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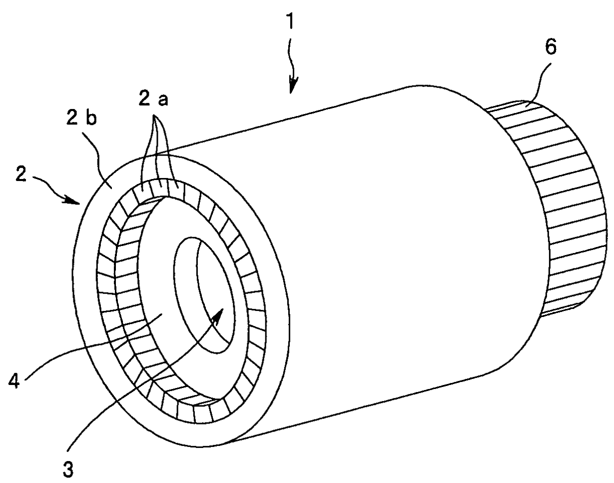
(54) **ULTRASONIC VIBRATOR AND METHOD OF PRODUCING THE SAME**

(57) An ultrasonic transducer comprises: an acoustic matching layer including at least a layer made up of a hard material; a piezoelectric member of which the length dimension is shorter than this acoustic matching layer, which is fixed and disposed at a predetermined position of a layer made up of the hard material which makes up the acoustic matching layer, and divided into a plurality of piezoelectric devices in this disposed state; and a transducer shape-formative member made up of a hard material, wherein, in a state in which the surfaces of the piezoelectric devices divided and formed are disposed on the inner circumferential surface side, the plurality of piezoelectric devices are arrayed in a predetermined shape, fixed and disposed on the surface where the piezoelectric devices of the acoustic matching layer protruding from the piezoelectric devices have been disposed.

FIG.1



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Description

Technical Field

[0001] The present invention relates to an ultrasonic transducer employed for an ultrasonic diagnostic apparatus and the like.

Background Art

[0002] In the medical field, various types of ultrasonic diagnostic apparatuses have been proposed in conventional art wherein information regarding living body tissue is obtained by transmitting an ultrasonic wave toward the living body tissue from an ultrasonic transducer, and also receiving a reflected wave reflected by the living body tissue with the same ultrasonic transducer as the ultrasonic transducer which transmitted the ultrasonic wave, or another ultrasonic transducer provided in another member to perform signal processing for making an image.

[0003] Examples of ultrasonic transducers employed for such an ultrasonic diagnostic apparatus include an ultrasonic transducer employing the electronic scanning method wherein a plurality of piezoelectric devices are arrayed regularly, and driven sequentially. Examples of such an ultrasonic transducer include a radial-array type wherein a plurality of piezoelectric devices are arrayed in a cylindrical shape, a convex-array type arrayed in a generally partially cylindrical shape, and a linear-array type arrayed in a flat plate shape.

[0004] Of these, the radial-array ultrasonic transducer is applied to the ultrasonic probe disclosed in Japanese Unexamined Patent Application Publication No. 2-271839, for example. With this ultrasonic transducer, a transducer unit is formed by sequentially bonding piezoelectric device plates and acoustic matching layers of which materials are lead zirconate titanate, or the like to a supporting member made up of a thin plate having flexibility with damper effects. Subsequently, a transducer array having a plurality of ultrasonic transducers are configured by forming grooves in a predetermined pitch orthogonal to one side in the longitudinal direction using cutting means while excluding lower supporting members, and the backsides of the supporting members making up this transducer array are bonded and formed around a damper member (backing member described in the specification of the present application) also serving as a circular fixing member.

[0005] Also, with Japanese Patent No. 2502685, the method for manufacturing an ultrasonic probe has been disclosed wherein a first acoustic matching layer, and a backside load member made up of a deformable member or the like, on both sides of a piezoelectric device is provided, grooves reaching part of the backside load member from the first acoustic matching layer side are formed in a predetermined interval using cutting means, and the backside load member is bonded and fixed on the outer side of a curved member formed with a desired curvature.

[0006] Also, an example of the above array ultrasonic transducer has been disclosed in Japanese Unexamined Patent Application Publication No. 10-308997. This ultrasonic transducer is formed by forming a recessed portion made up of a groove or a notch on at least any one of the first side and the second side of a piezoelectric member having electrodes, and engaging a conductive member with this recessed portion, and also electrically connecting this conductive member to the electrode near the recessed portion.

[0007] Also, with Japanese Patent No. 2729442, the ultrasonic probe has been disclosed wherein the ultrasonic probe comprises an ultrasonic transducer, a ground electrode provided on the front surface side of this ultrasonic transducer, a positive electrode provided on the back surface side of the ultrasonic transducer, an acoustic matching layer bonded on the ground electrode surface side of the ultrasonic transducer, and a conductive member for forming a superimposed structure by superimposing the acoustic matching layer and a backside load member provided on the positive electrode side of the ultrasonic transducer, also exposing the ground electrode by cutting and removing part of the side edge portion of one-side of this superimposed structure from the acoustic matching layer on the front surface side to the backside load member on the back surface side, and electrically connecting the cut surface of the backside load member and the edge surface of the ground electrode by firmly fixing the conductive member, which is connected to the positive electrode.

[0008] Also, the electronic scanning ultrasonic probe according to Japanese Unexamined Patent Application Publication No. 2-278143 has been disclosed wherein a damper member is flowed into a cylinder made up of a transducer unit to make up a radial scanning ultrasonic probe.

[0009] However, with the ultrasonic transducer formed by fixing a flexible supporting member and a damper member with an adhesive agent disclosed in the ultrasonic probe of Japanese Unexamined Patent Application Publication No. 2-271839, there has been the possibility of problems such as the pulse width being extended due to influence of an adhesive layer provided between the supporting member and the damper member. In particular, in the case in which a soft member is fixed by adhesion, unlike the case in which hard members are bonded, there has been the possibility of irregularities in the thickness of the adhesive layer, less precision in the shape of members, and problems in transducer shape precision after adhesion, resulting in unstable image quality of the ultrasonic image. Also, bonding and fixing the damper member and the supporting member while bending these members causes residual stress to apply to the damper member and the supporting member, which has been a factor in deterioration of reliability.

[0010] Also, with the methods for manufacturing an ultrasonic probe disclosed in Japanese Unexamined Patent Application Publication No. 2-271839 and Japanese Patent No. 2502685, a predetermined shape has been formed by bonding and fixing an flexible and deformable elastic member in a bent state to the damper member or the curved member. Consequently, there is the possibility of stress remaining in the elastic member, resulting in breaking of wires or the like.

[0011] Further, it has been difficult to maintain desired shape precision when an elastic soft member is fixed by adhesion, which causes irregularities in the thickness of the adhesive layers, and prevents high-precision formation of shapes of members, unlike with the case in which hard members are bonded.

[0012] Also, with the ultrasonic transducer disclosed in Japanese Unexamined Patent Application Publication No. 10-308997, forming a groove in the piezoelectric device to ensure ground wiring in a small space causes the possibility of deterioration in reliability of the device due to occurrence of micro-cracks and the like. On the other hand, realizing thinness of a conductive member for reduction in size causes a problem of lack of capacity.

[0013] Also, with the transducer probe in Japanese Patent No. 2729442, the edge surface portion is removed to expose the electroconductive member following bonding the acoustic matching layer, piezoelectric device, backing member, and the like, so work stress applied to between the electroconductive member and piezoelectric device is great as with the above-described ultrasonic transducers, and there is the possibility of reliability deterioration of the device due to occurrence of micro-cracks and the like at this portion.

[0014] Also, with the radial scanning ultrasonic probe in Japanese Unexamined Patent Application Publication No. 2-278143, the damper member is simply poured in and hardened, so when filler such as a powder member, fiber, and the like, mixed in a liquid resin member making up this damper member poured in to make up the damper member is hardened and formed into a damper member, irregularities occur in the distribution density of the filler. As a result, the properties of the backing member as to each piezoelectric device become uneven, and irregularities are caused in the properties of the respective piezoelectric devices disposed, resulting in problems wherein excellent ultrasonic images cannot be yielded with ease.

[0015] The present invention has been made in light of the above situations, and it is an object of the present invention to provide a highly-reliable ultrasonic transducer capable of yielding excellent ultrasonic images while reducing influence of residual stress.

[0016] The present invention also has an object to provide an ultrasonic transducer, which can ensure firm ground in a small space, and high reliability.

[0017] The present invention further has an object to provide a highly-reliable ultrasonic transducer capable of yielding excellent ultrasonic images by disposing a backing member having uniform acoustic properties as to each piezoelectric device.

Disclosure of Invention

[0018] An ultrasonic transducer according to the present invention comprises: an acoustic matching layer including at least a layer made up of a hard material; a piezoelectric member of which the length dimension is shorter than this acoustic matching layer, which is fixed and disposed at a predetermined position of a layer made up of the hard material which makes up the acoustic matching layer, and divided into a plurality of piezoelectric devices in this disposed state; and a transducer shape-formative member made up of a hard material, wherein, in a state in which the surfaces of the piezoelectric devices divided and formed are disposed on the inner circumferential surface side, the plurality of piezoelectric devices are arrayed in a predetermined shape, fixed and disposed on the surface where the piezoelectric devices of the acoustic matching layer protruding from the piezoelectric devices have been disposed. A method for manufacturing an ultrasonic transducer according to the present invention comprises: a process for forming an acoustic matching layer which layers at least a first acoustic matching layer made up of a hard material, and a second acoustic matching layer made up of a soft material; a process for forming a layered member by fixing a predetermined-shaped piezoelectric member having electrodes on the first acoustic matching layer surface of the acoustic matching layer; a process for providing a predetermined number of piezoelectric devices on the layered member by forming dividing grooves in a predetermined interval on the piezoelectric member; a process for configuring the layered member in a predetermined shape by disposing a shape-formative member at a predetermined position of the layered member having a plurality of piezoelectric devices; a process for putting the layered member formed in a predetermined shape in a turning state, and supplying a liquid resin mixed with filler on the layered member inner circumferential surface; and a process for putting the layered member in a turning state for a predetermined period, and hardening the liquid resin supplied on the layered member inner circumferential surface. Accordingly, residual stress can be prevented from occurring in a sure manner by disposing a liquid resin to which filler is mixed on the piezoelectric devices without using an adhesive agent. Also, a liquid resin to which filler is mixed is disposed evenly to each piezoelectric device, thereby yielding an ultrasonic transducer having uniform acoustic properties.

Brief Description of the Drawings

[0019]

Fig. 1 is a perspective view illustrating an ultrasonic transducer, Fig. 2A is a cross-sectional view in the longitudinal direction for describing the configuration of the ultrasonic transducer, Fig. 2B is an enlarged view of the portion shown with the arrow B in Fig.

