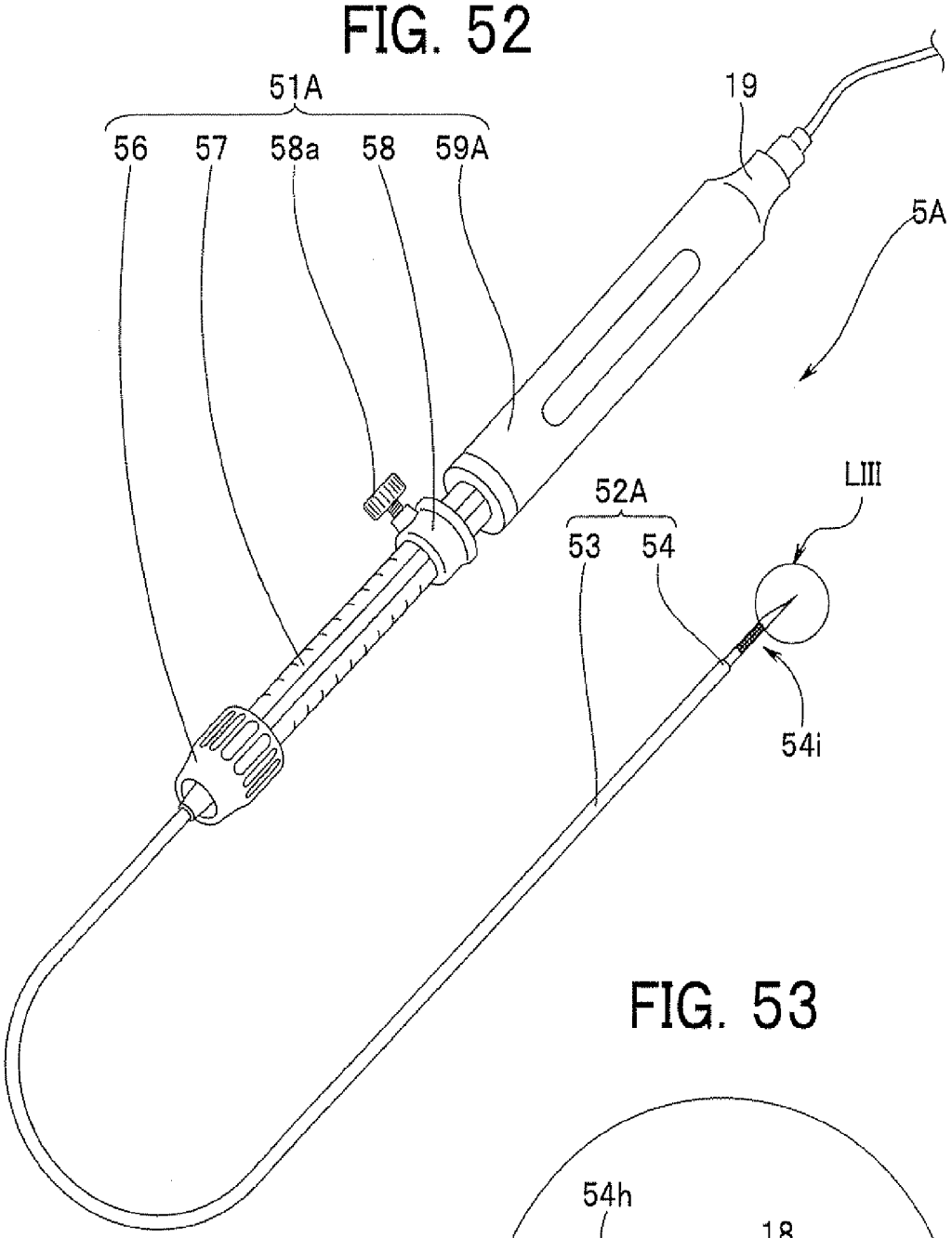


FIG. 53

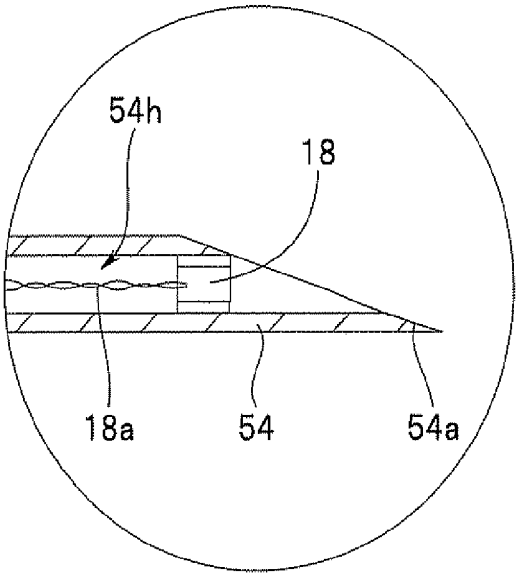


FIG. 54

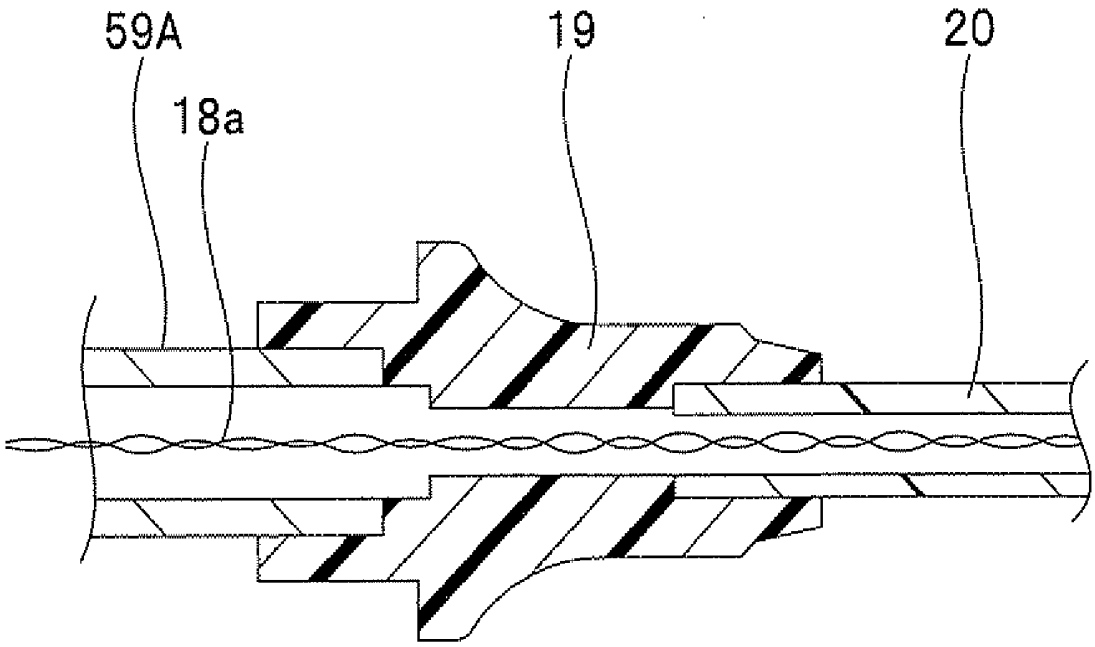


FIG. 55

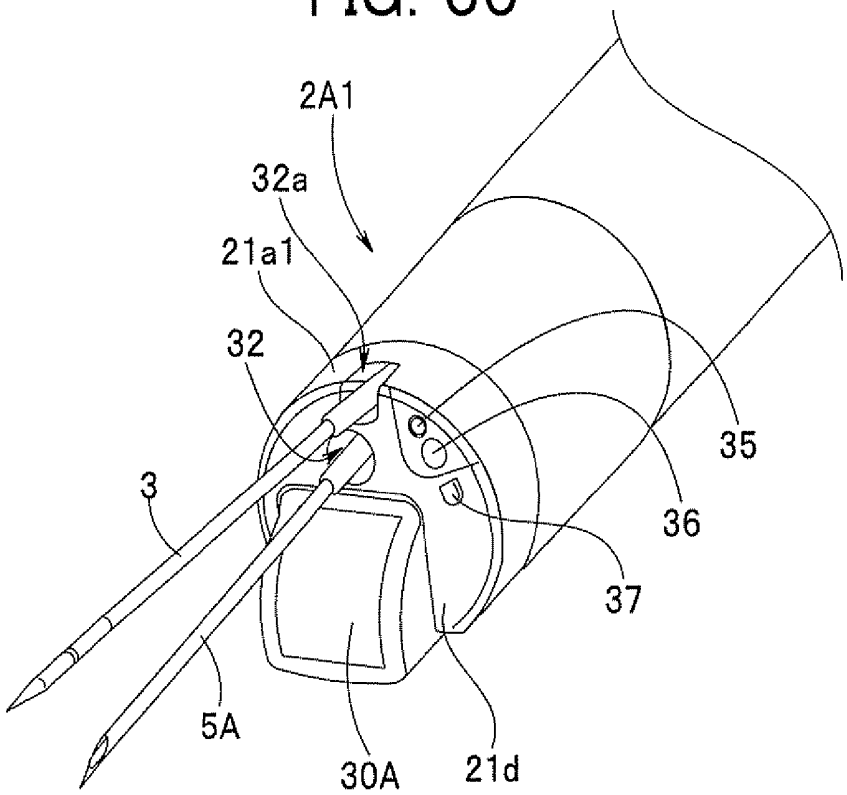


FIG. 56

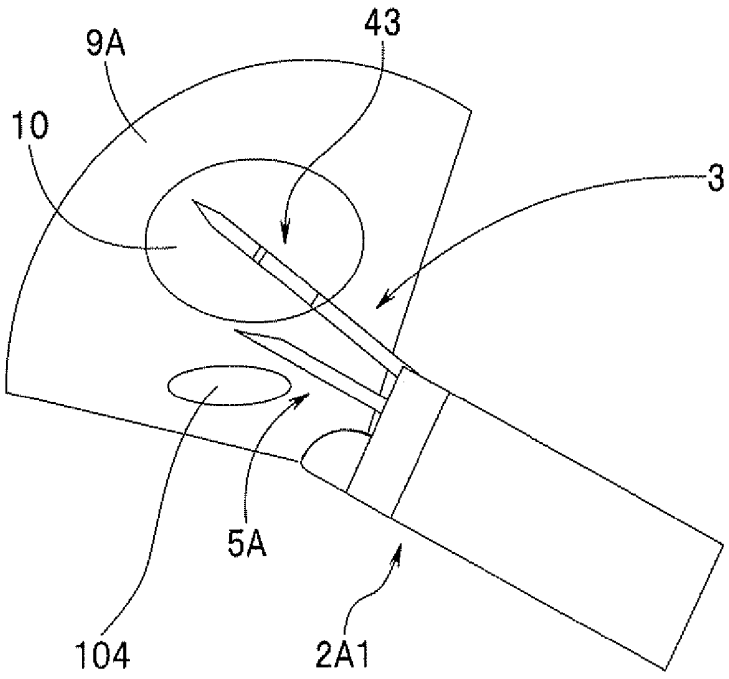


FIG. 57

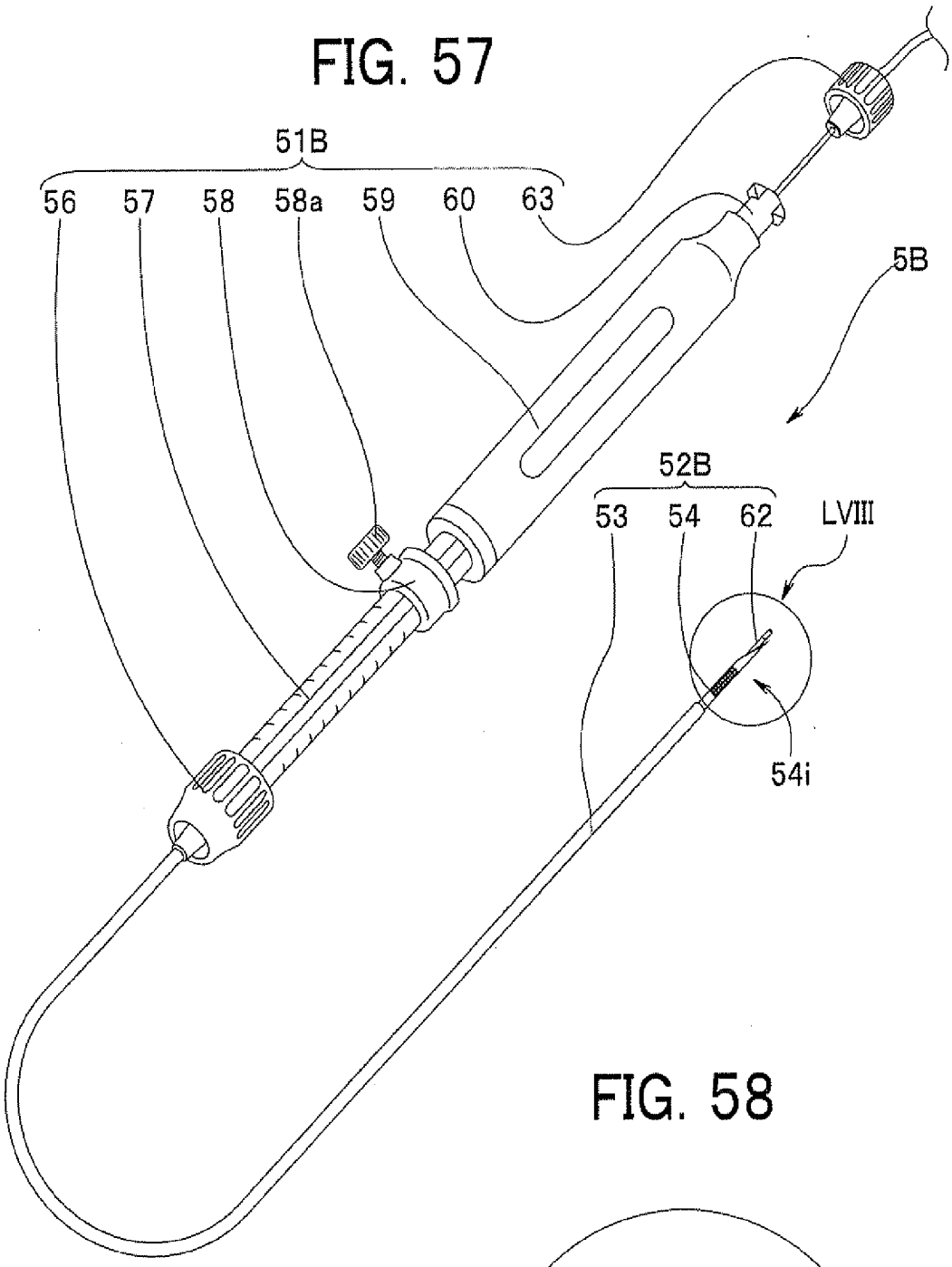

51B
56
57
58
58a
59
60
63
5B
52B
53
54
62
LVIII
54i

FIG. 58

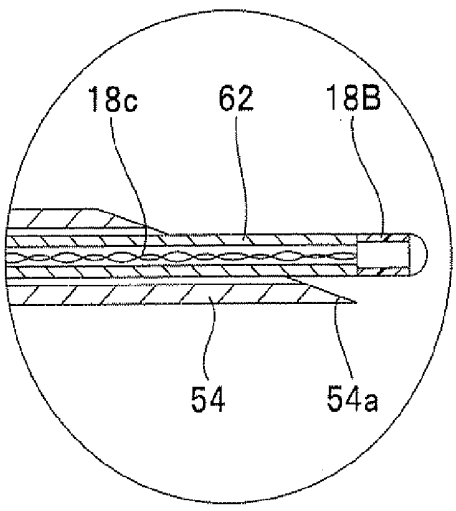

18c
62
18B
54
54a

FIG. 59

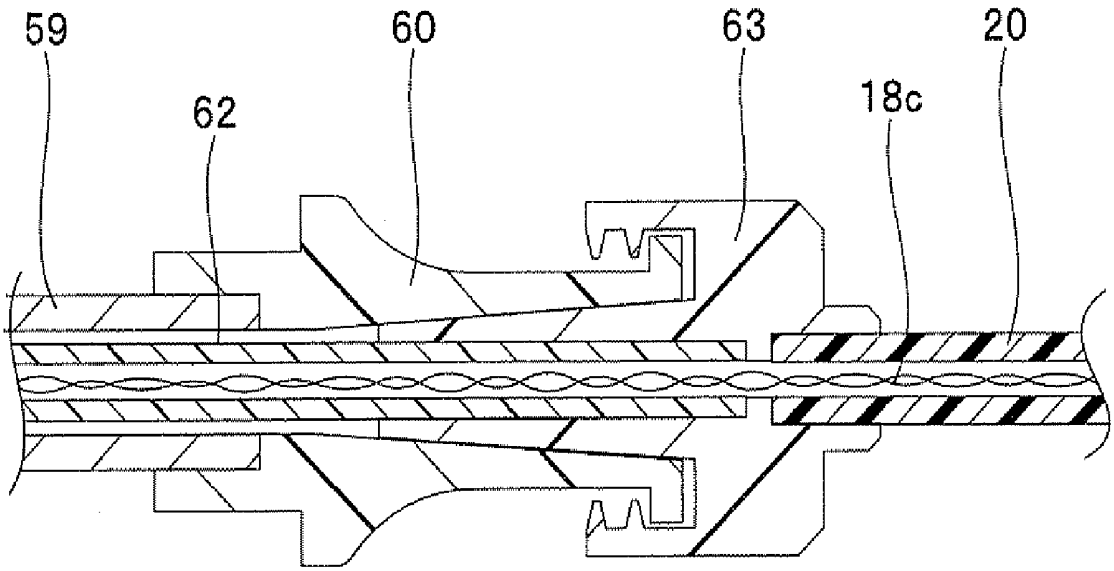


FIG. 60

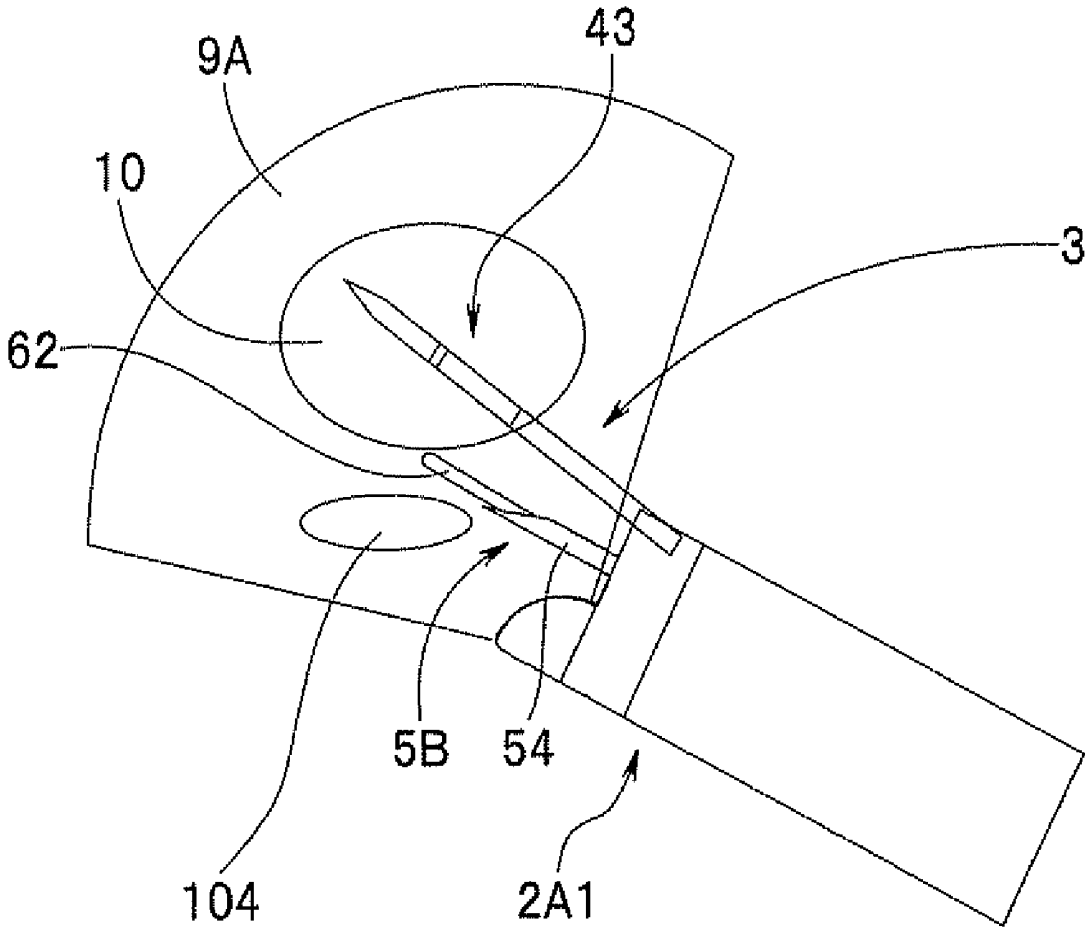


FIG. 61

