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(54) **ULTRASOUND PROBE**

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(57) **ABSTRACT**

An ultrasound probe includes: a transducer unit having a plurality of ultrasound transducers; a flexible substrate configured to be flat L-shaped in a relaxed state; and a plurality of coaxial wires configured to electrically connect the transducer unit to the flexible substrate. The flexible substrate has thereon: a plurality of signal lines configured to be electrically connected to the transducer unit via the plurality of coaxial wires; and a first return GND that is a ground for the plurality of signal lines and is formed on an inner side of the L-shaped flexible substrate with respect to the plurality of signal lines.

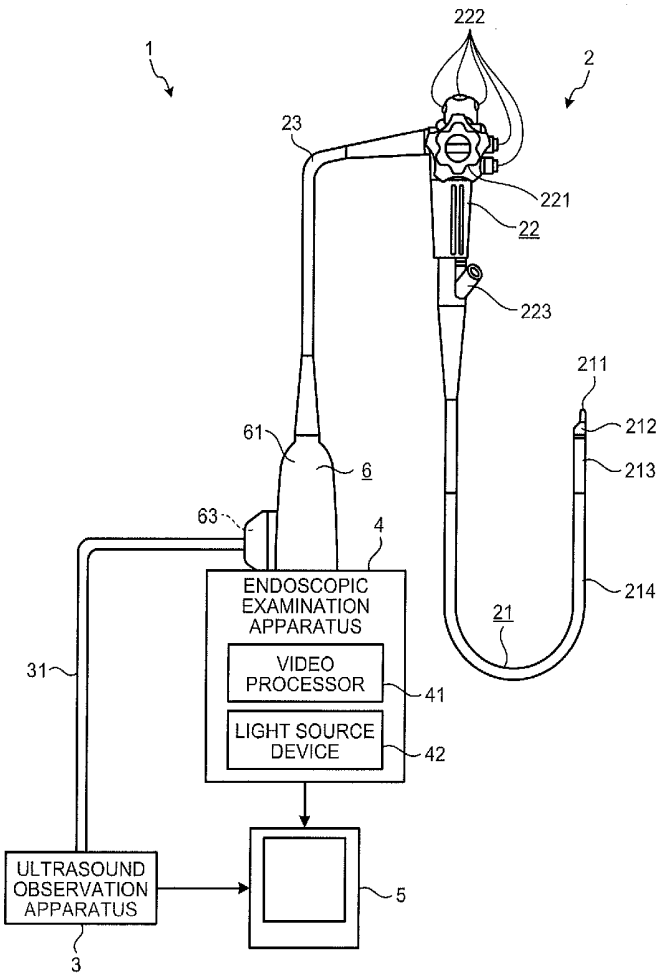


FIG.1

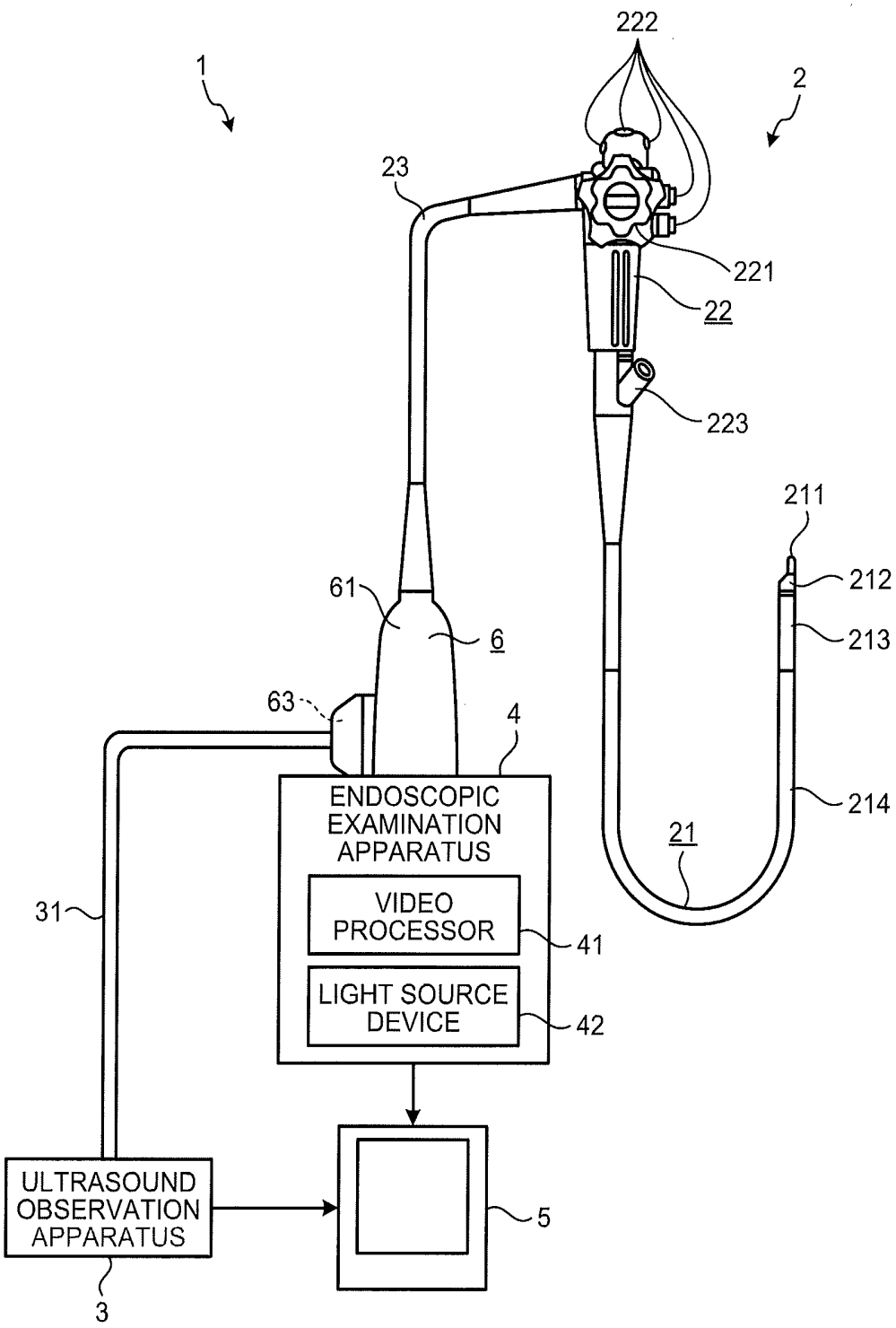

1
2
222
23
221
22
223
211
212
213
214
21
61
6
63
4
ENDOSCOPIC EXAMINATION APPARATUS
VIDEO PROCESSOR
41
LIGHT SOURCE DEVICE
42
31
ULTRASOUND OBSERVATION APPARATUS
3
5