2A, Fig. 2C is a diagram for describing another configuration example of the portion shown with the arrow B in Fig. 2A, Fig. 2D is a diagram for describing another configuration example of the portion shown with the arrow B in Fig. 2A, Fig. 2E is an enlarged view of the portion shown in the arrow C in Fig. 2A, Fig. 3 is a cross-sectional view taken along line A-A in Fig. 2A, Fig. 4A is a diagram for describing members making up an acoustic matching layer, Fig. 4B is a diagram for describing the acoustic matching layer, Fig. 5A is a diagram for describing members making up a first layered member, Fig. 5B is a diagram for describing the first layered member, Fig. 6A is a diagram for describing members making up a second layered member, Fig. 6B is a diagram for describing the second layered member, Fig. 7 is a diagram for describing a process for electrically connecting an electroconductive pattern of a substrate and a one-face side electrode of a piezoelectric ceramic, Fig. 8A is a diagram illustrating a state wherein dividing grooves are formed, and the piezoelectric ceramic is divided into piezoelectric devices, Fig. 8B is a side view of the second layered member having dividing grooves formed in a cutting process as viewed from the cutting direction, Fig. 9 is a diagram wherein the second layered member on which a plurality of piezoelectric devices are provided is deformed to a cylindrical shape, Fig. 10A is a diagram for describing members making up a cylindrical transducer unit, Fig. 10B is a diagram for describing a state wherein a shape-formative member is disposed in a first acoustic matching layer, Fig. 10C is a diagram for describing a state wherein a shape-formative member is disposed in the substrate, Fig. 11A is a diagram illustrating shape-formative members and a second layered member for forming a convex-array transducer unit, Fig. 11B is a diagram illustrating shape-formative members and a second layered member for forming a linear-array transducer unit, Fig. 12 is a diagram for describing another method for forming a ground electrode to be provided on the first acoustic matching layer, Fig. 13 is a diagram for describing a cylindrical transducer unit in a turning state, Fig. 14 is a diagram for describing a state wherein a liquid resin is supplied to the inner circumferential surface of the cylindrical transducer unit, Fig. 15 is a cross-sectional view in the longitudinal direction of a cylindrical ultrasonic transducer, Fig. 16 is a cross-sectional view taken along line E-E of Fig. 15, Fig. 17A is a diagram illustrating a shape-formative member and a second layered member for forming a convex-array transducer unit, Fig. 17B is a diagram for describing another method for forming a convex-array ultrasonic transducer, and Fig. 17C is a diagram for describing another method for forming a convex-array ultrasonic transducer.

Best Mode for Carrying Out the Invention

[0020] The present invention will be described in more detail with reference to the appended drawings.

[0021] As shown in Fig. 1, an ultrasonic transducer 1 according to the present embodiment is configured as a radial array type. The ultrasonic transducer 1 comprises an acoustic matching layer 2, a backing member 3, a first transducer shape-formative member 4a formed in a cylindrical shape, a second transducer shape-formative member (hereafter, abbreviated as shape-formative member) 4b, and a piezoelectric device 5. The acoustic matching layer 2 is formed by layering a first acoustic matching layer 2a made up of a hard material, and a second acoustic matching layer 2b made up of a soft material. Here, the term "hard" means a degree of hardness wherein a shape formed beforehand can be maintained. On the other hand, the term "soft" means to have flexibility regarding deformation and so forth.

[0022] As shown in Fig. 2A and Fig. 3, the backing member 3, the piezoelectric device 5, the first acoustic matching layer 2a, and the second acoustic matching layer 2b are disposed in order from the center of the cylindrical shape of the ultrasonic transducer 1 toward the outer circumferential side. The first shape-formative member 4a is disposed so as to be adjacent to one end sides of the backing member 3 and the piezoelectric device 5 in the inner direction of the first acoustic matching layer 2a making up the acoustic matching layer 2. A substrate 6 is disposed on the other end side of the piezoelectric device 5.

[0023] Note that the substrate 6 is also formed in a cylindrical shape by simulating the shape of the ultrasonic transducer 1 and the like. As for the substrate 6, a three-dimensional substrate, an alumina substrate, a glass epoxy substrate, a rigid flexible substrate, a flexible substrate, or the like is employed.

[0024] The second shape-formative member 4b is disposed so as to be adjacent to the other end side of the backing member 3 in the inner circumferential side of the substrate 6. Also, the acoustic matching layer 2 is disposed on one end side serving as a side wherein the first shape-formative member 4a of the ultrasonic transducer 1 is disposed, so as to protrude in the longitudinal axial direction as compared with the piezoelectric device 5.

[0025] The acoustic matching layer 2 is made up of the first acoustic matching layer 2a and the second acoustic matching layer 2b as described above, but as for a material of the first acoustic matching layer 2a, for example, a material obtained by mixing a resin member such as epoxy, silicone, polyimide, or the like with a powder member or fiber such as metal, ceramic, glass, or the like, or glass, machinable ceramics, silicon, or the like is employed. On the other hand, as for a material of the second acoustic matching layer 2b, for example, a resin member such as silicone, epoxy, PEEK, polyimide, polyetherimide, polysulfone, polyethersulfone, fluororesin, or the like, or rubber or the like is employed.

[0026] As shown in Fig. 1 and Fig. 3, the first acoustic matching layer 2a and the piezoelectric device 5 are divided into a predetermined number, e.g., 192, and arrayed.

[0027] As for the backing member 3, a member obtained by hardening an epoxy resin including alumina powder is employed, for example. Note that as the backing member 3, a resin member such as epoxy, silicon, polyimide, polyetherimide, PEEK, urethane, fluorine, or the like, a rubber member such as chloroprene rubber, propylene rubber, butadiene rubber, urethane rubber, silicone rubber, fluororubber, or the like, or a member obtained by mixing such a resin member or rubber member with metal such as tungsten, ceramics such as alumina, zirconia, silica, tungstic oxide, piezoelectric ceramics powder, ferrite, or the like, or a powder member or fiber such as glass or resin or the like, or a single or plurality of fillers in material or a shape made up of hollow particles, or the like, may be employed.

[0028] The piezoelectric device 5 is formed by cutting a piezoelectric ceramic such as lead zirconate titanate, lead titanate, barium titanate, BNT-BS-ST, or the like, or piezoelectric crystal or relaxor ferroelectric such as $LiNbO_3$ or PZNT or the like, which is formed in a plate shape. A one-face side electrode 5a and an other-face side electrode 5b are obtained by providing an electroconductive member such as gold, silver, copper, nickel chrome, or the like on the surface of the plate-shaped piezoelectric ceramic beforehand as a single layer, multi layer, or alloy layer by sintering or by a thin film or plating such as vapor deposition, sputtering, ion plating, or the like.

[0029] Now, description will be made regarding an electroconductive system in the ultrasonic transducer 1 based on Fig. 2B through Fig. 2D serving as partially enlarged views of the range B in Fig. 2A, and Fig. 2E serving as a partially enlarged view of the range C.

[0030] As shown in Fig. 2B, the inner circumferential side of the piezoelectric device 5 is provided with the one-face side electrode 5a, and the outer circumferential side thereof is provided with the other-face side electrode 5b. On the inner circumferential side of the first acoustic matching layer 2a making up the acoustic matching layer 2, a ground electrode 8 is disposed and formed along generally the entire circumference. The ground electrode 8 is in contact with the electrode 5b provided on the outer circumference of the piezoelectric device 5 and with an electroconductive portion 7 provided on the outer circumference of the first shape-formative member 4a.

[0031] Note that description will be made later regarding placement of the ground electrode 8 as well as description regarding the manufacturing method.

[0032] The first shape-formative member 4a is bonded and fixed to the inner circumferential face of the first acoustic matching layer 2a with an electroconductive member, e.g., an electroconductive adhesive agent (not shown). Thus, the electroconductive portion 7 and the ground electrode 8 become an electroconductive state. Note that the electroconductive member is not restricted to an electroconductive adhesive agent, a brazing metal member such as solder, brazing silver, brazing gold, or the like, or an electroconductive film or the like may be employed.

[0033] Thus, the other-face side electrode 5b, the electroconductive portion 7, and the ground electrode 8 are electrically connected.

[0034] In Fig. 2B, the other-face side electrode 5b and the electroconductive portion 7 are integrally formed, but the other-face side electrode 5b, the electroconductive portion 7, and the ground electrode 8 should be connected so as to be electrically equal. For example, as shown in Fig. 2C, the ground electrode 8 may be consecutively provided up to one end side of the acoustic matching layer 2.

[0035] Also, as shown in Fig. 2D, an arrangement may be made wherein the ground electrode 8 may be made a little larger than the thickness of the first shape-formative member 4a serving as the length of the longitudinal axial direction thereof such that only a part of around the longitudinal direction thereof is in contact with the other-face side electrode 5b and the electroconductive portion 7. In this case, let us say that the ground electrode 8 is configured so as to be exposed to the outside, and between the electroconductive portion 4a and the ground electrode 6 is in an electroconductive state with an electroconductive member such as an electroconductive resin, electroconductive painting, or the like, or an electroconductive film such as various types of electroconductive thin film, electroconductive thick film, plating, or the like. Also, a combination of these materials may be employed.

[0036] As shown in Fig. 2E, in the vicinity of a portion where the piezoelectric device 5 and the substrate 6 are adjacently disposed, an electroconductive member 9 is disposed in the inner circumferential side of the backing member 3 so as to electrically connect the electroconductive pattern 6a provided in the inner circumferential side of the substrate 6, and the one-face side electrode 5a.

[0037] A method for manufacturing the ultrasonic transducer 1 configured as described above will be described with reference to Fig. 4A through Fig. 10C.

[0038] The method for manufacturing the ultrasonic transducer 1 comprises the following processes.

(1) Process for forming the acoustic matching layer 2

[0039] In order to form the acoustic matching layer 2, first, the first acoustic matching layer 2a and the second acoustic matching layer 2b, which have predetermined dimensions and a predetermined shape as shown in Fig. 4A, and also are adjusted to a predetermined acoustic impedance value, are prepared. Subsequently, the ground electrode 8 in a plate shape is disposed at a predetermined position on one face side of the first acoustic matching layer 2a.

[0040] Next, as shown in Fig. 4B, the acoustic matching layer 2 is formed by integrally layering the first acoustic matching layer 2a and the second acoustic matching layer 2b. At this time, the second acoustic matching layer 2b is disposed on the other face side of the first acoustic matching layer 2a on which the ground electrode 6 is not provided. The acoustic matching layer 2 may be integrated following each of the first acoustic matching layer 2a and the second acoustic matching 2b being formed in a predetermined thickness, or may be formed in a predetermined thickness following integration, or may be directly formed by applying or casting or film-forming one to the other without bonding, or may be formed by a combination of these.

