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(54) **ULTRASOUND PROBE AND ULTRASOUND ENDOSCOPE INCLUDING ULTRASOUND PROBE**

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ABSTRACT

A transducer wiring pad group provided in a distal end portion of an ultrasound transducer printed circuit board provided with signal patterns that transmit and receive signals to and from a plurality of ultrasound transducers, a flexible printed circuit board wiring pad group arranged in a longitudinal axis direction of the ultrasound transducer printed circuit board, a second signal pattern group that is connected between the transducer wiring pad group and the flexible printed circuit board wiring pad group and bends at substantially degrees in the middle thereof, and a relay flexible printed circuit board that is connected to the flexible printed circuit board wiring pad group and changes a direction of a signal pattern into the longitudinal axis direction are provided.

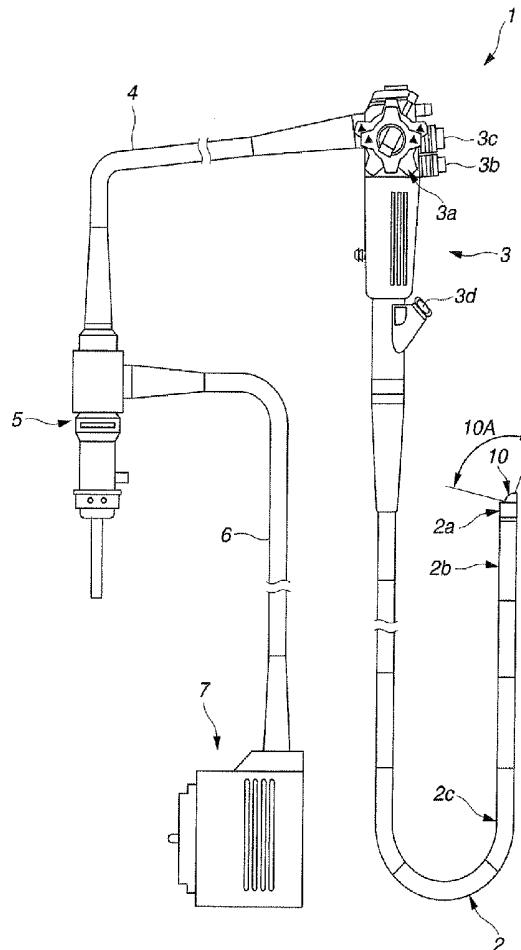


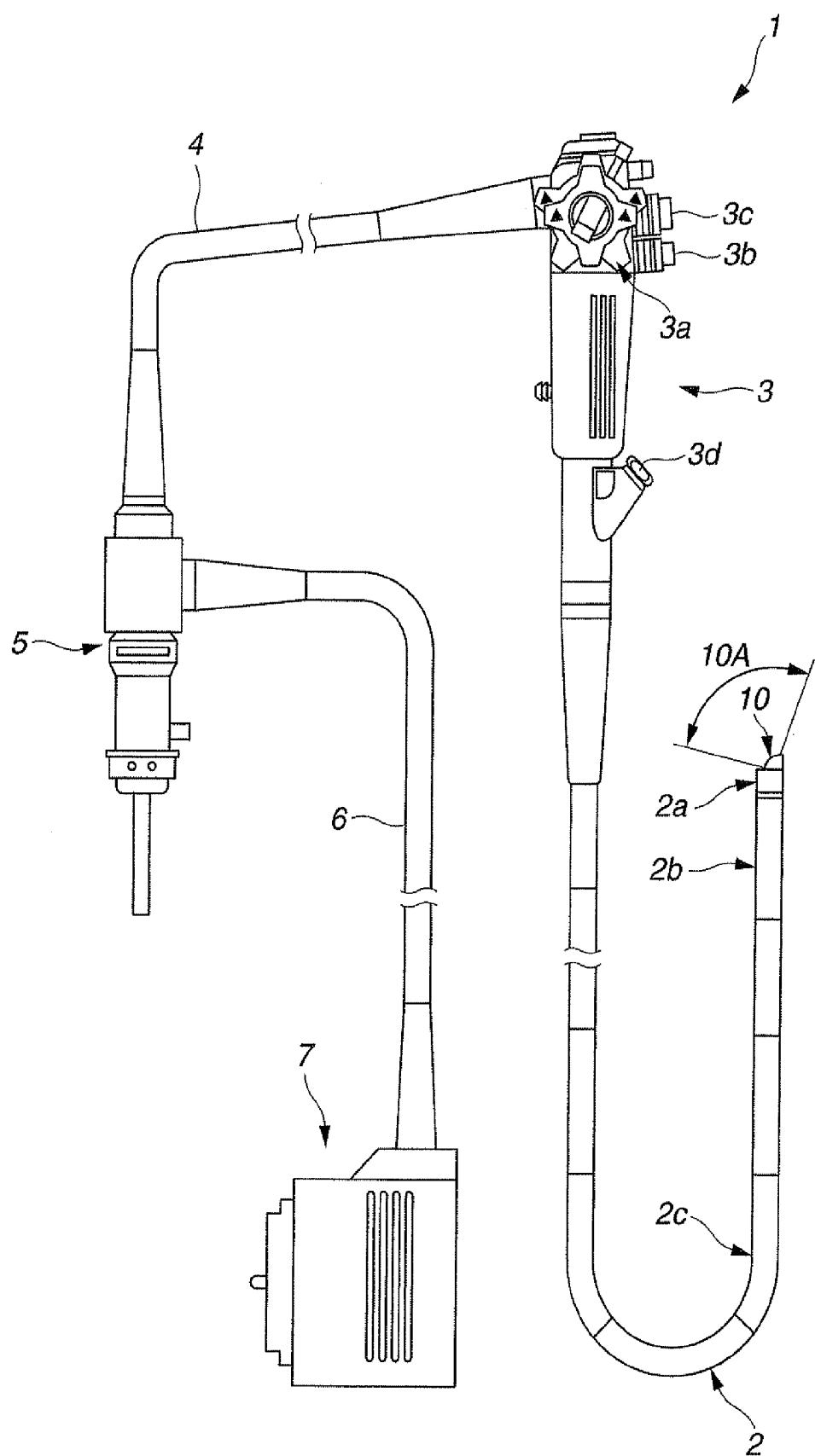
FIG.1

FIG.2

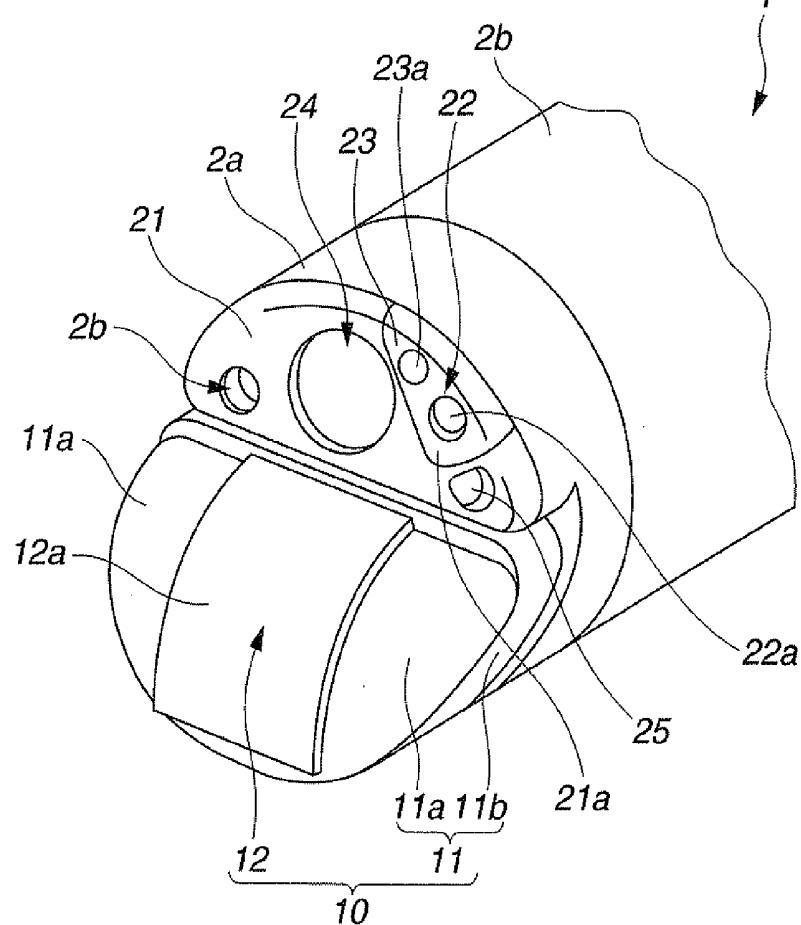


FIG.3

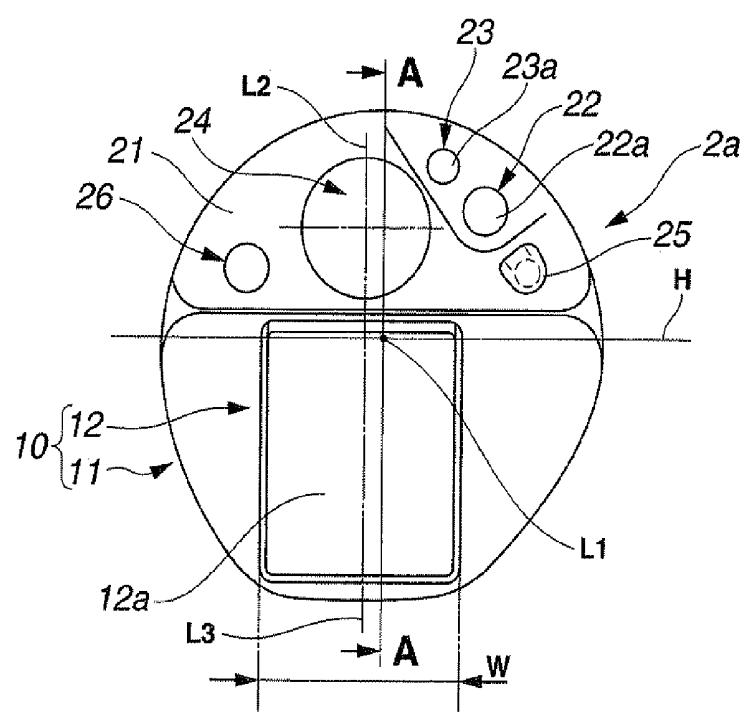


FIG. 4

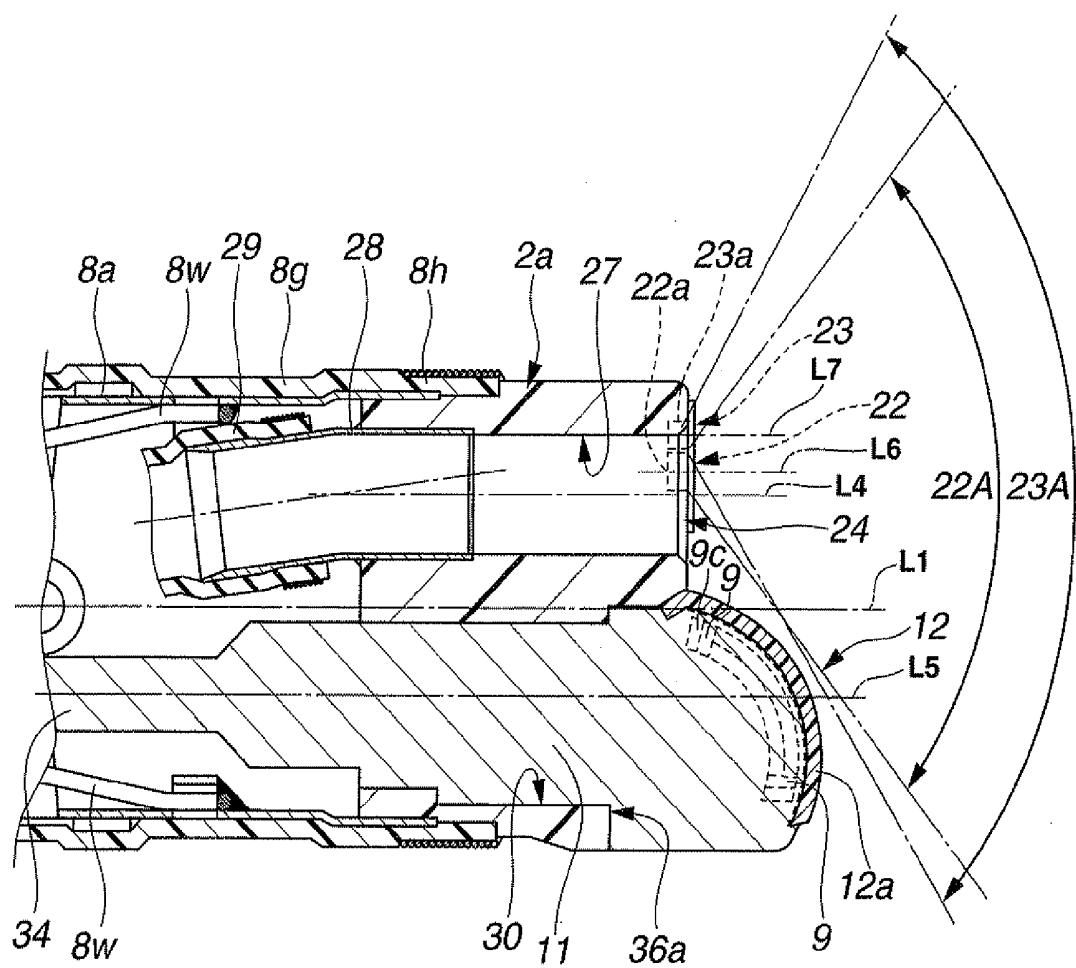


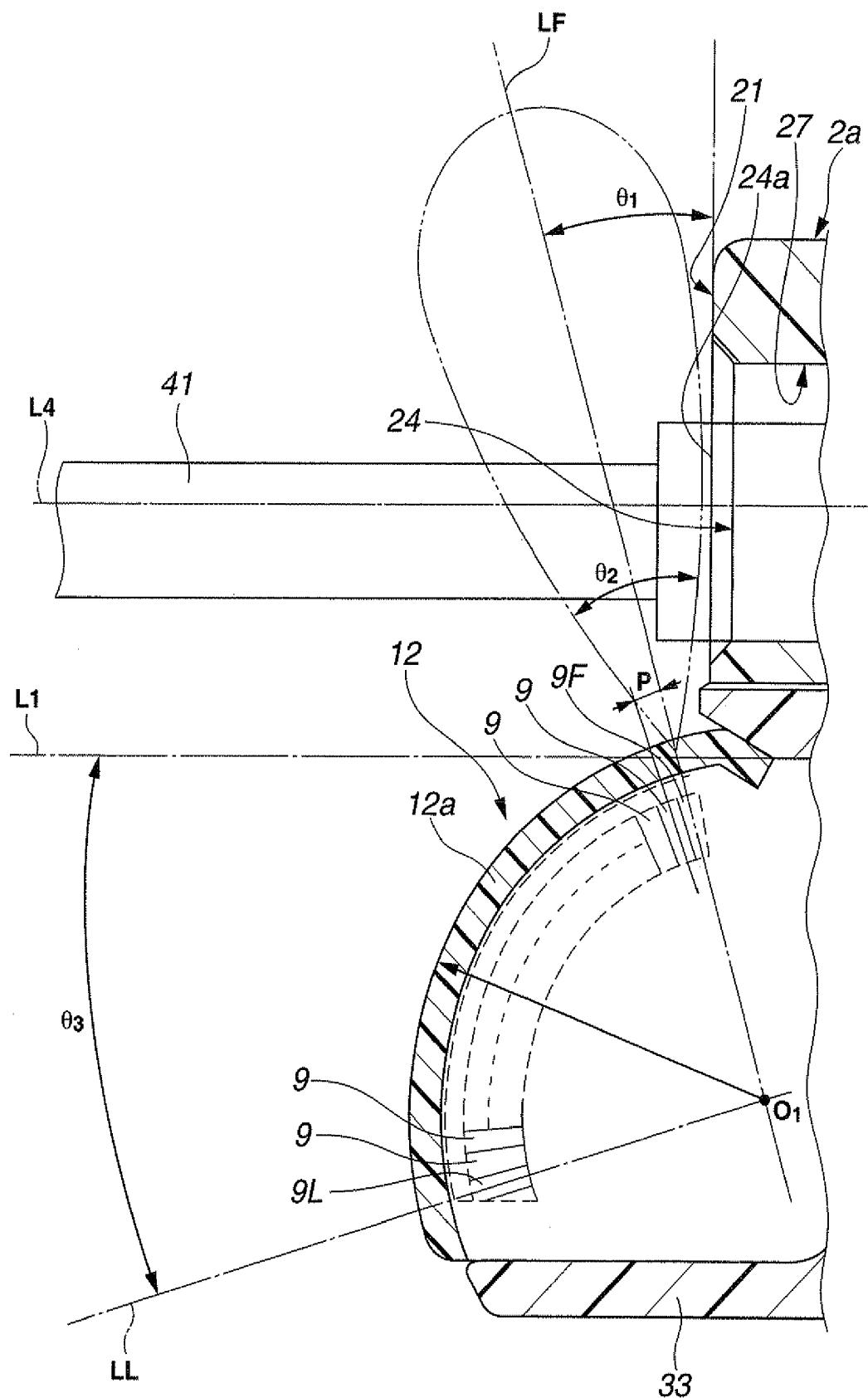
FIG.5

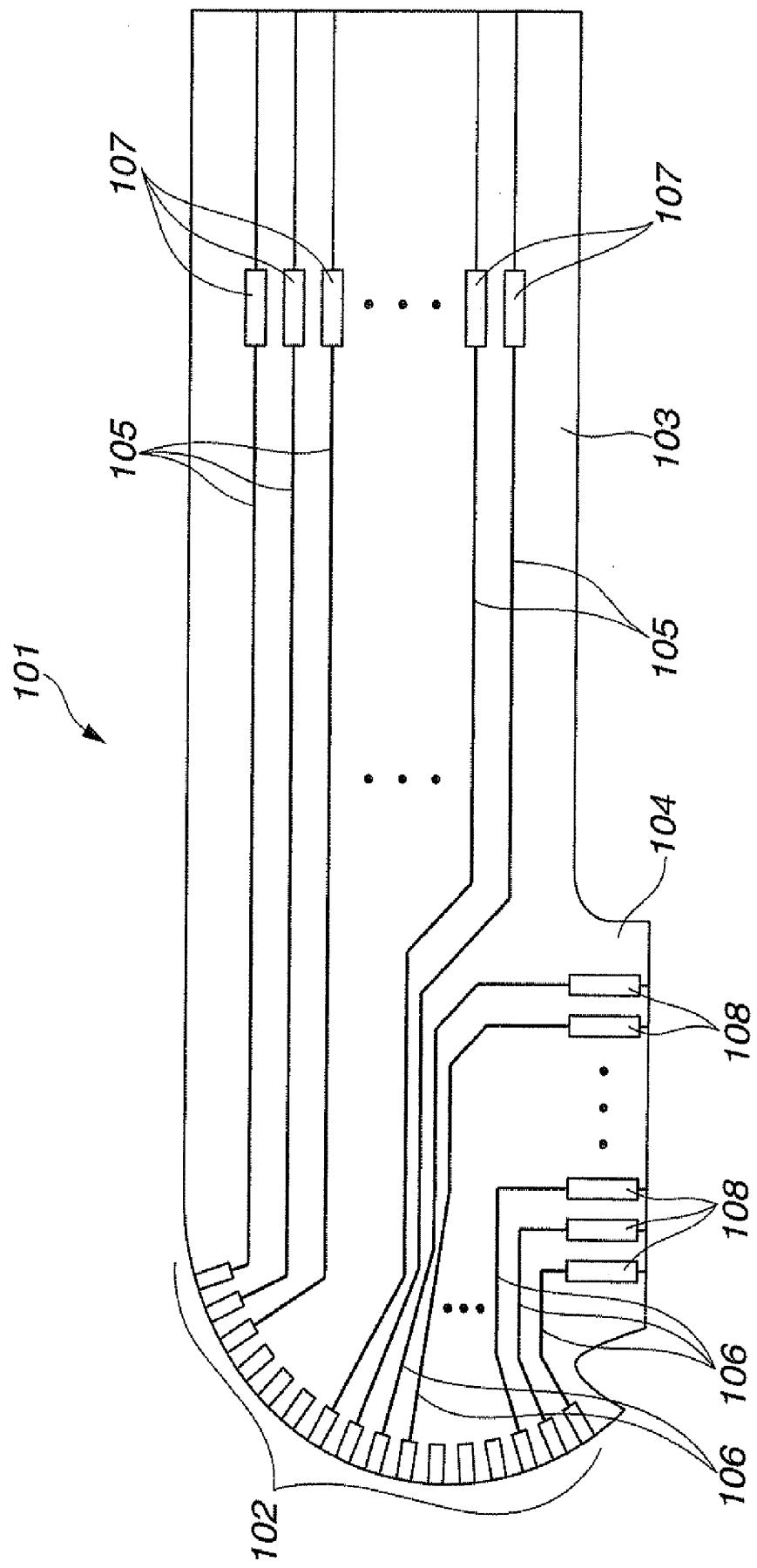
FIG. 6

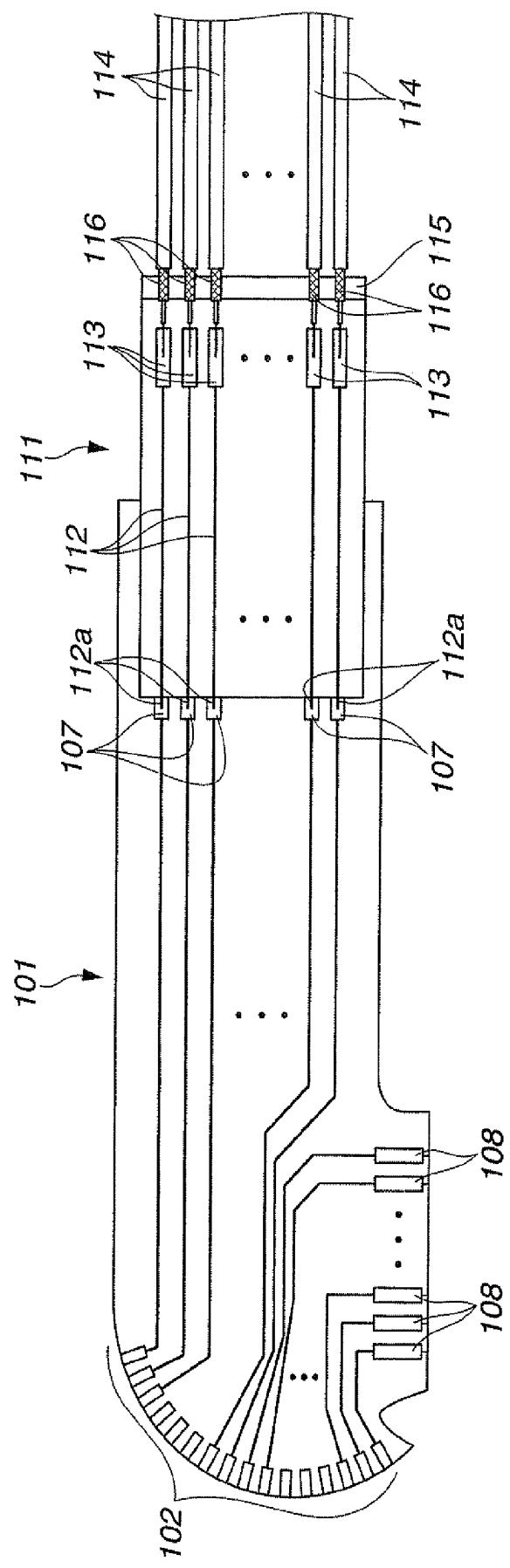
FIG.7

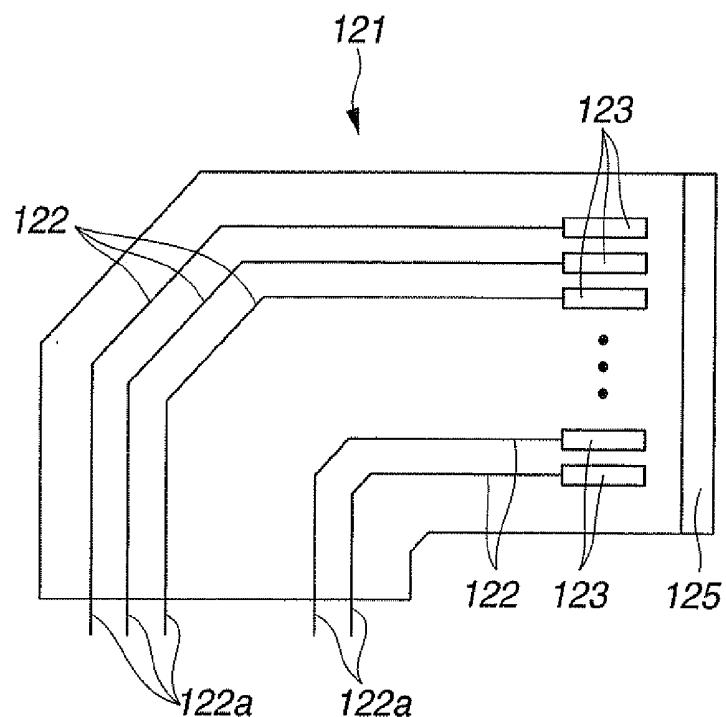
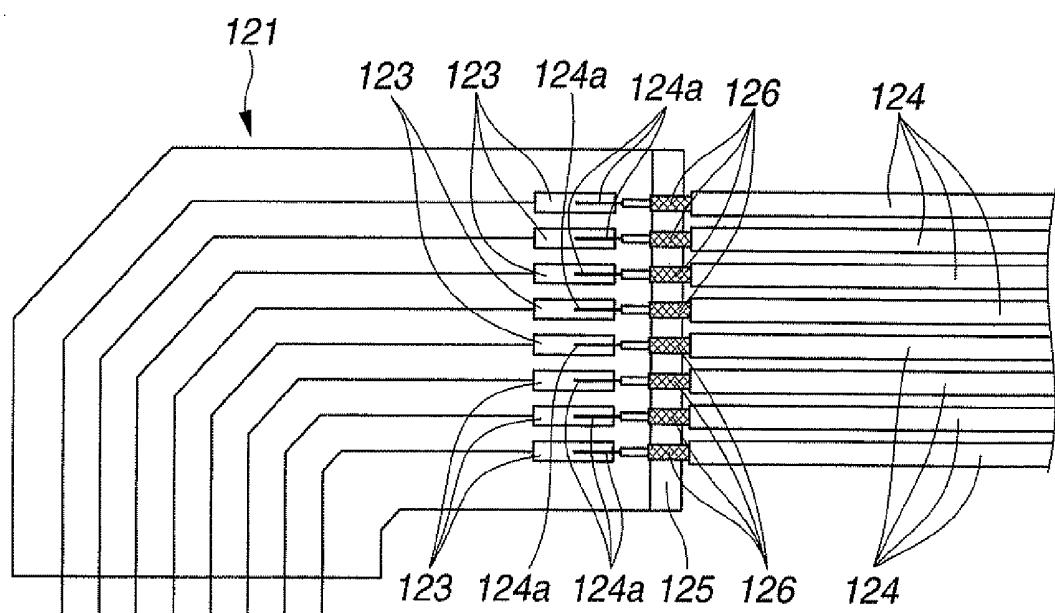
FIG.8**FIG.9**