FIG.2

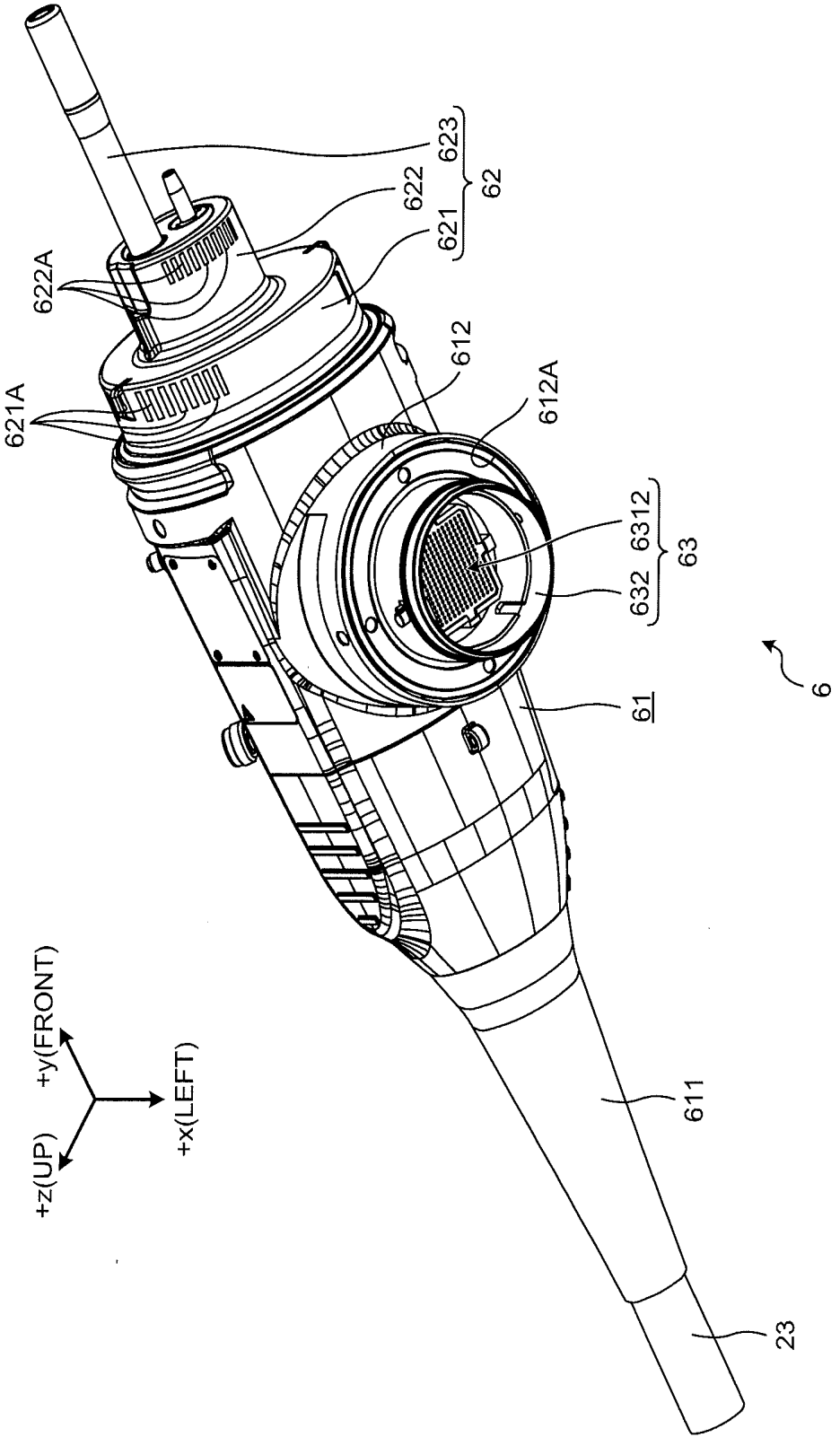

623
622
621
62
622A
621A
612
612A
6312
632
63
61
6
611
23
+y(FRONT)
+x(LEFT)
+z(UP)

