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(54) **ULTRASONIC TRANSDUCER MODULE AND ULTRASONIC ENDOSCOPE**

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(57) **ABSTRACT**

An ultrasonic transducer module including: piezoelectric elements, each being aligned in the same direction that is a longitudinal direction thereof; electrodes that are formed on surfaces of the respective piezoelectric elements; a substrate that includes wiring members extending from at least one surface of the substrate, the wiring members being connected one by one to the electrodes of the piezoelectric elements; and reinforcing layers that are provided on a surface of each of the wiring members, the surface being opposite to a surface of the corresponding wiring member where the corresponding electrode is connected.

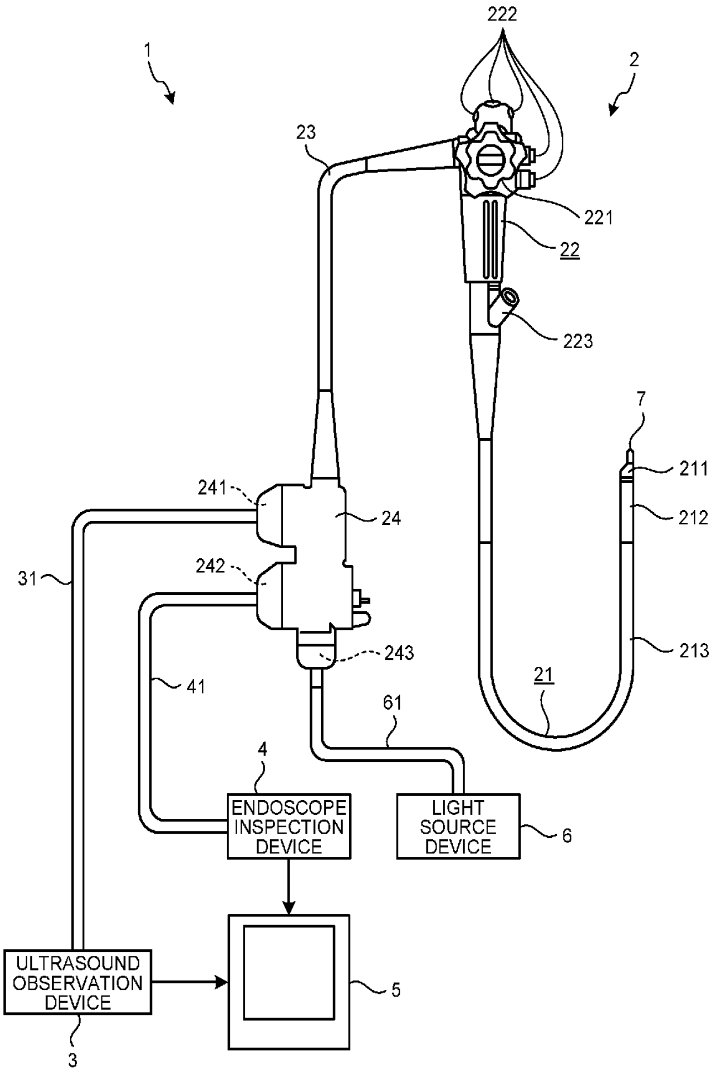


FIG.1

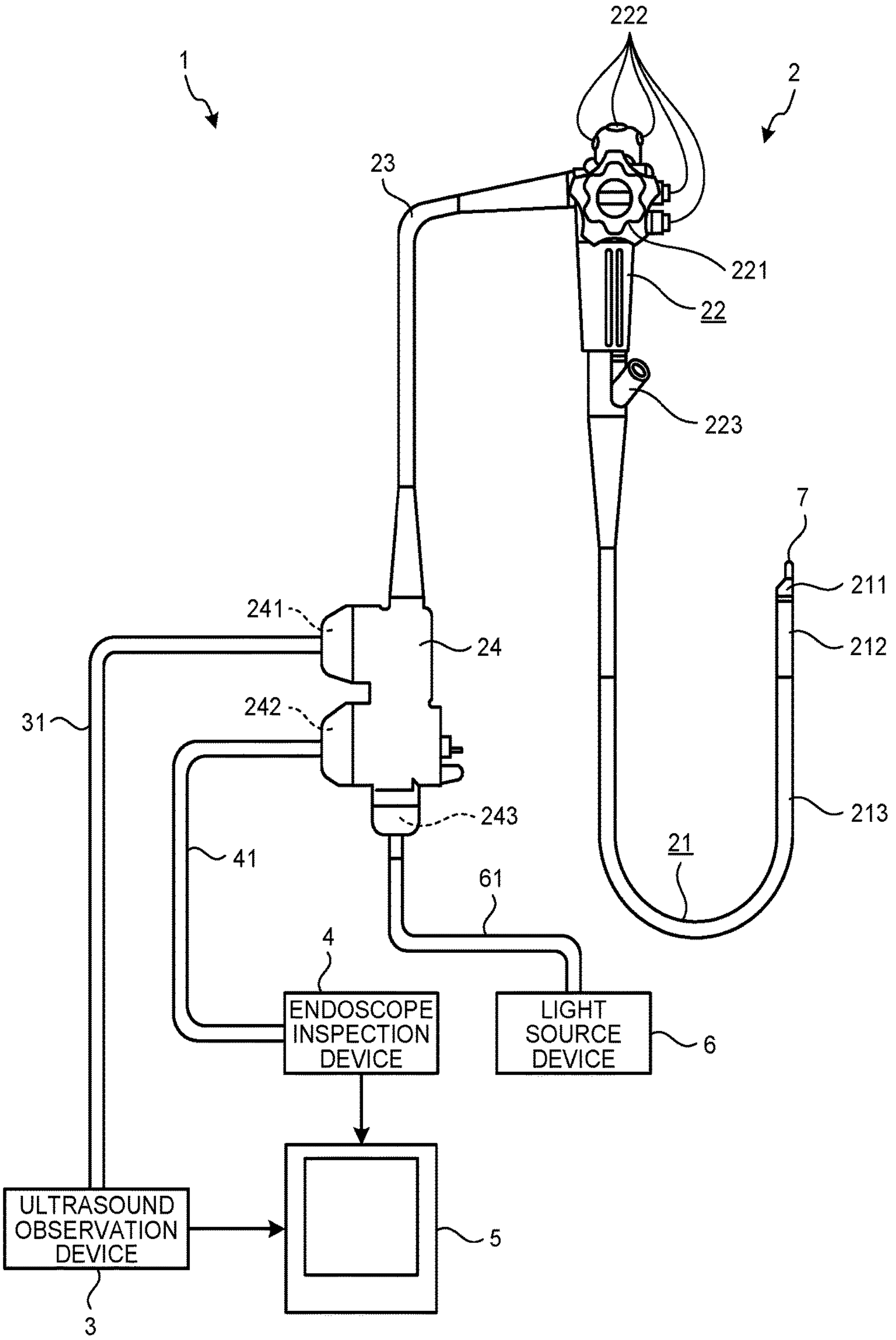

222
1
2
23
221
22
223
7
211
241
24
212
31
242
41
243
213
21
61
4
ENDOSCOPE INSPECTION DEVICE
LIGHT SOURCE DEVICE
6
ULTRASOUND OBSERVATION DEVICE
5
3