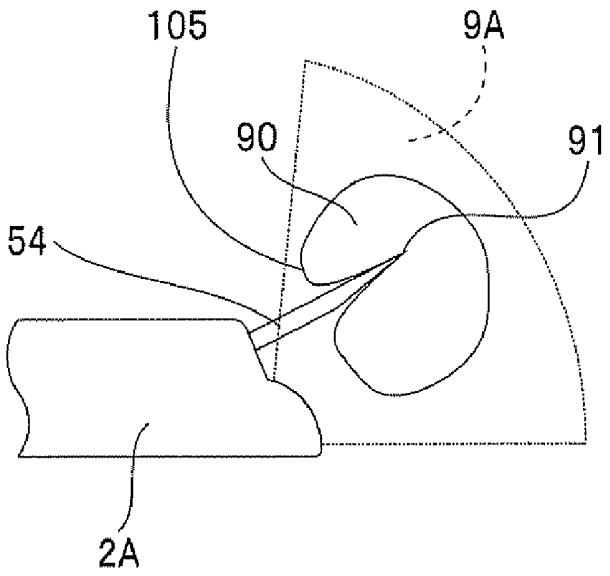


FIG. 62

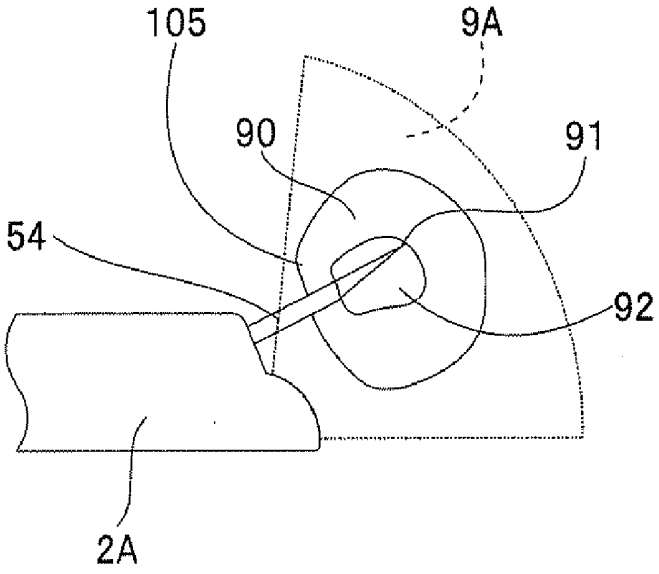


FIG. 63

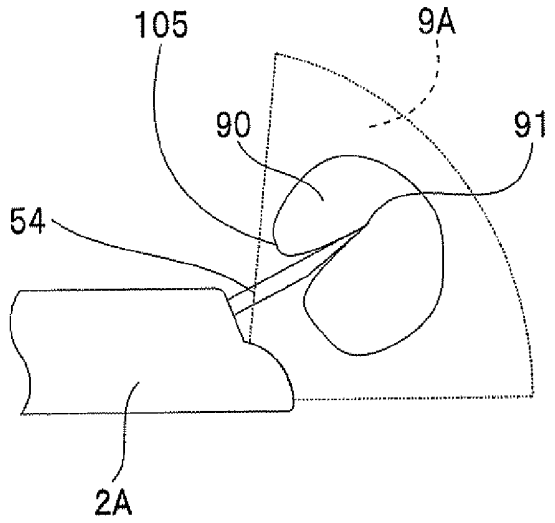


FIG. 64

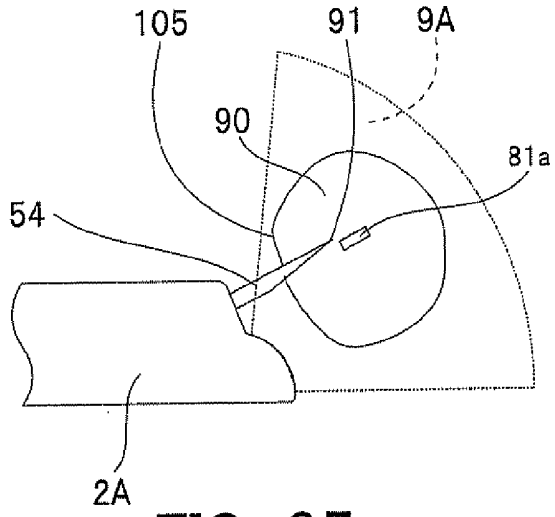
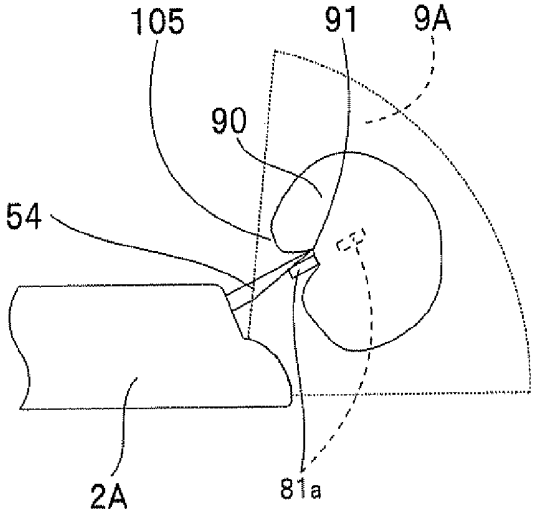


FIG. 65



ULTRASOUND-GUIDED ABLATION METHOD AND ULTRASOUND-GUIDED ABLATION SYSTEM

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to an ultrasound-guided ablation method and an ultrasound-guided ablation system for treating an objective area such as tumor by ablation under the guidance of ultrasound.