FIG.3

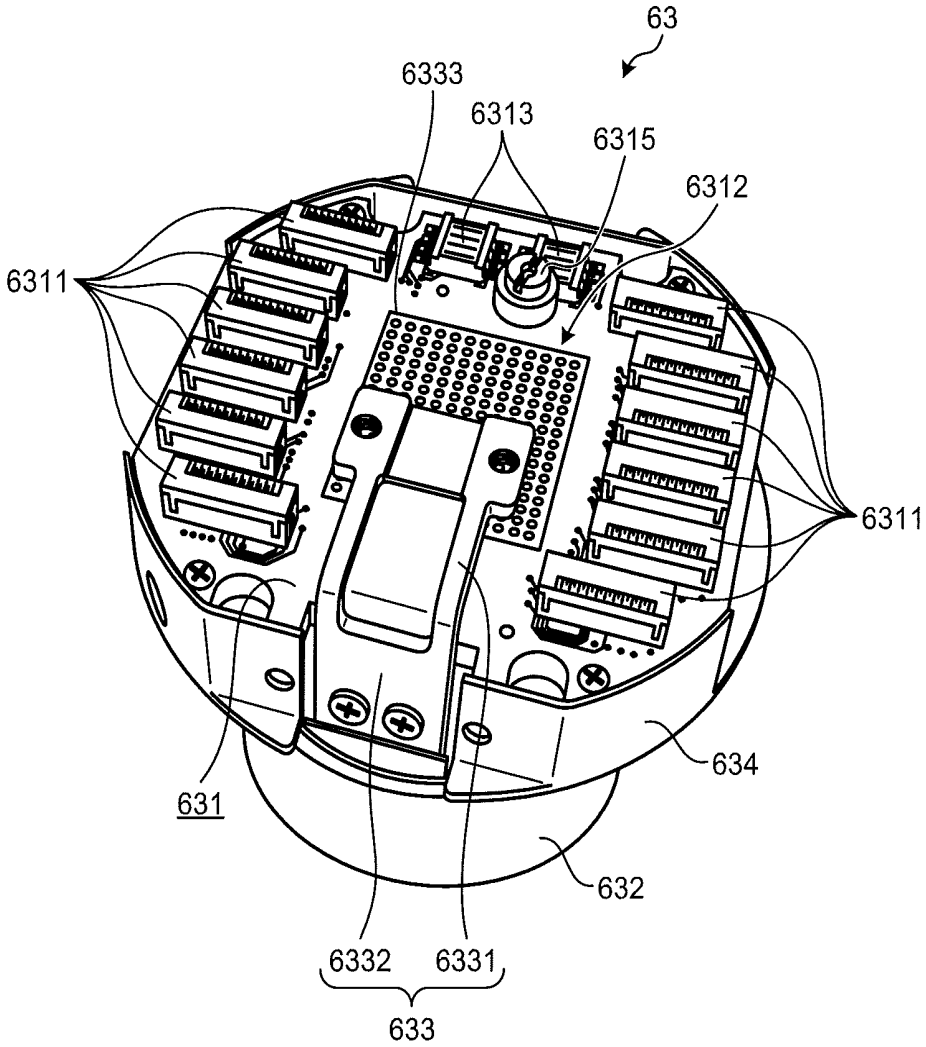


FIG.4

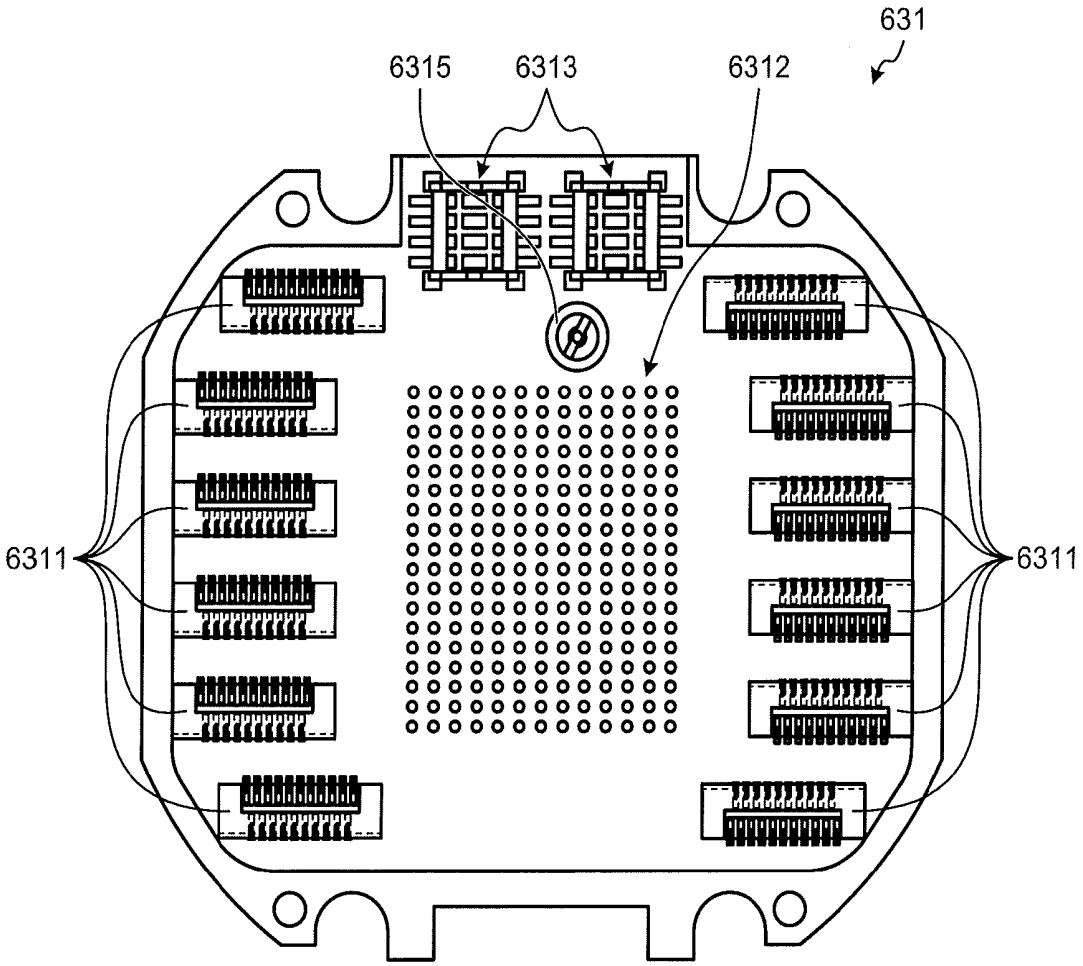


FIG.5A

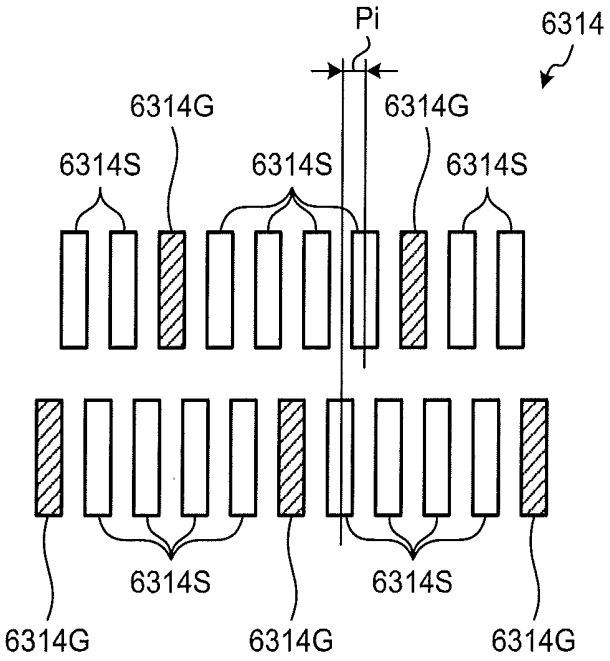

Pi
6314
6314G
6314G
6314S
6314S
6314S
6314S
6314S
6314G
6314G
6314G

FIG.5B

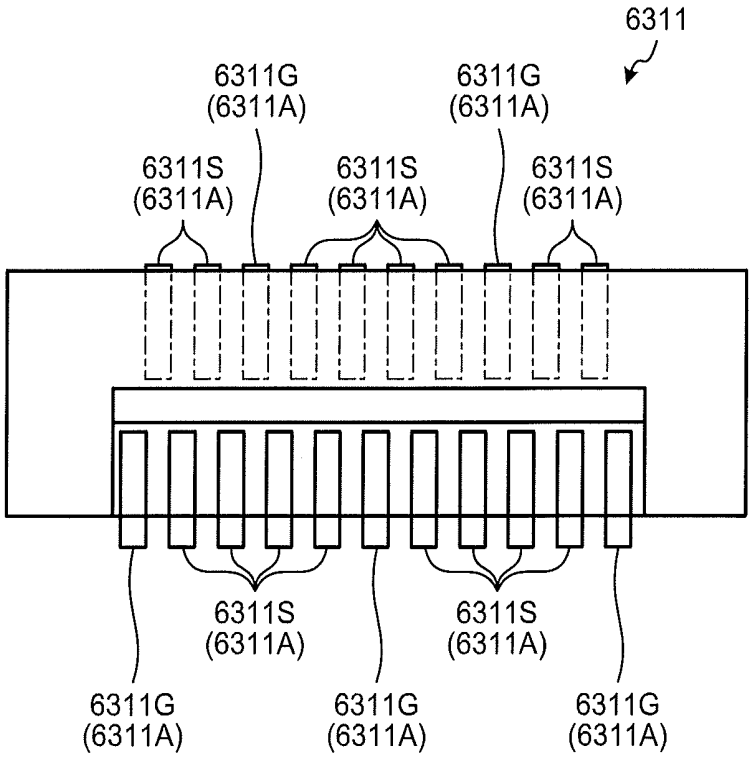

6311
6311G (6311A)
6311G (6311A)
6311S (6311A)
6311S (6311A)
6311S (6311A)
6311S (6311A)
6311S (6311A)
6311G (6311A)
6311G (6311A)
6311G (6311A)