[0041] Note that as for the ground electrode 8, an electroconductive member 12 in a plate shape formed with a predetermined width dimension and thickness dimension may be bonded and disposed in a groove 11 formed with a predetermined width dimension and depth dimension at a predetermined position of the first acoustic matching layer 2a. Also, as for the ground electrode 8, a plate-shaped electroconductive member formed with a predetermined width dimension and thicker dimension than the above depth dimension may be bonded and disposed in the groove 11. Also, as for the ground electrode 8, following an unshown electroconductive resin or the like being applied or filled so as to be protruded, the protruding portion of this electroconductive member may be worked and formed such that the face thereof matches the face of the first acoustic matching layer 2a. Also, as for the ground electrode 8, following an electroconductive member being bonded, applied, or filled in the groove 11 of the first acoustic matching layer 2a formed with thicker dimension than a predetermined thickness dimension, the entirety may be worked and formed so as to become a predetermined thickness dimension. Also, the ground electrode 8 may be formed by various types of conductive film.

[0042] As for the ground electrode 8, a conductive material such as an electroconductive resin, electroconductive painting, metal, or the like, or a conductive film such as various types of conductive thin film, conductive thick film, plating, or the like is employed.

(2) Process for forming the first layered member

[0043] A first layered member 21 is formed from the acoustic matching layer 2 formed in the first process, and a piezoelectric ceramic 13 wherein the one-face side electrode 5a and the other-face side electrode 5b are provided on both faces of a piezoelectric device. With the piezoelectric ceramic 13, the length dimension is formed shorter than the length dimension of the acoustic matching layer 2 by a predetermined dimension, the width dimension is formed with generally the same dimension, and the thickness dimension is formed with a predetermined dimension.

[0044] Specifically, first, the acoustic matching layer 2 and the piezoelectric ceramic 13 are prepared as shown in Fig. 5A.

[0045] Next, as shown in Fig. 5B, the other-face side electrode 5b of the piezoelectric ceramic 13 is bonded and fixed at a position shifted by, for example, a distance a serving as a predetermined amount from one side of the generally rectangular acoustic matching layer 2 on the surface of the acoustic matching layer 2 on which the ground electrode 8 is formed such that at least part thereof is in contact with the ground electrode 8.

[0046] Thus, the integral first layered member 21 is formed in an electroconductive state between the other-face side electrode 5b and the ground electrode 6 of the piezoelectric ceramic 13. At this time, one end face side of the acoustic matching layer 2 on which the ground electrode 6 is disposed becomes a protruding state from one end face side of the piezoelectric ceramic 13 by the distance a.

(3) Process for forming a second layered member

[0047] A second layered member 22 is formed from the first layered member 21 formed in the above process, and electroconductive patterns 6a.

[0048] First, as shown in Fig. 6A, the first layered member 21 formed in the second process and the substrate 6 of which one face sides are regularly arrayed with a plurality of electroconductive patterns 6a, ··· , 6a in a predetermined interval, are prepared. The thickness dimension of this substrate is generally the same as the thickness dimension of the piezoelectric ceramic 13.

[0049] Next, as shown in Fig. 6B, the substrate 6 is disposed in a state wherein the electroconductive patterns 6a, ··· , 6a are turned upward so as to be adjacent to the piezoelectric ceramic 13, and bonded and fixed as to the first acoustic matching layer 2a.

[0050] Thus, the second layered member 22 is formed wherein the piezoelectric ceramic 13 and the substrate 6 are adjacently disposed on the face of the first acoustic matching layer 2a. Note that the width dimension and length dimension of the substrate 6 are set to be predetermined dimensions.

(4) Process for electrically connecting the electroconductive patterns 6a, ··· , 6a of the substrate and the one-face side electrode 5a of the piezoelectric ceramic 13

[0051] As shown in Fig. 7, an electroconductive film portion 14 is provided by disposing an unshown mask member at a predetermined position on the surface of the piezoelectric ceramic 13 on which the one-face side electrode 5a is provided, and the substrate 7 on which the electroconductive patterns 6a of the second layered member 22 are formed, applying electroconductive painting or an electroconductive adhesive agent or the like serving as a film member thereupon, or accreting metal such as gold, silver, chrome, indium dioxide, or the like, or a conductive member by means of vapor deposition, sputtering, ion plating, CVD, or the like.

[0052] The electroconductive film portion 14 is thus formed, thereby electrically connecting the electroconductive patterns 6a, ··· , 6a and the one-face side electrode 5a.

(5) Process for dividing the piezoelectric ceramic 13 into a plurality of piezoelectric devices 5, ··· , 5

[0053] As shown in Fig. 8A, dividing grooves 15 having a predetermined depth dimension, and a predetermined width dimension or a predetermined shape which passes through the first acoustic matching layer 2a making up the acoustic matching layer 2 from the surface side of the piezoelectric ceramic 13 and the substrate 6, and reaches part of the second acoustic matching layer 2b are formed with a predetermined pitch in the direction orthogonal to the longitudinal direction. Note that the dividing grooves 15 are formed using cutting means such as an unshown dicing saw or laser apparatus, or the like. At this time, the cutting means are disposed on the center line, which divides the two electroconductive patterns 6a and 6a.

[0054] With this process, the substrate 6 on which the plurality of electroconductive patterns 6a, ··· , 6a are provided is divided into a plurality of substrates 6, ··· , 6 on which at least the single electroconductive pattern 6a is disposed, and also the piezoelectric ceramic 13 is divided into a plurality of piezoelectric ceramics 13. At this time, the electroconductive film portion 14 is divided into a plurality of electroconductive members 9. Thus, a plurality of piezoelectric devices 5, ··· , 5 which electrically connect the respective electroconductive patterns 6a with the electroconductive members 9 are arrayed on the single acoustic matching layer 2.

[0055] As shown in Fig. 8B, a predetermined number of dividing grooves 15 are formed with a predetermined pitch in the second layered member 22. Thus, the piezoelectric ceramic 13, the substrate 6, the electroconductive film portion 14, and the first acoustic matching layer 2a are divided into a predetermined number, the second layered member 22 made up of the piezoelectric ceramic 13 and the substrate 6 becomes a second layered member 22a made up of a group of layered members on which the plurality of piezoelectric devices 5, ···, 5 and the plurality of substrates 6, ··· , 6 are disposed. In other words, it can be said that the second layered member 22 becomes a state wherein the plurality of piezoelectric devices 5, ··· , 5 are arrayed on the second acoustic matching layer 2b having flexibility making up the acoustic matching layer 2.

[0056] Subsequently, the second layered member 22a is subjected to curved deformation such that the second acoustic matching layer 2b is disposed on the outermost circumferential side, and formed in a cylindrical shape as shown in Fig. 9.

[0057] Note that following the dividing grooves 15 being formed, the acoustic matching layer 2 shown with hatched lines in Fig. 8A for example is removed, which is unnecessary for forming the ultrasonic transducer 1. Also similarly, with regard to the respective members making up the second layered member 22, an arrangement may be made wherein the lengths thereof for example are employed greater than predetermined shapes, and consequently, unnecessary portions are removed. Further as necessary, an electroconductive check regarding whether or not the one-face side electrode 5a of the respective piezoelectric devices 5, ··· , 5 is electrically connected to the electroconductive pattern 6a of the respective substrates 6, ··· , 6 through the electroconductive member 9.

(6) Process for forming a cylindrical transducer unit (hereafter, abbreviated as cylindrical unit) 23

[0058] A cylindrical unit 23 is formed from the second layered member 22a formed in the above process, and the first and second shape-formative members 4a and 4b.

[0059] Specifically, following the second layered member 22a being formed in a cylindrical shape as shown in Fig. 10A, the first shape-formative member 4a is integrally bonded and fixed to the first acoustic matching layer 2a of the acoustic matching layer 2 with an electroconductive adhesive agent, as shown in Fig. 10B. Also, as shown in Fig. 10C, the second shape-formative member 4b is integrally bonded and fixed to the inner circumferential surface side of the substrates 6, ··· , 6 adjacent to the piezoelectric devices 5, ···, 5 with a non-electroconductive adhesive agent.

[0060] Thus, the cylindrical unit 23 having a predetermined curvature is formed from the second layered member 22a by bonding and fixing the first acoustic matching layer 2a made up of a hard material, the first shape-formative member 4a and the substrate 6, and the second shape-formative member 4b. At this time, the ground electrode 8 in an electroconductive state as to the other-face side electrode 5b provided on the divided piezoelectric devices 5, ··· , 5, and the electroconductive portion 7 of the first shape-formative member 4a become an integrally electroconductive state.

[0061] The electroconductive portion 7 is connected with a ground wire extending from an unshown ultrasonic observation apparatus, thereby ensuring ground having sufficient capacity. Now, an arrangement may be made wherein the first shape-formative member 4a is bonded to the first acoustic matching layer 2a using a non-electroconductive adhesive agent, following which may be electrically connected by means of a conductive thin film, an electroconductive resin, a conductive thick film, or the like.

[0062] Thus, the other-face side electrode 5b provided on the respective piezoelectric devices 5, ··· , 5 is connected to the ground electrode 8 integrated by the electroconductive portion 7 so as to ensure ground having large capacity by providing the ground electrode 8 on the acoustic matching layer 2 beforehand, which becomes an electroconductive state as to a predetermined electrode and the electroconductive portion of a predetermined shape-formative member provided on the piezoelectric ceramic 13, and electrically connecting this ground electrode 8 and the predetermined electrode and the electroconductive portion 7 of the predetermined shape-formative member provided on the piezoelectric ceramic 13 at the time of an assembly process.

[0063] Note that with the present embodiment, the process for forming the radial-array ultrasonic transducer 1 using the first shape-formative member 4a and the second shape-formative member 4b has been described, but instead of employing the shape-formative members 4a and 4b shown in the present process, a convex-array transducer unit may be formed by fixing a third shape-formative member 4c and a fourth shape-formative member 4d formed in a partially cylindrical shape for example as shown in Fig. 11A to the first acoustic matching layer 2a of the second layered member 22b having the piezoelectric devices 5, ··· , 5 which are divided into a predetermined number in a predetermined shape, as with the above description.

[0064] Now, as shown in Fig. 11B, a linear-array transducer unit is formed by fixing the shape-formative member 4e of which the end portion is flat such that the flat portion is in contact with the first acoustic matching layer 2a of the second layered member 22c, as with the above description. Further, the end portion shape of the shape-formative member is not restricted to an arc or a straight line, and a combination of these and deformation may be employed, whereby a plurality of arrays can be disposed without restriction, and accordingly, the ultrasonic scanning direction may be set without restriction.