[0003] 2. Description of the Related Art

[0004] Conventionally, a treatment procedure has been known in which an ablation apparatus, such as a radio-frequency ablation device, a high-frequency ablation device, and a micro-wave ablation device, is punctured under the guidance of ultrasound from the body surface to liver tumor or the like to ablate an objective area such as a lesion.

[0005] In recent years, an ultrasound endoscope-guided ablation procedure is being studied as an example in which an ultrasound endoscope provided with a linear/convex transducer is used for performing the procedure.

[0006] In the ablation procedure, leaving a diseased tissue such as a tumor cell needs to be prevented. Therefore, it is desirable to ablate an area with a margin of, for example, 5 mm with respect to the objective area such as a lesion.

[0007] However, in an ultrasound image, the boundary between an ultrasound image of the objective area such as a lesion and an ultrasound image of surrounding tissues become unclear, because the protein of the ablated tissue is denatured. As a result, even if the ablation is performed with the margin of 5 mm, with how much margin the ablation has been actually performed may not be able to be determined from the ultrasound image after the ablation.

SUMMARY OF THE INVENTION

[0008] An ultrasound-guided ablation method of the present invention comprises: capturing an objective area to be ablated in an ultrasound scan area of an ultrasound transducer and delineating the objective area on an ultrasound image; specifying an ablation target area to display the ablation target area with a margin necessary for ablating the objective area on the ultrasound image processed by an ultrasound observation device and displayed on a display device; ablating, by an ablation device, the ablation target area displayed on the ultrasound image; and checking, on the ultrasound image, that an ablated area ablated by the ablation device has reached the ablation target area displayed on the ultrasound image.

[0009] The above and other objects, features and advantages of the invention will become more clearly understood from the following description referring to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIGS. **1** to **16** illustrate a first embodiment;

[0011] FIG. **1** is a diagram for explaining a configuration of an ultrasound endoscope- guided ablation system;

[0012] FIG. **2** is a diagram for explaining a distal end rigid portion of an ultrasound endoscope and an ultrasound transducer arranged on the distal end rigid portion used in the present ultrasound endoscope-guided ablation system;

[0013] FIG. **3** is a perspective view for explaining a puncture needle that also serves as a marker placing device;

[0014] FIG. **4** is an enlarged sectional view of the part shown with IV in FIG. **3**;

[0015] FIG. **5** is a diagram for explaining the ablation by the ultrasound endoscope-guided ablation system;

[0016] FIG. **6** is a diagram for explaining the placement of a marker near the center of an objective area;

[0017] FIG. **7** is a diagram for explaining the distance measurement from the marker to a peripheral border of the objective area;

[0018] FIG. **8** is a diagram for explaining the distance measurement from the marker in a different cross section of the objective area to the peripheral border of the objective area;

[0019] FIG. **9** is a diagram for explaining a spherical ablation target area set by adding an ablation margin to a maximum value of the measured distances from the marker to the peripheral border of the objective area and a state in which an electrode portion of an ablation device is arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0020] FIGS. **10** to **12** are diagrams for explaining another ablation method of the ultrasound endoscope-guided ablation system;

[0021] FIG. **10** is a diagram for explaining an ablation target area set by placing a plurality of markers in different sizes to the outside of the peripheral border of the objective area and adding an ablation margin to the peripheral border of the objective area;

[0022] FIG. **11** is a diagram for explaining a plurality of markers and an ablation target area in a different cross section of the objective area;

[0023] FIG. **12** is a diagram for explaining a state in which the electrode portion of the ablation device is arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0024] Another ablation method of the ultrasound endoscope-guided ablation system will be described with reference to FIGS. **13** to **17**;

[0025] FIG. **13** is a diagram for explaining the placement of a plurality of markers with an ablation margin outside the peripheral border of the objective area;

[0026] FIG. **14** is a diagram for explaining a state in which a plurality of markers are placed with the ablation margin outside the peripheral border of the objective area;

[0027] FIG. **15** is a diagram for explaining a plurality of markers placed outside the peripheral border of the objective area in a cross section of a XV-XV line of FIG. **14**;

[0028] FIG. **16**A is a diagram for explaining a state in which the electrode portion of the ablation device is arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0029] FIG. **16**B is a diagram for explaining the ablation performed such that the ablated area reaches an ablation target area defined by a virtual line connecting the markers;

[0030] FIGS. **17** to **37** illustrate a second embodiment;

[0031] FIG. **17** is a diagram for explaining another configuration of the ultrasound endoscope-guided ablation system;

[0032] FIG. **18** is a diagram for explaining a distal end rigid portion of the ultrasound endoscope and an ultrasound transducer arranged in the distal end rigid portion used in the present ultrasound endoscope-guided ablation system;

[0033] FIG. **19** is a diagram for explaining a state in which the objective area is captured in an ultrasound scan area of the ultrasound transducer;

[0034] FIG. **20** is a diagram for explaining an ultrasound image delineating the objective area captured by the ultrasound transducer;

[0035] FIG. **21** is a diagram for explaining the acquisition of peripheral line data of the delineated objective area in the ultrasound image;

[0036] FIG. **22** is a diagram for explaining the acquisition of ablation target area data in which the ablation margin is added to the acquired peripheral line data of the objective area;

[0037] FIG. **23** is a diagram for explaining a state in which the electrode portion of the ablation device is arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0038] FIG. **24** is a diagram for explaining the ablation performed while observing whether the ablated part has reached the ablation target area;

[0039] FIGS. **25** to **31** are diagrams for explaining another ablation method of the ultrasound endoscope-guided ablation system;

[0040] FIG. **25** is a diagram for explaining an ultrasound endoscope including a 2D array type ultrasound transducer;

[0041] FIG. **26** is a diagram for explaining a state in which the objective area is captured in an ultrasound scan area of the 2D array type ultrasound transducer;

[0042] FIG. **27** is a diagram for explaining two ultrasound images delineating the objective area captured by the 2D array type ultrasound transducer;

[0043] FIG. **28** is a diagram for explaining the acquisition of peripheral line data of the delineated objective areas on two ultrasound images;

[0044] FIG. **29** is a diagram for explaining the acquisition of ablation target area data in which the ablation margin is added to the peripheral line data of the acquired objective area;

[0045] FIG. **30** is a diagram for explaining a state in which the electrode portion of the ablation device is arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0046] FIG. **31** is a diagram for explaining the ablation performed while observing whether the ablated part has reached the ablation target area;

[0047] FIGS. **32** to **37** are diagrams for explaining another ablation method of the ultrasound endoscope-guided ablation system;

[0048] FIG. **32** is a diagram for explaining a state in which the objective area is captured in the ultrasound scan area of the ultrasound transducer and the placement of the marker outside the peripheral border of the objective area;

[0049] FIG. **33** is a diagram for explaining the delineated objective area and a delineated marker captured on the ultrasound image;

[0050] FIG. **34** is a diagram for explaining the acquisition of peripheral line data of the delineated objective area and the delineated marker on the ultrasound image;

[0051] FIG. **35** is a diagram for explaining the acquisition of ablation target area data in which the ablation margin is added to the peripheral line data of the acquired objective area;

[0052] FIG. **36** is a diagram for explaining a state in which the electrode portion of the ablation device is arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0053] FIG. **37** is a diagram for explaining the ablation performed while observing whether the ablated part has reached the ablation target area;

[0054] FIG. **38** is a diagram for explaining a configuration of the ultrasound endoscope for preventing the movement of the ultrasound transducer during an ablation procedure;

[0055] FIG. **39** is a diagram for explaining a configuration in which two ablation devices are arranged in the ultrasound endoscope to perform the ablation on a wide scale at a time;

[0056] FIG. **40** is a diagram for explaining a state in which the electrode portions of two ablation devices are arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0057] FIG. **41**A is a longitudinal sectional view for explaining a configuration example of the ultrasound endoscope capable of installing three ablation devices to perform the ablation on a wide scale at a time;

[0058] FIG. **41**B is a diagram of the ultrasound endoscope of FIG. **41**A as seen from the distal end side;

[0059] FIG. **42** is a diagram for explaining a state in which the electrode portions of three ablation devices are arranged in the objective area and the ablation is performed under the guidance of the ultrasound endoscope;

[0060] FIGS. **43** to **48** are diagrams for explaining operation from an operator operating the ultrasound endoscope to delineating the objective area on the ultrasound image;

[0061] FIG. **43** is a diagram for explaining a state in which a large vessel as a base point is captured in the ultrasound scan area of the ultrasound transducer;

[0062] FIG. **44** is a diagram for explaining the placement of a first marker after moving the ultrasound transducer from the base point into an objective area direction in an anatomical sense and capturing a first mark;

[0063] FIG. **45** is a diagram for explaining the placement of a second marker after moving the ultrasound transducer from a first marker placement point into an objective area direction in an anatomical sense and capturing a second mark;

[0064] FIG. **46** is a diagram for explaining the placement of a third marker, a state in which the objective area is captured in the ultrasound scan area, and a state in which a needle tube is punctured in the objective area after moving the ultrasound transducer from a second marker placement point into an objective area direction in an anatomical sense and capturing a third mark;

[0065] FIG. **47** is a diagram for explaining an example of markers that enable to easily determine, at a glance of the markers, the arranged order of the markers;

[0066] FIG. **48** is a diagram for explaining another example of markers that enable to easily determine, at a glance of the markers, the arranged order of the markers;

[0067] FIG. **49** is a diagram for explaining an example of rod-shaped ultrasound markers;

[0068] FIG. **50** is a diagram for explaining a rod-shaped ultrasound marker including a barb at the distal end;

[0069] FIG. **51** is a diagram for explaining a configuration example of a marker usable both as an ultrasound marker and as an endoscopic marker;

[0070] FIGS. **52** to **60** relate to a procedure that can preserve the function of a surrounding organ located near the objective area and that can surely ablate the objective area;

[0071] FIG. **52** is a diagram for explaining a configuration of a puncture needle with temperature sensor;

[0072] FIG. **53** is an enlarged view of the part shown with LIII of FIG. **52**;

[0073] FIG. **54** is a cross-sectional view for explaining a configuration of a sensor cable connection part;

[0074] FIG. **55** is a diagram for explaining a state in which the ablation device and the puncture needle with temperature sensor are projected from two distal end openings included in the ultrasound endoscope;

[0075] FIG. **56** is a diagram for explaining a state in which the electrode portion of the ablation device is arranged at the objective area and a needlepoint of the puncture needle with temperature sensor is arranged between the objective area and the surrounding organ;

[0076] FIG. **57** is a diagram for explaining another configuration of the puncture needle with temperature sensor;

[0077] FIG. **58** is an enlarged view of the part shown with LVIII of FIG. **57**;

[0078] FIG. **59** is a cross-sectional view for explaining a configuration of a stylet cap;

[0079] FIG. **60** is a diagram for explaining a state in which the electrode portion of the ablation device is arranged at the objective area and the stylet of the puncture needle with temperature sensor is arranged between the objective area and the surrounding organ;

[0080] FIGS. **61** to **63** are diagrams for explaining a puncture method enabling to determine whether the needlepoint has reached inside the objective area on the ultrasound image;

[0081] FIG. **61** is a diagram for explaining a state in which the needle tube is punctured into the objective area under the guidance of ultrasound;

[0082] FIG. **62** is a diagram for explaining a state in which the needlepoint is arranged in the objective area and an ultrasound contrast agent is injected into the objective area;

[0083] FIG. **63** is a diagram for explaining a state in which the ultrasound contrast agent is not injected into the objective area because the objective area is transformed and the needlepoint is not arranged in the objective area;

[0084] FIG. **64** is a diagram for explaining another puncture method enabling to determine whether the needlepoint has reached inside the objective area on the ultrasound image;

[0085] FIG. **64** is a diagram for explaining a state in which the needlepoint is arranged in the objective area and the marker is placed in the objective area; and

[0086] FIG. **65** is a diagram for explaining a state in which the marker is placed outside the peripheral border of the objective area because the needlepoint is not arranged in the objective area.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0087] Preferred embodiments of the present invention will now be described with reference to the drawings.

[0088] A first embodiment of the present invention will be described with reference to FIGS. **1** to **16**B.

[0089] As shown in FIG. **1**, an ultrasound endoscope-guided ablation system **1** of the present embodiment is mainly constituted by an ultrasound endoscope (hereinafter abbreviated as EUS) **2** that is a kind of endoscope, an ablation device **3**, an ablation power source device (hereinafter abbreviated as power source device) **4**, a puncture needle **5**, an ultrasound observation device **6**, and a display device **7**.

[0090] The EUS **2** is mainly constituted by: an insertion portion **21** inserted into the body; an operation portion **22** located at a proximal end of the insertion portion **21**; a universal code **23** extending from a side of the operation portion **22**; and a light source cable **24** that is branched, for example, in the middle of the universal code **23**.