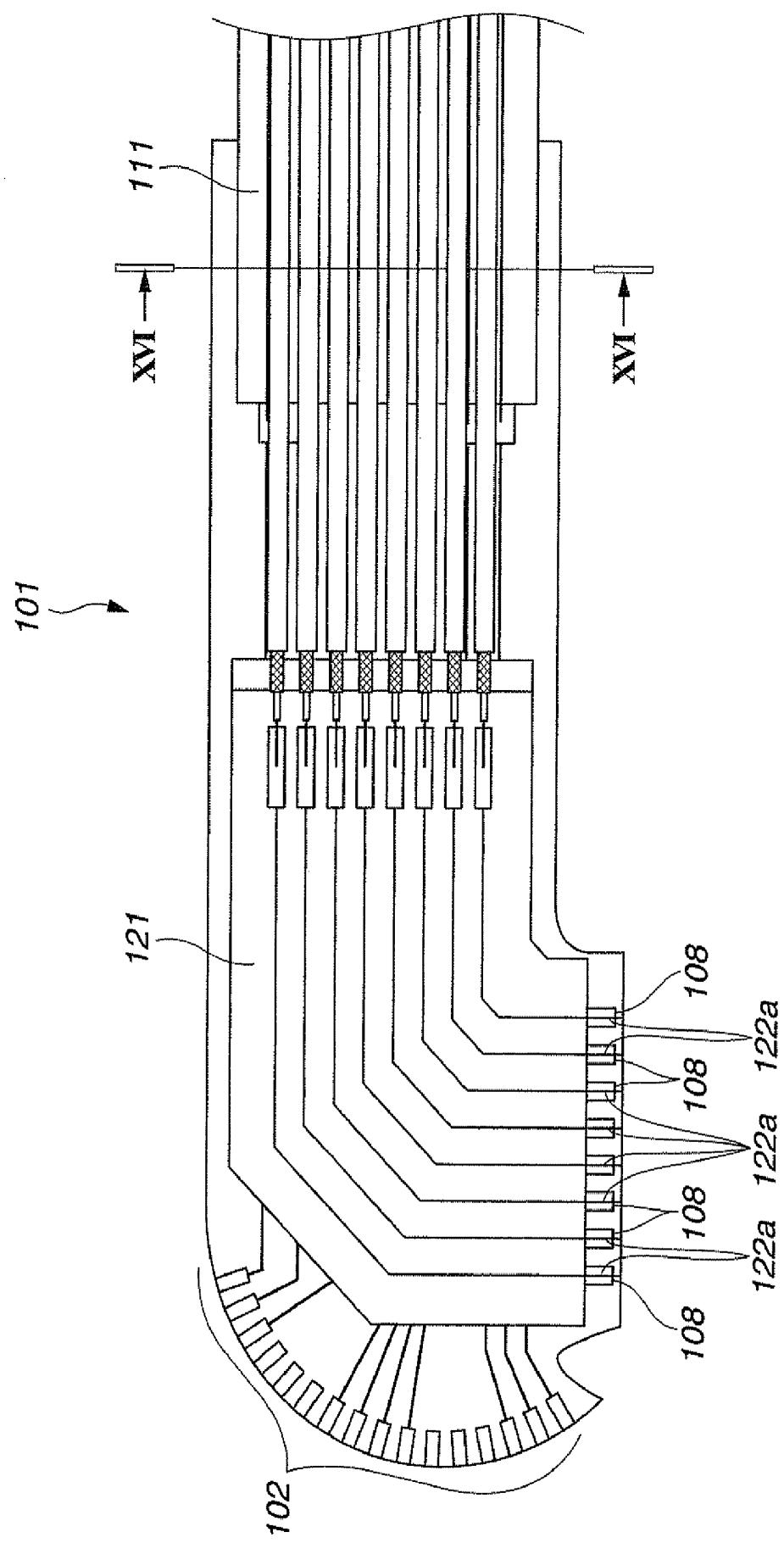
FIG. 10

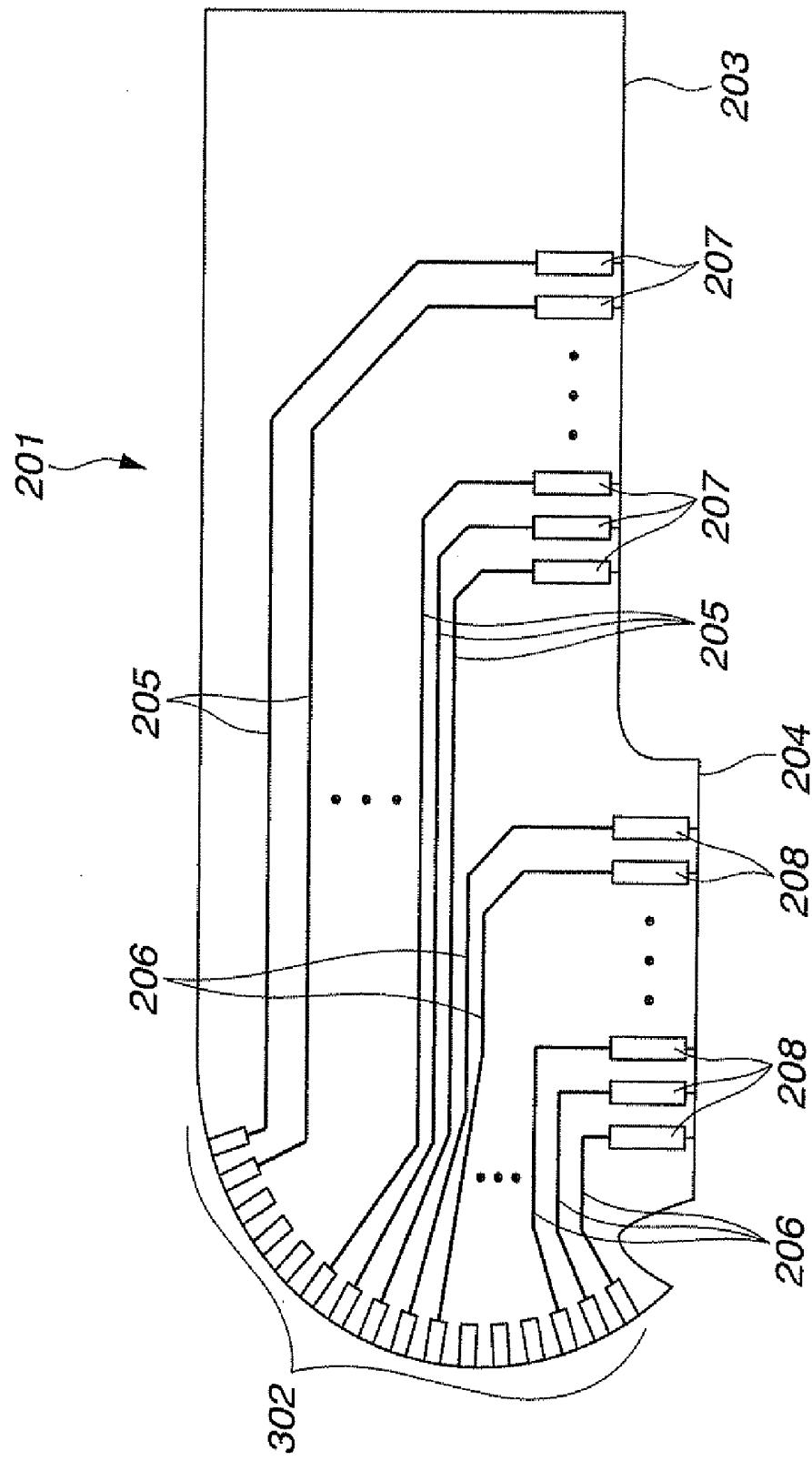
FIG. 11

FIG.12

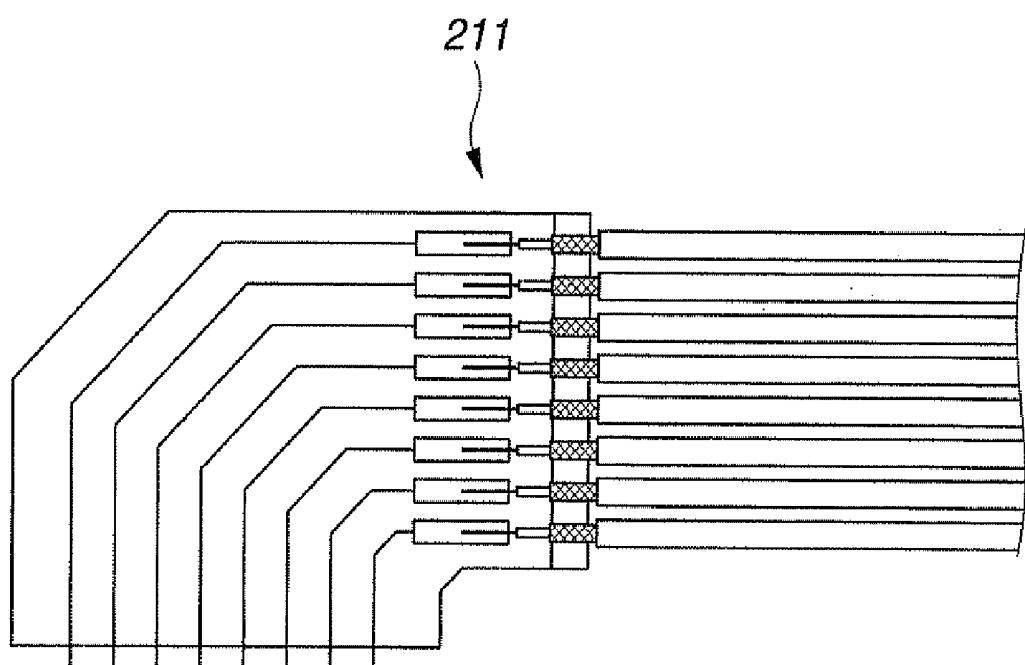


FIG. 13

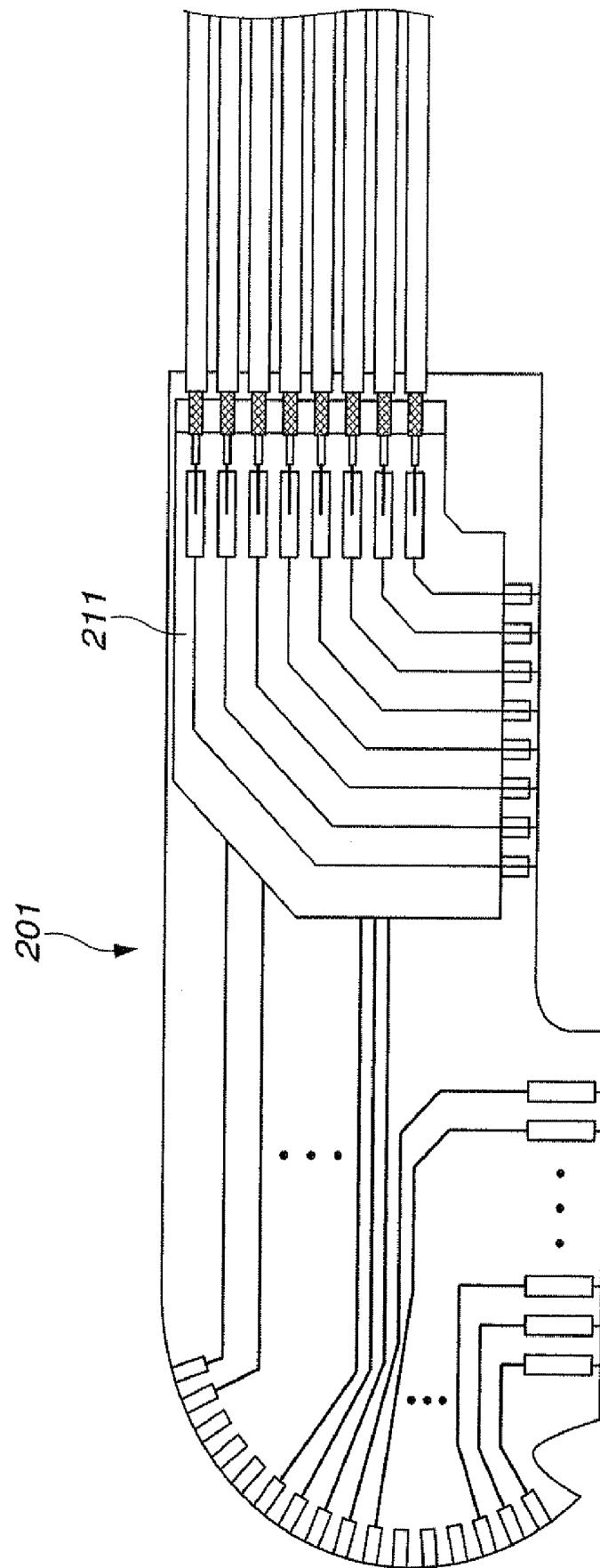


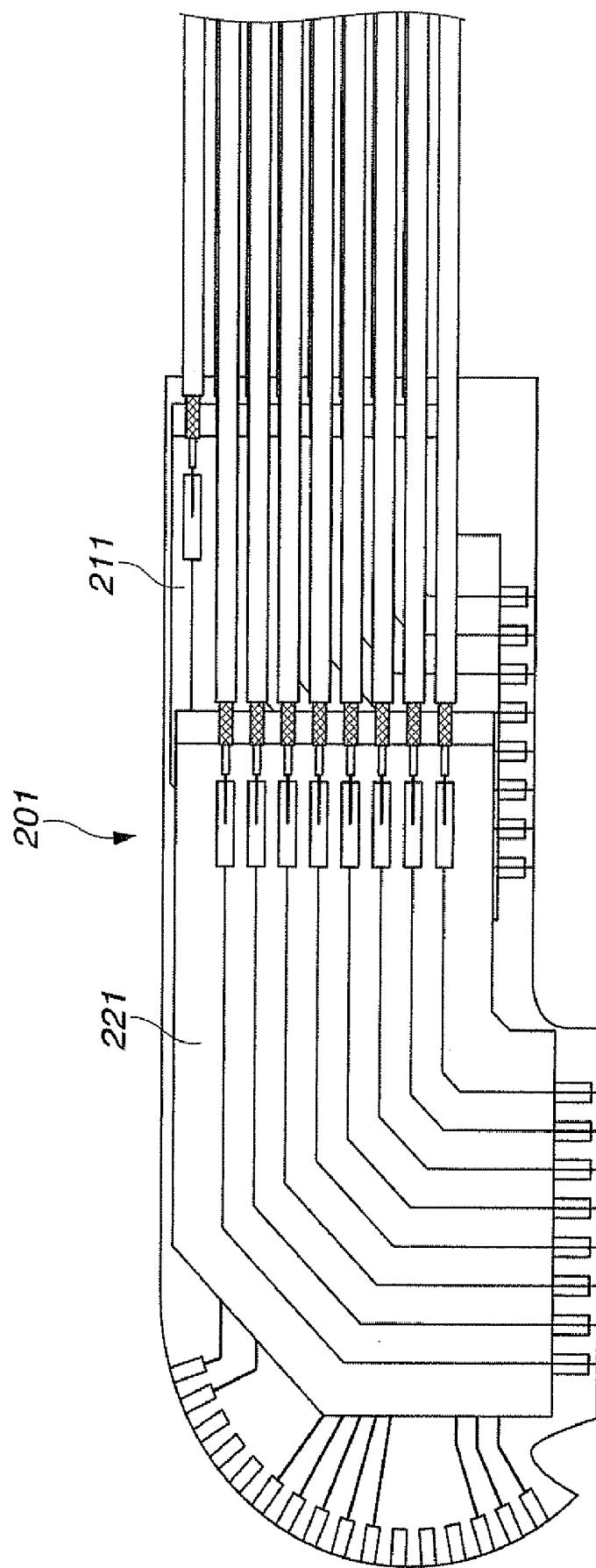
FIG. 14

FIG. 15

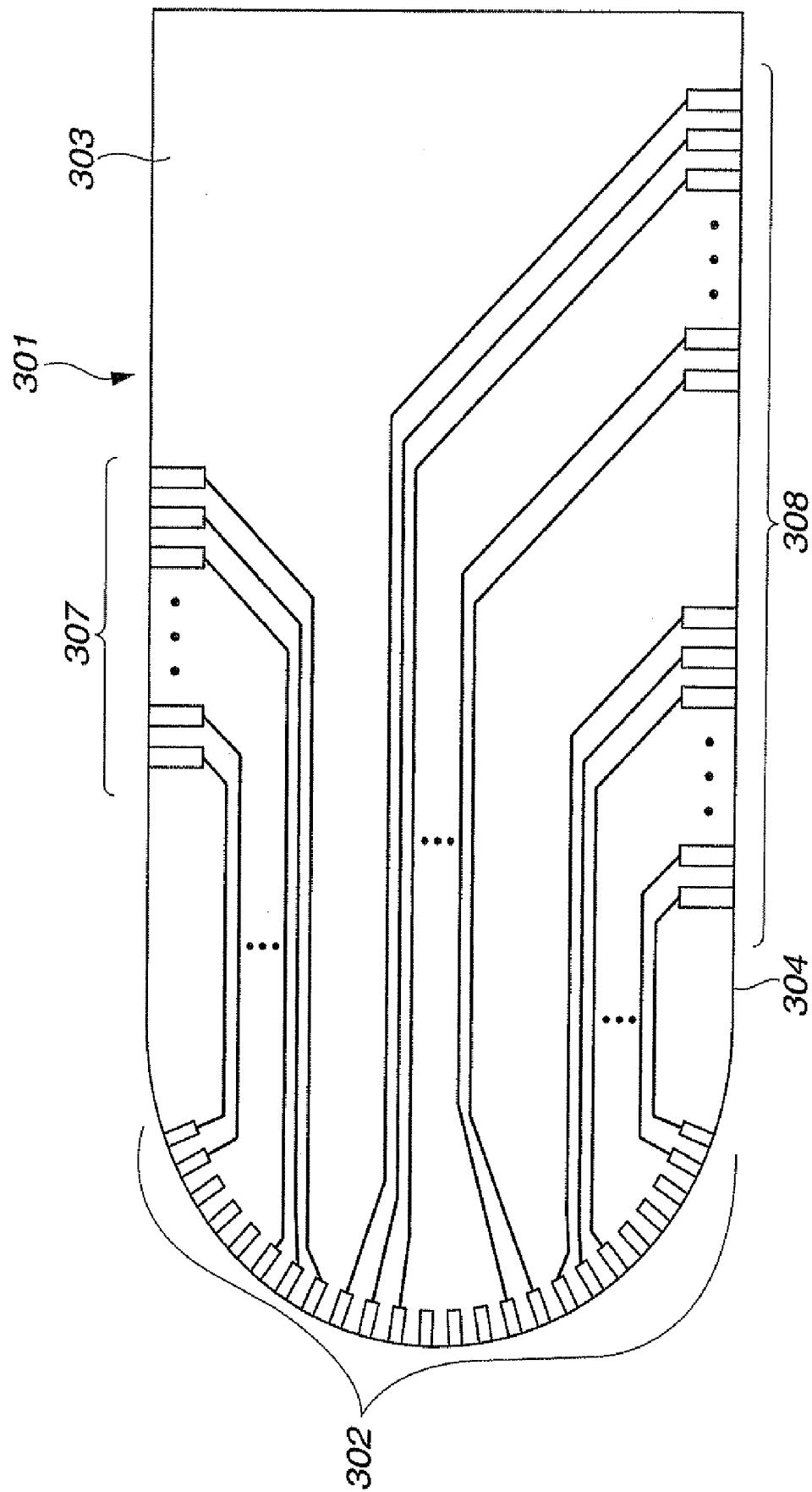


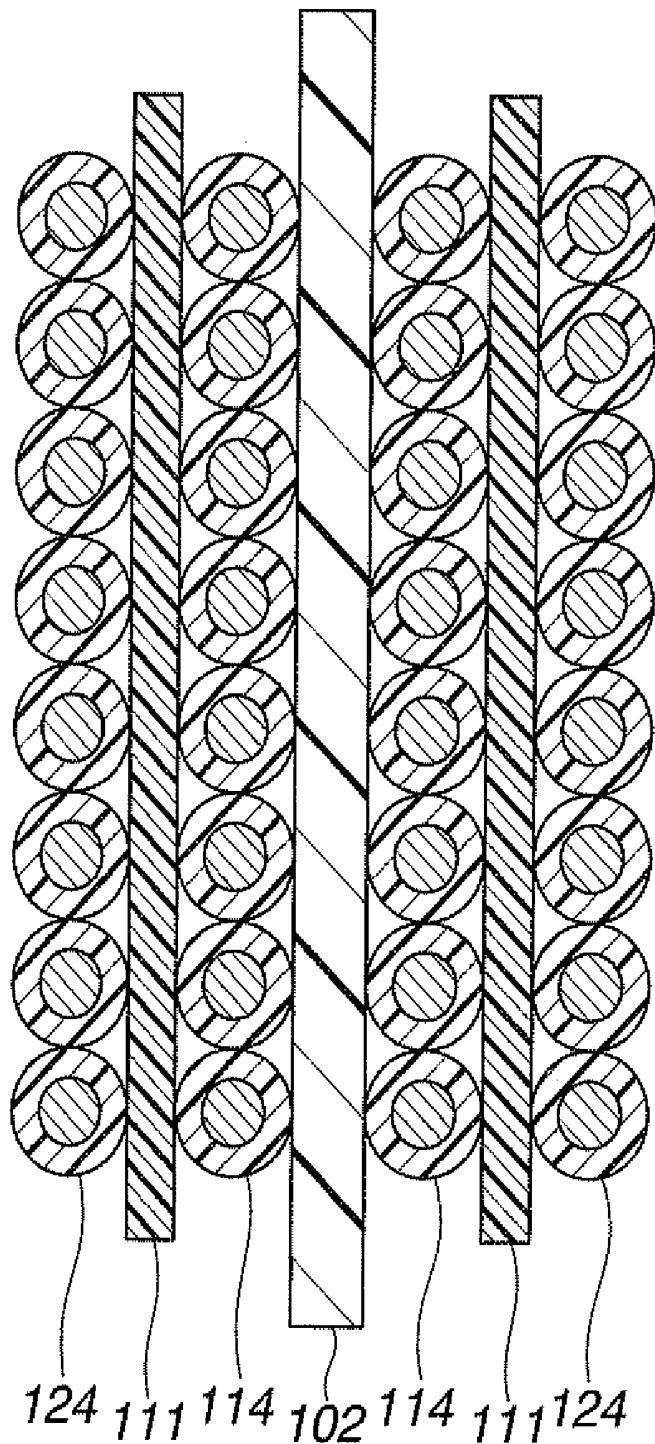
FIG.16

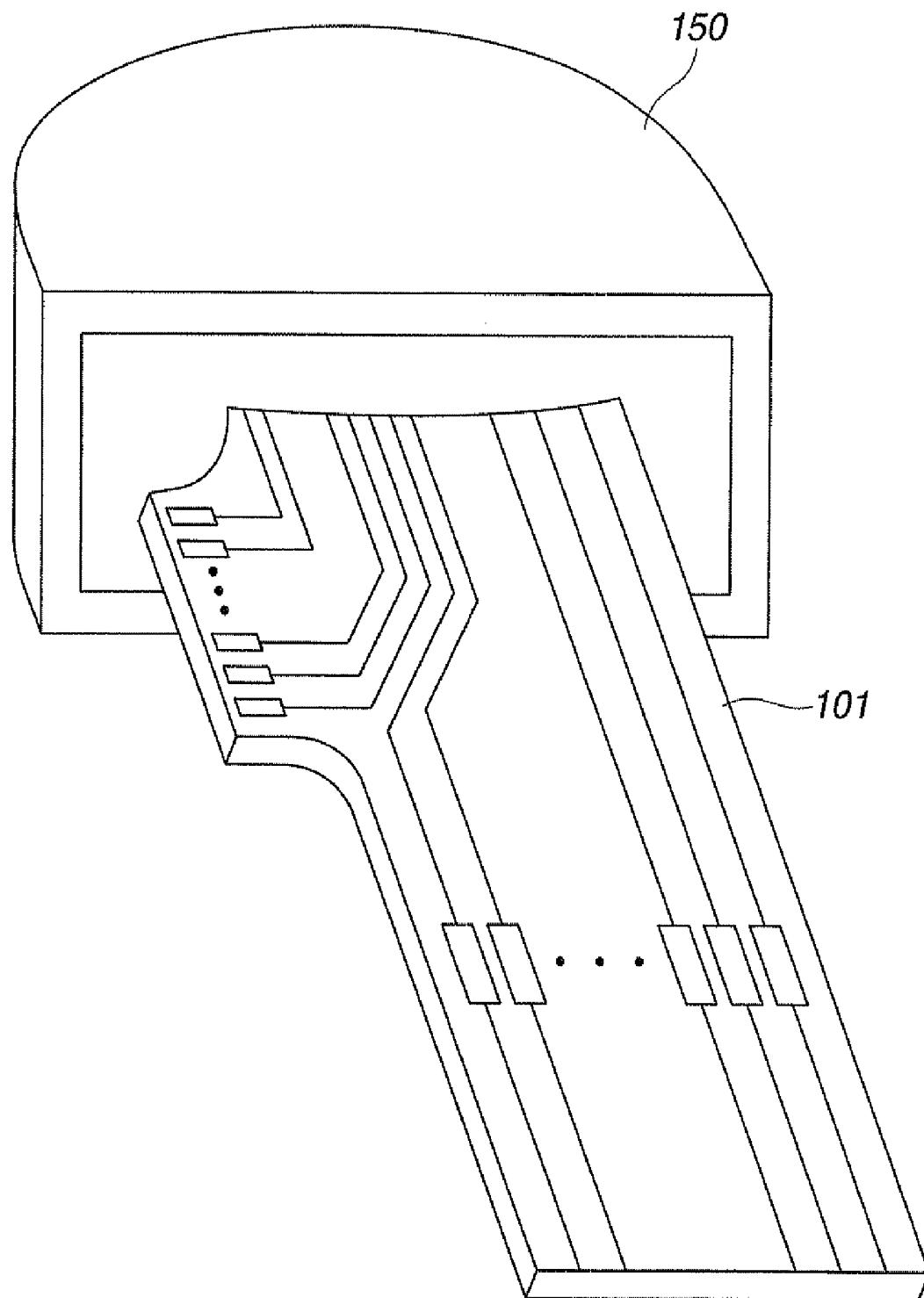
FIG.17

FIG. 18

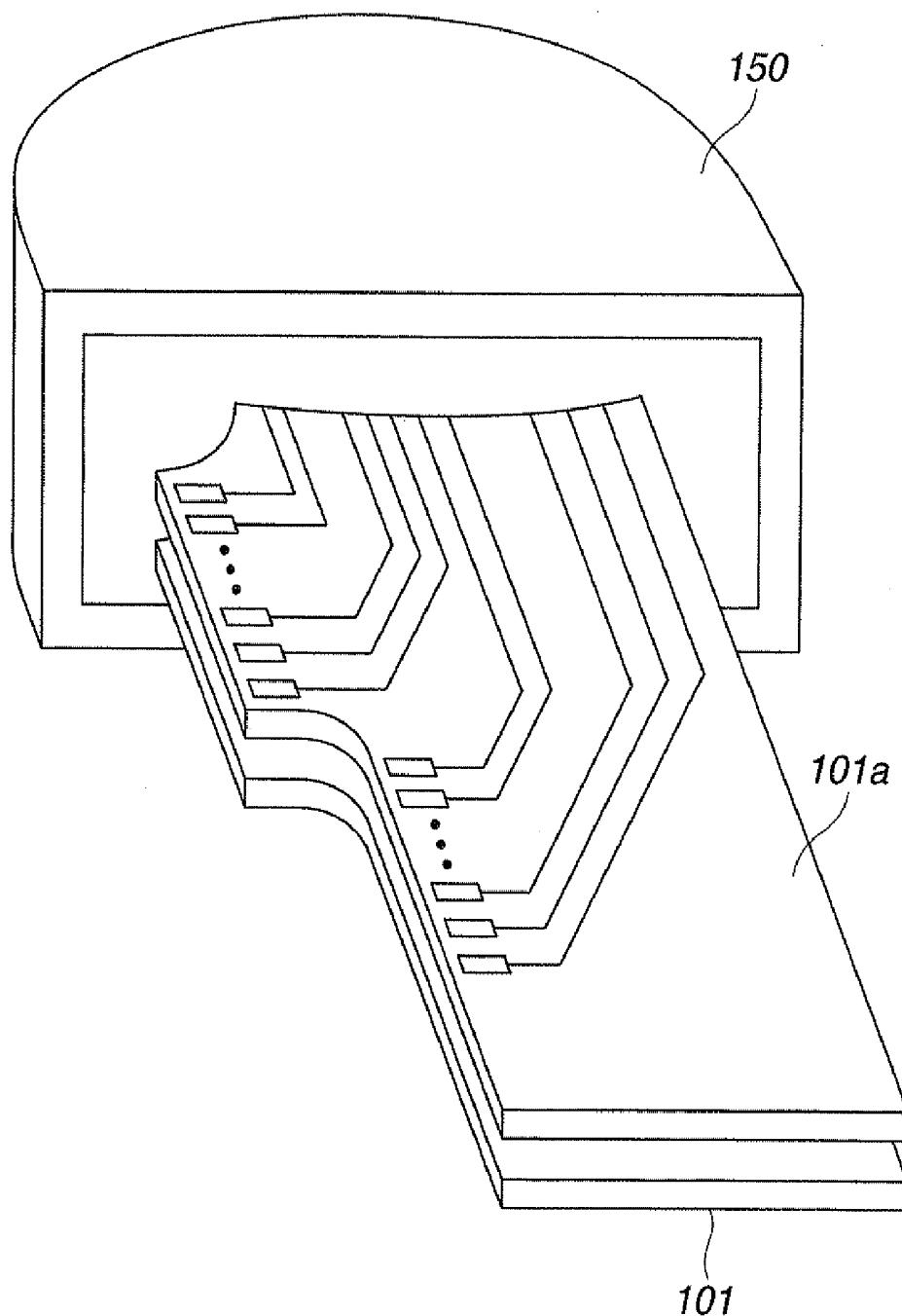
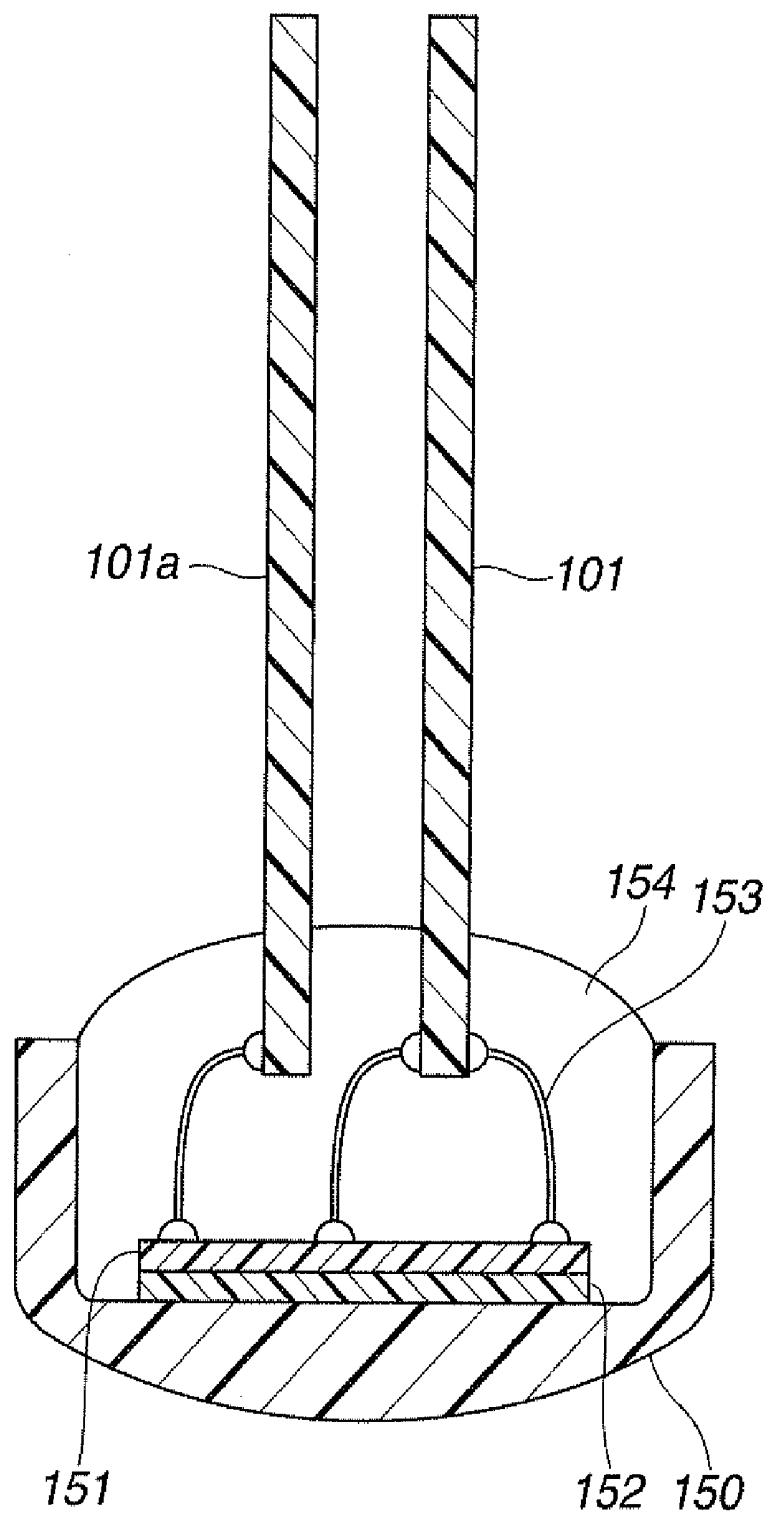


FIG. 19

ULTRASOUND PROBE AND ULTRASOUND ENDOSCOPE INCLUDING ULTRASOUND PROBE

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation application of PCT/JP2007/061759 filed on Jun. 11, 2007 and claims benefit of Japanese Application No. 2006-162938 filed in Japan on Jun. 12, 2006, the entire contents of which are incorporated herein by this reference.

BACKGROUND OF INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an ultrasound probe including a plurality of ultrasound transducers provided at a distal end of an endoscope insertion section, and an ultrasound endoscope including the ultrasound probe.

[0004] 2. Description of the Related Art

[0005] Ultrasound diagnostic apparatuses that transmit ultrasound to a living body such as a human body and receive echo signals reflected from living tissue to obtain tomograms of the inside of the living body can obtain image information of the inside of the living body noninvasively in real time, and are thus widely used and play an important role in diagnostic medical fields.

[0006] Ultrasound endoscopes including an ultrasound probe have been known in which a plurality of ultrasound transducers are arranged in a projecting arcuate shape, a so-called convex shape, and the ultrasound transducers are successively electronically switched at high speed for a certain time at certain intervals to obtain tomograms.