[0065] Also, with the present embodiment, the ground electrode 8 is configured by bonding and disposing the plate-shaped electroconductive member 12 in the groove 11 having a predetermined width dimension and depth dimension formed at a predetermined position of the first acoustic matching layer 2a, but as shown in Fig. 12, a ground film portion 24 made up of an electroconductive material may be provided at a predetermined position of the first acoustic matching layer 2a. Specifically, the ground film portion 24 may be formed by subjecting an electroconductive member such as gold, silver, copper, nickel chrome, or the like to sintering, vapor deposition, or the like, or may be formed by applying electroconductive painting, an electroconductive adhesive agent, or the like.

[0066] Thus, the ground electrode 6 can be provided at a predetermined position of the first acoustic matching layer 2a without forming a groove having a predetermined width dimension and depth dimension at a predetermined position of the first acoustic matching layer 2a.

(7) Process for forming the backing member

[0067] A radial-array ultrasonic transducer having a configuration such as shown in Fig. 1 through Fig. 3 is formed by forming the backing member 3 using a rubber member including ferrite, epoxy including alumina powder, or the like as a material by means of a method such as bonding, casting, or the like, on the one-face side electrode 5a side of the piezoelectric device 5.

Description thereof will be made below.

[0068] As shown in Fig. 13, a cylindrical unit 23 is mounted on an unshown tool, and this cylindrical unit 23 is turned in the direction shown in the arrow for example at a predetermined speed with the center of curvature as a turning axis. In this state, as shown in Fig. 14, a liquid resin 33 having predetermined viscosity, in which alumina powder is mixed in an epoxy resin and stirred with a mixing apparatus 32 beforehand, is supplied to the inner circumferential surface 23a of the cylindrical unit 23 via a supplying pipe 31. Next, a predetermined amount of the liquid resin 33 is supplied in a state wherein the cylindrical unit 23 is turning, and then the turning state is maintained for a predetermined period, following which the liquid resin 33 is hardened. Note that the turning direction of the cylindrical unit 23 is not restricted to the direction shown in the arrow, and may be the opposite direction thereof.

[0069] Thus, the radial-array ultrasonic transducer 1 is formed wherein the backing member 3 is provided on the one-face side electrode 5a side of the plurality of piezoelectric devices 5, ---, 5.

[0070] At this time, the backing member 3 is formed by the liquid resin 33 being hardened in a state wherein the cylindrical unit 23 is turning, so is formed with uniform thickness as to the respective piezoelectric devices 5, ··· , 5 as shown in Fig. 15, and also is formed in a state wherein alumina powder is evenly distributed to the center direction from the inner circumferential surface side of the one-face side electrode 5a of the respective piezoelectric devices 5, ··· 5 as shown in Fig. 16. Specifically, the backing member 3 is formed such that alumina powder is disposed in a range 51 shown in a chain line from the inner circumferential surface side of the one-face side electrode 5a in high density, as headed to the center direction, the density of the alumina powder is gradually reduced, and a so-called skimming layer 52 made up of a epoxy resin alone is formed from the chain double-dashed line to the center side.

[0071] Thus, the cylindrical unit is formed and turned at a predetermined speed. A predetermined amount of a liquid resin member in which filler serving as a backing member is mixed is supplied. Then, the resin member supplied with the cylindrical unit in a turning state is hardened and filler is evenly distributed from the inner circumferential surface side of the respective piezoelectric devices to the center direction, a backing member having uniform thickness is formed, thereby yielding a radial-array ultrasonic transducer. Thus, the ultrasonic images of excellent radial images can be obtained by performing ultrasonic observation using the radial-array ultrasonic transducer wherein the backing member having uniform acoustic properties as to each piezoelectric device is disposed.

[0072] Note that the backing member can be prevented from occurrence of residual stress in a sure manner by disposing the backing member without using an adhesive agent on the one-face side electrode side of the piezoelectric devices.

[0073] Also, an accommodation space for accommodating the contents making up an ultrasonic endoscope may be expanded by removing the skimming layer of the backing member, and forming the inner diameter of the inner hole of an ultrasonic transducer to be a large diameter.

[0074] Also, with the present embodiment, the processes for forming the radial-array ultrasonic transducer have been described, but though not shown in the drawing, a convex-array ultrasonic transducer can be obtained, for example, by cutting at a predetermined angle such as cutting along the diameter in the longitudinal direction to change the cross-sectional shape to a generally half-round shape or the like.

[0075] Further, as shown in Fig. 17A, for example, a convex-array transducer unit 22c is formed by fixing shape-formative members 4c and 4d provided with a recessed portion for inserting a supply pipe formed in a half-round shape or the like to the first acoustic matching layer 2a of the second layered member 22b having the piezoelectric devices 5, ···, 5 divided into a predetermined number in a predetermined shape, as with the above description. Subsequently, as shown in Fig. 17B, the convex-array transducer unit 22c is disposed integrally with a dummy member 24 making 22c a generally the same shape as the cylindrical unit 23. Subsequently, in this state, the liquid resin 33 is supplied, and also is hardened to form a backing member, as with the above description. Subsequently, a convex-array ultrasonic transducer can be obtained by removing unnecessary portions of the dummy member 24 and the backing member, as with the above description.

[0076] Also, as shown in Fig. 17C, the convex-array transducer unit 22c is disposed on an unshown tool. Subsequently, a convex-array ultrasonic transducer wherein the backing member having uniform acoustic properties as to each piezoelectric device is disposed can be obtained by supplying a predetermined amount of the liquid resin 33 in that state while oscillating the convex-array transducer unit 22c in a predetermined state, and also maintaining the oscillating state for a predetermined period to harden the liquid resin 33, as with the above embodiment.

[0077] Thus, an ultrasonic transducer in a predetermined shape can be formed with high precision by fixing and disposing a shape-formative member made up of a hard material formed in a predetermined shape on the first acoustic matching layer made up of a hard material making up the acoustic matching layer protruding from the piezoelectric devices, and also an ultrasonic transducer wherein occurrence of malfunction due to residual stress is prevented in a sure manner can be formed.

[0078] Thus, the piezoelectric devices formed by dividing the piezoelectric ceramic into a plurality of piezoelectric devices are arrayed with high precision, and high-quality ultrasonic observation images can be obtained for a long period in a stable manner.

[0079] Note that the present invention is not restricted to the above embodiment alone; rather, various modifications can be made without departing from the spirit or scope of the present invention. For example, with the present embodiment, the substrate 6 and the piezoelectric device 5 are disposed in parallel, and are electrically connected by the electroconductive member, but the present invention is not restricted to this, for example, the substrate may be positioned on the inside or the side face of the backing member, the frame and the substrate may be united, or the substrate and the piezoelectric device may be connected with a metal fine wire or the like.

Industrial Applicability

[0080] As described above, the ultrasonic transducer according to the present invention is useful as an ultrasonic observation apparatus or the like for obtaining ultrasonic tomographic images since reliability is high.

Claims

1. An ultrasonic transducer comprising:

an acoustic matching layer including at least a layer made up of a hard material;
a piezoelectric member of which the length dimension is shorter than this acoustic matching layer, which is fixed and disposed at a predetermined position of a layer made up of the hard material which makes up the acoustic matching layer, and divided into a plurality of piezoelectric devices in this disposed state; and
a transducer shape-formative member made up of a hard material, wherein, in a state in which the surfaces of the piezoelectric devices divided and formed are disposed on the inner circumferential surface side, the plurality of piezoelectric devices are arrayed in a predetermined shape, fixed and disposed on the surface where the piezoelectric devices of the acoustic matching layer protruding from the piezoelectric devices have been disposed.

2. An ultrasonic transducer comprising:

an acoustic matching layer formed by layering at least a first acoustic matching layer made up of a hard material, and a second acoustic match-

ing layer made up of a soft material;
a piezoelectric member of which the length dimension is shorter than this acoustic matching layer, which is fixed and disposed at a predetermined position on the first acoustic matching layer surface, and divided into a plurality of piezoelectric devices in this disposed state; and
a transducer shape-formative member made up of a hard material, wherein, in a state in which the surfaces of the piezoelectric devices divided and formed are disposed on the inner circumferential surface side, the plurality of piezoelectric devices are arrayed in a predetermined shape, fixed and disposed on the surface of the first acoustic matching layer side making up the acoustic matching layer protruding from the piezoelectric devices.

3. An ultrasonic transducer according to Claim 2, wherein the piezoelectric devices are formed by providing dividing grooves in a predetermine interval to the second acoustic matching layer passing through the first acoustic matching layer from the surface of a piezoelectric member fixed and disposed on the first acoustic matching layer.

4. An ultrasonic transducer according to Claim 2, wherein the transducer shape-formative member is a circular shape.

5. An ultrasonic transducer according to Claim 2, wherein the transducer shape-formative member is a partially cylindrical shape.

6. An ultrasonic transducer according to Claim 2, wherein the transducer shape-formative member is a flat plate shape.

7. An ultrasonic transducer comprising:

an acoustic matching layer including a layer made up of a hard material;
a piezoelectric member, fixed and disposed in a positional relation wherein part of the acoustic matching layer protrudes at a predetermined position of a hard layer making up the acoustic matching layer, providing one face side electrode and the other face side electrode on both flat surface portions to be divided into a plurality of piezoelectric devices in this disposed state; and
a transducer shape-formative member made up of a hard material, wherein, in a state in which the surfaces of the piezoelectric devices divided and formed are disposed on the inner circumferential surface side, the plurality of piezoelectric devices are arrayed in a predetermined shape, fixed and disposed on the surface where the piezoelectric devices of the acoustic matching layer protruding from the piezoelectric devices have been disposed,
and wherein, while a band-shaped electroconductive member in a predetermined width facing the electrode provided on the flat face portion of the piezoelectric member is provided at a predetermined position on the edge portion side of the acoustic matching layer in parallel with the piezoelectric member, an electroconductive portion is provided disposed on the transducer shape-formative member so as to face an electroconductive member extended from the piezoelectric member.

8. An ultrasonic transducer according to Claim 7, wherein at least one of electrical conductivity between the electrodes provided on the flat surface portions of the piezoelectric member and the band-shaped electroconductive member provided on the acoustic matching layer, and electrical conductivity between this electroconductive member and the electroconductive portion of the transducer shape-formative member, is performed by contact.

9. An ultrasonic transducer according to Claim 7, wherein at least one of electrical conductivity between the electrodes provided on the flat surface portions of the piezoelectric member and the band-shaped electroconductive member provided on the acoustic matching layer, and electrical conductivity between this electroconductive member and the electroconductive portion of the transducer shape-formative member, is performed through an electroconductive member.