FIG.2

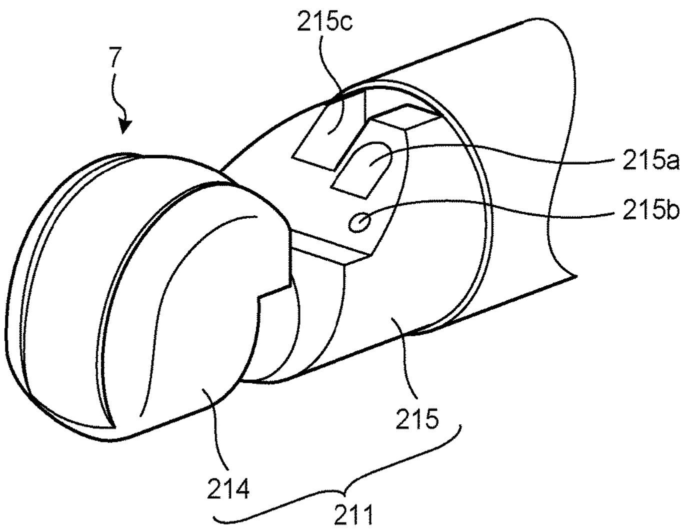


FIG.3

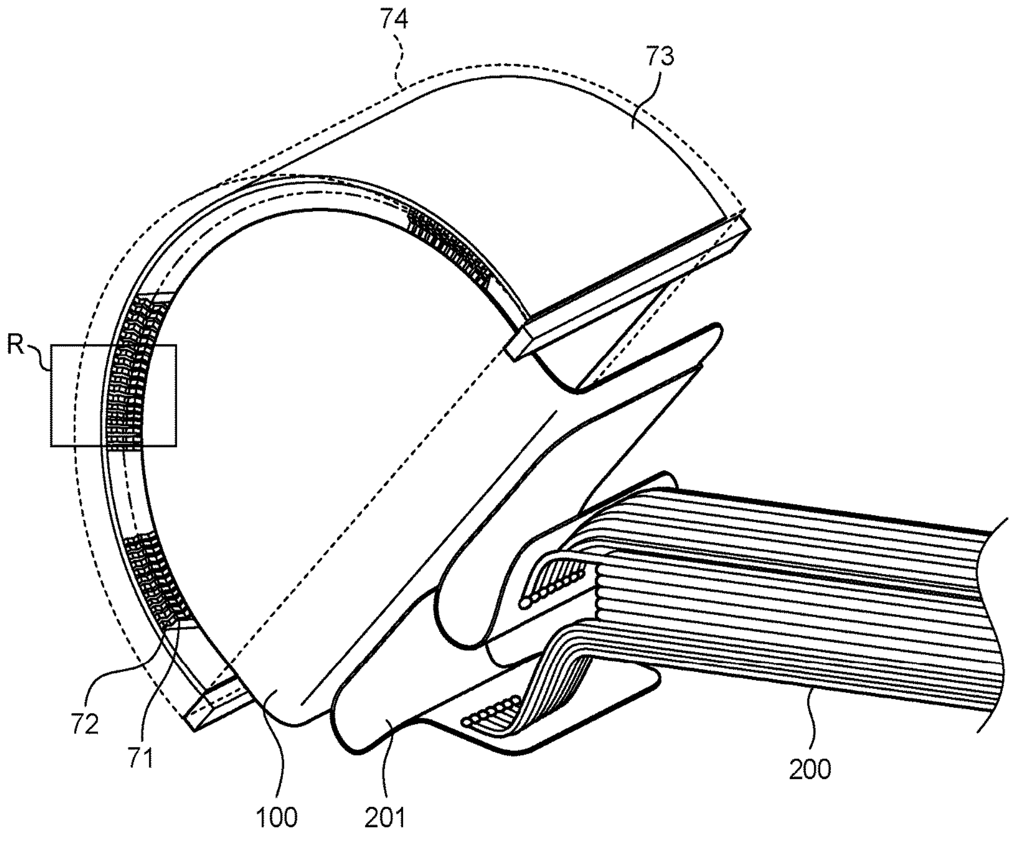


FIG.4

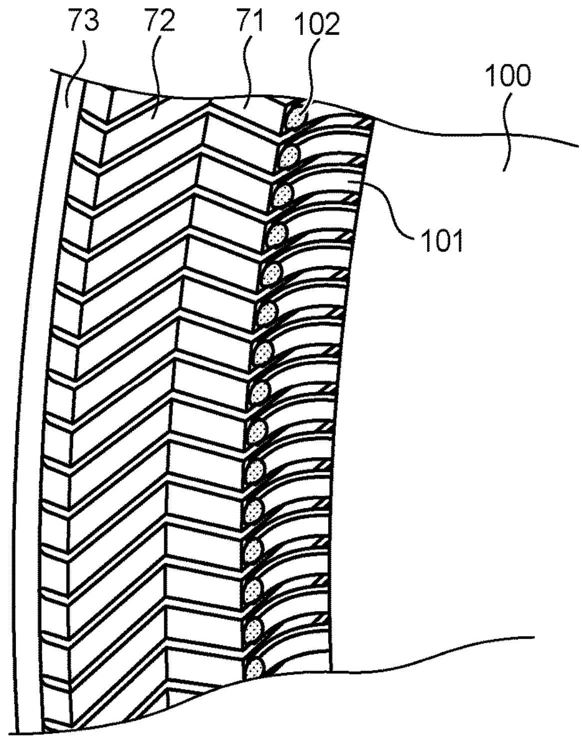


FIG.5

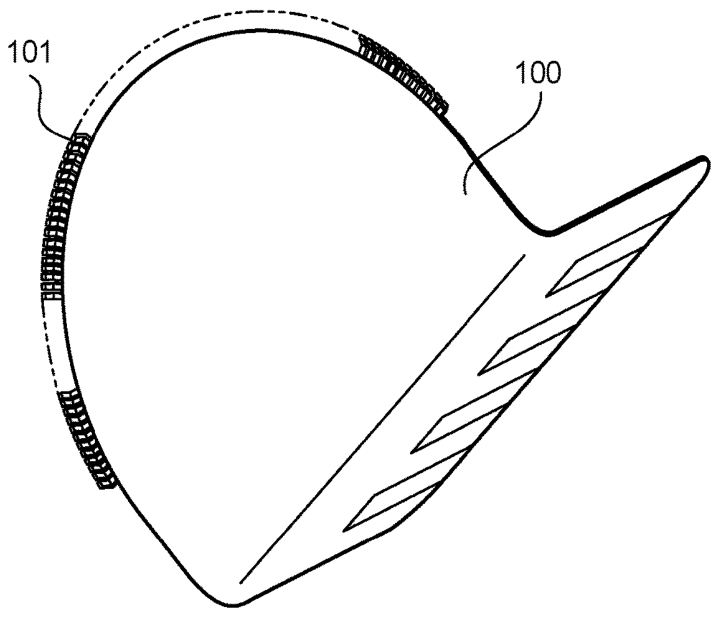


FIG.6

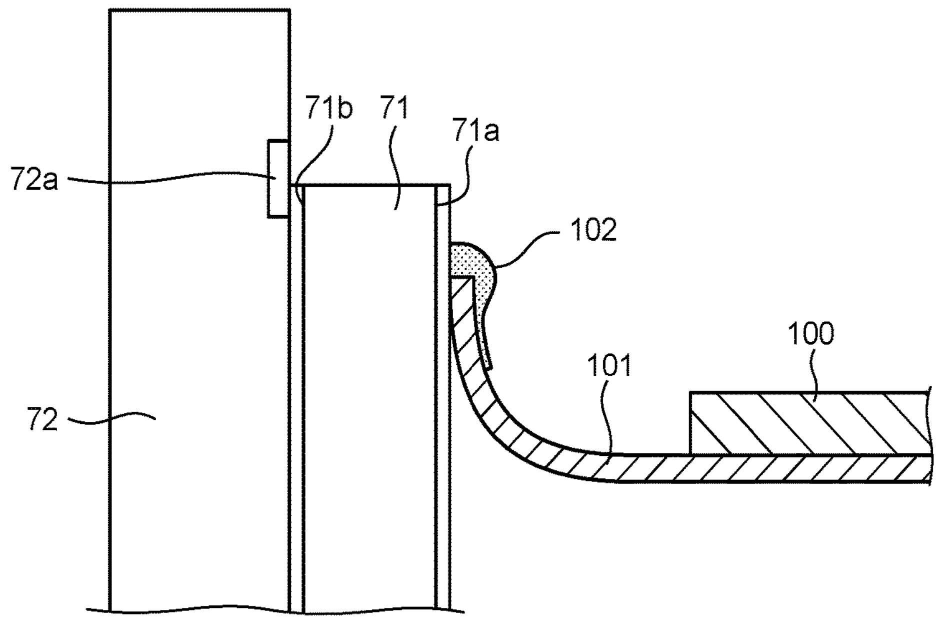


FIG.7

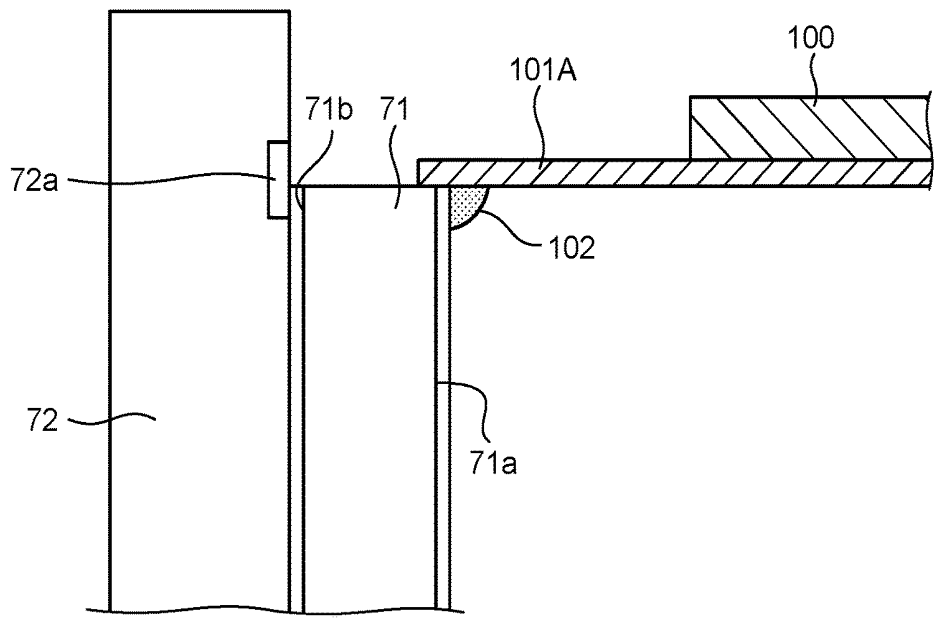


FIG.8

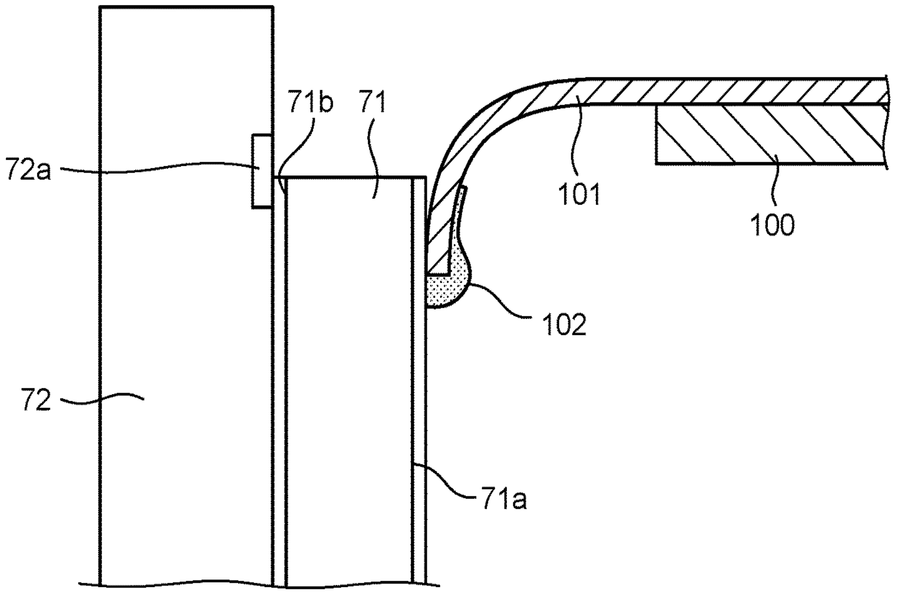


FIG.9

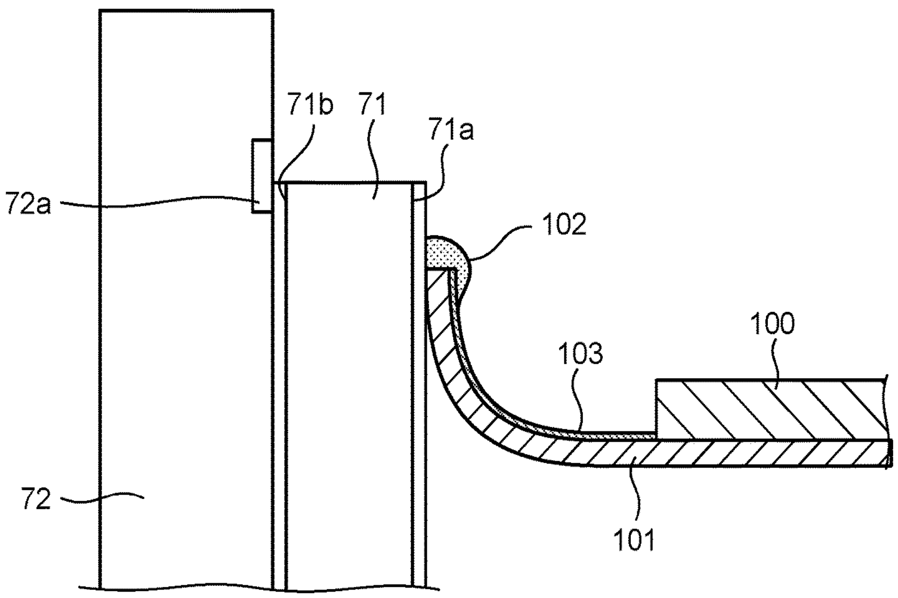


FIG.10

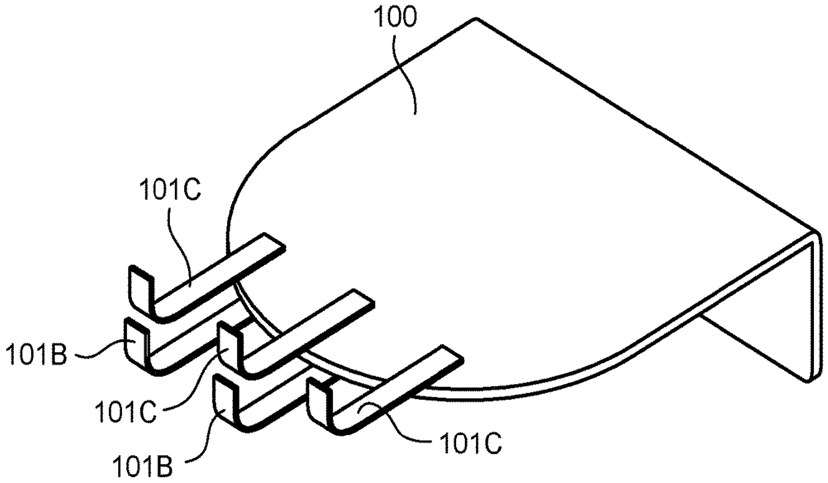

100
101C
101B
101C
101B
101C

FIG.11

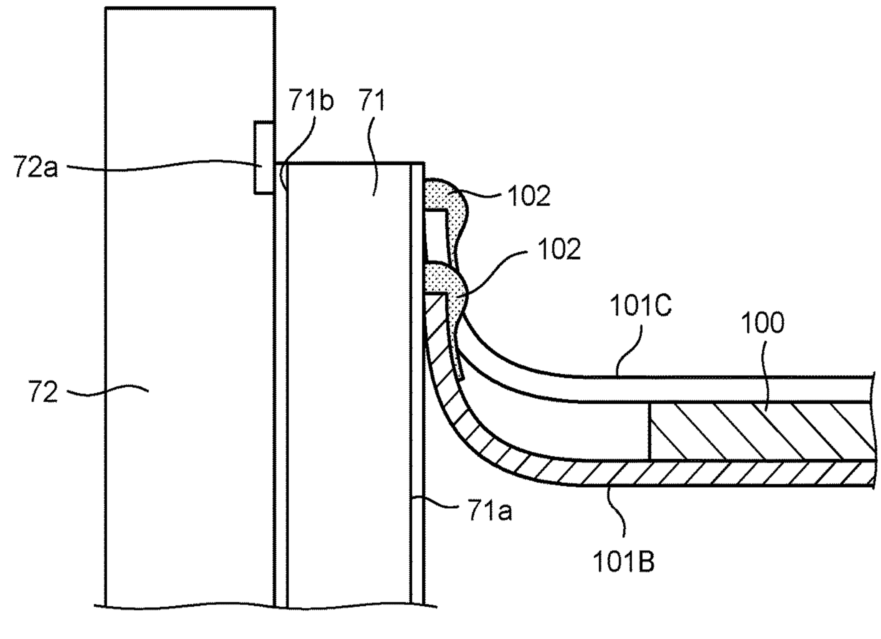

71b
71
72a
102
102
101C
100
72
71a
101B

FIG.12

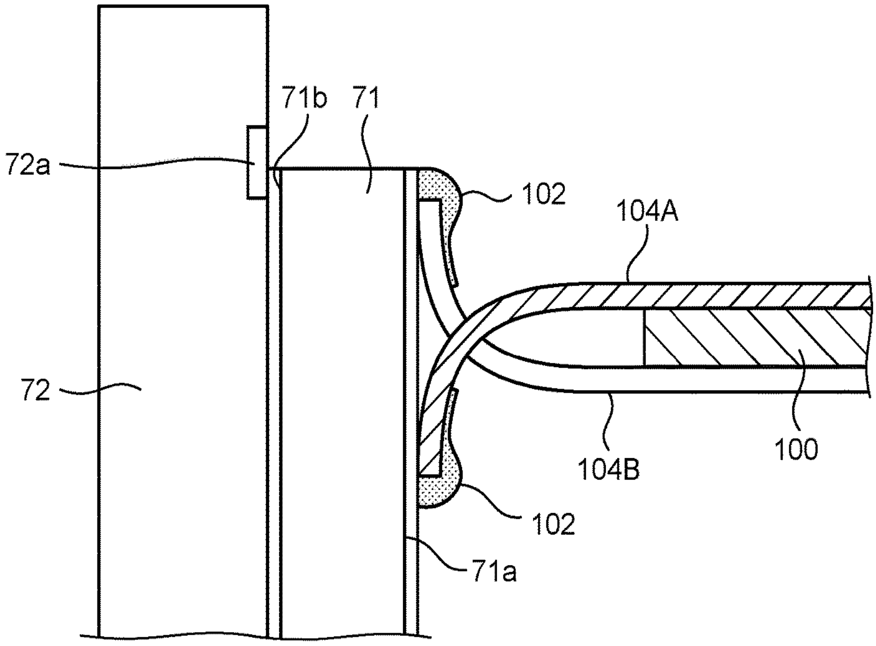
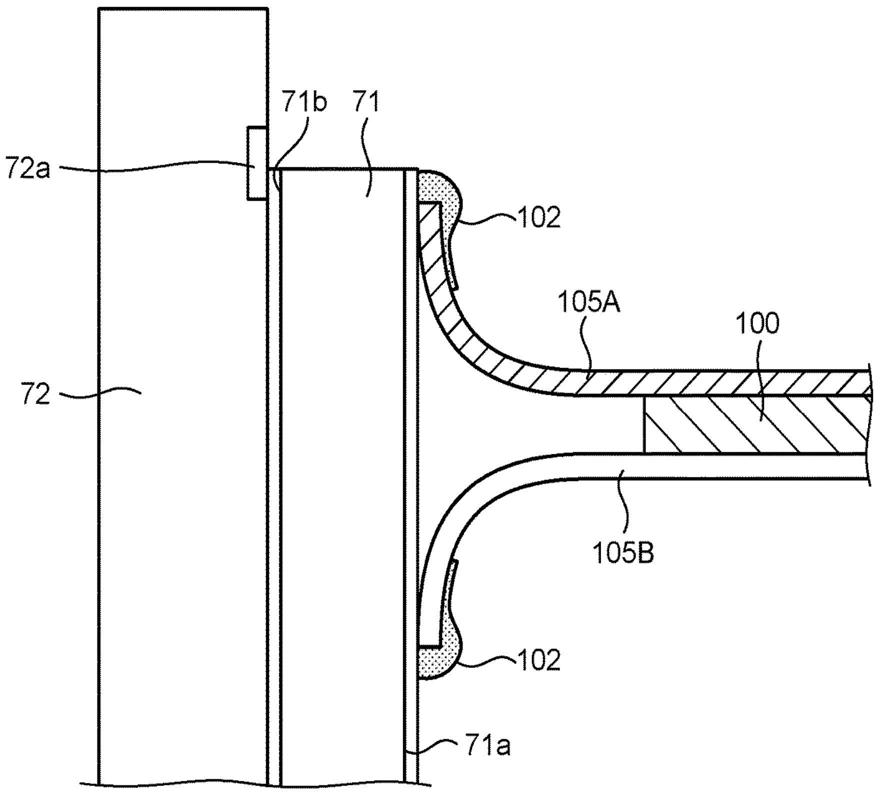

71b
71
72a
102
104A
72
100
104B
102
71a

FIG.13


71b
71
72a
102
105A
100
72
105B
102
71a

ULTRASONIC TRANSDUCER MODULE AND ULTRASONIC ENDOSCOPE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of PCT International Application No. PCT/JP2017/017917 filed on May 11, 2017 which claims the benefit of priority from Japanese Patent Application No. 2016-101628, filed on May 20, 2016, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] The present disclosure relates to an ultrasonic transducer module and an ultrasonic endoscope that includes an ultrasonic transducer at a distal end of an insertion portion.

[0003] Ultrasonic waves can be used to observe characteristics of a tissue of a living body or a material that is an object to be observed. Specifically, an ultrasonic observation apparatus subjects an ultrasonic echo received from an ultrasonic transducer that transmits and receives ultrasonic waves to a predetermined signal process, and thereby obtains information relating to characteristics of an object to be observed.

[0004] The ultrasonic transducer includes plural piezoelectric elements that converts an electrical pulse signal into an ultrasonic pulse (acoustic pulse) to irradiate to an object to be observed, and that converts an ultrasonic echo reflected by the object to be observed into an electrical echo signal to output. For example, the piezoelectric elements are aligned along a predetermined direction, and devices involved in transmission and reception are switched thereamong, thereby acquiring ultrasonic echo from the object to be observed.