[0007] Known ultrasound endoscopes including the convex type ultrasound probe are described in, for example, Japanese Patent Application Laid-open Publication No. 8-131442 and Japanese Patent Application Laid-open Publication No. 2004-350700. The ultrasound endoscopes include an observation optical system at a distal rigid portion near the ultrasound probe, and the observation optical system has an optical axis in a front oblique direction.

[0008] The above described ultrasound probe is configured by electrically connecting a board provided with a signal pattern that transmits and receives signals to and from each ultrasound transducer among a group of a plurality of ultrasound transducers including a piezoelectric element, an acoustic matching layer, and a backside damping layer.

[0009] Such an ultrasound endoscope including the type of ultrasound probe needs to have an extremely small outer shape, and thus adjacent elements of the ultrasound transducers need to be placed at short intervals, and a plurality of signal patterns on boards connected to the ultrasound transducers placed at extremely short intervals also have to be placed at extremely short intervals.

[0010] To end electrode sections of the plurality of signal patterns on the boards, a coaxial cable having a plurality of signal lines corresponding to the plurality of ultrasound transducers are connected, and in such a device, the plurality of signal lines and pad electrodes at ends of the signal patterns need to be connected one by one, for example, by soldering.

[0011] Further, in recent years, it has been desired that an ultrasound endoscope including an ultrasound probe has a smaller diameter, and also that a printed circuit board pro-

vided with signal patterns corresponding to a plurality of ultrasound transducers has a smaller diameter.

[0012] The present invention is achieved in view of the above described circumstances, and has an object to provide an ultrasound probe and an ultrasound endoscope including an ultrasound probe that allow a reduction in diameter of the ultrasound endoscope and allow reliable and easy electrical connection of signal lines extending from ultrasound transducers in the ultrasound endoscope including the ultrasound probe.

SUMMARY OF THE INVENTION

[0013] A first ultrasound probe of the present invention including a plurality of ultrasound transducers provided in a distal end portion, includes: an ultrasound transducer printed circuit board provided with signal patterns that transmit and receive signals to and from the plurality of ultrasound transducers; a first electrode group that faces the plurality of ultrasound transducers and constituted by a plurality of electrode sections provided in a distal end portion of the ultrasound transducer printed circuit board; a second electrode group that is constituted by a plurality of electrode sections connected to ends of signal patterns extending from at least a part of the electrode group of the first electrode group, and arranged in a longitudinal axis direction of the ultrasound transducer printed circuit board; a first signal pattern group that is connected between each electrode section of the second electrode group and the part of the electrode sections of the first electrode group, extends from the part of the electrode sections of the first electrode group toward a proximal end side of the ultrasound transducer printed circuit board, then bends in an angle direction different from the longitudinal axis direction, and further extends toward each electrode section of the second electrode group; and a signal pattern direction changing printed circuit board provided with a second signal pattern group that has one end connectable to each electrode section of the second electrode group, extends from the one end in an angle direction different from the longitudinal axis direction, then bends in an angle direction different from the extending direction, and further extends in the longitudinal axis direction toward the proximal end portion.