FIG.6

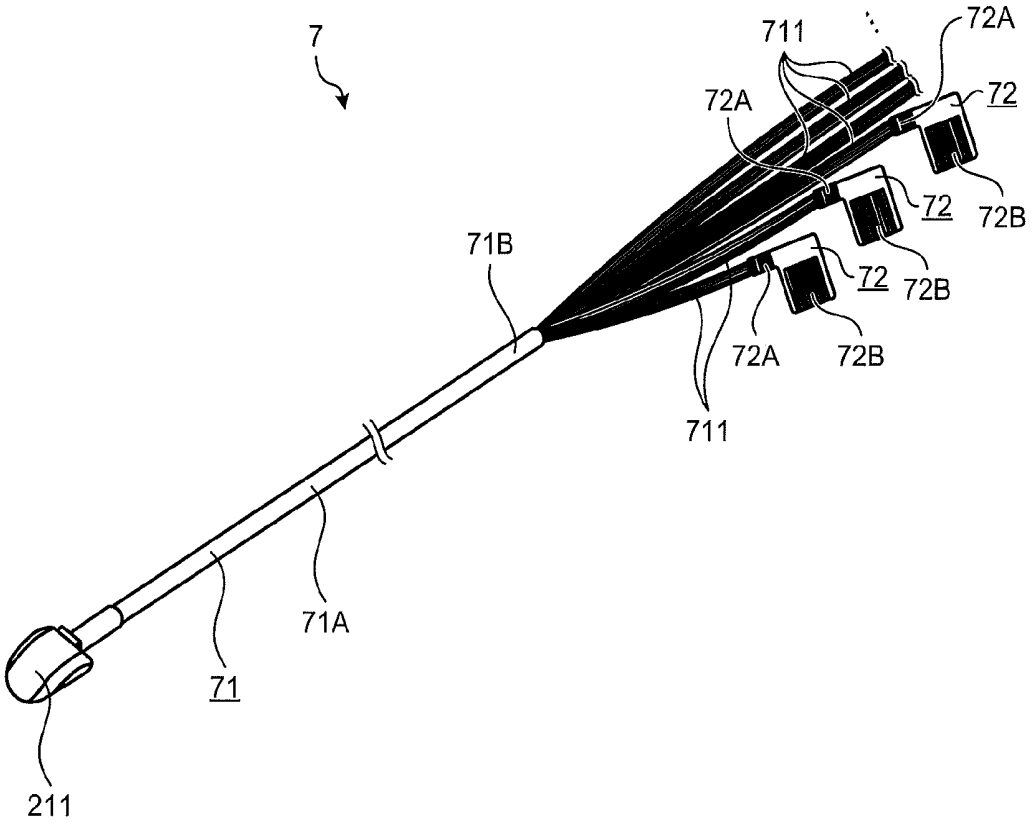
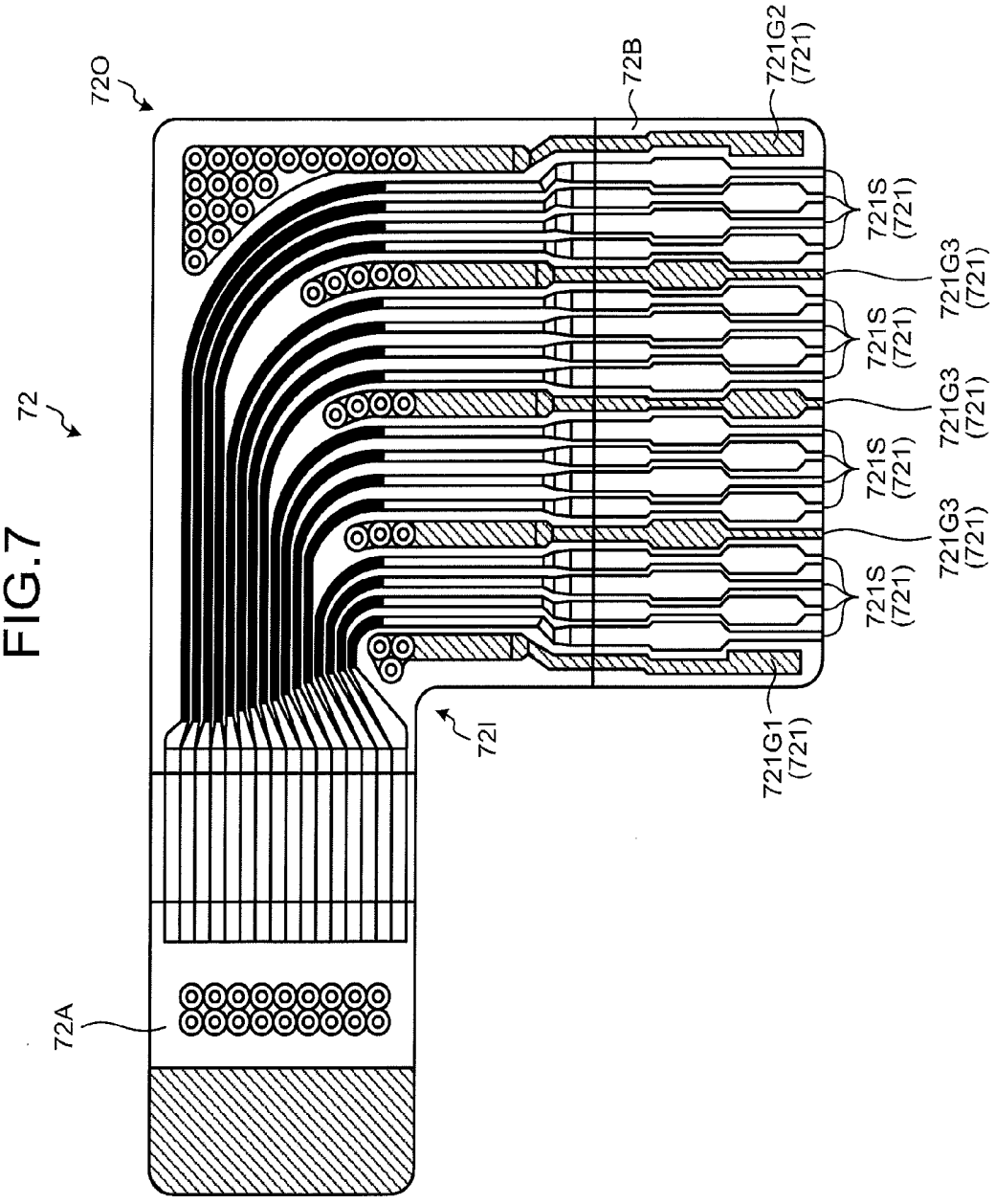


FIG.7


72
72O
72B
721G2
(721)
721S
(721)
721G3
(721)
721S
(721)
721G3
(721)
721S
(721)
721G3
(721)
721S
(721)
721G1
(721)
72I
72A

ULTRASOUND PROBE

CROSS REFERENCES TO RELATED APPLICATIONS

[0001] This application is a continuation of PCT international application Ser. No. PCT/JP2016/061807, filed on Apr. 12, 2016 which designates the United States, incorporated herein by reference, and which claims the benefit of priority from Japanese Patent Application No. 2015-172884, filed on Sep. 2, 2015, incorporated herein by reference.

BACKGROUND

[0002] 1. Technical Field

[0003] The disclosure relates to an ultrasound probe.

[0004] 2. Related Art

[0005] Conventionally, an ultrasound endoscope for observing the inside of a subject by utilizing an ultrasound probe including a plurality of ultrasound transducers has been known (for example, refer to JP 2012-65862 A).

[0006] An ultrasound probe that is used for the ultrasound endoscope described in JP 2012-65862 A includes a transducer unit (ultrasound scanning unit block) including a plurality of ultrasound transducers, a flexible substrate, and a plurality of coaxial wires (signal wire bundle) that electrically connects the transducer unit and the flexible substrate.

[0007] In the ultrasound endoscope described in JP 2012-65862 A, the flexible substrate is flat L-shaped in a relaxed state.

SUMMARY

[0008] In some embodiments, an ultrasound probe according to the invention includes: a transducer unit having a plurality of ultrasound transducers; a flexible substrate configured to be flat L-shaped in a relaxed state; and a plurality of coaxial wires configured to electrically connect the transducer unit to the flexible substrate. The flexible substrate has thereon: a plurality of signal lines configured to be electrically connected to the transducer unit via the plurality of coaxial wires; and a first return GND that is a ground for the plurality of signal lines and is formed on an inner side of the L-shaped flexible substrate with respect to the plurality of signal lines.

[0009] The above and other features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a schematic diagram illustrating an endoscope system according to an embodiment of the present invention;

[0011] FIG. **2** is a perspective view of an endoscope connector illustrated in FIG. **1** and viewed from a front side and an upper left side;

[0012] FIG. **3** is a perspective view of an ultrasound connector removed from the endoscope connector illustrated in FIG. **2** and viewed from the inside of an exterior housing;

[0013] FIG. **4** is a schematic view illustrating a surface of an ultrasound substrate (viewed from the inside of the exterior housing) illustrated in FIG. **3**;

[0014] FIG. **5**A is a schematic diagram illustrating an array of a single group of FPC connector lands provided on the ultrasound substrate illustrated in FIG. **4** and to which a single FPC connector is electrically connected;

[0015] FIG. **5**B is a schematic diagram illustrating an array of a single group of contacts on the single FPC connector illustrated in FIG. **4**;

[0016] FIG. **6** is a schematic view illustrating an ultrasound probe that is connected to the FPC connector illustrated in FIGS. **4** and **5**B; and

[0017] FIG. **7** is a schematic view illustrating a flexible substrate illustrated in FIG. **6**.