10. An ultrasonic transducer comprising:

an acoustic matching layer including at least a layer made up of a hard material;
a piezoelectric member, fixed and disposed in a positional relation wherein part of the acoustic matching layer protrudes at a predetermined position of a hard layer making up the acoustic matching layer, providing one face side electrode and the other face side electrode on both flat surface portions to be divided into a plurality of piezoelectric devices in this disposed state; and
a transducer shape-formative member made up of a hard material, wherein, in a state in which the surfaces of the piezoelectric devices divided and formed are disposed on the inner circumferential surface side, the plurality of piezoelectric devices are arrayed in a predetermined shape, fixed and disposed on the surface where the piezoelectric devices of the acoustic matching layer protruding from the piezoelectric de-

vices have been disposed,
and wherein while a band-shaped electroconductive member in a predetermined width facing the electrode provided on the flat face portion of the piezoelectric member is provided at a predetermined position on the edge portion side of the acoustic matching layer in parallel with the piezoelectric-member, an electroconductive portion is provided disposed on the transducer shape-formative member so as to face an electroconductive member extended from the piezoelectric member.

11. An ultrasonic transducer according to Claim 10, wherein at least one of electrical conductivity between the electrodes provided on the flat surface portions of the piezoelectric member and the band-shaped electroconductive member provided on the acoustic matching layer, and electrical conductivity between this electroconductive member and the electroconductive portion of the transducer shape-formative member, is performed by contact.

12. An ultrasonic transducer according to Claim 10, wherein at least one of electrical conductivity between the electrodes provided on the flat surface portions of the piezoelectric member and the band-shaped electroconductive member provided on the acoustic matching layer, and electrical conductivity between this electroconductive member and the electroconductive portion of the transducer shape-formative member is performed through an electroconductive member.

13. An ultrasonic transducer according to Claim 12, wherein the electroconductive member is a brazing metal or solder, an electroconductive adhesive agent, or a conductive film.

14. An ultrasonic transducer comprising a plurality of piezoelectric devices arrayed on the circumference, and disposing an acoustic matching layer on one face side of the plurality of piezoelectric devices, and a backing member on the other face side;
wherein the backing member is configured of a layered member in a predetermined shape beforehand, which integrates the acoustic matching layer and the plurality of piezoelectric devices, this layered member is put in a turning state, a liquid resin mixed with filler is supplied to the layered member inner circumferential surface, is hardened in this turning state, and is integrally disposed as to the piezoelectric devices.

15. An ultrasonic transducer according to Claim 1, wherein the ultrasonic transducer is an array type.

16. An ultrasonic transducer according to Claim 2, wherein the ultrasonic transducer is an array type.

17. An ultrasonic transducer according to Claim 7, wherein the ultrasonic transducer is an array type.

18. An ultrasonic transducer according to Claim 10, wherein the ultrasonic transducer is an array type.

19. An ultrasonic transducer according to Claim 14, wherein the ultrasonic transducer is an array type.

20. A method for manufacturing an ultrasonic transducer comprising:

a process for forming an acoustic matching layer which layers at least a first acoustic matching layer made up of a hard material, and a second acoustic matching layer made up of a soft material;
a process for forming a layered member by fixing a predetermined-shaped piezoelectric member having electrodes on the first acoustic matching layer surface of the acoustic matching layer;
a process for providing a predetermined number of piezoelectric devices on the layered member by forming dividing grooves in a predetermined interval on the piezoelectric member;
a process for configuring the layered member in a predetermined shape by disposing a shape-formative member at a predetermined position of the layered member having a plurality of piezoelectric devices;
a process for putting the layered member formed in a predetermined shape in a turning state, and supplying a liquid resin mixed with filler on the layered member inner circumferential surface; and
a process for putting the layered member in a turning state for a predetermined period, and hardening the liquid resin supplied on the layered member inner circumferential surface.

21. A method for manufacturing an ultrasonic transducer according to Claim 20, wherein the ultrasonic transducer is an array type.