[0005] As types of ultrasonic transducers, various types with which transmission/reception directions of ultrasonic beams differ, such as a convex type, a linear type, and a radial type, have been known. Out of these, in a convex ultrasonic transducer, plural piezoelectric elements are aligned along a curved surface, and each emits an ultrasonic beam toward a diameter direction of the curved surface (for example, refer to Japanese Patent No. 2555376). In Japanese Patent No. 2555376, after arranging plural piezoelectric elements on a flat surface and connecting flexible printed circuits (FPC), the plural piezoelectric elements are bent, thereby manufacturing a convex ultrasonic transducer.

SUMMARY OF THE DISCLOSURE

[0006] An ultrasonic transducer module according to one aspect of the present disclosure includes: piezoelectric elements, each being aligned in the same direction that is a longitudinal direction thereof; electrodes that are formed on surfaces of the respective piezoelectric elements; a substrate that includes wiring members extending from at least one surface of the substrate, the wiring members being connected one by one to the electrodes of the piezoelectric elements; and reinforcing layers that are provided on a surface of each of the wiring members, the surface being opposite to a surface of the corresponding wiring member where the corresponding electrode is connected.

[0007] An ultrasonic endoscope according to one aspect of the present disclosure includes: an ultrasonic transducer module that is provided at a distal end portion of the ultrasonic endoscope; and an insertion portion that is inserted into a subject.

[0008] The above and other features, advantages and technical and industrial significance of this disclosure will be better understood by reading the following detailed description of presently preferred embodiments of the disclosure, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a diagram schematically showing an endoscope system according to a first embodiment;