DETAILED DESCRIPTION

[0018] Hereinafter, modes for carrying out the present invention (hereinafter referred to as "embodiment(s)") will be described with reference to the drawings. The present invention is not limited by the embodiments described below. The same reference signs are used to designate the same elements throughout the drawings.

Schematic Configuration of Endoscope System

[0019] FIG. **1** is a diagram schematically illustrating an endoscope system **1** according to an embodiment of the present invention.

[0020] The endoscope system **1** is a system for performing an ultrasound diagnosis on the inside of a subject such as a human using an ultrasound endoscope. The endoscope system **1** includes, as illustrated in FIG. **1**, an endoscope **2**, an ultrasound observation apparatus **3**, an endoscopic examination apparatus **4**, and a display device **5**.

[0021] The endoscope **2**, a part of which is configured to be inserted into the subject, is an ultrasound endoscope having a function of sending an ultrasound pulse to a body wall in the subject and receiving an ultrasound echo reflected from the subject to output an echo signal, and a function of capturing the inside of the subject to output an image signal.

[0022] A detailed configuration of the endoscope **2** will be described later.

[0023] The ultrasound observation apparatus **3** is electrically connected to the endoscope **2** via an ultrasound cable **31** (FIG. **1**), and outputs a pulse signal to the endoscope **2** via the ultrasound cable **31**. The echo signal is input from the endoscope **2** to the ultrasound observation apparatus **3**. The ultrasound observation apparatus **3** then performs a predetermined process on the echo signal to generate an ultrasound image.

[0024] An endoscope connector **6** (refer to FIG. **2**) of the endoscope **2** to be described later is detachably connected to the endoscopic examination apparatus **4**. The endoscopic examination apparatus **4** includes, as illustrated in FIG. **1**, a video processor **41** and a light source device **42**.

[0025] The video processor **41** outputs a control signal to the endoscope **2** via the endoscope connector **6**. The image signal from the endoscope **2** is input to the video processor **41** via the endoscope connector **6**. The video processor **41** then performs a predetermined process on the image signal to generate an endoscope image.

[0026] The light source device **42** supplies illumination light that illuminates the inside of the subject to the endoscope **2** via the endoscope connector **6**.

[0027] The display device **5** is configured by use of liquid crystal or organic electro luminescence (EL), and displays, for example, the ultrasound image generated in the ultrasound observation apparatus **3** or the endoscope image generated in the endoscopic examination apparatus **4**.

Configuration of Endoscope

[0028] The endoscope **2** includes, as illustrated in FIG. **1**, an insertion portion **21**, an operating unit **22**, a universal cable **23**, and the endoscope connector **6**.

[0029] Inside the endoscope **2** (inside of the insertion portion **21**, the operating unit **22**, the universal cable **23**, and the endoscope connector **6**), a light guide for transmitting the illumination light supplied from the light source device **42**, a US cable **71** (refer to FIG. **6**) for the ultrasound observation (for the transmission of the pulse signal or the echo signal), and an imaging cable for the endoscope examination (for the transmission of the control signal or the image signal) are provided. The light guide, the US cable **71**, and the imaging cable are not specifically illustrated.

[0030] The insertion portion **21** is a part that is inserted into the subject. The insertion portion **21** includes, as illustrated in FIG. **1**, a transducer unit **211**, a rigid member **212**, a bending portion **213**, and a flexible pipe portion **214**. The transducer unit **211** is provided at a distal end. The rigid member **212** is joined to a proximal end side (close to the operating unit **22**) of the transducer unit **211**. The bending portion **213** is joined to a proximal end side of the rigid member **212** and is bendable. The flexible pipe portion **214** is joined to a proximal end side of the bending portion **213** and has flexibility.

[0031] Inside the insertion portion **21** (the rigid member **212**, the bending portion **213**, and the flexible pipe portion **214**), an image guide for guiding an optical image of the inside of the subject and a treatment tool tube into which various treatment tools (for example, a puncture needle or the like) are inserted are provided in addition to the light guide and the US cable **71** (refer to FIG. **6**) mentioned above. The image guide and the treatment tool tube are not specifically illustrated.

[0032] In the example illustrated in FIG. **1**, the transducer unit **211** is a convex ultrasound probe and configured in such a manner that a plurality of ultrasound transducers (not illustrated) is regularly arrayed so as to form a projecting arc.

[0033] The ultrasound transducer as used herein has an acoustic lens, a piezoelectric element, and a matching layer, and acquires the ultrasound echo that contributes to an ultrasound tomographic image of the inside of the body wall in the subject. In the embodiment, the number of ultrasound transducers is a multiple of eight.

[0034] The transducer unit **211** then converts, into the ultrasound pulse, the pulse signal input from the ultrasound observation apparatus **3** via the above-mentioned US cable **71** (refer to FIG. **6**) and the ultrasound cable **31**, and sends the ultrasound pulse to the inside of the subject. The transducer unit **211** also converts the ultrasound echo reflected from the inside of the subject into the electrical echo signal, and outputs the electrical echo signal to the ultrasound observation apparatus **3** via the above US cable **71** (refer to FIG. **6**) and the ultrasound cable **31**.

[0035] The rigid member **212** is a hard member including a resin material and has a substantially columnar shape.

[0036] In the rigid member **212**, an observation window, an illumination window, and a treatment tool passage or the like, which are not specifically illustrated, are formed.

[0037] The observation window, the illumination window, and the treatment tool passage are holes passing through the rigid member **212** from a proximal end (end portion close to the operating unit **22**) to a distal end, and specifically have the following functions.

[0038] The observation window is the hole for acquiring the optical image of the inside of the subject. An incident end side of the above-mentioned image guide is inserted into the observation window. An objective lens (not illustrated) is linked to the incident end of the above-mentioned image guide.

[0039] The illumination window is the hole for illuminating the inside of the subject with the illumination light. An emitting end side of the above-mentioned light guide is inserted into the illumination window.

[0040] The treatment tool passage is the hole for causing various treatment tools to protrude to the outside. The above-mentioned treatment tool tube is connected to the treatment tool passage.

[0041] The operating unit **22** is a part that is joined to a proximal end side of the insertion portion **21** and accepts various operations from a medical doctor or the like. The operating unit **22** includes, as illustrated in FIG. **1**, a bending knob **221** for performing the curve operation on the bending portion **213** and a plurality of operating members **222** for performing various operations.

[0042] A treatment tool insertion opening **223** communicating with the above-mentioned treatment tool tube and configured to cause various treatment tools to be inserted into the treatment tool tube is formed in the operating unit **22**.

[0043] Furthermore, an imaging sensor (not illustrated) and an optical system (not illustrated) are arranged inside the operating unit **22**. The imaging sensor outputs the image signal that depends on the optical image of the inside of the subject. The optical system forms the optical image guided by the above-mentioned image guide on the imaging sensor. The image signal output from the imaging sensor is transmitted to the endoscopic examination apparatus **4** (video processor **41**) via the above-mentioned imaging cable.