FIG.1

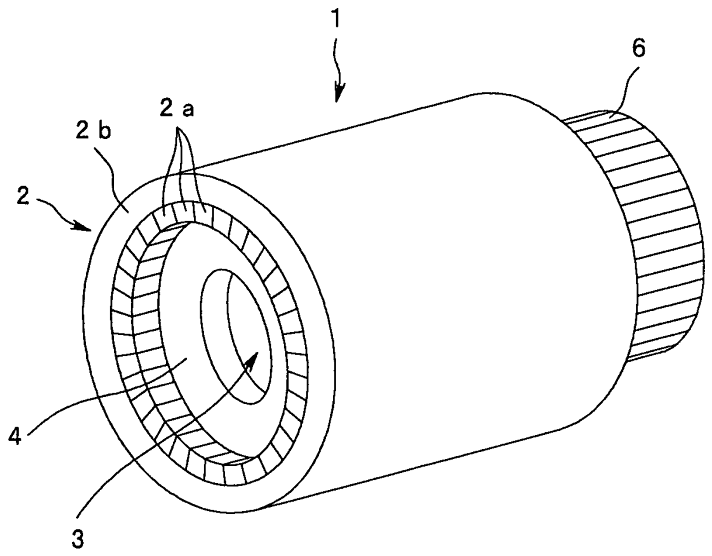


FIG.3

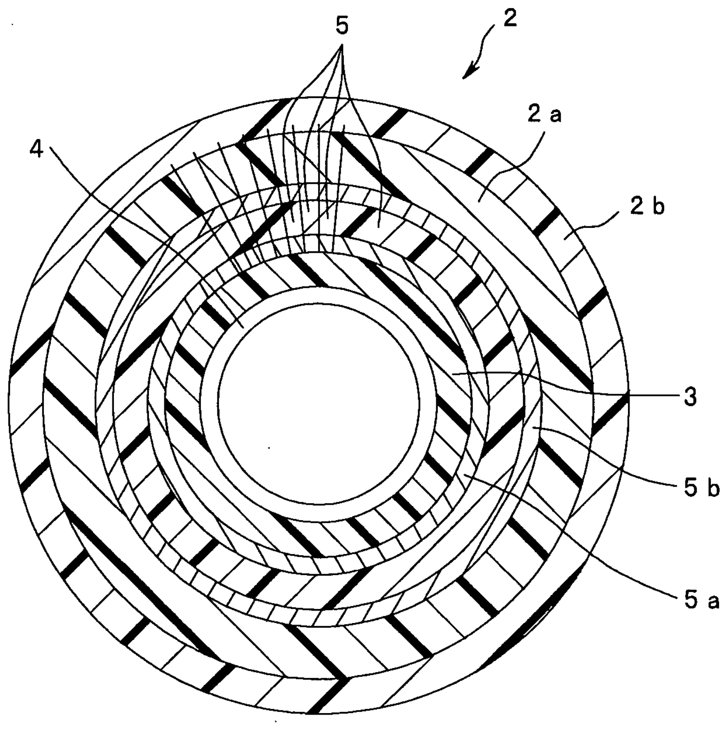


FIG.2A

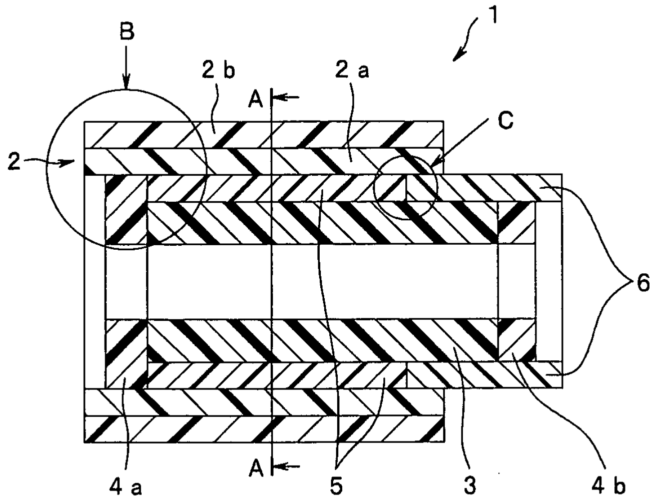


FIG.2B

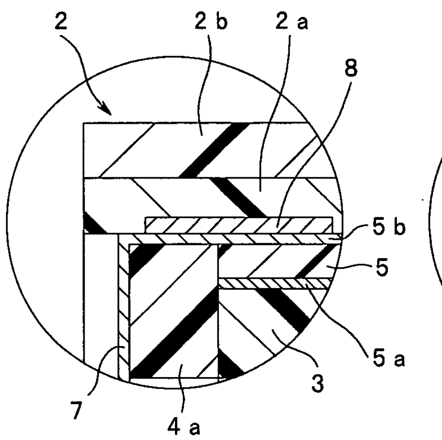


FIG.2C

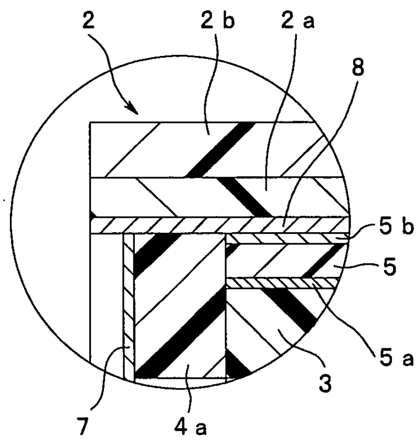


FIG.2D

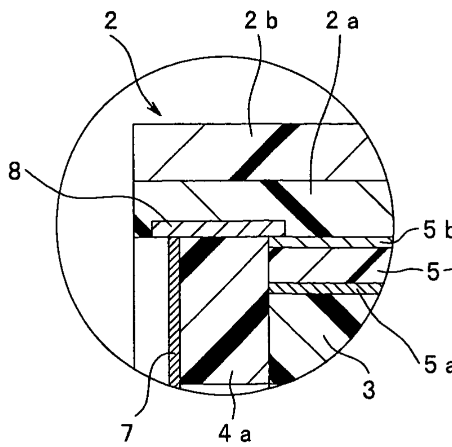


FIG.2E

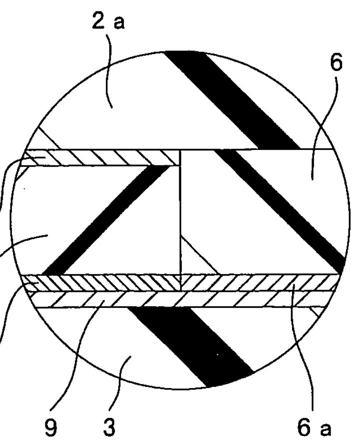


FIG.4A

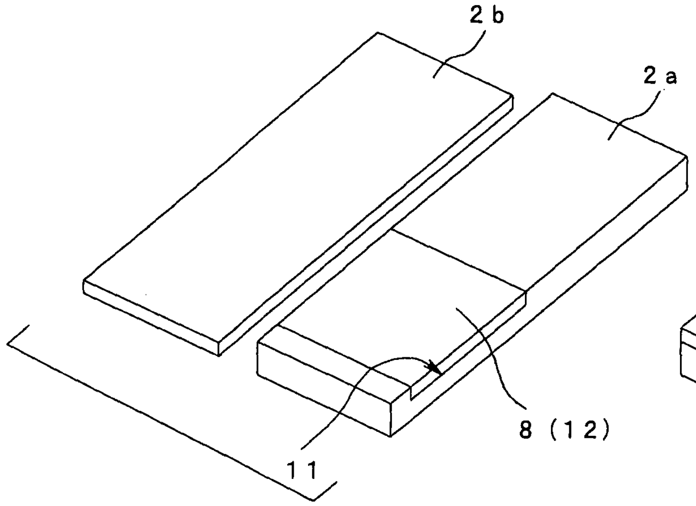


FIG.4B

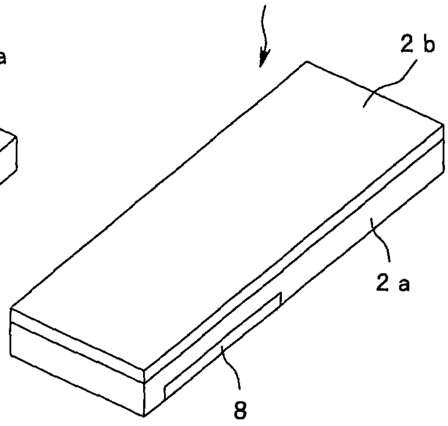


FIG.5A

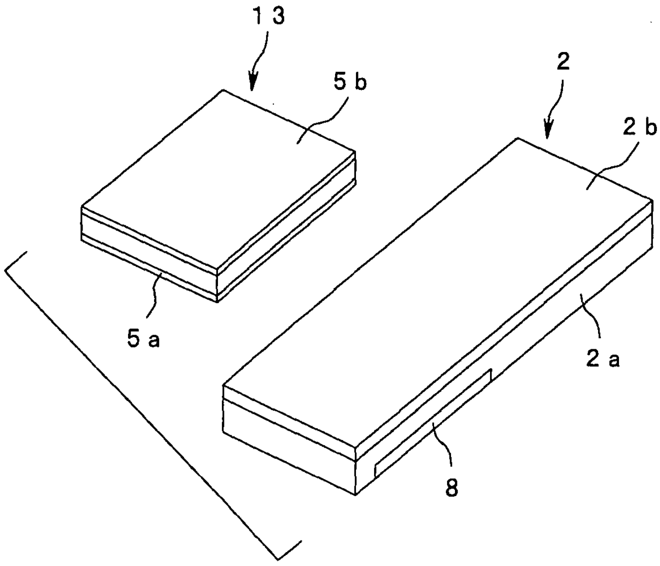


FIG.5B

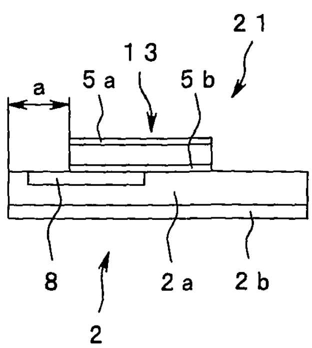


FIG.6A

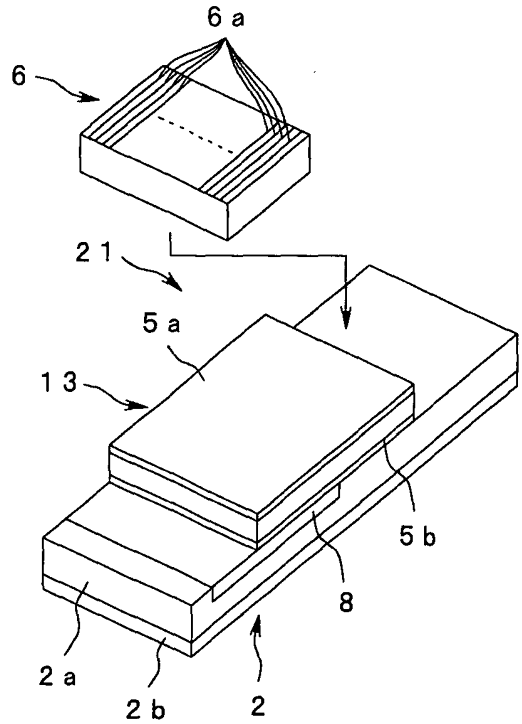


FIG.6B

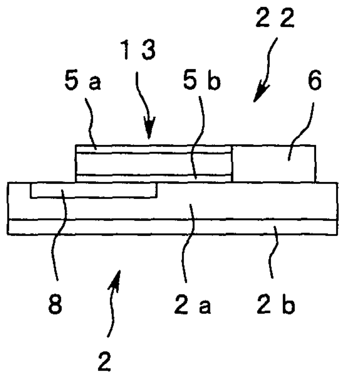


FIG.7

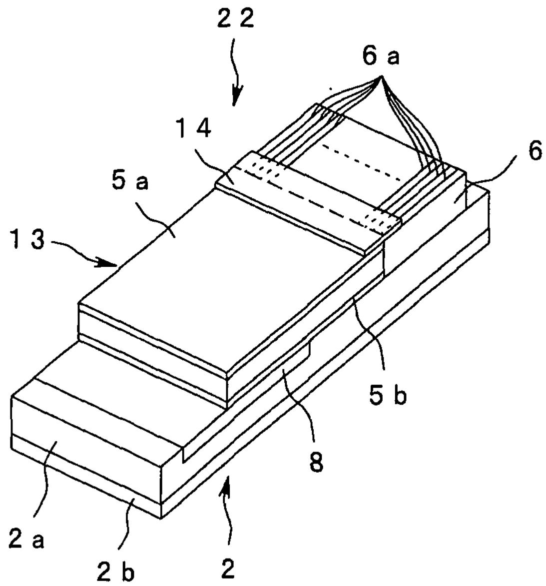


FIG.8A

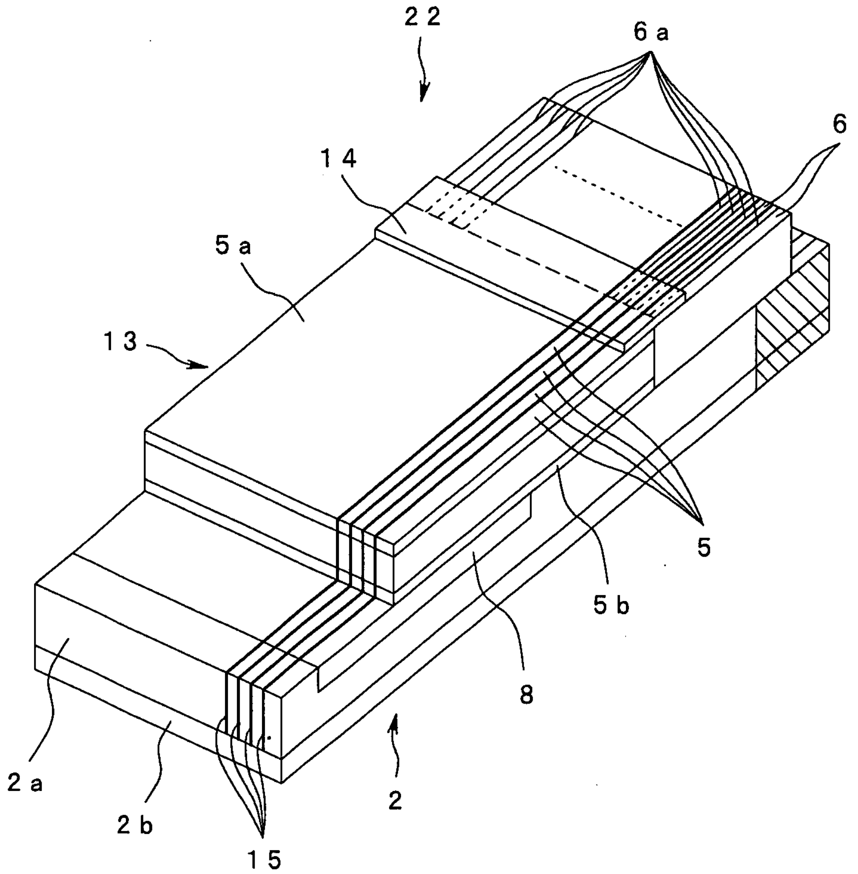


FIG.8B

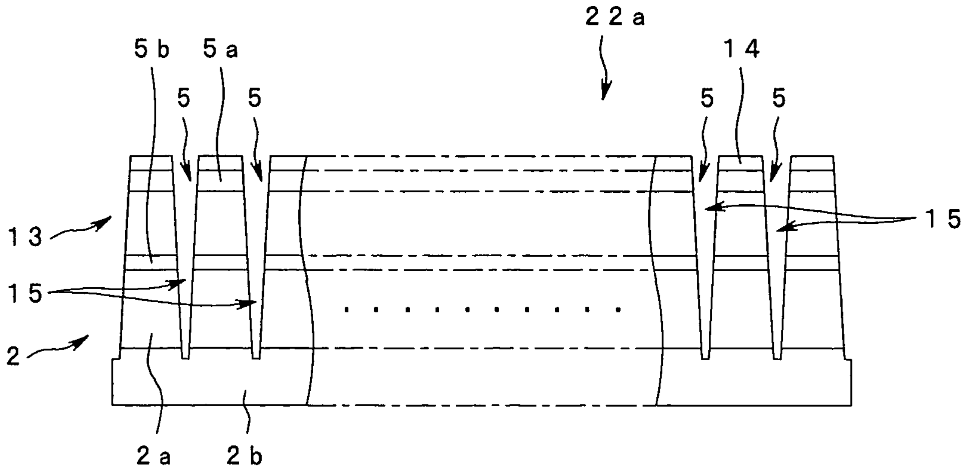


FIG.9

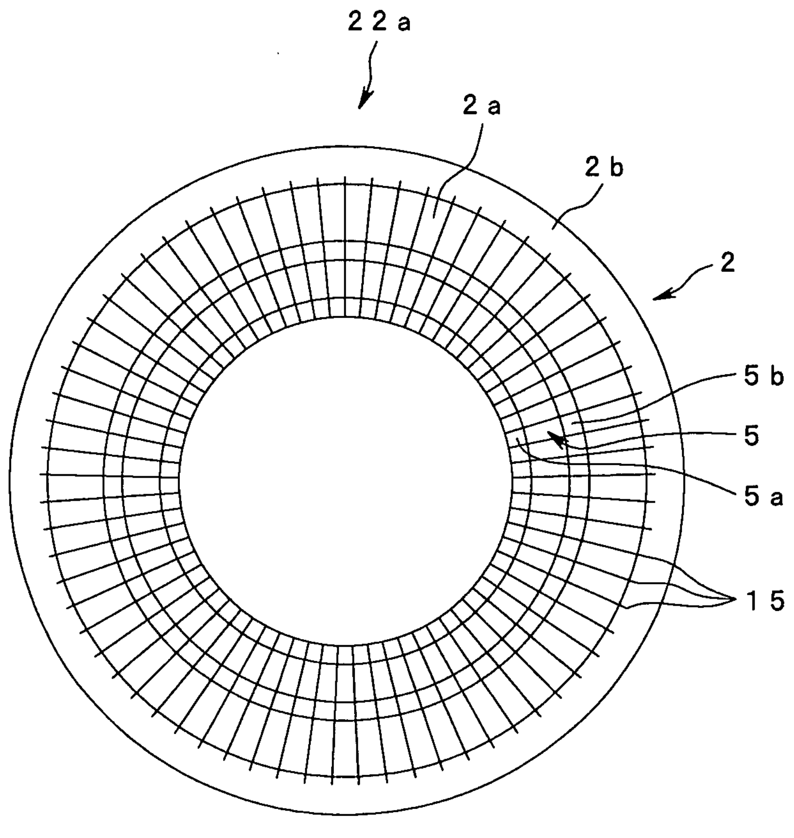


FIG.10A

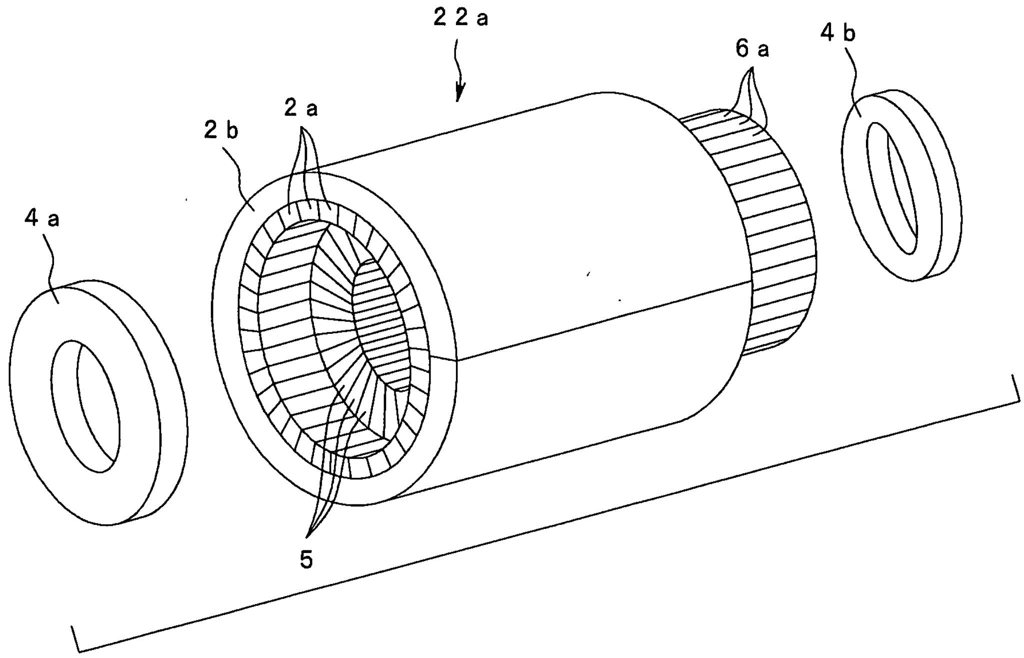


FIG.10B

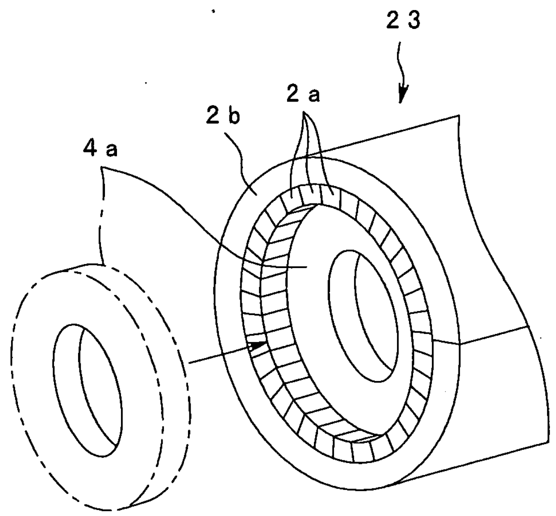


FIG.10C

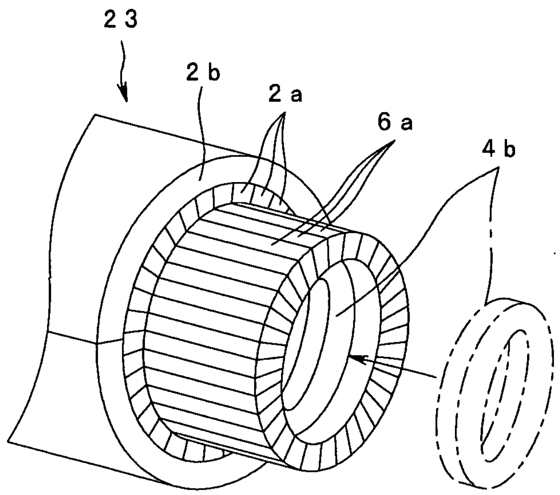


FIG.11A

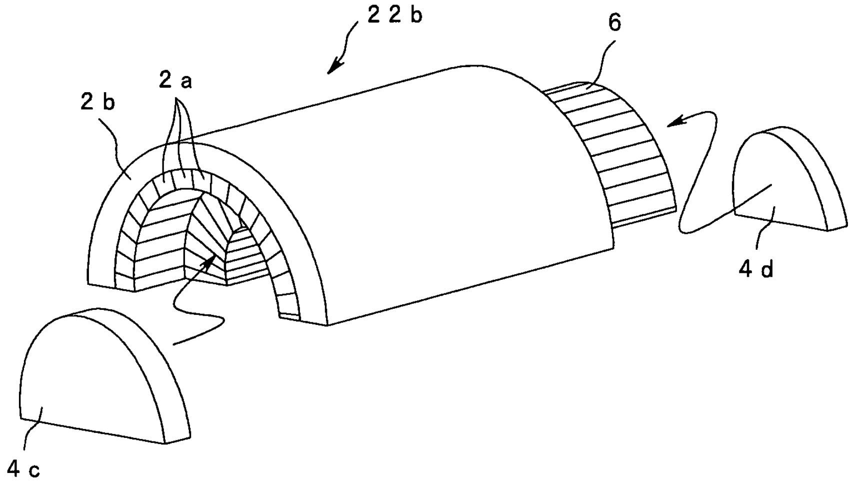


FIG.11B

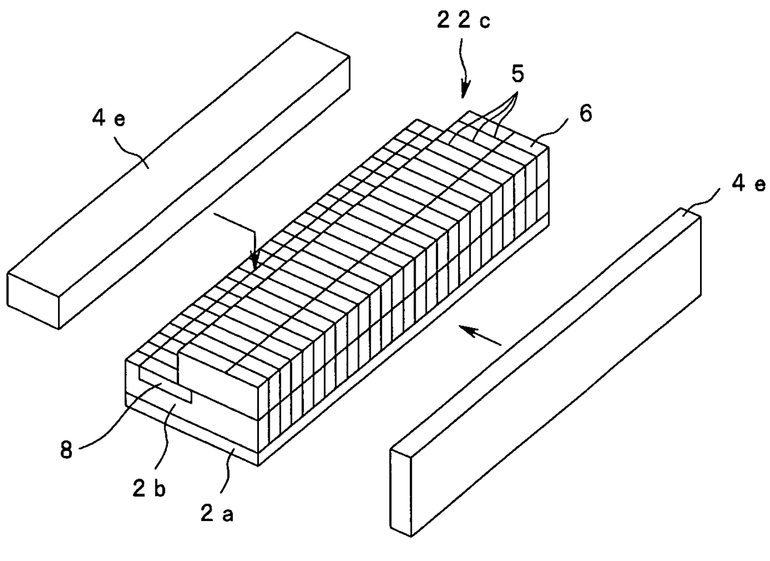


FIG.12

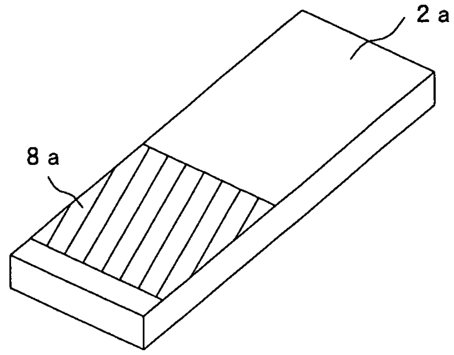