[0014] A second ultrasound probe of the present invention further includes, in the first ultrasound probe, a third electrode group that is constituted by a plurality of electrode sections connected to ends of signal patterns extending from the other part of the electrode group of the first electrode group, and arranged in a width direction of the ultrasound transducer printed circuit board; and a third signal pattern group that is connected between each electrode section of the third electrode group and the other part of the electrode group of the first electrode group, and extends in the longitudinal axis direction toward the proximal end side of the ultrasound transducer printed circuit board.

[0015] In a third ultrasound probe of the present invention, in the first or second ultrasound probe, the plurality of ultrasound transducers are arranged in a projecting arcuate shape.

[0016] The ultrasound probe of the present invention includes any one of the first to third ultrasound probes at a distal end of an insertion section of an endoscope.

[0017] According to the present invention, an ultrasound probe and an ultrasound endoscope including the ultrasound probe that allows a reduction in diameter of the ultrasound

probe and the ultrasound endoscope and allows reliable and easy electrical connection of signal lines extending from ultrasound transducers.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is an appearance view of an entire configuration of an ultrasound endoscope including an ultrasound probe according to a first embodiment of the present invention;

[0019] FIG. 2 is an enlarged perspective view of essential portions showing a configuration of a distal end portion of the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0020] FIG. 3 is an enlarged front view of essential portions showing the configuration of the distal end portion of the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0021] FIG. 4 is a vertical sectional view of the distal end portion of the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0022] FIG. 5 is an enlarged sectional view of essential portions of the distal end portion of the ultrasound endoscope showing an ultrasound observation region of the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0023] FIG. 6 is a plan view of an upper surface of an ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0024] FIG. 7 is a plan view of a state where a predetermined relay flexible printed circuit board is connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0025] FIG. 8 is a plan view of an upper surface of a relay flexible printed circuit board for changing a signal pattern direction connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0026] FIG. 9 is a plan view of a state where a coaxial cable group is connected to the relay flexible printed circuit board for changing a signal pattern direction connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0027] FIG. 10 is a plan view of a state where a plurality of predetermined relay flexible printed circuit boards are connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment;

[0028] FIG. 11 is a plan view of an upper surface of a printed circuit board provided with signal lines corresponding to a plurality of ultrasound transducers in an ultrasound endoscope including an ultrasound probe according to a second embodiment of the present invention;

[0029] FIG. 12 is a plan view of an upper surface of a first relay flexible printed circuit board for changing a signal pattern direction connected to an ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the second embodiment;

[0030] FIG. 13 is a plan view of a state where the first relay flexible printed circuit board for changing a signal pattern direction is connected to the ultrasound transducer printed

circuit board in the ultrasound endoscope including the ultrasound probe according to the second embodiment;

[0031] FIG. 14 is a plan view of a state where a plurality of predetermined relay flexible printed circuit boards for changing a signal pattern direction are connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the second embodiment;

[0032] FIG. 15 is a plan view of an upper surface of a printed circuit board provided with signal lines corresponding to a plurality of ultrasound transducers in an ultrasound endoscope including an ultrasound probe according to a third embodiment of the present invention;

[0033] FIG. 16 is a sectional view taken along the line XVI-XVI in FIG. 10;

[0034] FIG. 17 is an appearance perspective view of an engagement state between the ultrasound transducer printed circuit board and an ultrasound probe unit in the first embodiment;

[0035] FIG. 18 is an appearance perspective view of an engagement state between the ultrasound transducer printed circuit board and the ultrasound probe unit in a variant of the first embodiment; and

[0036] FIG. 19 is an enlarged sectional view of essential portions of the engagement state between the ultrasound transducer printed circuit board and the ultrasound probe unit in the variant of the first embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0037] Now, the present embodiments will be described with reference to the drawings.

[0038] The present invention provides an ultrasound endoscope including an ultrasound probe having features in a printed circuit board provided with signal lines corresponding to a plurality of ultrasound transducers as patterns and a flexible printed circuit board connected to the printed circuit board in the ultrasound probe. Prior to the description on the boards, the ultrasound endoscope including the ultrasound probe having the boards and the like will be described.

[0039] FIG. 1 is an appearance view of an entire configuration of an ultrasound endoscope including an ultrasound probe according to a first embodiment of the present invention, FIG. 2 is an enlarged perspective view of essential portions showing a configuration of a distal end portion of the ultrasound endoscope including the ultrasound probe according to the first embodiment, FIG. 3 is an enlarged front view of essential portions showing the configuration of the distal end portion of the ultrasound endoscope including the ultrasound probe according to the first embodiment, FIG. 4 is a vertical sectional view of the distal end portion of the ultrasound endoscope including the ultrasound probe according to the first embodiment, and FIG. 5 is an enlarged sectional view of essential portions of the distal end portion of the ultrasound endoscope showing an ultrasound observation region of the ultrasound endoscope including the ultrasound probe according to the first embodiment.

[0040] As shown in FIG. 1, an ultrasound endoscope (hereinafter also referred to as an endoscope) 1 of the present embodiment includes an elongated insertion section 2 inserted into a body cavity, an operation section 3 provided at a proximal end of the insertion section 2, and a universal cord 4 extending from a side portion of the operation section 3.

[0041] An endoscope connector 5 is provided at the other end of the universal cord 4. An ultrasound cable 6 extends from a side portion of the endoscope connector 5. An ultrasound connector 7 is provided at the other end of the ultrasound cable 6.

[0042] The insertion section 2 includes a distal rigid portion 2a formed of a rigid member, a bending portion 2b configured to be bendable, and a flexible tube portion 2c that is long and flexible and extends from a proximal end of the bending portion 2b to a distal end of the operation section 3 in order from a distal end side.

[0043] On the operation section 3, an angle knob 3a for a bending operation is provided. Also on the operation section 3, an air/water feeding button 3b for feeding air and water, and a suction button 3c for suction are provided. Further, in the operation section 3, a treatment instrument insertion opening 3d for introducing a treatment instrument into a body cavity is provided.

[0044] Reference numeral 10 denotes an ultrasound unit including an ultrasound probe having a convex type ultrasound scanning surface. The ultrasound unit 10 forms an ultrasound scanning range 10A for scanning a forward direction in an endoscope insertion axis direction.

[0045] As shown in FIGS. 2 and 3, the ultrasound unit 10 for obtaining acoustic image information by ultrasound is provided in the distal rigid portion 2a of the insertion section 2. The ultrasound unit 10 includes a nose piece 11 that is a casing and an ultrasound probe 12. The ultrasound probe 12 is provided integrally at a notch portion formed substantially in the middle of the nose piece 11. As shown in the drawings, a tissue contact surface 11a that constitutes the nose piece 11 and an acoustic lens surface 12a of the ultrasound probe 12 project from a distal end surface 21 of the distal rigid portion 2a.

[0046] As shown in FIGS. 4 and 5, the ultrasound probe 12 includes a plurality of ultrasound transducers 9 arranged in a projecting arcuate shape, a so-called convex shape, the acoustic lens 12a, and an unshown electric wire, and when the ultrasound probe 12 is connected to an observation device, an ultrasound image is obtained.

[0047] On the other hand, as shown in FIGS. 2 and 3, in the distal end surface 21 of the distal rigid portion 2a, an observation window 22a that constitutes an observation optical system 22, an illumination window 23a that constitutes an illumination optical system 23, a treatment instrument lead-out opening 24 through which a treatment instrument such as a puncture needle is led out, an air/water feeding nozzle 25 that ejects a fluid such as water or air toward the observation window 22a, and a sub-water feeding channel opening 26 for feeding water forward. Instead of providing the sub-water feeding channel opening 26, the sub-water feeding channel opening 26 may be configured as a second treatment instrument lead-out opening.

[0048] A central axis of the treatment instrument lead-out opening 24 is arranged in line with a centerline L2 of the ultrasound probe 12 so that the treatment instrument led out of the treatment instrument lead-out opening 24 is placed within the ultrasound scanning range 10A obtained by the ultrasound probe 12.

[0049] The observation window 22a, the illumination window 23a, and the air/water feeding nozzle 25 are collectively placed, for example, on the right side in the drawings, relative to the treatment instrument lead-out opening 24, and outside the ultrasound scanning range 10A. Among the observation

window 22a, the illumination window 23a, and the air/water feeding nozzle 25, the air/water feeding nozzle 25 is placed at the most distant position from the ultrasound observation region 10A. In the present embodiment, the illumination window 23a, the observation window 22a, and the air/water feeding nozzle 25 are placed in line in view of improvement in observation performance, improvement in cleaning property, and reduction in outer diameter of the distal end portion of the endoscope.

[0050] The observation window 22a has an observation field range (see a range of reference numeral 22A shown by dash-single-dot lines in FIG. 4) of the observation optical system 22. The illumination window 23a has an illumination light application range (see a range of reference numeral 23A shown by dash-double-dot lines in FIG. 4) of the illumination optical system 23. The observation field range 22A and the illumination light application range 23A are formed so as not to include the ultrasound probe 12.

[0051] The observation window 22a and the illumination window 23a are provided in an observation distal end surface 21a slightly projecting from the distal end surface 21. The sub-water feeding channel opening 26 is placed on the other side opposite from one side provided with the observation window 22a, the illumination window 23a, and the air/water feeding nozzle 25 with the treatment instrument lead-out opening 24 therebetween, and outside the ultrasound scanning range 10A. When the sub-water feeding channel opening 26 is formed as the second treatment instrument lead-out opening, a diameter of the channel is set according to a treatment instrument to be used.

[0052] This allows a procedure using two treatment instruments to be performed under observation by the endoscope. Thus, the treatment instrument projected through the second treatment instrument lead-out opening and used under observation by the endoscope, and the treatment instrument projected through the treatment instrument lead-out opening 24 and used under ultrasound diagnosis are combined to allow efficient diagnosis and medical treatment.

[0053] As shown in FIG. 4, a distal bending piece Sa that constitutes the bending portion 2b is connected and secured to a proximal end side of the distal rigid portion 2a. A plurality of bending pieces (not shown) are connected to the distal bending piece 8a. A centerline of the bending portion 2b constituted by the connected bending pieces is an endoscope insertion axis L1.

[0054] To predetermined positions on the distal bending piece 8a, distal end portions of top, bottom, left and right bending wires 8w are secured. Thus, an operator operates the angle knob 3a to pull or loosen a bending wire 8w corresponding to the operation, and thus the bending portion 2b performs a bending operation. The plurality of bending pieces are coated with bending rubber 8g. A distal end portion of the bending rubber 8g is integrally secured by a bobbin bonding section 8h provided in the distal rigid portion 2a.

[0055] The distal end surface 21 and the observation distal end surface 21a of the distal rigid portion 2a are formed perpendicularly to the endoscope insertion axis L1. In the distal rigid portion 2a, a treatment instrument passing channel hole (hereinafter referred to as a treatment instrument hole) 27 that constitutes the treatment instrument lead-out opening 24, and a positioning hole 30 are formed.

[0056] In the distal rigid portion 2a, besides the holes 27 and 30, a through hole in which the observation optical system is provided, a through hole in which the illumination

optical system is provided, a through hole for air/water feeding for supplying the fluid ejected from the air/water feeding nozzle 25, a through hole that constitutes the sub-water feeding channel opening 26, or the like are provided, though not shown.

[0057] A longitudinal central axis L4 of the treatment instrument hole 27 is formed substantially in parallel with the endoscope insertion axis L1. A longitudinal central axis L5 of the positioning hole 30 is formed substantially in parallel with the endoscope insertion axis L1. An optical axis L6 of the observation optical system and an optical axis L7 of the illumination optical system provided in the ultrasound endoscope 1 are also formed in parallel with the endoscope insertion axis L1.

[0058] Thus, the observation optical system provided in the ultrasound endoscope 1 of the present embodiment is of a so-called forward viewing type in which an observation field is set in a forward front, in other words, in an insertion direction forward of the endoscope insertion axis L1.

[0059] With a proximal end side of the treatment instrument hole 27, one end of a tube connection pipe 28 formed to be tilted by a predetermined amount communicates. The tube connection pipe 28 communicates at the other end with one end of a channel tube 29 that constitutes a treatment instrument passing channel. The other end of the channel tube 29 communicates with the treatment instrument insertion opening 3d.

[0060] The treatment instrument inserted through the treatment instrument insertion opening 3d smoothly moves in the channel tube 29, the tube connection pipe 28, and the treatment instrument hole 27, and is led out of the treatment instrument lead-out opening 24. The treatment instrument led out of the treatment instrument lead-out opening 24 is led out forward that is the insertion direction of the insertion section 2, in parallel with the endoscope insertion axis L1.

[0061] Specifically, with, for example, a distal end portion of a puncture needle as a treatment instrument placed in the treatment instrument hole 27, a needle tube that constitutes the puncture needle is projected. Then, the needle tube is projected from the treatment instrument lead-out opening 24 to the forward front observed through the observation window 22a, substantially in parallel with the endoscope insertion axis L1.