[0010] FIG. **2** is a perspective view schematically showing a distal end structure of an insertion portion of an ultrasonic endoscope according to the first embodiment;

[0011] FIG. **3** is a perspective view schematically showing a structure of an ultrasonic transducer module according to the first embodiment;

[0012] FIG. **4** is a diagram for explaining a structure of a principal part of the ultrasonic transducer module shown in FIG. **3**;

[0013] FIG. **5** is a schematic diagram showing a structure of a principal part of the ultrasonic transducer module according to the first embodiment, and is a schematic diagram for explaining a structure of a relay board;

[0014] FIG. **6** is a partial cross-section for explaining a structure of principal part of the ultrasonic transducer module shown in FIG. **3**;

[0015] FIG. **7** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a first modification of the first embodiment;

[0016] FIG. **8** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a second modification of the first embodiment;

[0017] FIG. **9** is a partial cross-section for explaining a principal part of an ultrasonic transducer module according to a third modification of the first embodiment;

[0018] FIG. **10** is a schematic diagram showing a structure of a principal part of an ultrasonic transducer module according to a second embodiment, and is a schematic diagram for explaining a structure of a relay board;

[0019] FIG. **11** is a partial cross-section for explaining a structure of a principal part of the ultrasonic transducer module according to the second embodiment;

[0020] FIG. **12** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a first modification of the second embodiment; and

[0021] FIG. **13** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a second modification of the second embodiment.