[0044] The universal cable **23**, one end of which is connected to the operating unit **22**, is a cable in which the light guide, the US cable **71** (refer to FIG. **6**), and the imaging cable or the like mentioned above are incorporated.

[0045] The endoscope connector **6** is a connector provided at the other end of the universal cable **23** and configured to be connected to the ultrasound cable **31** connected to the ultrasound observation apparatus **3** and the endoscopic examination apparatus **4** (the video processor **41** and the light source device **42**).

Configuration of Endoscope Connector

[0046] Next, a configuration of the endoscope connector **6** will be described.

[0047] Hereinafter, with reference to a posture in which the endoscope connector **6** is connected to the endoscopic examination apparatus **4**, an upper side in the posture is referred to as "up", a lower side in the posture is referred to as "down", a side close to the endoscopic examination apparatus **4** is referred to as "front", a side apart from the endoscopic examination apparatus **4** is referred to as "rear",

a left side viewed from the front side in the posture is referred to as "left", and a right side viewed from the front side in the posture is referred to as "right".

[0048] FIG. **2** is a perspective view of the endoscope connector **6** viewed from the front side and the upper left side.

[0049] In FIG. **2**, XYZ orthogonal coordinates are illustrated to identify the above-mentioned "up-down", "front-rear", and "right-and-left" of the endoscope connector **6**. As used herein, the +Z axis direction is the "up direction" of the endoscope connector **6**. The +X axis direction is the "left direction" of the endoscope connector **6**. The +Y axis direction is the "front direction" of the endoscope connector **6**.

[0050] The endoscope connector **6** includes, as illustrated in FIG. **2**, an exterior housing **61**, a plug portion **62**, and an ultrasound connector **63**.

[0051] The exterior housing **61** has, as illustrated in FIG. **2**, a substantially cylindrical shape extending in the front-rear direction (Y axis direction). The universal cable **23** (the light guide, the US cable **71** (refer to FIG. **6**), and the imaging cable or the like mentioned above) is inserted into the exterior housing **61** via an opening part on the rear side thereof. As illustrated in FIG. **2**, a bending prevention member **611** is provided on the rear side of the exterior housing **61**.

[0052] As illustrated in FIG. **2**, a bulge portion **612** bulging in the +X axis direction is formed on a side surface of the above-described exterior housing **61**.

[0053] The bulge portion **612** communicates with the inside of the exterior housing **61** and has a hollow shape. In the bulge portion **612**, as illustrated in FIG. **2**, an opening plane is located on the YZ plane, and an attachment hole **612**A communicating with the inside and outside of the exterior housing **61** is formed. The attachment hole **612**A is a hole to which the ultrasound connector **63** is attached.

[0054] The plug portion **62** is a part that is inserted into the endoscopic examination apparatus **4** and connected to the video processor **41** and the light source device **42**. As illustrated in FIG. **2**, the plug portion **62** is attached to an opening part on the front side of the exterior housing **61**. The plug portion **62** includes, as illustrated in FIG. **2**, first and second electrical connector portions **621** and **622** and a light guide base **623**.

[0055] As illustrated in FIG. **2**, the first electrical connector portion **621** is located on the rearmost side of the plug portion **62**, and has a columnar shape extending in the front-rear direction.

[0056] A plurality of first electrical contact points **621**A is provided on a part of an outer peripheral surface of the first electrical connector portion **621** along a circumferential direction.

[0057] As illustrated in FIG. **2**, the second electrical connector portion **622** is integrally formed on the front side of the first electrical connector portion **621**, and has a columnar shape having an outer diameter dimension smaller than an outer diameter dimension of the first electrical connector portion **621**.

[0058] A plurality of second electrical contact points **622**A is provided on a part of an outer peripheral surface of the second electrical connector portion **622** along a circumferential direction.

[0059] The plurality of first and second electrical contact points **621**A and **622**A are electrically connected to the above-mentioned imaging cable. The plurality of first and second electrical contact points **621**A and **622**A are also electrically connected to the video processor **41**, with the plug portion **62** inserted into the endoscopic examination apparatus **4**. In other words, the plurality of first and second electrical contact points **621**A and **622**A are the parts that electrically connect the above-mentioned imaging cable to the video processor **41**.

[0060] The light guide base **623** is attached to an end surface on the front side of the second electrical connector portion **622**, and protrudes from the end surface on the front side in the +Y axis direction.

[0061] An incident end side of the above-mentioned light guide is inserted into the light guide base **623**. The light guide base **623** is also connected to the light source device **42**, with the plug portion **62** inserted into the endoscopic examination apparatus **4**. In other words, the light guide base **623** is the part that optically connects the above-mentioned light guide to the light source device **42**.

[0062] FIG. **3** is a perspective view of the ultrasound connector **63** removed from the endoscope connector **6** and viewed from the inside of the exterior housing **61**.

[0063] The ultrasound connector **63** is an electrical connector for electrically connecting the above-mentioned US cable **71** (refer to FIG. **6**) to the ultrasound cable **31**. The ultrasound connector **63** includes, as illustrated in FIG. **2** or **3**, an ultrasound substrate **631** (FIG. **3**), a frame member **632**, an electrical connection member **633** (FIG. **3**), and a spacer **634** (FIG. **3**).

[0064] FIG. **4** is a schematic view illustrating a surface of the ultrasound substrate **631** (viewed from the inside of the exterior housing **61**).

[0065] The ultrasound substrate **631** is a substrate having a substantially disk-like shape. A plurality of FPC connectors **6311** (FIGS. **3** and **4**), a plurality of pin-shaped terminals **6312** (FIGS. **2** to **4**), and a plurality of slide switches **6313** (FIGS. **3** and **4**) are mounted on the surface of the ultrasound substrate **631**.

[0066] The plurality of FPC connectors **6311** (twelve in the embodiment) is connectors to which a plurality of flexible substrates **72** (refer to FIG. **6**) of an ultrasound probe **7** (refer to FIG. **6**) is connected.

[0067] A configuration of the ultrasound probe **7** will be described later.

[0068] The twelve FPC connectors **6311** are separated into two groups of six and arranged on both sides (both the right and left sides in FIG. **4**) with respect to the plurality of pin-shaped terminals **6312**. In FIG. **4**, the six FPC connectors **6311** arranged on the right side and the six FPC connectors **6311** arranged on the left side are arranged in an upside-down posture in FIG. **4**.

[0069] FIG. **5**A is a schematic diagram illustrating an array of a single group of FPC connector lands **6314** provided on the ultrasound substrate **631** and to which a single FPC connector **6311** is electrically connected. FIG. **5**B is a schematic diagram illustrating an array of a single group of contacts **6311**A on the single FPC connector **6311**.

[0070] The up-down direction and the right-and-left direction in FIGS. **5**A and **5**B are the same as the up-down direction and the right-and-left direction in FIG. **4**, respectively. The single group of FPC connector lands **6314** to which the single FPC connector **6311** out of the six FPC connectors **6311** arranged on the right side in FIG. **4** is electrically connected is illustrated in FIG. **5**A. Similarly, the

single FPC connector **6311** out of the six FPC connectors **6311** arranged on the right side in FIG. **4** is illustrated in FIG. **5**B.

[0071] On the surface of the ultrasound substrate **631**, a plurality of groups of FPC connector lands **6314** (twelve groups in the embodiment) (only the single group of FPC connector lands out of the six groups of FPC connector lands provided on the right side of the ultrasound substrate **631** in FIG. **4** is illustrated in FIG. **5**A) is provided.

[0072] The single group of FPC connector lands **6314** is arranged side by side in two rows that are next to each other in the up-down direction in FIG. **5**A.