[0091] An ultrasound connector **23***a* that can be attached to and detached from the ultrasound observation device **6** is arranged at a proximal end portion of the universal code **23**. An endoscope connector **24***a* that can be attached to and detached from a light source device and a video processor device not shown is arranged at a proximal end portion of the light source cable **24**.

[0092] A treatment instrument insertion port **25** is arranged at a distal end side of the operation portion **22**. The treatment instrument insertion port **25** is in communication with a treatment instrument channel (see reference numeral **31** of FIG. **2**) arranged in the insertion portion **21**. The treatment instrument insertion port **25** includes a ferrule, and a securing ring **56** arranged in a handle portion **51** of the puncture needle **5** and the like is connected to the ferrule. The securing ring **56** can be attached to and detached from the ferrule.

[0093] Reference numerals **26***a* and **26***b* denote bending operation knobs, reference numeral **27***a* denotes an air and water feeding button, reference numeral **27***b* denotes a suction button, and reference numeral **28** denotes a switch. The switch **28**, for example, switches the display of the display device **7**, provides a freeze instruction of a displayed image, provides a release instruction, or provides an ablation start/end instruction. Metal or the like is not arranged inside a treatment instrument channel **31** which is insulated from metals inside the endoscope.

[0094] The insertion portion **21** connects, in order from the distal end, a distal end rigid portion **21***a*, a bending portion **21***b*, and a flexible tube portion **21***c*. The bending portion **21***b* is configured to be actively bent, for example, in the vertical and horizontal directions by the operation of the bending operation knobs **26***a* and **26***b*. The flexible tube portion **21***c* is flexible.

[0095] As shown in FIG. **2**, an electronically scanning ultrasound transducer **30** is arranged on the distal end side of the distal end rigid portion **21***a*. The ultrasound transducer **30** is, for example, a convex array and includes a plurality of ultrasound elements aligned inside.

[0096] A distal end opening **32** is arranged at the distal end of the treatment instrument channel **31** arranged at the distal end rigid portion **21***a*. A forceps raising table **33** is swingably arranged near the distal end opening **32**. Swinging the forceps raising table **33**, with a sheath **53** being mounted on the forceps raising table **33**, enables to move a needle tube **54** to a desired position in a scanned surface S of the ultrasound transducer **30**.

[0097] The distal end rigid portion **21** a includes a slope portion **34** on the distal end side, and the slope portion **34** includes an illumination lens cover **35**, an observation lens cover **36**, and an air and water feeding nozzle **37**.

[0098] The ablation device **3** is a radio-frequency ablation device and is mainly constituted by a grasping portion **41** grasped by the operator, a flexible tube portion **42**, and an electrode portion **43**. The grasping portion **41** is an insulating member and is cylindrical. The flexible tube portion **42** is constituted by an insulating flexible member and the proximal end of the flexible tube portion **42** is fixed to the grasping portion **41**. The electrode portion **43** is arranged at a distal end surface of the flexible tube portion **42**. A signal cable **44** extends from the grasping portion **41**. The proximal end of the signal cable **44** is connected to the power source device **4**. The power source device **4** is connected to the ultrasound obser-

vation device **6** through a connection cable **45** or to a video processor device not shown and is configured to transmit a signal of an ablation start/end instruction by the switch **28**.

[0099] The electrode portion **43** arranged at the distal end surface of the flexible tube portion **42** is, for example, a bipolar electrode portion and is constituted by a first electrode **43***a*, a second electrode **43***b*, and an insulating portion **43***c*. The first electrode **43***a* and the second electrode **43***b* are annularly formed on the surface of the circumference of the flexible tube portion **42**. The insulating portion **43***c* is arranged between the first electrode **43***a* and the second electrode **43***b*. The distal end of the signal cable **44** is inserted into the grasping portion **41** and into the flexible tube portion **42** and is connected to the first electrode **43***a* and the second electrode **43***b*.

[0100] The power source device **4** supplies high frequency radio waves with different polarities to the first electrode **43***a* and the second electrode **43***b* of the electrode portion **43** through the signal cable **44**. When the power source device **4** supplies a radio frequency while the electrode portion **43** is inserted into body tissues, the electrode portion **43** is energized through body tissues between the first electrode **43***a* and the second electrode **43***b* and ablates the body tissues.

[0101] As shown in FIGS. **3** and **4**, the puncture needle **5** includes the handle portion **51** and a channel insertion portion **52**. The channel insertion portion **52** includes the sheath **53** and the needle tube **54**. The channel insertion portion **52** is inserted into the treatment instrument channel **31** from the treatment instrument insertion port **25** and projects from the distal end opening **32** shown in FIG. **2**.

[0102] In the present embodiment, the puncture needle **5** is an ablation target area specifying unit, the puncture needle **5** also serving as a marker placing device for placing a marker, which can be delineated on an ultrasound image, in a living body. Therefore, as shown in FIG. **4**, a pusher **55**, which can be inserted into and pulled out from the needle tube **54**, is arranged in the needle tube **54**. The pusher **55** is made of a metal rod such as stainless and nickel titanium alloy and is inserted into the needle tube **54** for pushing out the marker **8** arranged at the distal end of the needle tube **54** outside the needle tube **54**.

[0103] The marker **8** is made of magnesium alloy that is absorbed in the living body in the course of time and is, for example, spherical. A plurality of ultrasound reflecting surfaces **8***a* are formed on the outer surface of the marker **8**. The ultrasound reflecting surfaces **8***a* are, for example, circular concave portions.

[0104] The ultrasound reflecting surfaces **8***a* are not limited to be circular concave portions, but may also be annular concave portions including circular convex portions at the center. The marker **8** may also be made of biocompatible metal such as gold and titanium.

[0105] The needle tube **54** is inserted into the sheath **53** and is movable back and forth with respect to the sheath **53**. The needle tube **54** is formed of a metal pipe such as a stainless pipe and a nickel titanium pipe. A sharp blade portion **54***a* is formed at the distal end of the needle tube **54**.

[0106] The handle portion **51** includes, for example, in order from the distal end, a securing ring **56**, an operation portion main body **57**, a stopper member **58**, a needle slider **59**, a ferrule portion **60**, and a pusher knob **61**.

[0107] The proximal end portion of the pusher **55** is integrally fixed to the pusher knob **61** by, for example, gluing. The proximal end portion of the needle tube **54** is integrally fixed to the ferrule portion **60** by gluing or the like. The proximal end portion of the sheath **53** is integrally fixed to a predetermined location of the proximal end portion of the operation portion main body **57** by gluing or the like.

[0108] The stopper member **58** includes a fixing screw **58***a*. The stopper member **58** can adjust the position with respect to the operation portion main body **57** as necessary, with the fixing screw **58***a* being loosened. A projected length of the needle tube **54** from the distal end of the sheath **53** is adjusted by adjusting the position of the stopper member **58**.

[0109] The flexible tube portion **42** of the ablation device **3** can be inserted into the needle tube **54**.

[0110] An ablation method of the ultrasound endoscope-guided ablation system **1** configured as described above will be described with reference to FIGS. **5** to **9**.

[0111] As shown in FIG. **5**, an operator **101** inserts the insertion portion **21** of the EUS **2** into the body of a patient **102** through, for example, the mouth, observes an endoscopic image displayed on the display device **7**, and inserts the ultrasound transducer **30** near the objective area. The operator then brings the ultrasound transducer **30** into contact with a lumen wall **103**, as shown in FIG. **6**.

[0112] The operator **101** then displays the ultrasound image on the display device **7** and, as shown in FIG. **6**, captures an objective area **10**, such as cancer, at a desired location in an ultrasound scan area **9**.

[0113] The operator **101** then punctures the puncture needle **5** as a marker placing device under the guidance of the ultrasound endoscope such that the needle tube **54** is located near the center of the objective area **10**. Subsequently, the operator **101** pushes in the pusher knob **61** to move the pusher **55** to place the marker **8** arranged at the distal end portion of the needle tube **54** into the objective area **10**.

[0114] After checking the placement of the marker **8** to the objective area **10** based on the ultrasound image, the operator asks a medical personnel (hereinafter referred to as staff) to measure a distance from the marker **8** to an objective area peripheral border **10***a*.

[0115] Consequently, the staff selects, for example, four points P**1**, P**2**, P**3**, and P**4** on the delineated objective area peripheral border **10***a* on the ultrasound image as shown in FIG. **7** and measures distances from the delineated marker **8**. Reference numerals L**1**, L**2**, L**3**, and L**4** of FIG. **7** denote the distances from the marker **8** as a base point to the points P**1**, **2**, **3**, and **4**.

[0116] The operator then performs a hand-side operation to move the distal end side of the EUS **2** in an arrow A direction or in an arrow B direction of FIG. **7** to thereby move the ultrasound transducer **30**. Consequently, an ultrasound image of a different cross section of the objective area **10** is delineated on the display device **7**.

[0117] The operator then asks the staff to measure a distance from the marker **8** to an objective area peripheral border **10***b* as described above. Consequently, the staff selects, for example, four points P**11**, P**12**, P**13**, and P**14** on the ultrasound image as shown in FIG. **8** and measures distances from the delineated marker **8**. Reference numerals L**11**, L**12**, L**13**, and L**14** denote the distances from the marker **8** as a base point to the points P**11**, **12**, **13**, and **14**. Subsequently, if necessary, the operator moves the ultrasound transducer **30** to delineate an ultrasound image of a different cross section of the objective area **10** to measure the distances.

[0118] The operator determines a value Lmax+α, in which an arbitrary ablation margin α is added to a maximum value

Lmax among a plurality of measurement results as shown in FIG. **9**, as an ablation distance LA from the marker **8**. Thus, the operator **101** sets a sphere **11**, with the value Lmax+α as a radius, as the ablation target area and stores the value.

[0119] After setting the sphere **11** as an ablation target area, the operator arranges the electrode portion **43** of the ablation device **3** at a desired location in the objective area **10** and performs the ultrasound endoscope-guided ablation.

[0120] When the ablation of the objective area **10** has advanced for some degree, the operator instructs the measurement of an ablated part **10**Z with the marker **8** as a base point. The operator checks whether the actual ablated part **10**Z has reached a circumference **11***a* of the sphere **11** having preset Lmax+α as a radius.

[0121] The operator determines that the ablation is completed if the ablated area **10**Z has reached the circumference **11***a* of the sphere **11** and if the ablated area **10**Z has not reached the circumference **11***a* of the sphere **11** arranges the electrode portion **43** at the part to perform the ablation. The operator moves the ultrasound transducer **30** to check a plurality of locations.

[0122] In this way, a marker that is excellent in the ultrasound reflection intensity is placed in the objective area, and the distances from the marker as a base point to the objective area peripheral border are measured. A sphere of the ablation target area is set, with a value, in which a predetermined ablation margin is added to the maximum distance among the measurement results, as an ablation radius. Subsequently, the ablation device is arranged in the objective area to perform the ablation, and the distances from the marker after the ablation are measured. At this point, the objective area peripheral border on the ultrasound image becomes unclear due to the denaturation of the objective area and the denaturation of the surrounding tissues. However, the ablation of the objective area can be surely performed by checking whether the ablated part on the ultrasound image has reached Lmax+α based on the marker.

[0123] This solves a conventional problem, which has been occurring when the ablation target area is determined based on the objective area peripheral border, that with how much margin the ablation has been performed cannot be recognized as the delineated objective area peripheral border becomes unclear after the ablation. In other words, reliable ablation can be performed without depending on the skill of the operator and without leaving a diseased tissue.

[0124] As shown with a broken line in the ultrasound observation device **6**, a storage unit **6***m* (see FIG. **6**) may be arranged, and the ablation target area may be stored in the storage unit **6***m*. The configuration includes, for example, as shown in FIG. **9**, a function of superimposing and displaying, on the ultrasound image and around the delineated marker **8**, the circumference **11***a* of the sphere **11** with a radium Lmax+α shown with a broken line.

[0125] The ablation can be performed without losing the ablation target area by displaying the circumference **11***a* on the display device **7** when performing the ultrasound endoscope-guided ablation. Furthermore, whether the ablated area has reached Lmax+α can be easily and visually checked without measuring the ablated part.

[0126] The marker can also be checked on the ultrasound image after the ablation.

[0127] In general, the impedance and/or the temperature and/or the like are monitored in the ablation device during energization. Therefore, the output is terminated if the output exceeds a preset threshold, preventing the application of heat such that the tissues carbonize.

[0128] Another ablation method of the ultrasound endoscope-guided ablation system **1** will be described with reference to FIGS. **10** to **12**. In the present embodiment, an injection needle, in which the pusher **55** and the marker **8** are excluded from the puncture needle **5**, is used.

[0129] As in the above embodiment, the operator brings the ultrasound transducer **30** into contact with the lumen wall **103** and then causes the display device **7** to display the ultrasound image. The operator captures the objective area **10**, such as cancer, at a desired location in the ultrasound scan area **9**, as shown in FIG. **10**.

[0130] The operator then uses the injection needle to place three markers **12**, **13**, and **14** at different locations that are outside and near the periphery of the objective area **10** under the guidance of the ultrasound endoscope. Thus, the operator punctures a needle tube **54***c* of the injection needle near the objective area **10** and injects, for example, jelly with contrast agent or with air bubbles.

[0131] At this point, the injection volume of the jelly is adjusted to change the sizes of the markers **12**, **13**, and **14**. As a result, three markers **12**, **13**, and **14** in different sizes are placed in a scan plane.