DETAILED DESCRIPTION

[0022] Forms to implement the present disclosure (hereinafter, embodiments) are explained below with reference to the drawings. Embodiments explained below are not intended to limit the present disclosure. Furthermore, like reference symbols are assigned to like parts throughout the drawings.

First Embodiment

[0023] FIG. **1** is a diagram schematically showing an endoscope system according to a first embodiment. An endoscope system **1** is a system to perform ultrasonic diagnosis of the inside of a subject, such as a human, by using an ultrasonic endoscope. This endoscope system **1** includes, as shown in FIG. **1**, an ultrasonic endoscope **2**, an ultrasonic observation device **3**, an endoscope inspection device **4**, a display device **5**, and a light source device **6**.

[0024] The ultrasonic endoscope **2** irradiates, to a subject, an ultrasonic pulse (acoustic pulse) that is obtained by converting an electrical pulse signal received from the ultrasonic observation device **3** by an ultrasonic transducer that is provided at a distal end portion thereof, and outputs an electrical echo signal expressed by voltage change that is obtained by converting an ultrasonic echo reflected by the subject.

[0025] The ultrasonic endoscope **2** includes an imaging optical system and an imaging device, and is capable of imaging any one of a digestive canal and a respiratory organ, inserted into a digestive canal (the esophagus, the duodenum, the large intestine) or a respiratory organ (the trachea, the bronchus). Moreover, it is capable of imaging the peripheral organs (the pancreas, the gallbladder, the biliary duct, the biliary tract, a lymph node, a mediastinum organ, a blood vessel, and the like) by using ultrasonic waves. Furthermore, the ultrasonic endoscope **2** includes a light guide that guides illumination light to be irradiated to the subject an optical imaging. A distal end portion of this light guide reaches to a distal end of an insertion portion of the ultrasonic endoscope **2** inserted to a subject, and a proximal end portion thereof is connected to the light source device **6** that generates the illumination light.

[0026] The ultrasonic endoscope **2** includes, as shown in FIG. **1**, an insertion portion **21**, an operation portion **22**, a universal cord **23**, and a connector **24**. The insertion portion **21** is a portion to be inserted into the subject. This insertion portion **21** includes, as shown in FIG. **1**, a hard distal end portion **211** that is arranged at a distal end and that holds an ultrasonic transducer **7**, a bending portion **212** that is connected to a proximal end side of the distal end portion **211** and that is bendable, and a flexible tube **213** that is connected to a proximal end side of the bending portion **212** and that has flexibility. Although a specific illustration is omitted, in the insertion portion **21**, a light guide that transmits illumination light supplied by the light source device **6** and plural signal cables that transmit various kinds of signals are routed, and a treatment-tool insertion channel to insert a treatment tool is formed.

[0027] The ultrasonic transducer **7** is a convex ultrasonic transducer that is provided with multiple piezoelectric elements in an array, and that performs electronic scanning by electronically switching piezoelectric elements to be involved in transmission and reception, or by giving a delay time to transmission and reception of the respective piezoelectric elements. A structure of the ultrasonic transducer **7** is described later.

[0028] FIG. **2** is a perspective view schematically showing a distal end structure of the insertion portion of the ultrasonic endoscope according to the first embodiment. As shown in FIG. **2**, the distal end portion **211** includes an ultrasonic transducer module **214** holding the ultrasonic transducer **7**, and an endoscope module **215** having an objective lens **215*a*** that constitutes a part of the imaging optical system, and through which light is taken in from the outside and an illumination lens **215*b*** that condenses illumination light to emit it the outside. In the endoscope module **215**, a treatment-tool protrusion outlet **215*c*** that communicates with the treatment-tool insertion channel formed in the insertion portion **21** and that lets a treatment tool protrude out from a distal end of the insertion portion **21** is formed. The treatment-tool insertion channel is arranged such that a portion near an end communicating with the treatment-tool protrusion outlet **215*c*** is tilted with respect to a longitudinal axis of the insertion portion **21**, and that a treatment tool protrudes out in a direction tilted with respect to the longitudinal axis from the treatment-tool protrusion outlet **215*c***. The longitudinal axis herein is an axis along a direction of length of the insertion portion **21**. While the axis direction varies in the bending portion **212** or the flexible tube **213** according to the position, the longitudinal axis in the hard distal end portion **211** is an axis of an invariant straight line.

[0029] The operation portion **22** is a portion that is connected to a proximal end side of the insertion portion **21**, and that accepts various kinds of operation from a user, such as a doctor. This operation portion **22** includes, as shown in FIG. **1**, a bending knob **221** to bend the bending portion **212**, and plural operating members **222** to perform various kinds of operation. Moreover, in the operation portion **22**, a treatment tool inlet **223** that communicates with the treatment-tool insertion channel, to insert a treatment tool into the treatment-tool insertion channel is formed.

[0030] The universal cord **23** is a cable that extends from the operation portion **22**, and in which multiple signal cables to transmit various kinds of signals, an optical fiber to transmit illumination light supplied by the light source device **6**, and the like are arranged.

[0031] The connector **24** is provided at a distal end of the universal cord **23**. The connector **24** includes first to third connector portions **241** to **243** to which an ultrasonic cable **31**, a video cable **41**, and an optical fiber cable are connected, respectively.

[0032] The ultrasonic observation device **3** is electrically connected to the ultrasonic endoscope **2** through the ultrasonic cable **31** (refer to FIG. **1**), and outputs a pulse signal to the ultrasonic endoscope **2** through the ultrasonic cable **31**, and receives an echo signal input from the ultrasonic endoscope **2**. The ultrasonic observation device **3** subjects the echo signal to a predetermined process to generate an ultrasonic image.

[0033] The endoscope inspection device **4** is electrically connected to the ultrasonic endoscope **2** through the video cable **41** (refer to FIG. **1**), and receives an image signal input from the ultrasonic endoscope **2** through the video cable **41**. The endoscope inspection device **4** subjects the image signal to a predetermined process to generate an endoscopic image.

[0034] The display device **5** is structured using a liquid crystal or an organic electroluminescence (EL), a projector, a cathode ray tube (CRT), or the like, and displays an ultrasonic image generated by the ultrasonic observation device **3**, an endoscopic image generated by the endoscope inspection device **4**, and the like.

[0035] The light source device **6** is connected to the ultrasonic endoscope **2** through an optical fiber cable **61** (refer to FIG. **1**), and supplies illumination light to illuminate inside the subject to the ultrasonic endoscope **2** through the optical fiber cable **61**.

[0036] Subsequently, a structure of the ultrasonic transducer **7** arranged at a distal end of the insertion portion **21** is explained, referring to FIG. **2** to FIG. **5**. FIG. **3** is a perspective view schematically showing a structure of the ultrasonic transducer module according to the first embodiment. FIG. **4** is a diagram for explaining a structure of a principal part of the ultrasonic transducer module shown in FIG. **3**, and is a diagram showing a structure of a region R shown in FIG. **3**. In the first embodiment, explanation is given assuming that the ultrasonic transducer **7** is a convex ultrasonic transducer as shown in FIG. **2**, and that the piezoelectric elements **71** are of one-dimensional array (**1**D array) in which the piezoelectric elements **71** are arranged in a single row. In other words, in the ultrasonic transducer **7** according to the first embodiment, the piezoelectric elements **71** are arranged in a curved manner along an external surface of the ultrasonic transducer **7** forming a curved surface, and transmit and receive ultrasonic waves on a plane including a longitudinal axis and parallel to the longitudinal direction.