[0062] Meanwhile, the positioning hole 30 is provided in the distal rigid portion 2a. The ultrasound unit 10 fits in the positioning hole 30, and a contact surface of the nose piece 11 and an abutment surface 36 of the distal rigid portion 2a contact each other to position the ultrasound unit 10 in the positioning hole 30. From the other end of the ultrasound unit 10, an ultrasound cable 34 connected to the ultrasound probe 12 is led out.

[0063] An outer shape from the abutment surface 36 to the distal end of the distal rigid portion 2a (a surface of reference numeral 11b in FIG. 2) has an elevation width W of the ultrasound probe 12 and the contact surface 11a, and has substantially the same size as an outer size of the distal end of the distal rigid portion 2a as shown in FIG. 2.

[0064] Thus, when the ultrasound unit 10 is abutted against body tissue in ultrasound observation, a force of the operator gripping the operation section 3 in the direction of the endoscope insertion axis L1 is reliably transmitted to the ultrasound unit 10. This allows the tissue contact surface 11a and the acoustic lens surface 12a to be substantially uniformly brought into close contact with the body tissue. Thus, the

tissue contact surface 11a and the acoustic lens surface 12a of the ultrasound unit 10 can be stably abutted against the body tissue to obtain a good ultrasound observation image.

[0065] The ultrasound probe 12 in FIGS. 4 and 5 is configured by arranging a plurality of ultrasound transducers 9 including, for example, a packing material, a piezoelectric transducer, a matching layer, and an acoustic lens stacked, and providing an electric wire such as a cable.

[0066] The plurality of ultrasound transducers 9 are arranged from a first ultrasound transducer 9F that is placed closest to the treatment instrument projecting opening and emits ultrasound to a final ultrasound transducer 9L placed the most distant from the treatment instrument projecting opening at a predetermined interval p. As shown in FIG. 5, the center of curvature O1 of the arc of the ultrasound probe 12 is positioned closer to the proximal end side than an opening surface 24a of the treatment instrument lead-out opening 24 provided in the distal rigid portion 2a. In the ultrasound transducer 9, an MUT (Micromachined Ultrasound Transducer) element may be used instead of the piezoelectric element.

[0067] Thus, the center of curvature O1 of the arc of the ultrasound probe 12 is positioned closer to the proximal end side than the opening surface 24a of the treatment instrument lead-out opening 24 to reduce the length of the distal rigid portion of the endoscope 1. This improves an insertion property of the endoscope into the body cavity. The ultrasound probe 12 is not placed within the observation field range of the endoscope 1, thereby eliminating inconvenience that a part of an endoscope image is lost by the ultrasound probe 12. Further, the ultrasound probe 12 is not placed within the illumination light application range of the endoscope 1, and thus a part of illumination light is not blocked by the ultrasound probe 12, and the illumination light can be applied over the observation field range of the endoscope 1 to obtain a good endoscope image.

[0068] In the ultrasound probe 12, a direction of a central axis LF of a sound ray of the first ultrasound transducer 9F is tilted by an angle θ1 toward the distal end side relative to the distal end surface 21 with reference to the distal end surface 21 (specifically, the distal end surface 21 having the treatment instrument lead-out opening 24) of the distal rigid portion 2a.

[0069] Next, a printed circuit board provided with signal lines corresponding to the plurality of ultrasound transducers as patterns, and a flexible printed circuit board connected to the printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment of the present invention will be described.

[0070] FIG. 6 is a plan view of an upper surface of a printed circuit board provided with signal lines corresponding to the plurality of ultrasound transducers (hereinafter referred to as an ultrasound transducer printed circuit board) in the ultrasound endoscope including the ultrasound probe according to the first embodiment of the present invention.

[0071] As shown, an ultrasound transducer printed circuit board 101 is a long and substantially rectangular printed circuit board provided in an insertion section axial direction in the distal rigid portion 2a of the insertion section 2 of the ultrasound endoscope, and is preferably a printed circuit board formed of a rigid member for use as a positioning member with high accuracy in assembly of the ultrasound probe.

[0072] On a distal end side of the ultrasound transducer printed circuit board 101, a group of a plurality of transducer

wiring pads **102** facing the plurality of ultrasound transducers **9** arranged in the convex shape are arranged in a convex shape according to the arrangement of the ultrasound transducers **9**. [0073] From the group of the plurality of transducer wiring pads **102**, a first signal pattern group **105** and a second signal pattern group **106** extend toward the proximal end side of the ultrasound transducer printed circuit board **101**.

[0074] The first signal pattern group **105** is connected at one end to pads of about a half of the group on one side of the board of the transducer wiring pad group **102**, and then extends in a longitudinal axis direction of the ultrasound transducer printed circuit board **101** toward a proximal end portion **103** of the ultrasound transducer printed circuit board **101**.

[0075] In the proximal end portion **103**, a first flexible printed circuit board wiring pad group **107** connected to the other end of the first signal pattern group **105** is arranged in a width direction of the ultrasound transducer printed circuit board **101** (in a short axis direction, that is, a direction substantially perpendicular to the longitudinal axis direction of the ultrasound transducer printed circuit board **101**; a direction perpendicular to an insertion axis of the endoscope). The first flexible printed circuit board wiring pad group **107** is arranged within a range of several millimeters with reduction in diameter of the ultrasound endoscope, and provided at a distance reliably connectable to a plurality of signal lines on a flexible printed circuit board described later.

[0076] Closer to the proximal end side than the first flexible printed circuit board wiring pad **107**, a signal pattern for checking in production is provided.

[0077] Meanwhile, the second signal pattern group **106** is connected at one end to pads of about a half of the group on the other side of the board of the transducer wiring pad group **102**, then once extends in the longitudinal axis direction of the ultrasound transducer printed circuit board **101**, and then bends substantially at 90 degrees and extends toward a distal projecting portion **104** in the ultrasound transducer printed circuit board **101**.

[0078] The distal projecting portion **104** is formed along a side surface of the board that has no influence on the arrangement of the first flexible printed circuit board wiring pad group **107** in the ultrasound transducer printed circuit board **101**. In the distal projecting portion **104**, a second flexible printed circuit board wiring pad group **108** connected to the other end of the second signal pattern group **106** is arranged in the longitudinal axis direction of the ultrasound transducer printed circuit board **101**.

[0079] The second flexible printed circuit board wiring pad group **108** is provided at a distance reliably connectable to the plurality of signal lines on the flexible printed circuit board described later like the first flexible printed circuit board wiring pad **107**, but the second flexible printed circuit board wiring pad group **108** is arranged in the longitudinal axis direction of the ultrasound transducer printed circuit board **101** and thus can be placed relatively with space unlike the first flexible printed circuit board wiring pad **107**.

[0080] FIG. 7 is a plan view of a state where a predetermined relay flexible printed circuit board is connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment of the present invention, FIG. 8 is a plan view of an upper surface of a relay flexible printed circuit board for changing a signal pattern direction connected to the ultrasound transducer printed circuit board in the ultrasound

endoscope including the ultrasound probe according to the first embodiment of the present invention, FIG. 9 is a plan view of a state where a coaxial cable group is connected to the relay flexible printed circuit board for changing a signal pattern direction connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment of the present invention, and FIG. 10 is a plan view of a state where a plurality of predetermined relay flexible printed circuit boards are connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the first embodiment of the present invention.

[0081] In the ultrasound endoscope, an unshown signal cable electrically connected to the ultrasound connector **7** (see FIG. 1) passes through the insertion section **2** and reaches near the ultrasound transducer printed circuit board **101**. The signal cable **34** (see FIG. 4) is preferably constituted by a plurality of coaxial cables corresponding to the plurality of ultrasound transducers **9**.

[0082] As shown in FIG. 7, the ultrasound endoscope of the present embodiment includes a first coaxial cable group **114** that includes a part of signal cables of the plurality of coaxial cables and corresponds to the first signal pattern group **105**, and a first relay flexible printed circuit board **111** that relays the first coaxial cable group **114** and the first signal pattern group **105**.

[0083] The first relay flexible printed circuit board **111** has a rectangular shape with a smaller width than the ultrasound transducer printed circuit board **101**, and is provided with a signal pattern group **112** of the same number as the first signal pattern group **105**. A distal end of the signal pattern group **112** is a flying lead section **112a** projecting from an end surface of the board by a so-called flying lead structure, and is connectable to the first flexible printed circuit board wiring pad group **107** by soldering or the like. On the other hand, a first coaxial cable wiring pad group **113** for connecting the first coaxial cable group **114** is arranged on the other end of the signal pattern group **112**.

[0084] Shield wires (ground wires) **116** of the first coaxial cable group **114** are collectively connected to a ground pad **115** of the first relay flexible printed circuit board **111** by soldering or the like.

[0085] In the present embodiment, the first relay flexible printed circuit board **111** on which a core line (signal line) of the first coaxial cable group **114** is previously connected to the first coaxial cable wiring pad **113** is connected to the ultrasound transducer printed circuit board **101**. Specifically, the flying lead section **112a** is connected to the first flexible printed circuit board wiring pad group **107** by soldering or the like.

[0086] As shown in FIGS. 8 and 9, the ultrasound endoscope of the present embodiment includes a second coaxial cable group **124** that is a part of signal cables of the plurality of coaxial cables and corresponds to the second signal pattern group **106**, and a second relay flexible printed circuit board **121** that relays the second coaxial cable group **124** and the second signal pattern group **106**.

[0087] The second relay flexible printed circuit board **121** has a proximal end portion having a rectangular shape with the same width as or a slightly smaller width than the ultrasound transducer printed circuit board **101**, and a distal end portion slightly projecting toward a side surface of the proximal end portion, and thus forms a substantially L shape.

[0088] The second relay flexible printed circuit board 121 is provided with a signal pattern group 122 of the same number as the second signal pattern group 106 along the substantially L shape. A distal end of the signal pattern group 122 is formed with a flying lead section 122a similarly to the above, and is connectable to the second flexible printed circuit board wiring pad group 108 by soldering or the like.

[0089] The signal pattern group 122 once extends from a connecting portion to the second flexible printed circuit board wiring pad group 108, that is, the flying lead section 122a toward one side of the board, then bends at substantially 90 degrees in the middle of the signal pattern, and extends toward the proximal end portion of the board. Then, a second coaxial cable wiring pad group 123 for connecting a core line of the second coaxial cable group 124 is arranged in the width direction (short axis direction) of the board on the other end of the signal pattern group 122.

[0090] Shield wires (ground wires) 126 of the second coaxial cable group 124 are collectively connected to a ground pad 125 of the second relay flexible printed circuit board 121 by soldering or the like.

[0091] Thus, the signal pattern group 122 changes a direction of the signal pattern extending from the second flexible printed circuit board wiring pad group 108 arranged in the longitudinal axis direction of the ultrasound transducer printed circuit board 101 (a direction at an angle of 90 degrees relative to the longitudinal axis direction) into the longitudinal axis direction of the ultrasound transducer printed circuit board 101.

[0092] Specifically, the second relay flexible printed circuit board 121 performs a direction changing function of changing the direction of the signal pattern from the second flexible printed circuit board wiring pad group 108 that can be relatively placed with space into the longitudinal direction of the ultrasound transducer printed circuit board 101 (axial direction of the insertion section 2).

[0093] In the present embodiment, the first relay flexible printed circuit board 111 is connected to the ultrasound transducer printed circuit board 101 (the state in FIG. 7), and then the second relay flexible printed circuit board 121 on which the second coaxial cable group 124 is previously connected to the second coaxial cable wiring pad group 123 is connected to the ultrasound transducer printed circuit board 101 (the state in FIG. 10). Specifically, the flying lead section 122a is connected to the second flexible printed circuit board wiring pad group 108 by soldering or the like.

[0094] In the above described example, the ultrasound transducer printed circuit board 101 is provided with the signal pattern and the wiring pad described above only on the upper surface as shown in FIG. 6, but not being limited thereto, components similar to the signal pattern and the wiring pad may be provided symmetrically on a back surface. Specifically, the board may be configured as a double-sided board, not limited to the single-sided board.

[0095] When the board is configured as a double-sided board, the first relay flexible printed circuit board 111 and the second relay flexible printed circuit board 121 may be connected to both sides, and at this time, a section taken along the line XVI-XVI in FIG. 10 has a configuration as shown in FIG. 16.

[0096] As described above, in the ultrasound endoscope using the ultrasound probe of the first embodiment,

[0097] (1) the plurality of signal patterns extending from the plurality of ultrasound transducers are divided into the two groups on the ultrasound transducer printed circuit board,

[0098] (2) one signal pattern group extends in the longitudinal axis direction of the ultrasound transducer printed circuit board, then the pad electrode section in the distal end portion is arranged in the short axis direction of the board, and the signal line extending from the pad electrode section toward the proximal end side extends in the longitudinal axis direction, and

[0099] (3) the other signal pattern group once extends in the longitudinal axis direction of the ultrasound transducer printed circuit board and then bends at substantially 90 degrees, the pad electrode section in the distal end portion is arranged in the longitudinal axis direction of the board, and the direction of the signal line extending from the pad electrode section in the short axis direction is changed into the longitudinal axis direction by the direction changing board.

[0100] This can provide the ultrasound probe and the ultrasound endoscope including the ultrasound probe that allows a reduction in diameter of the ultrasound probe and the ultrasound endoscope and allows reliable and easy electrical connection of the signal lines extending from the ultrasound transducers.