[0132] After checking the placement of the markers **12**, **13**, and **14** near the objective area **10**, the operator asks the staff to measure distances from the markers **12**, **13**, and **14** to the peripheral border of the objective area **10**.

[0133] In this case, instead of measuring a plurality of points of the peripheral border, the staff, for example, traces the peripheral border of the objective area delineated on the display device **7** with an input pen described below to acquire a peripheral line and then computes and obtains, with a computing unit described below, an objective area peripheral line **10***c* based on the center of the delineated markers **12**, **13**, and **14**. The staff also specifies an ablation margin a with an ablation margin setting unit described below. Consequently, an ablation target area setting line (hereinafter abbreviated as an ablation line) **11***c*, in which the ablation margin a is added to the objective area peripheral line **10***c*, shown with a broken line is superimposed and displayed on the display device **7**.

[0134] The staff registers the absolute objective area peripheral line **10***c* and the ablation line **11***c*, with the delineated markers **12**, **13**, and **14** as base points, in the storage unit **6***m*.

[0135] The operator then performs, for example, a hand-side operation for moving the distal end side of the EUS **2** around an axis connecting the markers **12** and **13** to move the ultrasound transducer **30**. Consequently, an ultrasound image of the objective area **10** of a different cross section, in which the markers **12** and **13** are displayed on the display device **7** as shown in FIG. **11**, is delineated.

[0136] The operator uses the injection needle to place a marker **15** with a large diameter, the size of which is different from the markers **12**, **13**, and **14**. As a result, the markers **12**, **13**, and **15** are placed in a scan plane. Therefore, four markers **12**, **13**, **14**, and **15** are placed around the objective area **10** without being arranged within one plane.

[0137] As described above, the operator asks the staff to acquire an absolute objective area peripheral line **10***d* and an ablation line **1***d* with the delineated markers **12**, **13**, and **15** as base points and to register the lines in the storage unit **6***m*.

[0138] After acquiring and registering the objective area peripheral line **10***d* and the ablation line **11***d*, the operator and

the staff move the ultrasound transducer **30** to acquire an absolute objective area peripheral border (not shown) and an ablation line (not shown) with the delineated markers **13**, **14**, and **15** as base points and to register the border and the line in the storage unit **6**m. The operator and the staff then acquire an absolute objective area peripheral border (not shown) and an ablation line (not shown) with the delineated markers **12**, **14**, and **15** as base points and register the border and the line in the storage unit **6***m*.

[0139] With the series of operations, the acquisition of four absolute ablation lines with respect to the cross section including three markers among four markers **12**, **13**, **14**, and **15** is completed.

[0140] In the above embodiment, the distal end side of the EUS **2** is moved around the axis connecting the markers **12** and **13** to obtain the ultrasound image, which is displayed with the markers **12** and **13**, of a different cross section of the objective area **10** upon the placement of the fourth marker. However, the distal end side of the EUS **2** may be moved around the axis connecting the markers **12** and **14** to place the fourth marker, or the distal end side of the EUS **2** may be moved around the axis connecting the markers **13** and **14** to place the fourth marker.

[0141] In the present embodiment, the injection volume of the jelly is adjusted to allow identification of a plurality of markers. However, as shown in FIG. **48** described below, the lengths of the markers may be changed to allow the identification of the plurality of markers.

[0142] In the present embodiment, the ultrasound observation device **6** further includes a peripheral border input unit, a computing unit, and an ablation margin setting unit that are described below.

[0143] In the present embodiment, the staff extracts the peripheral line of the objective area. However, the peripheral line of the objective area may be automatically extracted by a computer installed in the ultrasound observation device **6**.

[0144] After completing the acquisition of the ablation lines **11***c*, **11***d*, . . . with respect to four cross sections, the operator arranges the electrode portion **43** of the ablation device **3** at a desired location in the objective area **10** as shown in FIG. **12** to perform the ultrasound endoscope-guided ablation.

[0145] The operator checks an actual ablation state when the ablation of the objective area **10** has advanced to some degree. More specifically, the operator checks whether the actual ablated area has reached the ablation line **11***c* on the plane including the markers **12**, **13**, and **14**, checks whether the actual ablated area has reached the ablation line **11***d* on the plane including the markers **12**, **13**, and **15**, checks whether the actual ablated area has reached the ablation line on the plane including the markers **13**, **14**, and **15**, and checks whether the actual ablated area has reached the ablation line on the plane including the markers **12**, **14**, and **15**, while performing the operation to move the ultrasound transducer **30** as necessary.

[0146] The operator determines that the ablation is completed if the ablated area has reached all ablation lines. On the other hand, the operator arranges the electrode portion **43** at a desired location on the ultrasound image to perform the ablation if the ablated area has not reached any of the ablation lines.

[0147] In this way, four markers are placed in predetermined states, and an ablation line is set for each cross section based on three of the four markers. The objective area is ablated while whether the ablated area has reached the ablation line of each surface is checked. This enables to obtain similar effects and advantages as in the above described embodiment.

[0148] The present embodiment enables to shorten the treatment time because the ablation target area can be reduced as compared to the case in which the circumference of the sphere of the ablation target area is set with Lmax+α.

[0149] Another ablation method of the ultrasound endoscope-guided ablation system **1** will be described with reference to FIGS. **13** to **16**B.

[0150] The puncture needle **5** is used in the present embodiment.

[0151] As in the embodiment described above, the operator brings the ultrasound transducer **30** into contact with the lumen wall **103** and then displays the ultrasound image on the display device **7**. The operator then captures the objective area **10**, such as cancer, at a desired location in the ultrasound scan area **9** as shown in FIG. **13**.

[0152] Under the guidance of the ultrasound endoscope, the operator sequentially places markers **8***b*, **8***c*, . . . at locations separated by a distance of the ablation margin α, in consideration of the ablation margin a from the objective area peripheral line **10***a* of the objective area **10**. As a result, markers **8***b*, **8***c*, . . . , and **8***i* are placed, at locations with the ablation margin a from the objective area peripheral line **10***a*, within a single scan plane as shown in FIG. **14**.

[0153] The operator then moves the ultrasound transducer **30** to display an ultrasound image of a XV-XV cross section of FIG. **14** on the display device **7**. Consequently, the display device **7** displays the markers **8***b*, **8***f*, and the objective area **10**; as shown in FIG. **15**. At this point, under the guidance of the ultrasound endoscope, the operator sequentially places markers **8***k*, **8***m*, . . . , **8***p*, and **8***r* at locations with the ablation margin α from the objective area peripheral line **10***a* of the objective area **10**.

[0154] After placing the plurality of markers **8***b*, . . . , and **8***r*, the operator arranges the electrode portion **43** of the ablation device **3** at a desired location in the objective area **10** as shown in FIG. **16**A and performs the ultrasound endoscope-guided ablation.

[0155] When the ablation of the objective area **10** has advanced to some degree, the operator checks whether the actual ablated part **10**Z has reached an ablation line defined by a virtual line **16** connecting the markers shown in FIGS. **16**A and **16**B.

[0156] The operator determines that the ablation is completed if the operator can check that the ablated area has reached the virtual line connecting the markers. On the other hand, the operator arranges the electrode portion **43** to perform the ablation if the actual ablated area has not reached the virtual line.

[0157] In this way, the arrangement of the plurality of markers around the objective area in advance, taking the ablation margin a into consideration, allows the operator to check whether the ablated area has reached the virtual line connecting the makers to thereby surely perform the ablation of the objective area.

[0158] In the above described embodiment, an efficient procedure can be achieved by using a two-dimensional array as an ultrasound transducer or installing a two-plane scan type ultrasound transducer to delineate a plurality of ultrasound images of different scanned surfaces at the same time.

[0159] Alternatively, an extracorporeal probe may be brought into contact with the body surface to capture the objective area that is captured by the ultrasound transducer **30**. In this configuration, the same objective area **10**, the marker **8**, the needle tube **54** of the marker placing device **5**, and the electrode portion **43** of the ablation device **3** are displayed in the ultrasound image of the EUS **2** and the ultrasound image of the extracorporeal probe.

[0160] This enables to easily figure out the entire objective area **10** and to easily perform the orientation to the objective area **10**. Therefore, a procedure can be more quickly and surely performed, allowing to shorten the procedure time and to reduce the burden of the operator.

[0161] A second embodiment of the present invention will be described with reference to FIGS. **17** to **37**.

[0162] As shown in FIG. **17**, configurations of an EUS **2**A and an ultrasound observation device **6**A of the first embodiment are different in an ultrasound endoscope-guided ablation system **1**A of the present embodiment.

[0163] The ultrasound observation device **6**A includes, as an ablation target area specifying unit, a peripheral border input unit **6A1**, a computing unit **6A2**, an ablation margin setting unit **6A3**, and an image processing unit **6A4**. Reference numeral **6A5** denotes an input pen.

[0164] The input pen **6A5** is an objective area input function unit and is a device for tracing a line of the peripheral border of the objective area **10** on an ultrasound image **7***b* displayed on a screen **7***a* to acquire information of the objective area peripheral line. The peripheral line traced by the input pen **6A5** is displayed on the screen **7***a* through an image processing unit **6A4** described below. Information of the displayed peripheral line and the like is outputted to a peripheral border input unit **6A1** from the input pen **6A5**.

[0165] The computing unit **6A2** extracts objective area peripheral line data from the information of the peripheral line inputted to the peripheral border input unit **6**A and stores the data in the storage unit **6***m*.

[0166] The ablation margin setting unit **6A3** is a margin input function unit that sets an ablation margin necessary for the operator to manually ablate the objective area **10**. Once the operator sets the ablation margin a to the ablation margin setting unit **6A3**, the computing unit **6A2** extracts ablation line data, which is ablation target area data in which the ablation margin a is added to the objective area peripheral line data, and stores the data in the storage unit **6***m*.

[0167] The image processing unit **6A4** includes, in addition to a normal image processing function of an ultrasound observation device, a function to apply a predetermined process to the objective area peripheral line data and the ablation line data extracted by the computing unit **6A2** to superimpose and display the ultrasound image **7***b* as well as an ablation line **7***c*, as shown with a broken line as an example, on the screen **7***a*.

[0168] As shown in FIG. **18**, in the EUS **2**A, a distal end surface **21***d* of a distal end rigid portion **21***a***1** constituting the insertion portion **21** is constituted by a plane which is orthogonal to the longitudinal axis direction. An electronically scanning ultrasound transducer **30**A protrudes from the distal end surface, and as in the first embodiment, is configured as a convex array in which a plurality of ultrasound elements are aligned.

[0169] As in the first embodiment, the distal end opening **32**, the illumination lens cover **35**, the observation lens cover **36**, and the air and water feeding nozzle **37** are arranged on the distal end surface **21***d*. Thus, the observation optical system of the EUS **2** is an oblique-view type, while the observation optical system of the EUS **2**A is a forward-view type.

[0170] A forceps raising table is swingably arranged near the distal end opening **32**. Other configurations are similar to the first embodiment, and the same members are designated with the same reference numerals and the description will not be repeated. Although the ultrasound endoscope is EUS **2**A in the present embodiment, but the EUS **2** could be used as the ultrasound endoscope.

[0171] An ablation method of the ultrasound endoscope-guided ablation system **1**A configured as described above will be described with reference to FIGS. **19** to **24**.

[0172] As in the above described embodiment, the operator brings the ultrasound transducer **30**A into contact with the lumen wall **103** as shown in FIG. **19**. The operator captures the objective area **10**, such as cancer, at a desired location in an ultrasound scan area **9**A. Consequently, as shown in FIG. **20**, a delineated image **10***e* of the objective area **10** is delineated on the ultrasound image **7***b* of the screen **7***a* of the display device **7**. Reference numeral **7***d* denotes a projection indication that indicates a delivery start location of a treatment instrument such as a puncture needle.

[0173] When the delineated image **10***e* of the objective area **10** is delineated at the desired location on the ultrasound image **7***b*, the operator instructs the staff to acquire the peripheral border of the objective area **10**. The staff traces the peripheral border of the delineated image **10***e* displayed on the display device **7** with the input pen **6A5** and delineates a peripheral line **7***e* of the delineated image **10***e* on the screen **7***a* as shown in FIG. **21**. Information of the peripheral line **7***e* delineated on the screen **7***a* is outputted to the peripheral border input unit **6A1**, extracted by the computing unit **6A2** as objective area peripheral line data, and stored in the storage unit **6***m*.

[0174] While instructing the acquisition of the peripheral border, the operator observes the delineated image **10***e* and the situation in the surrounding to determine the ablation margin. Subsequently, the operator or the staff inputs the determined ablation margin α in the ablation margin setting unit **6A3**.

[0175] Once the ablation margin α is inputted to the ablation margin setting unit **6A3**, the computing unit **6A2** calculates ablation line data indicative of an ablation target area in which the ablation margin a is added to the extracted objective area peripheral line data. The calculated ablation line data is registered in the storage unit **6***m* and outputted to the image processing unit **6A4**. The image processing unit **6A4** applies a predetermined process to the ablation line data and outputs the data to the display device **7**. Consequently, an ablation line **7***f* is superimposed on the delineated image **10***e* and displayed on the screen **7***a* as shown with a broken line of FIG. **22**.