[0073] More specifically, a plurality of FPC connector lands **6314** (ten connector lands in the embodiment) arranged side by side in the upper first row is arranged side by side at predetermined pitches. A plurality of FPC connector lands **6314** (eleven connector lands in the embodiment) arranged side by side in the lower second row is arranged side by side at pitches similar to those of the plurality of FPC connector lands **6314** arranged side by side in the first row. When viewed from above in FIG. **5**A, each of the ten FPC connector lands **6314** arranged side by side in the first row is provided at a center position of the adjacent FPC connector lands **6314** arranged side by side in the second row.

[0074] Out of the twenty one FPC connector lands **6314**, five FPC connector lands **6314**G in total (FIG. **5**A (represented by hatching)), i.e. the third one from the left and the third one from the right in the first row in FIG. **5**A and both the right and left ones and the central one in the second row in FIG. **5**A, are respectively electrically connected to a plurality of ground wires (not illustrated) that is a conductor pattern provided on the ultrasound substrate **631**. Sixteen FPC connector lands **6314**S (FIG. **5**A) other than the five FPC connector lands **6314**G are respectively electrically connected to a plurality of signal wires (not illustrated) that is a conductor pattern provided on the ultrasound substrate **631**.

[0075] In the embodiment, the above pitch is set to 0.6 mm. Specifically, when viewed from above in FIG. **5**A, a pitch Pi between the FPC connector lands **6314** adjacently arranged side by side in the first and second rows is set to 0.3 mm.

[0076] Thus, since the pitch Pi is comparatively small, namely, 0.3 mm, the ultrasound substrate **631** can be reduced in size.

[0077] Although each of the six groups of FPC connector lands provided on the right side of the ultrasound substrate **631** in FIG. **4** is arrayed in a state illustrated in FIG. **5**A, each of the six groups of FPC connector lands provided on the left side is arrayed in an upside-down state of FIG. **5**A with respect to the state illustrated in FIG. **5**A.

[0078] The FPC connector **6311** includes, as illustrated in FIG. **5**B, twenty-one contacts **6311**A arrayed in a similar way to the array of the single group of FPC connector lands **6314** illustrated in FIG. **5**A. The respective twenty-one contacts **6311**A are electrically connected to the single group of FPC connector lands **6314** by means of solder or the like. Specifically, out of the twenty-one contacts **6311**A, five contacts **6311**G (FIG. **5**B) are electrically connected to the respective five FPC connector lands **6314**G, and sixteen contacts **6311**S (FIG. **5**B) are electrically connected to the respective sixteen FPC connector lands **6314**S.

[0079] As illustrated in FIG. **3** or **4**, the plurality of pin-shaped terminals **6312** is arrayed in a matrix on a substantially central part of the ultrasound substrate **631**. The plurality of pin-shaped terminals **6312** is electrically connected to the ultrasound probe **7** via the twelve FPC connectors **6311** and electrically connected to the ultrasound cable **31** when the ultrasound cable **31** is connected to the ultrasound connector **63**.

[0080] Each of the plurality of slide switches **6313** (two switches in the embodiment) is a switch of four bits or more which generates a probe ID (for example, information indicating the type of the transducer unit **211** (type such as a convex type and a radial type or the like)) which is individual information of the ultrasound probe **7**.

[0081] Specifically, since the two slide switches **6313** are provided, the probe ID of eight bits or more can be generated only by means of the on/off operation for the switch, and the convenience can be improved.

[0082] A vent, which is not specifically illustrated, is formed in the ultrasound substrate **631** so as to pass through the ultrasound substrate **631** from the front to the back. As illustrated in FIG. **3** or **4**, a ventilation base **6315** having a hole communicating with the vent is attached to the vent.

[0083] A ventilation waterproof sheet, which is not specifically illustrated, having a ventilation property and a waterproof property is provided inside of the ventilation base **6315** so as to close the above-mentioned hole.

[0084] The vent and the ventilation base **6315** mentioned above are used for what is called a watertight inspection for confirming the waterproof property of the endoscope connector **6**.

[0085] The watertight inspection is performed in the following manner. For example, a waterproof cap (not illustrated) is put on the ultrasound connector **63**, and pressurized air from a separate pressure device is delivered to the inside of the ultrasound connector **63** (inside of the endoscope connector **6**) via the waterproof cap, during which the endoscope connector **6** is submerged in water. At this time, whether air bubbles are generated or not is examined, and the waterproof property of the endoscope connector **6** is confirmed.

[0086] To sum up, since the ventilation base **6315** is provided inside the ultrasound connector **63**, not inside the exterior housing **61**, even when, for example, a person accidentally forgets to put the waterproof cap on the ultrasound connector **63** and performs a process of cleaning the endoscope connector **6**, only the ultrasound substrate **631** or the like is submerged in water, and the submergence of various electrical members within the exterior housing **61** can be avoided.

[0087] As illustrated in FIG. **2** or **3**, the frame member **632** is a part including a cylindrical metal member and mechanically connected to a connector close to the ultrasound cable **31**. The frame member **632** supports the ultrasound substrate **631** at an opening part on one end side (close to the inside of the exterior housing **61**).

[0088] As illustrated in FIG. **3**, the electrical connection member **633** includes a metal member having an L-shaped cross-section. In such a posture that a part **6331** on one end side of the L-shaped cross-section faces the surface (close to the inside of the exterior housing **61**) of the ultrasound substrate **631**, a part **6332** on the other end side of the L-shaped cross-section is connected to the frame member **632**. An insulation sheet **6333** is arranged between the part

6331 on the one end side of the L-shaped cross-section of the electrical connection member **633** and the surface (plurality of pin-shaped terminals **6312**) of the ultrasound substrate **631**.

[0089] An extension end **71**B (refer to FIG. **6**) of the above-mentioned US cable **71** (refer to FIG. **6**) extending from the transducer unit **211** is fixed to the part **6331** on the one end side of the L-shaped cross-section of the electrical connection member **633**.

[0090] As illustrated in FIG. **3**, the spacer **634** is a substantially cylindrical metal member (shield member) that covers a part of an outer edge portion of the ultrasound substrate **631**, and fixed to the one end side (close to the inside of the exterior housing **61**) of the frame member **632**.

[0091] The ultrasound connector **63** is fixed by means of a screw or the like, with a side including the ultrasound substrate **631** inserted into the attachment hole **612**A.

Configuration of Ultrasound Probe

[0092] Next, the configuration of the ultrasound probe **7** will be described.

[0093] FIG. **6** is a schematic view illustrating the ultrasound probe **7** that is connected to the FPC connector **6311**.

[0094] The ultrasound probe **7** includes, as illustrated in FIG. **6**, the transducer unit **211**, the US cable **71**, and the plurality of flexible substrates **72**.

[0095] As mentioned above, the US cable **71** is the cable that transmits the pulse signal or the echo signal between the transducer unit **211** and the ultrasound observation apparatus **3**. More specifically, as illustrated in FIG. **6**, the US cable **71** is configured in such a manner that a plurality of coaxial wires **711** respectively electrically connected to the plurality of ultrasound transducers of the transducer unit **211** is bundled by means of a covering tube **71**A.

[0096] As illustrated in FIG. **6**, at the extension end extending from the transducer unit **211**, the plurality of coaxial wires **711** is bundled for each unit (bundled for each sixteen coaxial wires in the embodiment), and the plurality of flexible substrates **72** (twelve substrates in the embodiment) is attached to the respective bundles.

[0097] In other words, the plurality of coaxial wires **711** electrically connects the transducer unit **211** to the twelve flexible substrates **72**.