[0037] The ultrasonic transducer **7** includes plural piezoelectric elements **71** in a rectangular column shape arranged aligning the longitudinal axes, a first acoustic-matching layer **72** arranged on an external surface of the ultrasonic transducer **7** relative to the piezoelectric elements **71**, a second acoustic-matching layer **73** that is arranged on the opposite side to a side of the first acoustic-matching layer **72** in contact with the piezoelectric elements **71**, and an acoustic lens **74** that is arranged on the opposite side to a side of the second acoustic-matching layer **73** in contact with the first acoustic-matching layer **72**. On the opposite side to a side of the piezoelectric elements **71** in contact with the first acoustic-matching layer **72**, a backing material not shown is arranged. The backing material attenuates unnecessary ultrasonic vibrations that are caused by action of the piezoelectric elements **71**. The backing material is made from a material having a large attenuation factor, for example, by using epoxy resin in which filers, such as alumina and zirconia, are dispersed, or rubber in which the above fillers are dispersed.

[0038] The piezoelectric element **71** converts an electrical pulse signal into an acoustic pulse and irradiate it to the subject, and converts an ultrasonic echo reflected by the subject into an electrical echo signal expressing the ultrasonic echo by voltage change to output. The piezoelectric element **71** has, for example, a signal input/output electrode **71***a* on a principal surface on a side facing the backing material, and a ground electrode **71***b* for grounding on a principal surface on the side of the piezoelectric element **71** facing the first acoustic-matching layer **72** (refer to FIG. **6**). The respective electrodes are formed by using a metallic material or a resin material having conductivity. The principal surface herein signifies an acoustic radiation plane and a plane opposing to the acoustic radiation plane, and a plane intersecting the principal surface is referred to as side surface.

[0039] The first acoustic-matching layer **72** and the second acoustic-matching layer **73** match an acoustic impedance of the piezoelectric element **71** and an acoustic impedance to be observed for efficient transmission of sound (ultrasonic) between the piezoelectric element **71** and an object to be observed. The first acoustic-matching layer **72** and the second acoustic-matching layer **73** are made from materials different from each other. Although the first embodiment is explained supposing that two acoustic matching layers (the first acoustic-matching layer **72** and the second acoustic-matching layer **73**) are provided, the matching layer can be one layer or three or more layers according to the characteristics of the piezoelectric element **71** and an object to be observed.

[0040] In the first acoustic-matching layer **72**, a ground electrode **72***a* that is electrically connected to the ground electrode **71***b* of the piezoelectric element **71** is provided (refer to FIG. **6**). The ground electrode **72***a* is made from a conductive material having larger impedance than the acoustic impedance of the piezoelectric element **71**, and functions as a de-matching layer. The piezoelectric element **71** is grounded outside through the ground electrode **72***a*.

[0041] The acoustic lens **74** covers an external surface of the first acoustic-matching layer **72** and the second acoustic-matching layer **73**. The acoustic lens **74** forms an external surface of the ultrasonic transducer **7**. The acoustic lens **74** is formed by using silicone, polyethylpentene, epoxy resin, polyetherimide, or the like, has a convex or concave shape on one side to have a function of reducing ultrasonic waves, and emits ultrasonic waves that have passed through the second acoustic-matching layer **73** to the outside or takes in an ultrasonic echo from the outside. The acoustic lens **74** can be arranged arbitrarily, and a structure without the acoustic lens **74** is also applicable.

[0042] The ultrasonic transducer **7** having the above structure irradiates ultrasonic waves to an object to be observed through the first acoustic-matching layer **72**, the second acoustic-matching layer **73**, and the acoustic lens **74** by the piezoelectric elements **71** vibrating as a pulse signal is input thereto. At this time, in the piezoelectric element **71**, the backing material attenuates unnecessary ultrasonic vibrations from the piezoelectric element **71** on the opposite side to a side on which the first acoustic-matching layer **72**, the second acoustic-matching layer **73**, and the acoustic lens **74** are arranged. Moreover, an ultrasonic wave reflected from the object to be observed is transmitted to the piezoelectric element **71** through the acoustic lens **74**, the second acoustic-matching layer **73**, and the first acoustic-matching layer **72**. The piezoelectric element **71** vibrates by the transmitted ultrasonic wave, converts the vibration into an electrical echo signal, and outputs the echo signal to the ultrasonic observation device **3** through a wiring member **101** described later.

[0043] FIG. **5** is a schematic diagram showing a structure of a principal part of the ultrasonic transducer module according to the first embodiment, and is a schematic diagram for explaining a structure of a relay board. The ultrasonic transducer module **214** includes a relay board **100** that relays electrical connection between the ultrasonic transducer **7** and plural signal lines **200** (refer to FIG. **3**) constituting a part of a path that electrically connects between the ultrasonic transducer **7** (the ultrasonic transducer module **214**) and the ultrasonic observation device **3**. The relay board **100** is a flexible board (flexible printed circuits (FPC)) that is held by the ultrasonic transducer **7** at a side portion of the ultrasonic transducer **7**. The relay board **100** corresponds to a substrate in the present disclosure, and is electrically connected to the signal lines **200** through a second relay board **201**. The relay board **100** is formed by arranging wirings on a substrate from polyimide. Furthermore, the relay board **100** is electrically connected to the signal input/output electrode **71***a* by wiring members **101** extending out from one surface of the relay board **100**. In the first embodiment, the wiring members **101** extend out from one principal surface of the relay board **100**. The relay board **100** has an arc shape along the alignment of the piezoelectric elements **71** at an edge on the side from which the wiring member **101** extend out.

[0044] FIG. **6** is a partial cross-section for explaining a structure of principal part of the ultrasonic transducer module shown in FIG. **3**, and is a partial cross-section cut along a plane perpendicular to a direction of arrangement of the piezoelectric elements **71** and passing through the wiring members **101**. The wiring member **101** is a flying lead that is formed by using a conductive material, such as copper, and an alloy, a principal component of which is copper. The wiring members **101** extend outside from part of the relay board **100**, and has an L-shape formed by bending an end portion on a side connected to the signal input/output electrode **71***a*. To support formation of a joint portion **102**, nickel/gold plating or solder plating can be formed on a surface of the wiring members **101**.

[0045] Each of the wiring members **101** is joined with the signal input/output electrode **71***a* by the joint portion **102** at a bent distal end portion. The joint portion **102** is an electrolytic plating layer that is formed by an electrolytic plating method using a conductive material, such as nickel, copper, solder, and an alloy, a principal component of which is nickel, copper, or tin. The electrolytic plating method enables a quantitative control of material to form the joint portion **102** by controlling voltage and time. The joint portion **102** can be formed by joining by solder, or can be formed by molten soldering.

[0046] It is preferable that a joint portion formed by the joint portion **102** be a region piezoelectrically inactive for the piezoelectric element **17** to perform transmission and reception of ultrasonic waves accurately. Being piezoelectrically inactive is being not polarized, or being without application of an electric field.

[0047] Subsequently, a manufacturing method to manufacture the ultrasonic transducer module **214** described above is explained. First, the first acoustic-matching layer **72** and the second acoustic-matching layer **73** are laminated on the piezoelectric element **71**. At this time, the ground electrode **71***b* in the piezoelectric element **71** and the ground electrode **72***a* in the first acoustic-matching layer **72** come into contact with each other.

[0048] Thereafter, the signal input/output electrode **71***a* and the wiring members **101** are joined by the joint portion **102** in a state in which the signal input/output electrode **71***a* of the piezoelectric elements **71** and the wiring members **101** are in contact with each other. The joint portion **102** is formed, for example, by using the electrolytic plating method described above. By using the electrolytic plating method, generation of heat at the time of joining the signal input/output electrode **71***a* and the wiring members **101** can be suppressed, and thereby enabling to suppress thermal deterioration of the piezoelectric elements **71**. Moreover, by using the electrolytic plating method, multiple sets of the signal input/output electrode **71***a* and the wiring members **101** can be joined all together, thereby enabling to reduce manufacturing cost. The joint portion **102** can be formed by joining by solder or by molten soldering as described above.