[0176] When the ablation line **7***f* shown in FIG. **22** is displayed on the ultrasound image **7***b*, the operator holds the ultrasound transducer **30**A of the EUS **2**A such that the ultrasound transducer **30**A does not move and arranges the electrode portion **43** of the ablation device **3** at a desired location in the objective area **10** as shown in FIG. **23**.

[0177] The ultrasound endoscope-guided ablation is then started. Consequently, as the ablation progresses, the delineated image **10***e* displayed on the ultrasound image **7***b* gradually becomes unclear as shown in FIG. **24**. Meanwhile, an ablated objective part ablation image **10***f* is displayed in place

of the delineated image **10***e*. Reference numeral **3***e* denotes a delineated image of the ablation device **3** including the electrode portion **43**.

[0178] The operator performs a hand-side operation of only the ablation device **3** to continue the ablation such that the objective part ablation image **10***f* reaches the ablation line **7***f*. The operator then checks that the objective part ablation image **10***f* displayed on the ultrasound image **7***b* has reached the ablation line **7***f* and ends the ablation of the objective area **10**.

[0179] In this way, the operator traces the objective area displayed on the ultrasound image with an input pen to acquire objective area peripheral line data. In addition, the operator inputs an ablation margin to the ablation margin setting unit to obtain ablation line data, in which the ablation margin α is added to the objective area peripheral line data, and displays the ablation line in the ultrasound image. The operator ablates the objective area with the ablation line being displayed and performs the ablation while checking whether the objective part ablation image has reached the ablation line. This enables to obtain similar effects and advantages as in the above described embodiment.

[0180] In the present embodiment, the objective area is traced by the input pen to acquire the objective area peripheral line data. However, the operator or the staff may operate a pointing device such as a mouse or a trackball to instruct a rough area of the objective area, and based on the instructed information, the ultrasound observation device may automatically extract the boundary between the objective area and the surrounding tissues.

[0181] Another ablation method of the ultrasound endoscope-guided ablation system **1**A will be described with reference to FIGS. **25** to **31**. An EUS **2**B shown in FIG. **25** is used in place of the EUS **2**A in the present embodiment.

[0182] The EUS **2**B shown in FIG. **25** includes an ultrasound transducer **30**B. The ultrasound transducer **30**B uses a two-dimensional array type or the like to be controlled by the ultrasound observation device **6**A to scan two orthogonal surfaces to thereby obtain a first scanned surface S**1** and a second scanned surface S**2**. Other configurations are similar to the above described embodiment, and the same members are designated with the same reference numerals and the description will not be repeated.

[0183] In the EUS **2**B of the present embodiment, the operator brings the ultrasound transducer **30**B into contact with the lumen wall **103**, and as shown in FIG. **26**, captures the objective area **10**, such as cancer, at a desired location in an ultrasound scan area **9**B of the first scan surface S**1** and in an ultrasound scan area **9**C of the second scanned surface S**2**.

[0184] Consequently, as shown in FIG. **27**, a first ultrasound image **7***g* including a delineated image **10***g* captured in the first ultrasound scan area **9**B and a second ultrasound image **7***h* including a delineated image **10***h* captured in the second ultrasound scan area **9**C are displayed on the screen **7***a*. When the delineated images **10***g* and **10***h* are displayed in desired states on two ultrasound images **7***g* and **7***h* displayed on the screen **7***a*, the operator instructs the staff to acquire the peripheral border of the objective area **10**.

[0185] In the present embodiment, the staff traces the peripheral borders of the delineated images **10***g* and **10***h* displayed on the display device **7** with the input pen **6**A**5** to delineate peripheral lines **7***m* and **7***n* of the delineated images **10***g* and **10***h* on the screen **7***a* as shown in FIG. **28**. Information of the peripheral lines **7***m* and **7***n* delineated on the screen **7***a* is outputted to the peripheral border input unit **6**A**1**, extracted by the computing unit **6**A**2** as objective area peripheral line data of the peripheral lines **7***m* and **7***n*, and stored in the storage unit **6***m*.

[0186] The operator instructs the acquisition of the peripheral border while observing the situations in the delineated images **10***g*, **10***h*, and the surrounding to determine the ablation margin. Subsequently, the operator or the staff inputs the determined ablation margin α in the ablation margin setting unit **6**A**3**.

[0187] Once the ablation margin cc is inputted to the ablation margin setting unit **6**A**3**, the computing unit **6**A**2** calculates each of the ablation line data, in which the ablation margin ox is added to each of the extracted objective area peripheral line data. Each of the calculated ablation line data is registered in the storage unit **6***m* and outputted to the image processing unit **6**A**4**. The image processing unit **6**A**4** applies a predetermined process to each of the ablation line data and outputs the data to the display device **7**. Consequently, ablation lines **7***q* and **7***r* are superimposed on the delineated image **10***g* and displayed on the screen **7***a* as shown with a broken line of FIG. **29**.

[0188] When the ablation lines **7***q* and **7***r* shown in FIG. **29** are displayed on the ultrasound image **7***b*, the operator holds the ultrasound transducer **30**B of the EUS **2**B such that the ultrasound transducer **30**B does not move and arranges the electrode portion **43** of the ablation device **3** at a desired location in the objective area **10** as shown in FIG. **30**.

[0189] The ultrasound endoscope-guided ablation is then started. Consequently, as the ablation progresses, the delineated images **10***g* and **10***h* displayed in the ultrasound images **7***g* and **7***h* become gradually unclear as shown in FIG. **31**, and meanwhile, ablated objective part ablation images **10***j* and **10***k* are displayed in place of the delineated images **10***g* and **10***h*.

[0190] The operator performs a hand-side operation of only the ablation device **3** to continue the ablation such that the objective part ablation images **10***j* and **10***k* displayed in the ultrasound images **7***g* and **7***h* reach the ablation lines **7***q* and **7***r*, respectively.

[0191] The operator checks that the objective part ablation image **10***j* displayed in the ultrasound image **7***g* has reached the ablation line **7***q* and that the objective part ablation image **10***k* displayed in the ultrasound image **7***h* has reached the ablation line **7***r* and ends the ablation of the objective area **10**.

[0192] In this way, the two-dimensional array type ultrasound transducer is driven so as to scan two orthogonal planes to thereby display two ultrasound images on the screen. The objective area is displayed on each ultrasound image to acquire the objective area peripheral line data as well as to acquire the ablation line data in which the ablation margin α is added to the objective area peripheral line data. More accurate management of the ablation margin is made possible by displaying the ablation line in each ultrasound image during the procedure of the ablation to check whether the objective part ablation image has reached the ablation line.

[0193] Managing the ablation of the objective area with two planes enables to deal with a flat objective area, a complex objective area, and the like.

[0194] Although the two planes are orthogonal in the present embodiment, the angle could be set arbitrarily. Other effects and advantages are similar as in the above described embodiment.

[0195] Another ablation method of the ultrasound endoscope-guided ablation system **1**A will be described with reference to FIGS. **32** to **37**. The puncture needle **5** as well as the EUS **2**A shown in FIGS. **19** to **24** are used in the present embodiment. However, the EUS is not limited to the EUS **2**A, but may also be the EUS **2**B.

[0196] As in the above described embodiment, the operator brings the ultrasound transducer **30**A into contact with the lumen wall **103** as shown in FIG. **32**. The operator then captures the objective area **10**, such as cancer, to a desired location in the ultrasound scan area **9**A. Consequently, the delineated image **10***e* of the objective area **10** is delineated on the ultrasound image **7***b* of the screen **7***a* of the display device **7** as shown in FIG. **33**.

[0197] The operator **101** then arranges the distal end of the needle tube **54** near the objective area **10** under the guidance of the ultrasound endoscope to place the marker **8** with the above described procedure. Consequently, a marker image **8***t* is delineated on the ultrasound image **7***b* of FIG. **33**.

[0198] After checking the placement of the marker **8** to the objective area **10**, the operator **101** instructs the staff to acquire the peripheral border of the objective area **10**.

[0199] At this point, the staff traces the peripheral border of the delineated image **10***e* displayed on the display device **7** with the input pen **6**A**5** as described above and specifies the marker image **8***t*. Consequently, the peripheral line **7***e* of the delineated image **10***e* and an indicator **8***u* indicative of the location of the marker image **8***t* are displayed on the screen **7***a* as shown in FIG. **34**. Information of the locations of the peripheral line **7***e* and the indicator **8***u* are outputted to the peripheral border input unit **6**A**1**, and the computing unit **6**A**2** stores the information in the storage unit **6***m* as objective area peripheral line data with the location of the indicator **8***u* as a base point.

[0200] As described above, the operator **101** or the staff inputs the ablation margin a in the ablation margin setting unit **6**A**3** and acquires the ablation line **7***f* superimposed on the delineated image **10***e* and shown with a broken line as shown in FIG. **35**.

[0201] Subsequently, as in the above described embodiment, the electrode portion **43** of the ablation device **3** is arranged in the objective area **10** as shown in FIG. **36** to perform the ultrasound endoscope-guided ablation.

[0202] The operator **101** ablates the objective area **10** while checking whether the objective part ablation image **10***f* displayed on the ultrasound image **7***b* as shown in FIG. **37** has reached the ablation line **7***f*. The operator **101** then checks that the objective part ablation image **10***f* has reached the ablation line **7***f* and ends the ablation of the objective area **10**.

[0203] In the present embodiment, the operator **101** or the staff always checks the location of the marker image **8***t* during the procedure. Therefore, checking the displacement of the marker image **8***t* based on the indicator **8***u* indicative of the location of the marker image **8***t* enables to easily determine that the ultrasound transducer **30**A has moved. In response, if, by any chance, the ultrasound transducer **30**A has moved, a hand-side operation is performed to match the indicator **8***u* with the marker image **8***t*. As a result, the ablation target area that has once been displaced is reset to the original ablation target area.

[0204] In this way, the location of the marker image is also acquired upon the acquisition of the objective area peripheral line data of the objective area displayed on the ultrasound image. Specifically, the objective area peripheral line of the objective area is acquired based on the marker. This enables to easily determine that the ultrasound transducer has moved during the procedure and to easily put back the location of the ultrasound transducer to the original state to perform the ablation even if the ultrasound transducer has moved during the procedure. Other effects and advantages are similar as in the above described embodiment.

[0205] A second distal end opening **32***a* that is in communication with a second treatment instrument channel may be arranged on the distal end surface **21***d* of the EUS **2**A as shown in FIG. **38** as an example to prevent the movement of the ultrasound transducer during the procedure.

[0206] In this configuration, grasping forceps **17** are projected from the second distal end opening **32***a*, and the grasping forceps **17** grasp a body tissue near the ultrasound transducer **30**A. This enables to prevent the movement of the ultrasound transducer **30**A and perform the ablation.

[0207] The ablation device **3** is also used endoscopically. Therefore, the outer dimension or the hardness length of the ablation device **3** is limited. Thus, the ablation performance of the ablation device **3** tends to be poorer than that in an ablation device used percutaneously. Therefore, it is difficult to ablate the entire objective area of a large lesion or the like at once, and more than one ablation has been performed on the objective area. Thus, the procedure has been long.

[0208] To solve the problem, for example, the distal end surface **21**d of an EUS **2**A**1** shown in FIG. **39** includes the second distal end opening **32***a* in communication with the second treatment instrument channel. As a result, two ablation devices **3***a* and **3***b* are projected in the EUS **2**A**1**, thereby enabling to arrange electrode portions **43**D and **43**E in the objective area **10** as shown in FIG. **40**.

[0209] In this configuration, a first ablation device **3***a* is projected from the first distal end opening **32**, and as shown in FIG. **40**, an electrode portion **43**D is arranged not at the center of the objective area, but is displaced in the lower peripheral border direction of FIG. **40**. Subsequently, a second ablation device **3***b* is projected from the second distal end opening **32***a*, and an electrode portion **43**E is arranged in the upper peripheral border direction of FIG. **40** in the objective area **10**, apart from the electrode portion **43**D.

[0210] Radio frequencies are simultaneously outputted from the electrode portions **43**D and **43**E of two ablation devices **3***a* and **3***b* to perform the ablation. In the present embodiment, the electrode portions **43**D and **43**E include four electrodes **43***f*, **43***g*, **43***h*, and **43***i* in total, and therefore, the radio frequencies are outputted with all combinations of the electrodes. This allows the ablation on a wide scale at a time.

[0211] Arranging two ablation devices in the objective area and simultaneously outputting the radio frequencies from two electrode portions allow the ablation of a wide objective area in a short time at a time. Therefore, the procedure time can be shortened, and burdens of the patient and the operator can be reduced.

[0212] The number of the ablation devices punctured into the objective area is not limited to one or two, but may be more. For example, three distal end openings **32**, **32***a*, and **32***b* may be arranged on the slope portion **34** of the distal end rigid portion **21***a* of the EUS **2** as shown in FIGS. **41**A and **41**B.

[0213] As a result, three electrode portions **43**D, **43**E, and **43**K of the ablation devices **3***a*, **3***b*, and **3***c* are arranged in the objective area **10** through three treatment instrument channels as shown in FIG. **42**, allowing the ablation of a still wider

objective area **10** at a time. Reference numerals **31**, **31***a*, and **31***b* denote treatment instrument channels.