[0098] FIG. **7** is a schematic view illustrating the flexible substrate **72**.

[0099] In FIG. **7**, a surface of the flexible substrate **72** in a relaxed state is illustrated.

[0100] As illustrated in FIG. **6** or **7**, the flexible substrate **72** is flat L-shaped extending from one end **72**A to the other end **72**B in a relaxed state. A single bundle of (sixteen) coaxial wires **711** out of the plurality of bundles is electrically connected to the one end **72**A of the flexible substrate **72**. The other end **72**B of the flexible substrate **72** is connected to the FPC connector **6311**.

[0101] As illustrated in FIG. **7**, a conductor pattern **721** including sixteen signal lines **721**S and five return GNDs **721**G**1** to **721**G**3** is formed on the flexible substrate **72**.

[0102] The sixteen signal lines **721**S are conductively connected to the single bundle of respective (sixteen) coaxial wires **711**. The sixteen signal lines **721**S are also conductively connected to the respective sixteen contacts **6311**S (sixteen FPC connector lands **6314**S), with the other end **72**B of the flexible substrate **72** connected to the FPC connector **6311**.

[0103] The five return GNDs **721**G**1** to **721**G**3** are conductively connected to the respective five contacts **6311**G (five FPC connector lands **6314**G), with the other end **72**B of the flexible substrate **72** connected to the FPC connector **6311**.

[0104] As illustrated in FIG. **7**, the sixteen signal lines **721**S and the five return GNDs **721**G**1** to **721**G**3** are arranged side by side between an inner part **721** and an outer part **720** of the L shape of the flexible substrate **72**.

[0105] More specifically, the return GND **721**G**1** is formed on the inner part **721** of the L shape of the flexible substrate **72**. In other words, the return GND **721**G**1** corresponds to a first return GND according to the present invention.

[0106] The return GND **721**G**2** is formed on the outer part **720** of the L shape of the flexible substrate **72**. In other words, the return GND **721**G**2** corresponds to a second return GND according to the present invention.

[0107] The remaining three return GNDs **721**G**3** are uniformly allocated, with the respective four signal lines **721**S sandwiched between the three return GNDs **721**G**3** and the adjacent other return GNDs **721**G**1** to **721**G**3**. In other words, each of the three return GNDs **721**G**3** corresponds to a third return GND according to the present invention.

[0108] In the ultrasound probe **7** according to the embodiment, the flexible substrate **72** is flat L-shaped in the relaxed state. Out of the sixteen signal lines **721**S and the five return GNDs **721**G**1** to **721**G**3** formed on the flexible substrate **72**, the return GND **721**G**1** is formed on the inner part **721** of the L-shaped flexible substrate **72** with respect to the sixteen signal lines **721**S.

[0109] In other words, the signal line **721**S is not formed on the inner part **721** which might be cut off due to the external force or the like. Therefore, the ultrasound probe **7** according to the embodiment is able to suppress the disconnection of the signal line **721**S.

[0110] In addition, since the four return GNDs **721**G**2** and **721**G**3** are provided in addition to the return GND **721**G**1**, the return GND for the signal line **721**S can be stably maintained by the four return GNDs **721**G**2** and **721**G**3** even when the return GND **721**G**1** is disconnected.

[0111] If the external force is exerted on the flexible substrate **72**, the outer part **720** of the L-shaped flexible substrate **72** might also be cut off.

[0112] In this regard, in the ultrasound probe **7** according to the embodiment, out of the sixteen signal lines **721**S and the five return GNDs **721**G**1** to **721**G**3** formed on the flexible substrate **72**, the return GND **721**G**2** is formed on the outer part **720** of the L-shaped flexible substrate **72** with respect to the sixteen signal lines **721**S.

[0113] In other words, the signal line **721**S is not formed on the outer part **720** which might be cut off due to the external force or the like. Therefore, the ultrasound probe **7** according to the embodiment can further suppress the disconnection of the signal line **721**S.

[0114] If the pulse signal or the echo signal is transmitted in the ultrasound probe **7** while a magnetic material such as plating is used for the contact point, a magnetic field occurs in the contact part due to the ultrasound vibration in the transducer unit **211**, and noise (magnetostrictive noise) occurs in the ultrasound image.

[0115] In this regard, the present applicant has studied the noise and found that the noise can be reduced when the return GNDs are uniformly disposed.

[0116] In the ultrasound probe **7** according to the embodiment, the five return GNDs **721**G**1** to **721**G**3** are uniformly allocated. Therefore, the ultrasound probe **7** according to the embodiment can improve a noise resistance property by means of the GND stability and reduce the above-mentioned magnetostrictive noise.

OTHER EMBODIMENTS

[0117] Although the embodiment for practicing the present invention has been described so far, the present invention should not be limited only by the above-mentioned embodiment.

[0118] In the above-mentioned embodiment, the endoscope system **1** has both the function for generating the ultrasound image and the function for generating the endoscope image. However, the endoscope system **1** is not limited to this example, and may be configured in such a manner that the function for generating the endoscope image is removed.

[0119] In the above-mentioned embodiment, the sixteen signal lines **721**S are provided. However, a different number of signal lines **721**S may be provided as long as the number is a multiple of eight. Similarly, the number of return GNDs **721**G**3** is also not limited to three, and may be one or a different number as long as the return GNDs **721**G**3** can be uniformly allocated.

[0120] In the above-mentioned embodiment, the endoscope system **1** may be used not only in the medical field but also in the industrial field, and may serve as an endoscope system for observing the inside of a subject such as a machine structure.

[0121] According to an ultrasound probe of some embodiments, a flexible substrate is flat L-shaped in a relaxed state. From among a plurality of signal lines and a first return GND formed on the flexible substrate, the first return GND is formed on an inner side of the L-shaped flexible substrate with respect to the plurality of signal lines.

[0122] That is, the signal lines are not formed on the inner side of the L-shaped flexible substrate which may be cut off due to external force or the like. Therefore, according to the ultrasound probe of the present invention, it is possible to suppress disconnection of the signal lines.

[0123] Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

What is claimed is:

1. An ultrasound probe comprising:

a transducer unit having a plurality of ultrasound transducers;

a flexible substrate configured to be flat L-shaped in a relaxed state; and

a plurality of coaxial wires configured to electrically connect the transducer unit to the flexible substrate, wherein

the flexible substrate has thereon:

a plurality of signal lines configured to be electrically connected to the transducer unit via the plurality of coaxial wires; and

a first return GND that is a ground for the plurality of signal lines and is formed on an inner side of the L-shaped flexible substrate with respect to the plurality of signal lines.

2. The ultrasound probe according to claim **1**, wherein

the flexible substrate has thereon a second return GND that is a ground for the plurality of signal lines and is formed on an outer side of the L-shaped flexible substrate with respect to the plurality of signal lines.

3. The ultrasound probe according to claim **2**, wherein

the flexible substrate has thereon one or more third return GNDs that are grounds for the plurality of signal lines and are uniformly arranged between the first return GND and the second return GND.

4. The ultrasound probe according to claim **1**, wherein

the number of the plurality of signal lines is a multiple of eight.

5. The ultrasound probe according to claim **4**, wherein

the number of the plurality of signal lines is sixteen.

* * * * *

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摘要(译)

超声探头包括：具有多个超声换能器的换能器单元;柔性基板，其构造为在松弛状态下呈扁平L形;多个同轴线构造成将换能器单元电连接到柔性基板。柔性基板上具有：多条信号线，被配置为经由多条同轴线电连接到换能器单元;第一返回GND是多条信号线的接地，并且相对于多条信号线形成在L形柔性基板的内侧。