[0049] The manufacturing procedure described above can be in reverse order. Specifically, after the signal input/output electrode **71***a* and the wiring members **101** are joined, the first acoustic-matching layer **72** and the second acoustic-matching layer **73** can be laminated on the piezoelectric element **71**.

[0050] Thereafter, the backing material is filled on the opposite side to the first acoustic-matching layer **72** of the piezoelectric element **71**, and the acoustic lens **74** is mounted. Furthermore, this acoustic lens **74** is placed in the casing. Thus, the ultrasonic transducer module **214** shown in FIG. **2** is manufactured.

[0051] According to the first embodiment explained above, when the piezoelectric elements **71** and the relay board **100** are joined, the signal input/output electrodes **71***a* of the piezoelectric elements **71** and the L-shaped wiring members **101** extending from the relay board **100** are joined by the joint portion **102**. Because the wiring members **101** integrated with the relay board **100** are joined with the piezoelectric elements **71**, respectively, the positioning accuracy in connecting the piezoelectric elements **71** and the relay board **100** can be improved compared to the case when independent multiple signal lines are connected to the piezoelectric elements **71** one by one. Thus, the array density of the piezoelectric elements **71** can be increased while a sufficient joint strength between the piezoelectric element **71** and the wiring member **101** is kept.

[0052] Furthermore, according to the first embodiment, the distal end of the wiring member **101** is bent in an L-shape to connect this distal end with the signal input/output electrode **71***a* and, therefore, stress externally applied thereto can be dispersed by this L-shape, and stress on the piezoelectric elements **71** can be reduced.

[0053] In the first embodiment described above, it has been explained that the relay board **100** is electrically connected to the signal lines **200** through the second relay board **201**, but it can be directly connected to the signal lines **200** without the second relay board **201**.

[0054] First Modification of First Embodiment

[0055] FIG. **7** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a first modification of the first embodiment. As shown in FIG. **7**, in the first modification, a wiring member **101**A extending in a flat plate shape is included in addition to the wiring members **101** described above. As the first modification, wiring members that are not bent in an L-shape are also applicable, and the positioning accuracy in connecting the piezoelectric elements **71** and the relay board **100** can be improved compared to the case in which independent multiple signal lines are connected to the piezoelectric elements **71** one by one.

[0056] Second Modification of First Embodiment

[0057] FIG. **8** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a second modification of the first embodiment. As shown in FIG. **8**, in the second modification, the wiring members **101** described above are positioned outside a region extending in a lamination direction of the piezoelectric elements **71**, the first acoustic-matching layer **72**, and the second acoustic-matching layer **73**, that is, outside a region according to the matching layer, except the joint portion by the joint portion **102**. By arranging the wiring members **101** outside the region according to the matching layer as the second modification, ultrasonic waves are not transmitted to the wiring members **101** from the piezoelectric elements **71**, and ultrasonic waves reflected by the wiring members **101** do not enter the piezoelectric elements **71**. Therefore, it is possible to suppress reception of unnecessary ultrasonic echo by the piezoelectric elements **71**. Thus, suppressing noises due to an unnecessary ultrasonic echo, it is possible to enhance the image quality of ultrasonic images acquired by the ultrasonic transducer **7**.

[0058] Moreover, other than the arrangement in the second modification described above, the wiring members **101** can be arranged in a region according to the de-matching layer formed by the ground electrode **72***a*. In this case also, ultrasonic waves reflected by the wiring members **101** do not enter the piezoelectric elements **71** as described above and, therefore, reception of an unnecessary ultrasonic echo by the piezoelectric elements **71** can be suppressed.

[0059] Third Modification of First Embodiment

[0060] FIG. **9** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a third modification of the first embodiment. As shown in FIG. **9**, in the third modification, an elastic deformable reinforcing layer **103** is arranged on a surface of the wiring members **101** where the relay board **100** is arranged, the surface being opposite to a surface where the signal input/output electrode **71***a* is connected.

[0061] The reinforcing layer **103** is, for example, made from polyimide, which is the same material forming the relay board **100**. The reinforcing layer **103** extends up to the distal end of the wiring members **101** from an end portion of the relay board **100**, and gives resilience to the wiring members **101**. This enables to increase a load applied to the signal input/output electrode **71***a* by the wiring members **101** by the reinforcing layer **103** when the wiring members **101** are pressure-welded to the signal input/output electrode **71***a*, and to obtain firmer connection between the wiring members **101** and the signal input/output electrode **71***a*. Moreover, by arranging the reinforcing layer **103**, it is possible to improve the shape stability of the wiring members **101**, enabling to suppress a break of the wiring member **101** at an end portion on a side extending from the relay board **100**, or to suppress deformation of the wiring members **101**.

[0062] Note that as long as the reinforcing layer **103** is elastic and deformable and capable of giving resilience to wiring members, the material thereof is not limited to polyimide described above. Moreover, the thickness of the reinforcing layer **103** can be adjusted appropriately according to a load applied to the piezoelectric elements **71** by the wiring members **101**, as long as it is equal to or smaller than the thickness of the relay board **100**. Furthermore, by combining with the second modification described above, it is possible to obtain firmer connection between the wiring members **101** and the signal input/output electrode **71***a*, while suppressing reception of unnecessary ultrasonic echoes by the piezoelectric elements **71**.

[0063] Moreover, the reinforcing layer **103** is not necessarily required to be arranged for all of the wiring members **101**, but can be arranged for part of the wiring members **101**. Furthermore, although it has been explained that the reinforcing layer **103** extends up to the distal end of the wiring members **101** from the end portion of the relay board **100**, it can be arranged partially at part of that from the end of the relay board **100** to the distal end of the wiring members **101**.

Second Embodiment

[0064] FIG. **10** is a schematic diagram showing a structure of a principal part of an ultrasonic transducer module according to a second embodiment, and is a schematic diagram for explaining a structure of a relay board. While it has been explained that the wiring members **101** extend from one surface of the relay board **100** in the first embodiment, wiring members **101**B and **101**C respectively extend out from surfaces opposing to each other of the relay board **100** in the second embodiment. FIG. **10** shows a structure in which five pieces of wiring members extend out for explanation, but the number of wiring members arranged in an actual situation depends on the number of the piezoelectric elements **71**. The wiring members **101**B and **101**C are connected to wiring patterns formed on the relay board **100**, respectively.

[0065] In the relay board **100** shown in FIG. **10**, plural wiring members **101**B and plural wiring members **101**C are arranged. The wiring members **101**B extend out from one surface of the relay board **100**. On the other hand, the wiring members **101**B extend out from a surface different from the surface from which the wiring members **101**B extend. In the second embodiment, explanation is given assuming that the wiring members **101**B and the wiring members **101**C extend out from principal surfaces opposing to each other. Moreover, in the second embodiment, the wiring members **101**B and the wiring members **101**C are arranged in a staggered arrangement in a planer view from a direction perpendicular the principal surface of the relay board **100**. The wiring members **101**B and **101**C are arranged in a zig zag alignment in a side view.

[0066] The wiring members **101**B and **101**C are flying leads that are formed by using a conductive material, such as copper, and an alloy, a principal component of which is copper. The wiring members **101**B and **101**C have an L-shape formed by bending an end portion on a side connected to the signal input/output electrode **71***a*. The wiring members **101**B and **101**C have the same shape, and are held by the relay board **100** such that the bending directions are the same.

[0067] FIG. **11** is a partial cross-section for explaining a structure of a principal part of the ultrasonic transducer module according to the second embodiment, and is a partial cross-section cut along a plane perpendicular to the alignment direction of the piezoelectric elements **71** and passing through the wiring members **101**B. The wiring members **101**B and **101**C are joined with the signal input/output electrodes **71***a* at bent distal end portions.

[0068] According to the second embodiment explained above, similarly to the first embodiment described above, when the piezoelectric elements **71** and the relay board **100** are joined, the signal input/output electrodes **71***a* of the piezoelectric elements **71** and the L-shaped wiring members **101**B and **101**C extending from the relay board **100** are joined by the joint portion **102**. Because the wiring members **101** integrated with the relay board **100** are joined with the piezoelectric elements **71**, respectively, the positioning accuracy in connecting the piezoelectric elements **71** and the relay board **100** can be improved compared to the case when independent multiple signal lines are connected to the piezoelectric elements **71** one by one. Thus, the array density of the piezoelectric elements **71** can be increased while a sufficient joint strength between the piezoelectric element **71** and the wiring member **101** is kept.