[0101] Next, a second embodiment of the present invention will be described.

[0102] FIG. 11 is a plan view of an upper surface of a printed circuit board provided with signal lines corresponding to a plurality of ultrasound transducers in an ultrasound endoscope including an ultrasound probe according to a second embodiment of the present invention, FIG. 12 is a plan view of an upper surface of a first relay flexible printed circuit board for changing a signal pattern direction connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the second embodiment of the present invention, FIG. 13 is a plan view of a state where the first relay flexible printed circuit board for changing a signal pattern direction is connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the second embodiment of the present invention, and FIG. 14 is a plan view of a state where a plurality of predetermined relay flexible printed circuit boards for changing a signal pattern direction are connected to the ultrasound transducer printed circuit board in the ultrasound endoscope including the ultrasound probe according to the second embodiment of the present invention.

[0103] As shown in FIG. 11, an ultrasound transducer printed circuit board 201 in the second embodiment has the same function as the ultrasound transducer printed circuit board 101 in the first embodiment, but unlike the first embodiment, the ultrasound transducer printed circuit board 201 has a feature in that both of two divided signal pattern groups once extend in the longitudinal axis direction and then bend at an angle of substantially 90 degrees, pad electrode sections at distal end portions are arranged in the longitudinal axis direction, and directions of signal lines extending from the pad electrode sections in the short axis direction are changed into the longitudinal axis direction by a direction changing board in both of the signal pattern groups.

[0104] Other configurations are the same as in the first embodiment, and thus differences only will be herein described.

[0105] On a distal end side of the ultrasound transducer printed circuit board 201 in the second embodiment, a group of a plurality of transducer wiring pads 202 similar to the transducer wiring pad group 102 are arranged, and from the group of the plurality of transducer wiring pads 202, a first signal pattern group 205 and a second signal pattern group 206 extend toward a proximal end side of the ultrasound transducer printed circuit board 201.

[0106] The first signal pattern group 205 is connected at one end to pads of about a half of the group on one side of the board of the transducer wiring pad group 202, then extends in a longitudinal axis direction of the ultrasound transducer printed circuit board 201 toward a proximal end portion 203, and bends at substantially 90 degrees toward the other side in the proximal end portion 203.

[0107] In the proximal end portion 203, a first flexible printed circuit board wiring pad group 207 connected to the other end of the first signal pattern group 205 is arranged in the longitudinal axis direction of the ultrasound transducer printed circuit board 201.

[0108] Meanwhile, the second signal pattern group 206 is connected at one end to pads of about a half of the group on the other side of the board of the transducer wiring pad group 202, then once extends in the longitudinal axis direction of the ultrasound transducer printed circuit board 201, and then bends substantially at 90 degrees and extends toward a distal projecting portion 204 in the ultrasound transducer printed circuit board 201.

[0109] In the distal projecting portion 204, a second flexible printed circuit board wiring pad group 208 similar to the second flexible printed circuit board wiring pad group 108 in the first embodiment is arranged in the longitudinal axis direction of the ultrasound transducer printed circuit board 201.

[0110] As shown in FIGS. 12 and 13, a first relay flexible printed circuit board 211 (see FIG. 12) that plays the same role as the second relay flexible printed circuit board 121 in the first embodiment is connected to the first flexible printed circuit board wiring pad group 207 (see FIG. 13).

[0111] Further, as shown in FIG. 14, a second relay flexible printed circuit board 221 that plays the same role as the second relay flexible printed circuit board 121 in the first embodiment is connected to the second flexible printed circuit board wiring pad group 208. At this time, as in the first embodiment, the first relay flexible printed circuit board 211 is connected and then the second relay flexible printed circuit board 221 is connected.

[0112] As described above, in the ultrasound endoscope of the second embodiment,

[0113] (1) the plurality of signal patterns extending from the plurality of ultrasound transducers are divided into the two groups on the ultrasound transducer printed circuit board,

[0114] (2) both of the signal pattern groups once extend in the longitudinal axis direction of the ultrasound transducer printed circuit board and then bend at substantially 90 degrees, the pad electrode sections in the distal end portions are arranged in the longitudinal axis direction of the board, and the directions of the signal lines extending from

the pad electrode sections in the short axis direction are changed into the longitudinal axis direction by the direction changing board.

[0115] This allows a further reduction in diameter of the ultrasound endoscope as compared with the first embodiment depending on the shape of the ultrasound transducer printed circuit board.

[0116] Also in the second embodiment, the board may be configured as a double-sided board as in the first embodiment.

[0117] Further, in the above described ultrasound endoscope of the first and second embodiments, the signal pattern group bends at the angle of substantially 90 degrees, but the angle is not limited thereto as long as the signal pattern group can be effectively connected to the flexible printed circuit board wiring pad group provided in the longitudinal axis direction of the ultrasound transducer printed circuit board, and the above described advantage can be obtained, for example, at an angle of about 60 degrees.

[0118] Further, in the ultrasound endoscopes of the first and second embodiments, the signal patterns extending from the ultrasound transducers are divided into the two groups, but not being limited thereto, the signal patterns may be divided into three or more groups. In this case, it should be understood that a signal pattern group with an angle changed and a signal pattern group with an angle unchanged may be combined in any manner in view of the size and shape of the ultrasound transducer printed circuit board and cost, or the like.

[0119] Next, a third embodiment of the present invention will be described.

[0120] FIG. 15 is a plan view of an upper surface of a printed circuit board provided with signal lines corresponding to a plurality of ultrasound transducers in an ultrasound endoscope including an ultrasound probe according to a third embodiment of the present invention.

[0121] As shown in FIG. 15, an ultrasound transducer printed circuit board 301 in the third embodiment has the same function as the ultrasound transducer printed circuit board 101 in the first embodiment in terms of providing signal patterns from ultrasound transducers, but unlike the first embodiment, the ultrasound transducer printed circuit board 301 has a feature in that a plurality of signal pattern groups separately bend toward both sides of the board, and pad electrode sections in distal end portions are also arranged in a longitudinal axis direction separately on both sides of the board, and directions of signal lines extending from the pad electrode sections in the short axis direction are changed into the longitudinal axis direction by a direction changing board in the plurality of signal pattern groups.

[0122] Other configurations are the same as in the first embodiment, and thus differences only will be herein described.

[0123] On a distal end side of the ultrasound transducer printed circuit board 301 in the third embodiment, a group of a plurality of transducer wiring pads 302, which has a different shape from the transducer wiring pad group 102, are arranged in a convex shape like the pad group 102, and from the group of the plurality of transducer wiring pads 302, a group of a plurality of signal patterns extend toward a proximal end side of the ultrasound transducer printed circuit board 301.

[0124] On one side of the ultrasound transducer printed circuit board 301, a first flexible printed circuit board wiring pad group 307 is arranged in a longitudinal axis direction of the ultrasound transducer printed circuit board 301.

[0125] Meanwhile, on the other side of the ultrasound transducer printed circuit board **301**, a second flexible printed circuit board wiring pad group **308** is arranged in the longitudinal axis direction of the ultrasound transducer printed circuit board **301**.

[0126] All of the plurality of signal pattern groups once extend in the longitudinal axis direction of the ultrasound transducer printed circuit board **301** toward a proximal end portion **303**, then bend and extend toward the first flexible printed circuit board wiring pad group **307** or the second flexible printed circuit board wiring pad group **308** provided on either of the both sides, and are connected thereto.

[0127] To the first flexible printed circuit board wiring pad group **307** and the second flexible printed circuit board wiring pad group **308**, a relay flexible printed circuit board for changing a direction that plays the same role as the second relay flexible printed circuit board **121** in the first embodiment is connected, though not shown, and as in the first and second embodiments, the relay flexible printed circuit board is properly connected to a coaxial signal cable provided in the longitudinal axis direction of the ultrasound transducer printed circuit board **301**.

[0128] As described above, in the ultrasound endoscope of the third embodiment,

[0129] (1) the plurality of signal patterns extending from the plurality of ultrasound transducers are divided into the plurality of groups on the ultrasound transducer printed circuit board,

[0130] (2) all of the signal pattern groups once extend in the longitudinal axis direction of the ultrasound transducer printed circuit board and then bend at a predetermined angle, the pad electrode sections in the distal end portions are arranged in the longitudinal axis direction of the board, and the directions of the signal lines extending from the pad electrode sections substantially in the short axis direction are changed into the longitudinal axis direction by the direction changing board.

[0131] This allows a further reduction in diameter of the ultrasound probe and the ultrasound endoscope as compared with the first and second embodiment depending on the shape of the ultrasound transducer printed circuit board.

[0132] Also in the third embodiment, the board may be configured as a double-sided board as in the first embodiment.

[0133] Further, in the above described embodiments, the example of using one ultrasound transducer printed circuit board is described, but not being limited thereto, a plurality of ultrasound transducers printed circuit boards may be used in combination. In this case, for example, when one ultrasound transducer printed circuit board **101** is used, the distal end portion of the ultrasound transducer printed circuit board **101** engages an ultrasound probe unit **150** as shown in FIG. 17, while when two ultrasound transducer printed circuit boards **101** and **101a** are used, the ultrasound transducer printed circuit boards **101** and **101a** are provided to be stacked in a plane direction, and distal end portions thereof engage the ultrasound probe unit **150** as shown in FIG. 18.

[0134] At this time, when the ultrasound transducer printed circuit board **101** is a double-sided board, while the ultrasound transducer printed circuit board **101a** is a single-sided board among the two ultrasound transducer printed circuit boards **101** and **101a**, a transducer wiring pad group of each thereof and an ultrasound transducer (piezoelectric element) **151** are connected by a wire **153** as shown in FIG. 19. In FIG.

19, reference numerals **152**, **154** and **155** denote an acoustic matching layer, a packing material, and an acoustic lens.

[0135] In the present embodiments, the ultrasound probe including the transducers arranged in the convex shape that has a significant advantage in reduction in diameter, and the ultrasound endoscope including the ultrasound probe are described as an example, but the same advantage can be obtained by transducers arranged in line or two-dimensionally.

[0136] The present invention is not limited to the above described embodiments, and it should be understood that various modifications and applications may be made without departing from the gist of the invention.

What is claimed is:

1. An ultrasound probe including a plurality of ultrasound transducers provided in a distal end portion, comprising:

an ultrasound transducer printed circuit board provided with signal patterns that transmit and receive signals to and from the plurality of ultrasound transducers; a first electrode group that faces the plurality of ultrasound transducers and constituted by a plurality of electrode sections provided in a distal end portion of the ultrasound transducer printed circuit board;

a second electrode group that is constituted by a plurality of electrode sections connected to ends of signal patterns extending from at least a part of the electrode group of the first electrode group, and arranged in a longitudinal axis direction of the ultrasound transducer printed circuit board;

a first signal pattern group that is connected between each electrode section of the second electrode group and the part of the electrode sections of the first electrode group, extends from the part of the electrode sections of the first electrode group toward a proximal end side of the ultrasound transducer printed circuit board, then bends in an angle direction different from the longitudinal axis direction, and further extends toward each electrode section of the second electrode group; and

a signal pattern direction changing printed circuit board provided with a second signal pattern group that has one end connectable to each electrode section of the second electrode group, extends from the one end in an angle direction different from the longitudinal axis direction, then bends in an angle direction different from the extending direction, and further extends in the longitudinal axis direction toward the proximal end portion.

2. The ultrasound probe according to claim 1, further comprising:

a third electrode group that is constituted by a plurality of electrode sections connected to ends of signal patterns extending from the other part of the electrode group of the first electrode group, and arranged in a width direction of the ultrasound transducer printed circuit board; and

a third signal pattern group that is connected between each electrode section of the third electrode group and the other part of the electrode group of the first electrode group, and extends in the longitudinal axis direction toward the proximal end side of the ultrasound transducer printed circuit board.

3. The ultrasound probe according to claim 1, wherein the plurality of ultrasound transducers are arranged in a projecting arcuate shape.

4. The ultrasound probe according to claim **2**, wherein the plurality of ultrasound transducers are arranged in a projecting arcuate shape.

5. An ultrasound endoscope including an ultrasound probe, comprising an ultrasound probe according to claim **1** at a distal end of an insertion section of the endoscope.

6. An ultrasound endoscope including an ultrasound probe, comprising an ultrasound probe according to claim **2** at a distal end of an insertion section of the endoscope.

7. An ultrasound endoscope including an ultrasound probe, comprising an ultrasound probe according to claim **3** at a distal end of an insertion section of the endoscope.

8. An ultrasound endoscope including an ultrasound probe, comprising an ultrasound probe according to claim **4** at a distal end of an insertion section of the endoscope.

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摘要(译)

设置在超声波换能器印刷电路板的远端部分中的换能器布线焊盘组，其设置有向多个超声波换能器发送信号和从多个超声波换能器接收信号的信号图案，沿纵向轴线方向布置的柔性印刷电路板布线焊盘组超声换能器印刷电路板的第二信号图案组，连接在换能器布线焊盘组和柔性印刷电路板布线焊盘组之间并且在其中间基本上弯曲的第二信号图案组，以及中继柔性印刷电路板，连接到柔性印刷电路板布线焊盘组并且将信号图案的方向改变为纵轴方向。