[0214] Conventionally, the operator has reached the objective area with the following procedure when treating the objective area, such as cancer, with an EUS mounted with a convex ultrasound transducer.

[0215] The operator first delineates, on the display device, an organ, such as aorta, that can be most easily delineated and that is easy to be recognized in the ultrasound image and sets the organ as a base point. Subsequently, the operator moves the ultrasound transducer in the direction where the objective area anatomically exists. In this case, the operator sequentially delineates blood vessel, organ, and the like that serve as targets around the aorta to reach the objective area.

[0216] In the procedure, which part is being delineated cannot be determined in some cases when delineating a target in the middle. In that case, the operator had to return to the base point and start over from the first procedure.

[0217] The operator reaches the objective area **10** with the following procedure when treating the objective area **10** with the EUSs **2**, **2**A, and **2**B mounted with the convex ultrasound transducers **30**, **30**A, and **30**B.

[0218] The operator first brings the ultrasound transducer **30**A of the EUS **2**A into contact with the lumen wall **103** as shown in FIG. **43**, captures a large vessel **100**, which is an organ serving as a base point such as aorta, in the ultrasound scan area **9**A on the display device **7**, and delineates the large vessel **100** on the ultrasound image.

[0219] The operator then performs a hand-side operation for moving the ultrasound transducer **30**A from the base point into the arrow direction of FIG. **44** where the objective area anatomically exists. The operator then arranges the ultrasound transducer **30**A at a location in the ultrasound image where the organ, such as celiac artery or lymph node, is delineated, the organ being an indication located on the way to the objective area.

[0220] The operator places a first endoscopic marker **71** on the lumen inner wall as shown in FIG. **44** to record the location when delineating the organ serving as a mark. The first endoscopic marker **71** is a marker designed to be seen on an endoscopic image. The operator places, as necessary, a first ultrasound marker **81**, which is the marker **8**, in the delineated organ or near the organ under the guidance of the ultrasound endoscope. The first ultrasound marker **81** is a marker designed to be delineated on the ultrasound image.

[0221] The placement of the endoscopic marker is performed by an injection needle not shown through a treatment instrument channel included in the EUS **2**A. Meanwhile, the placement of the ultrasound marker is performed by the puncture needle **5** through the treatment instrument channel included in the EUS **2**A. Alternatively, the ultrasound marker may be placed first by the puncture needle **5**, and then the endoscopic marker may be placed using the same puncture needle **5**. In this case, the placement of the endoscopic marker is performed by pulling out the pusher **55** of the puncture needle **5** and connecting a syringe full of pigment or stain solution to the ferrule portion **60**. When using a pigment such as Indian ink, methylene blue, and indigo carmine, the puncture needle **5** is used to inject the pigment under mucosa to perform the placement. When using a stain solution such as iodine and methylene blue, the puncture needle **5** is used to disperse the pigment of the mucosal surface to stain the mucosa.

[0222] Subsequently, the operator continues a hand-side operation for moving the ultrasound transducer **30**A in the arrow direction where the objective area anatomically exists as shown in FIGS. **45** and **46**. The operator then arranges the ultrasound transducer **30**A at a location where blood vessel, lymph node, or the like is located on the way to the objective area. The operator then places a second endoscopic marker **72** and a second ultrasound marker **82**, a third endoscopic marker **73** and a third ultrasound marker **83**, . . . every time the organ serving as a mark is delineated and records the trajectory of the movement of the ultrasound transducer **30**A.

[0223] After placing, for example, the markers **73** and **83** as shown in FIG. **46**, the objective area **10** can be captured in the ultrasound scan area **9**A. The operator then performs the ultrasound observation of the objective area **10**, puncture of the needle tube **54** as shown with a broken line, or other treatments.

[0224] In the present embodiment, if the operator, by any chance, loses the delineated location as described above while moving the ultrasound transducer **30**A, the operator looks for the marker placed before the location. Thus, for example, if the operator loses the movement direction after placing the markers **73** and **84**, the operator finds the placed markers **73** and **83** so that the delineation of organ can be restarted from the place.

[0225] The endoscopic marker is not limited to Indian ink, methylene blue, indigo carmine, or the like that can be easily checked in the endoscopic image. A material, such as a clip, that can be discriminated in the endoscopic image and that does not easily drop out can be utilized.

[0226] As described, in a series of movement operations from capturing the base point to reaching the objective area, the endoscopic marker and the ultrasound marker are placed every time an intermediate mark is captured. Consequently, in the process of moving the ultrasound transducer toward the objective area, even if the operator loses the orientation, the operator can return to the endoscopic marker and the ultrasound marker placed previously to restart the movement of the ultrasound transducer toward the objective area without restarting from the base point.

[0227] This can surely prevent the significantly extended procedure time even if the orientation is lost during the movement of the ultrasound transducer.

[0228] In the above described embodiment, it is difficult to immediately determine, at a glance of a plurality of markers, the order of the placement of the markers from the base point. Therefore, the number of the endoscopic markers **71**, **72**, and **73** and the number of the ultrasound markers **81**, **82**, and **83** are increased as shown in FIG. **47** every time the ultrasound transducer **30**A is moved to enable to clearly determine the order of movement of the ultrasound transducer **30**A. Alternatively, the sizes of the endoscopic markers **71**, **72**, and **73** and the sizes of the ultrasound markers **81**, **82**, and **83** may be increased as shown in FIG. **48** every time the ultrasound transducer **30**A is moved.

[0229] In the endoscopic markers **71**, **72**, and **73** of FIG. **48**, the injection volume of the pigment is increased upon every movement. Meanwhile, in the ultrasound markers **81***a*, **82***a*, and **83***a*, the lengths are increased by a predetermined length upon every movement.

[0230] As shown in FIGS. **49** and **50**, the ultrasound markers **81***a*, **82***a*, and **83***a* are rod-shaped, and the length is set to a predetermined length. The cross-sectional shape of the ultrasound markers **81***a*, **82***a*, and **83***a* is circular or polygo-

nal, and ultrasound reflection processing, such as concave-convex dimple processing or sandblast processing, is applied to the surfaces.

[0231] A barb **84** is arranged at an acicular formation portion of the distal end, which is one end, of the ultrasound markers **81***a*, **82***a*, and **83***a* shown in FIG. **50** to prevent the movement or dropping out of the placed markers.

[0232] An ultrasound reflection coating layer containing air bubbles may also be arranged, instead of applying the ultrasound reflection processing on the surfaces of the ultrasound markers **81***a*, **82***a*, and **83***a*.

[0233] For example, ultrasound markers **82***b*, having the same length, are further arranged in the needle tube **54** as shown in FIG. **51**.

[0234] This allows the operator to insert the needle tube **54** near the organ to place the first ultrasound marker **82***b* in the organ and to slightly pull back the needle tube **54** to place the second ultrasound marker **82***b* on the lumen inner wall as an endoscopic marker when delineating the organ serving as a mark. Thus, the placement of the ultrasound marker and the placement of the endoscopic marker can be consecutively performed with one puncture operation. In this case, the marker **82***b* can be used as an endoscopic marker because the marker **82***b* can be placed projected halfway from the luminal surface due to the effect of the barb **84**.

[0235] Arranging at least two ultrasound markers, having the same length, in the needle tube enables to place the makers in the organ and in the lumen inner wall with one type of the ultrasound marker without selectively using the endoscopic marker and the ultrasound marker.

[0236] Placing, for example, three types of ultrasound markers **81***a*, **82***a*, and **83***a* with different lengths, two for each, enables to consecutively place the markers **81***a*, **82***a*, and **83***a* in the organ and the lumen inner wall in the movement from the base point to the objective area **10** without pulling out the puncture needle from the treatment instrument channel of the endoscope.

[0237] Although both of the endoscopic marker and the ultrasound marker are placed in the above described description, only one of them may be placed.

[0238] In the above described procedure for ablating the objective area **10** by the ablation device **3**, the ablation margin a is set before the ablation to prevent leaving the diseased tissue. In general, if the thermal denaturation is progressed such that the thermal denaturation of protein can be checked on the ultrasound image, the temperature may be reaching, for example, 100° C., far exceeding the temperature that the cells necrose. If the ablation is performed at 100° C., the surrounding of the cells may also be thermally influenced.

[0239] Therefore, the procedure needs to be performed with minimum required heat when ablating an objective area where main blood vessels or nerves are located nearby. It is significantly difficult to ablate without leaving the diseased tissue when performing the procedure with the minimum required heat.

[0240] To solve the problem, a temperature sensor can be installed in the ablation device to manage the temperature. However, only the temperature near the center of the ablated part can be managed with the configuration in which the temperature sensor is installed in the ablation device.

[0241] Therefore, a procedure is desired in which the functions of the surrounding organs located near the objective area can be preserved under the guidance of ultrasound and the objective area can be surely ablated without leaving the diseased tissue.

[0242] A procedure capable of preserving the functions of the surrounding organs located near the objective area and surely ablating the objective area will be described with reference to FIGS. **52** to **60**.

[0243] In the ablation method, for example, the EUS **2**A**1** shown in FIG. **39** that includes a plurality of treatment instrument channels is used as the EUS. A puncture needle **5**A with temperature sensor shown in FIGS. **52** to **54** is also used in the procedure.

[0244] As shown in FIG. **52**, the puncture needle **5**A with temperature sensor includes a handle portion **51**A and a channel insertion portion **52**A. The channel insertion portion **52**A includes the sheath **53** and the needle tube **54**. Reference numeral **54***i* denotes an ultrasound reflecting unit. Concave-convex dimple processing or sandblast processing is applied to the surface of the distal end portion of the ultrasound reflecting unit **54***i*, the distal end portion being projected from the sheath **53**.

[0245] The needle tube **54** is inserted into and slidable with respect to the sheath **53**. In the needle tube **54** of the present embodiment, a temperature sensor **18** is arranged at the distal end side in a through hole **54***h* as shown in FIG. **53**. The temperature sensor **18** is fixed to a predetermined location with, for example, an adhesive. A sensor signal line **18***a* extends from the temperature sensor **18**.

[0246] The handle portion **51**A includes, for example, in order from the distal end, the securing ring **56**, the operation portion main body **57**, the stopper member **58**, and a needle slider **59**A.

[0247] One end of a sensor cable connection part **19** shown in FIG. **54** is fixedly provided to the proximal end of the needle slider **59**A. A sensor cable **20** is fixedly provided to the other end of the sensor cable connection part **19**.

[0248] One end of the sensor signal line **18***a* inserted into the sensor cable **20** is connected to the temperature sensor **18** passing through inside the sensor cable connection part **19**, the needle slider **59**A, and a needle tube **53***a*. The other end of the sensor signal line **18***a* is connected to a temperature measuring device not shown.

[0249] The temperature measuring device includes a temperature calculating unit and a temperature displaying unit. The temperature calculating unit calculates the temperature based on an outputted signal outputted from the temperature sensor **18** and outputs the calculated temperature to the temperature displaying unit. The temperature displaying unit displays the temperature outputted from the temperature calculating unit.

[0250] The temperature measuring device is connected to the power source device **4** and is configured to be able to output, to the power source device **4**, a control signal for terminating the output to the ablation device **3** when the measured temperature reaches a predetermined temperature.

[0251] As shown in FIG. **55**, for example, the ablation device **3** is projected from the distal end opening **32***a*, and the puncture needle **5**A with temperature sensor is projected from the distal end opening **32** to preserve the functions of the surrounding organs located near the objective area and to surely perform the procedure to ablate the objective area.

[0252] Specifically, as shown in FIG. **56**, if the objective area **10** and a surrounding organ **104**, the function of which is to be preserved, are delineated in the ultrasound image, the

operator arranges the electrode portion **43** of the ablation device **3** in the objective area **10**. Meanwhile, the operator arranges the needlepoint of the puncture needle **5**A with temperature sensor at a desired location between near the surrounding organ **104** and the objective area **10**. The ablation of the objective area **10** is then performed.

[0253] When performing the ablation, the operator sets the measured temperature of the temperature measuring device to, for example, 60° C. As a result, the temperature measuring device is set to output an output termination signal to the power source device when the temperature sensor **18** detects 60° C.

[0254] In the present embodiment, unlike the conventional ablation procedure, the operator can perform the ablation, with the temperature near the surrounding organs being monitored. Therefore, the ablation in the objective area can be raised to a desired temperature. Meanwhile, the thermal influence to the proximity of the surrounding organs can be minimized.

[0255] The objective area can be necrosed with minimum required input energy so that the procedure time can be shortened and the energy can be conserved.

[0256] The psychological burden of the operator can also be significantly reduced because the temperature near the area, the function of which is to be preserved, is monitored during the ablation and the output of the power source device is terminated when the temperature rises to the preset temperature.

[0257] In the present embodiment, the ablation device **3** is projected from the distal end opening **32***a*, and the puncture needle **5**A with temperature sensor is projected from the distal end opening **32**. However, the puncture needle **5**A with temperature sensor may be projected from the distal end opening **32***a* and the ablation device **3** may be projected from the distal end opening **32**.

[0258] The configuration of the puncture needle with temperature sensor is not limited to the configuration, but may also be configured as shown in FIGS. **57** to **59**.

[0259] As shown in FIG. **57**, a puncture needle **5**B with temperature sensor of the present embodiment includes a handle portion **51** B and a channel insertion portion **52**B. The channel insertion portion **52**B includes the sheath **53**, the needle tube **54**, and a stylet **62**.