[0069] Moreover, according to the second embodiment, the wiring members **101**B and **101**C extend out from the surfaces of the relay board **100** opposing to each other, respectively, and are arranged in a staggered arrangement in a planer view from a direction perpendicular to the principal surface of the relay board **100**. Therefore, intervals of wiring patterns in the relay board **100** can be widened. Thus, crosstalk between the wiring patterns can be suppressed.

[0070] Although it has been explained that the wiring members **101**B and **101**C respectively extend from the surfaces of the relay board opposing to each other, and are arranged in a staggered arrangement in a planer view from a direction perpendicular to the principal surface of the relay board **100** in the second embodiment described above, a different arrangement from the staggered arrangement, such as an arrangement in which the wiring members **101**B are next to each other in the planar view described above, can be applied as long as they extend from the surfaces of the relay board **100** opposing to each other.

[0071] Furthermore, although explanation has been given with the example in which the wiring members **101**B and **101**C extend from the two surfaces of the relay board **100** opposing to each other in the second embodiment described above, it is not limited thereto as long as they extend from surfaces different from each other. The surfaces different from each other herein are surfaces divided by a portion bent with a predetermined radius of curvature (for example, 90°) on a surface a substrate as a boundary. For example, it can be arranged such that wiring members extend from a side surface. In this case, the wiring members **101**B and **101**C can be arranged to extend from one of the principal surfaces opposing to each other and a side surface, to extend from the other principal surface and the side surface, or to extend from one principal surface, the other principal surface, and the side surface, respectively.

[0072] Although it has been explained that the wiring members **101**B and **101**C have the same shape and held by the relay board **100** such that the bending directions are the same in the second embodiment, it is not limited thereto as long as the wiring members **101**B and **101**C can be connected to the signal input/output electrodes **71***a*. For example, one having a different radius of curvature can be included, or the bending directions can vary. In following first modification and second modification, other examples of wiring members are explained.

[0073] First Modification of Second Embodiment

[0074] FIG. **12** is a partial cross-section for explaining a structure of a principal part of an ultrasonic transducer module according to a first modification of the second embodiment. As shown in FIG. **12**, in the first modification, wiring members **104**A, **104**B are arranged such that bent portions that are joined by the joint portion **102** intersect with each other. When the wiring members **104**A, **104**B are arranged such that the bent portions intersect with each other as in this first modification, joint portions of the wiring members **104**A, **104**B in the piezoelectric elements **71** are separated compared to the case of the second embodiment described above. Therefore, positions at which loads are applied to the piezoelectric elements **71** by the wiring members **104**A, **104**B are dispersed, and concentration of the loads applied by the wiring members **104**A, **104**B to the piezoelectric elements **71** can be suppressed. Moreover, by separating the joint portions, operation of joining of wiring members **104**A, **104**B and the piezoelectric elements **71** can be facilitated.

[0075] Second Modification of Second Embodiment

[0076] FIG. **13** is a partial cross-section for explaining a principal part of an ultrasonic transducer module according to a second modification of the second embodiment. As shown in FIG. **13**, in this second modification, wiring members **105**A, **105**B are arranged such that end portions joined by the joint portion **102** are separated from each other. When the wiring members **105**A, **105**B are arranged such that the end portions are separated from each other as in this second modification, the joint portions of the wiring members **105**A, **105**B in the piezoelectric elements **71** are further separated compared to the first modification of the second embodiment. Therefore, positions at which loads are applied to the piezoelectric elements **71** by the wiring members **105**A, **105**B are dispersed, and concentration of the loads applied by the wiring members **105**A, **105**B to the piezoelectric elements **71** can be further suppressed.

[0077] The embodiments to implement the present disclosure have been explained, but the present disclosure is not to be limited to the embodiments and the modifications described above. The present disclosure can include various embodiments within a range not departing from the technical ideas described in claims, not limited to the embodiments and the modifications explained above. Moreover, configurations of the embodiments and the modifications can be combined as appropriate.

[0078] Furthermore, although the above first and second embodiments have been explained using the piezoelectric elements as an example of a device that emits ultrasonic waves and converts ultrasonic waves entering from outside into an echo signal, it is not limited thereto, and it can be a device that is manufactured by using micro electro mechanical systems (MEMS), such as a capacitive micromachined ultrasonic transducer (C-MUT) and a piezoelectric micromachined ultrasonic transducer (P-MUT).

[0079] Moreover, as for the ultrasonic endoscope, it can be applied to a thin ultrasonic probe that performs scanning by mechanically rotating transducers without an optical system. The ultrasonic probe is usually inserted into the biliary tract, the biliary duct, the pancreatic duct, the trachea, the bronchus, the urethra, or the ureter, and used to observe the peripheral organs (the pancreas, the lungs, the prostate, the bladder, a lymph node, and the like).

[0080] Furthermore, the ultrasonic transducer can be any of a linear transducer, a radial transducer, and a convex transducer. When the ultrasonic transducer is a linear transducer, the scanning region is in a rectangular shape (rectangle, square), and the ultrasonic transducer is a radial transducer or a convex transducer, the scanning region is in a fan shape or in an annular shape. Moreover, the ultrasonic endoscope can be one that causes ultrasonic transducers to scan mechanically, or one in which multiple devices as ultrasonic transducers are arranged in an array, and in which devices to be involved in transmission and reception are electronically switched, or delay time is given to transmission and reception of the respective devices, to perform scanning electronically.

[0081] Moreover, as the ultrasonic endoscope, an external ultrasonic probe that irradiates ultrasonic waves from a body surface of a subject can be applied. The external ultrasonic probe is usually used to observe abdominal organs (the liver, the gallbladder, the bladder), the breast (particularly, mammary glands), and the thyroid.

[0082] According to the present disclosure, an effect that an array density of piezoelectric elements can be increased while a sufficient joint strength between a piezoelectric element and a wiring is kept is obtained.

[0083] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the disclosure in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. An ultrasonic transducer module comprising:

piezoelectric elements, each being aligned in the same direction that is a longitudinal direction thereof;

electrodes that are formed on surfaces of the respective piezoelectric elements;

a substrate that includes wiring members extending from at least one surface of the substrate, the wiring members being connected one by one to the electrodes of the piezoelectric elements; and

reinforcing layers that are provided on a surface of each of the wiring members, the surface being opposite to a surface of the corresponding wiring member where the corresponding electrode is connected.

2. The ultrasonic transducer module according to claim **1**, wherein each of the wiring members is bent at an end portion connected to the corresponding electrode.

3. The ultrasonic transducer module according to claim **1**, wherein each of the reinforcing layers is formed with a material that is the same as a material of the substrate.

4. The ultrasonic transducer module according to claim **1**, wherein the wiring members extend from different surfaces of the substrate.

5. The ultrasonic transducer module according to claim **3**, wherein the wiring members are arranged in a staggered arrangement in a planer view from a direction perpendicular to the principal surface of the substrate.

6. The ultrasonic transducer module according to claim **1**, wherein the piezoelectric elements are arranged along a curved surface.

7. An ultrasonic endoscope comprising:

an ultrasonic transducer module that is provided at a distal end portion of the ultrasonic endoscope, the ultrasonic transducer module including

piezoelectric elements, each being aligned in the same direction that is a longitudinal direction thereof,

electrodes that are formed on surfaces of the respective piezoelectric elements,

a substrate that includes wiring members extending from at least one surface of the substrate, the wiring members being connected one by one to the electrodes of the piezoelectric elements, and

reinforcing layers that are provided on a surface of each of the wiring members, the surface being opposite to a surface of the corresponding wiring member where the corresponding electrode is connected; and

an insertion portion that is inserted into a subject.

* * * * *

专利名称(译)	超声换能器模块和超声内窥镜		
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摘要(译)

一种超声换能器模块，包括：压电元件，每个压电元件沿与其纵向相同的方向排列;在各个压电元件的表面上形成的电极;基板，包括从基板的至少一个表面延伸的布线构件，布线构件一个接一个地连接到压电元件的电极;设置在每个布线构件的表面上的加强层，该表面与相应的布线构件的连接相应电极的表面相对。