[0260] The stylet **62** is a pipe-shaped insulating portion and is inserted into and slidable with respect to the needle tube **54**. As shown in FIG. **58**, a temperature sensor **18**B is arranged at the distal end of the stylet **62** of the present embodiment. An insulation coating is applied to the temperature sensor **18**B. The temperature sensor **18**B is fixed by, for example, adhesion. A sensor signal line **18***c* extends from the temperature sensor **18**B.

[0261] The handle portion **51**A includes, in order from the distal end, the securing ring **56**, the operation portion main body **57**, the stopper member **58**, the needle slider **59**, the ferrule portion **60**, and a stylet mouthpiece **63**.

[0262] One end of the ferrule portion **60** shown in FIG. **59** is fixedly provided to the proximal end of the needle slider **59**. The proximal end portion of the stylet **62** is fixed to one end of the stylet mouthpiece **63**, and the sensor cable **20** is fixedly provided to the other end.

[0263] One end of the sensor signal line **18***c* inserted into the sensor cable **20** is connected to the temperature sensor **18**B passing through inside the stylet mouthpiece **63** and the stylet **62**. The other end of the sensor signal line **18***c* is connected to the temperature measuring device as in the above described embodiment.

[0264] Other configurations are similar to the puncture needle **5**A with temperature sensor, and the same members are designated with the same reference numerals and the description will not be repeated.

[0265] According to the puncture needle **5**B with temperature sensor thus configured, if the objective area **10** and the surrounding organ **104**, the function of which is to be preserved, are delineated in the ultrasound image as shown in FIG. **60**, the operator arranges the electrode portion **43** of the ablation device **3** in the objective area **10**. Meanwhile, the needlepoint of the puncture needle **5**B with temperature sensor is arranged apart from the electrode portion **43** arranged in the objective area **10**. In other words, the temperature sensor **18**B that is projecting from the needle tube **54**, arranged in the stylet **62** formed of the insulating member, and applied with the insulation coating is arranged at a desired location between near the surrounding organ **104** and the objective area **10**. This enables to perform the ablation treatment, with the metal member separated from the ablation device.

[0266] Whether the punctured needlepoint has reached the objective area is determined by the ultrasound image, for example, in the procedure of puncturing the puncture needle in the objective area under the guidance of ultrasound. However, if the objective area is a relatively soft organ such as benign lymph node and gall bladder, even in case where a needlepoint **91** is not penetrated through an outer membrane **105** as shown in FIG. **61**, the needlepoint may be delineated as if it has reached the objective area on the ultrasound image. Therefore, a puncture method capable of surely determining on the ultrasound image whether the needlepoint **91** has reached inside the objective area **90** is desired.

[0267] The puncture method that enables to determine on the ultrasound image whether the needlepoint has reached inside the objective area will be described with reference to FIGS. **61** to **63**.

[0268] The operator first punctures the needle tube **54** into the objective area **90** under the guidance of ultrasound as shown in FIG. **61**. The operator then supplies an ultrasound contrast agent through the needle tube **54**. At this point, an ultrasound contrast agent **92** is injected into the objective area **90** as shown in FIG. **62** if the needle tube **54** has broken through the outer membrane **105** and the needlepoint **91** is located in the objective area **90**. Therefore, how the ultrasound contrast agent spreads inside the objective area is delineated in the ultrasound image.

[0269] On the other hand, the ultrasound contrast agent **92** is not injected into the objective area **90**, but is leaked outside if the needlepoint **91** of FIG. **63** is only significantly transforming the outer membrane **105**. Thus, although the ultrasound contrast agent is injected, how the ultrasound contrast agent spreads in the objective area displayed in the ultrasound image is not delineated.

[0270] In this way, whether the needlepoint has broken through the outer membrane and reached inside the objective area can be easily and surely determined by injecting the ultrasound contrast agent through the needle tube after puncturing the needle tube.

[0271] This enables to accurately determine whether the transition to the next treatment, such as the collection of a specimen or the placement of a guide wire, is possible. Furthermore, an erroneous collection, such as the collection of a

specimen other than the objective area, can be surely prevented when collecting the specimen.

[0272] The operator can quickly take a measure such as increasing the puncture speed when checking that the needlepoint of the puncture needle has not reached inside the objective area. This can shorten the procedure time and reduce the burden of the operator and the patient.

[0273] Another puncture method that enables to determine on the ultrasound image whether the needlepoint has reached inside the objective area will be described with reference to FIGS. **61** and **64**. In the present embodiment, the ultrasound marker **81***a* is used, for example, instead of injecting the ultrasound contrast agent for determining whether the needlepoint **91** has reached inside the objective area **90**.

[0274] The operator first punctures the needle tube **54** in the objective area **90** under the guidance of ultrasound as shown in FIG. **61**. In the present embodiment, the operator squeezes the pusher **55** after the puncture and places the ultrasound marker **81***a* outside the needle tube **54**. Subsequently, the operator pulls out the needle tube **54**.

[0275] At this point, the ultrasound marker **81***a* is placed in the objective area **90** in spite of the retraction of the needlepoint **91** as shown in FIG. **64** if the needle tube **54** pierces the outer membrane **105** and the needlepoint **91** is located in the objective area **90**. Thus, the ultrasound marker **81***a* arranged inside the objective area is delineated in the ultrasound image.

[0276] Meanwhile, when the needlepoint **91** is only significantly transforming the outer membrane **105**, after the needle tube **54** is pulled out, the ultrasound marker **81***a* is moved from a location of a broken line to a location of a solid line as the outer membrane **105** is restored as shown in FIG. **65**. Thus, the ultrasound marker **81***a* located outside the peripheral border of the objective area **90** is delineated in the ultrasound image.

[0277] After the puncture, implementing a step of placing the marker enables to easily and surely determine whether the needle point has broken through the outer membrane and reached the objective area.

[0278] This enables to obtain effects and advantages that are similar in the case where the ultrasound contrast agent is injected.

[0279] Having described the preferred embodiments of the invention referring to the accompanying drawings, it should be understood that the present invention is not limited to those precise embodiments and various changes and modifications thereof could be made by one skilled in the art without departing from the spirit or scope of the invention as defined in the appended claims.

What is claimed is:

1. An ultrasound-guided ablation method comprising:
- capturing an objective area to be ablated in an ultrasound scan area of an ultrasound transducer and delineating the objective area on an ultrasound image;
- specifying an ablation target area to display the ablation target area with a margin necessary for ablating the objective area on the ultrasound image processed by an ultrasound observation device and displayed on a display device;
- ablating, by an ablation device, the ablation target area displayed on the ultrasound image; and
- checking, on the ultrasound image, that an ablated area ablated by the ablation device has reached the ablation target area displayed on the ultrasound image.

2. The ultrasound-guided ablation method according to claim **1**, wherein
- the ultrasound transducer for delineating the objective area on the ultrasound image is included in an ultrasound endoscope.

3. The ultra-sound guided ablation method according to claim **1**, further comprising:
- arranging, in the objective area, at least one marker that can be delineated on the ultrasound image.

4. The ultrasound-guided ablation method according to claim **3**, wherein
- the specifying the area to be ablated for displaying the ablation target area on the ultrasound image comprises:
- placing one of the markers in the objective area;
- measuring distances from the delineated marker to a peripheral border of the delineated objective area at a plurality of locations on the ultrasound image;
- calculating an ablation distance in which a maximum value of measured values of the plurality of locations is added to an ablation margin; and
- setting a spherical area, having the ablation distance as a radius, as the ablation target area.

5. The ultrasound-guided ablation method according to claim **3**, wherein:
- the specifying the area to be ablated for displaying the ablation target area on the ultrasound image comprises:
- placing three of the markers on the ultrasound image on which the objective area is delineated;
- delineating an ultrasound image of a different tomographic surface while delineating two of the three placed markers on the ultrasound image and placing a fourth marker on the ultrasound image; and
- delineating three of the four placed markers on the ultrasound image to set an ablation target area by adding the ablation margin to the peripheral border of the delineated objective area for each tomographic surface including the three markers and storing the ablation target area with delineated three markers as base points.

6. The ultrasound-guided ablation method according to claim **3**, wherein
- the specifying the area to be ablated for displaying the ablation target area on the ultrasound image is performed by placing a plurality of the markers at locations that are around the objective area and that are separated by a distance of the ablation margin from the peripheral border of the objective area.

7. The ultrasound-guided ablation method according to claim **1**, wherein
- the specifying the area to be ablated for displaying the ablation target area on the ultrasound image comprises:
- acquiring a peripheral line of the delineated objective area on the ultrasound image.

8. The ultrasound-guided ablation method according to claim **7**, wherein
- the peripheral line of the delineated objective area is obtained by an input function unit, which is included in the ultrasound observation device, tracing the peripheral border of the delineated objective area on the ultrasound image.

9. The ultrasound-guided ablation method according to claim **7**, wherein
- the peripheral line of the delineated objective area is obtained by automatically extracting, on the ultrasound image, a boundary between the delineated objective area

and a delineated periphery by an extraction function included in the ultrasound observation device.

10. The ultrasound-guided ablation method according to claim **1**, wherein

when the ultrasound transducer is a two-dimensional array type for obtaining orthogonal first scanned surface and second scanned surface, the specifying the area to be ablated for displaying the ablation target area on the ultrasound image acquires a peripheral line of the delineated objective area acquired from the first scanned surface and acquires a peripheral line of the delineated objective area acquired from the second scanned surface, the peripheral lines being delineated on the ultrasound image.

11. The ultrasound-guided ablation method according to claim **3**, wherein

when specifying the area to be ablated for displaying the ablation target area on the ultrasound image, the peripheral line of the delineated objective area is acquired on the ultrasound image and the delineated marker is acquired.

12. The ultrasound-guided ablation method according to claim **2**, wherein

the capturing the objective area in the ultrasound scan area of the ultrasound transducer included in the ultrasound endoscope and delineating the objective area on the ultrasound image comprises:

capturing a desired organ as a base point in the ultrasound scan area and delineating the organ on the ultrasound image; and

placing both or one of a marker that can be seen on the endoscopic image and a marker that can be delineated on the ultrasound image to record a captured location when capturing an organ serving as an indication in the ultrasound area after moving the ultrasound transducer from the base point into a direction where the objective area is anatomically located.

13. The ultrasound-guided ablation method according to claim **12**, wherein

types, sizes, or the number of placed markers are varied when placing the markers such that the order of placement of the markers can be recognized.

14. An ultrasound-guided ablation system comprising:

an ultrasound observation device that delineates, as an ultrasound image, an objective area captured in an ultrasound scan area of an ultrasound transducer on a screen of a display device;

an ablation target area specifying unit that specifies an ablation target area for displaying the ablation target area of the objective area on the ultrasound image; and

an ablation device that ablates the ablation target area of the objective area.

15. The ultrasound-guided ablation system according to claim **14**, wherein

the ultrasound transducer is included in an ultrasound endoscope.

16. The ultrasound-guided ablation system according to claim **14**, wherein

the ablation target area specifying apparatus is a marker placing device that arranges, around the objective area, at least one marker that can be delineated on the ultrasound image.

17. The ultrasound-guided ablation system according to claim **16**, wherein

the marker that can be delineated on the ultrasound image is a rod-shaped or spherical member, and ultrasound reflection processing is applied to the surface of the marker.

18. The ultrasound-guided ablation system according to claim **17**, wherein

the rod-shaped marker includes a barb on an acicular formation portion at one end side.

19. The ultrasound-guided ablation system according to claim **17**, wherein

a material of the marker is a substance absorbed in the living body in the course of time.

20. The ultrasound-guided ablation system according to claim **19**, wherein

the marker is made of magnesium alloy.

21. The ultrasound-guided ablation system according to claim **16**, wherein

the marker placing device comprises a needle tube and a pusher slidable in the needle tube,

a plurality of the markers can be loaded in a space section constituted by a distal end portion of the needle tube and a distal end surface of the pusher, and

the markers are sequentially arranged in the objective area by the movement of the pusher.

22. The ultrasound-guided ablation system according to claim **14**, wherein

the ultrasound observation device comprises:

an objective area input function unit that traces the peripheral border of the delineated objective area on the ultrasound image; and

the ablation target area specifying unit, the ablation target area specifying unit comprising:

an ablation margin setting unit that sets an ablation margin used when ablating the objective area;

a peripheral border input unit inputted with information of the peripheral border traced by the objective area input function unit and the ablation margin set by the ablation margin setting unit;

a computing unit that calculates ablation target area data from the two pieces of information inputted in the peripheral border input unit; and

an image processing unit that processes the ablation target area data calculated by the computing unit to display an ultrasound image and a line indicative of the ablation target area on a screen of the display device.

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摘要(译)

超声引导的消融方法捕获要在超声换能器的超声扫描区域中消融的物镜区域并描绘超声图像上的物镜区域;指定消融目标区域，以显示消融目标区域，该消融目标区域具有消融由超声波观察装置处理并显示在显示装置上的超声波图像上的目标区域所需的余量;通过消融装置消融超声图像上显示的消融目标区域;并且在超声图像上检查消融装置消融的消融区域是否已到达超声图像上显示的消融目标区域。