FIG.13

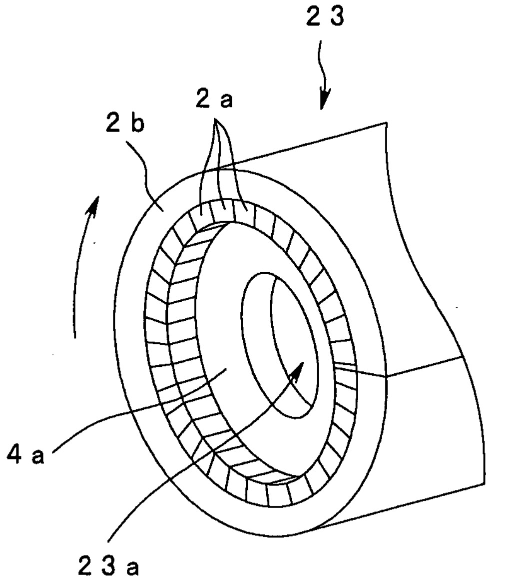


FIG.14

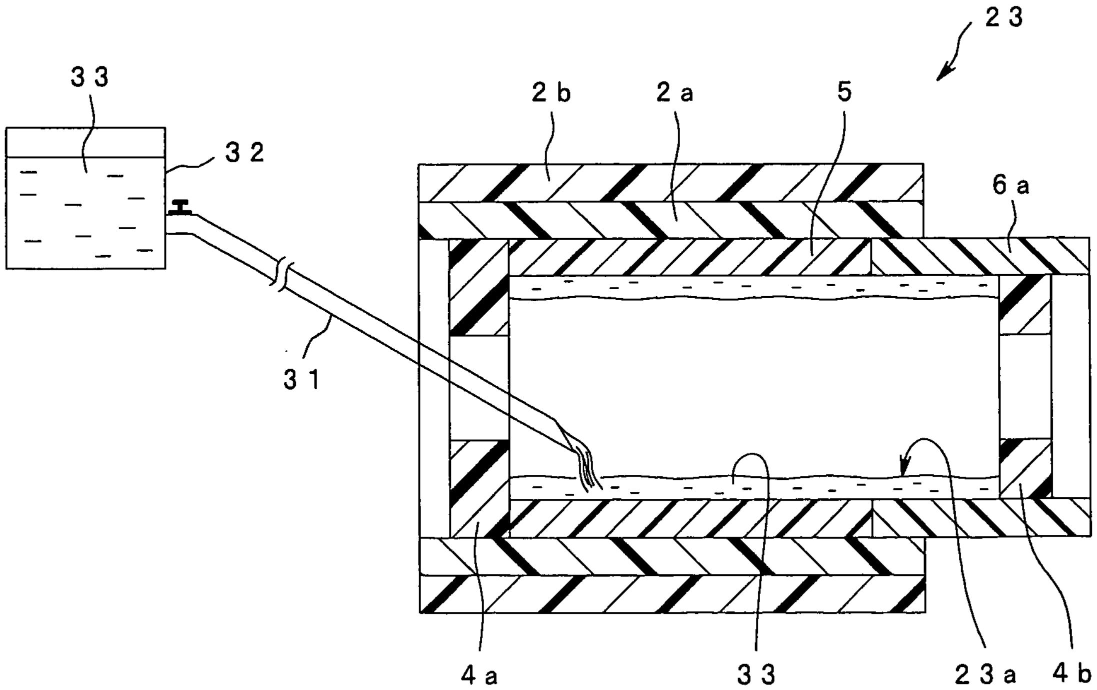


FIG.15

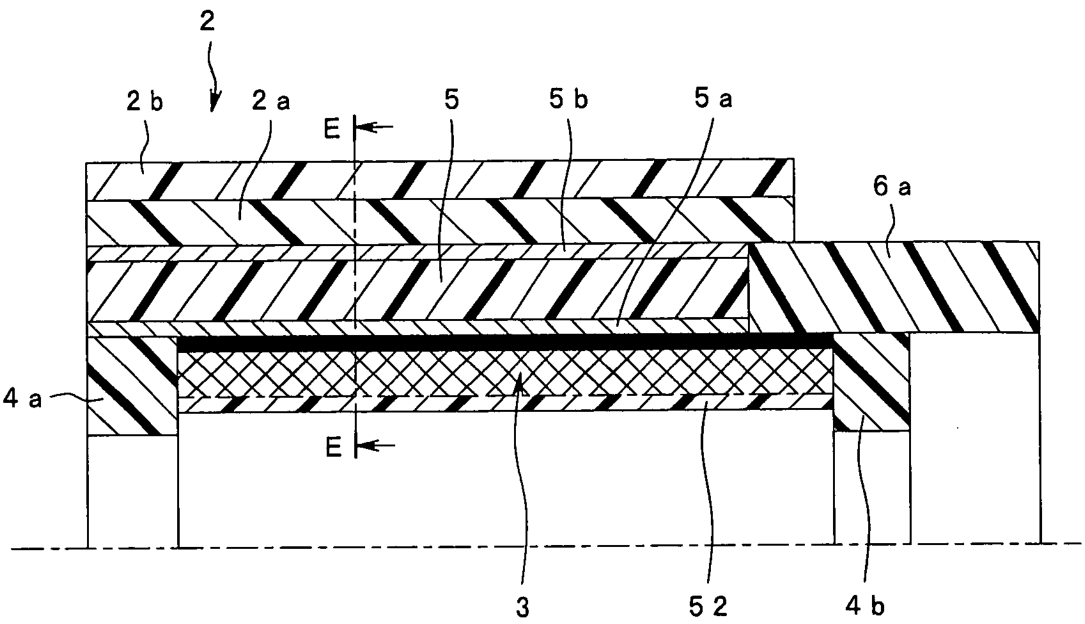


FIG.16

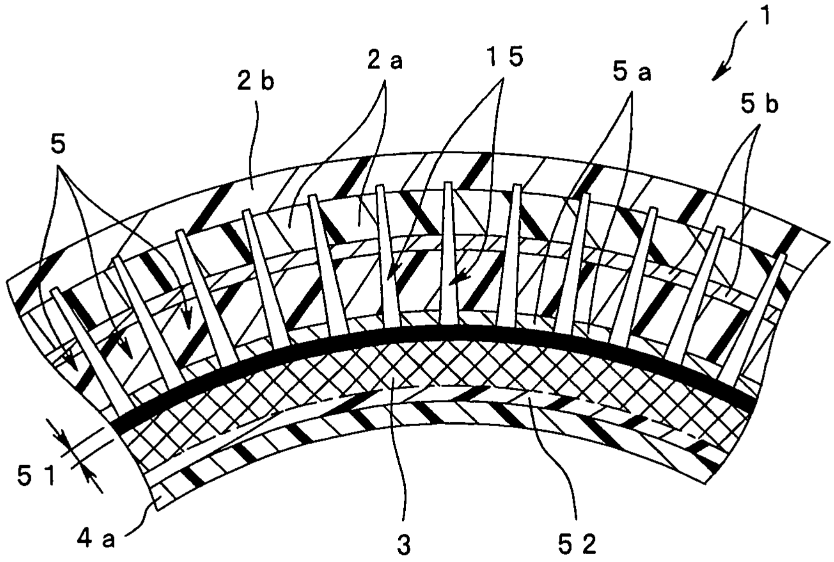


FIG.17A

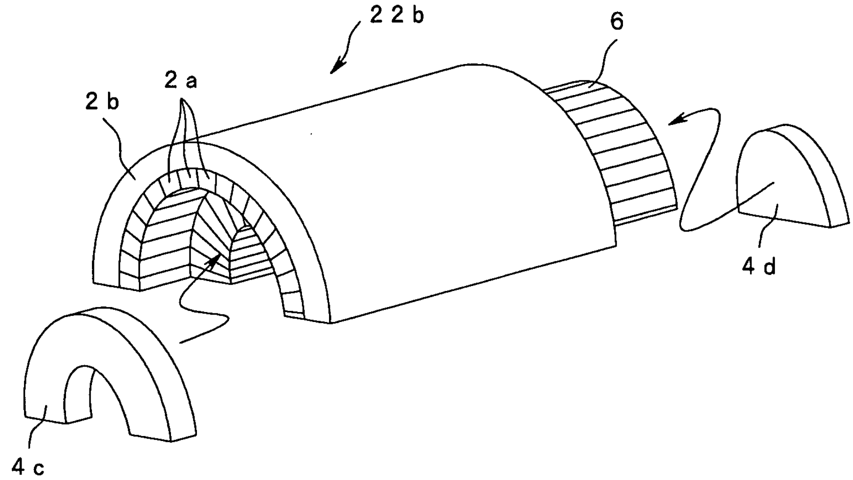


FIG.17B

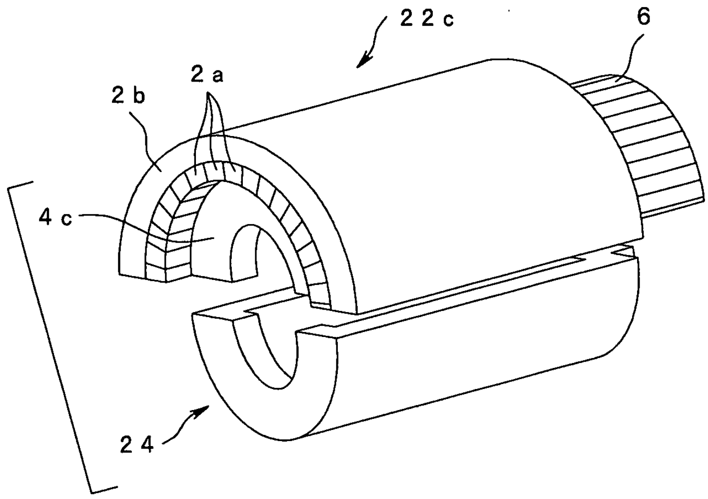
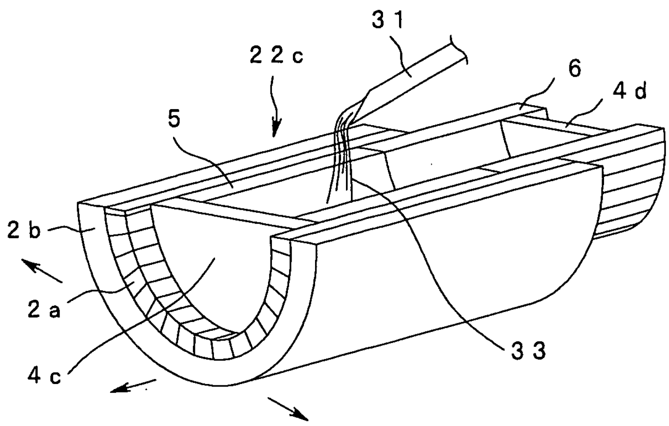


FIG.17C



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/004773

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] A61B8/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl[7] B61B8/00-8/15

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Toroku Jitsuyo Shinan Koho	1994-2004
Kokai Jitsuyo Shinan Koho	1971-2004	Jitsuyo Shinan Toroku Koho	1996-2004

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 11-501245 A (Endosonics Corp.), 02 February, 1999 (02.02.99), Full text; all drawings & WO 97/23865 A1	1,2,4-13, 15-18 3,14,19-21
Y A	JP 2002-336258 A (Hitachi Medical Corp.), 26 November, 2002 (26.11.02), Full text; all drawings (Family: none)	3 1,2,4-21
Y	JP 6-121389 A (Olympus Optical Co., Ltd.), 28 April, 1994 (28.04.94), Full text; all drawings (Family: none)	14,19-21

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 17 June, 2004 (17.06.04)	Date of mailing of the international search report 06 July, 2004 (06.07.04)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/004773

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 8-89505 A (Toshiba Corp.), 09 April, 1996 (09.04.96), Full text; all drawings & US 5810009 A	1-21
A	JP 2-271843 A (Olympus Optical Co., Ltd.), 06 November, 1990 (06.11.90), Full text; all drawings (Family: none)	1-21
A	JP 2000-115892 A (Olympus Optical Co., Ltd.), 21 April, 2000 (21.04.00), Full text; all drawings (Family: none)	14,19-21

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/004773

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

I. The invention of Claims 1 to 13, and 15 to 18 relates to an ultrasonic vibrator having a piezoelectric element with a length shorter than that of an acoustic matching layer and having a vibrator shape-forming member for fixing the piezoelectric element with the element arranged on the inner surface side.

(continued to extra sheet)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/004773

Continuation of Box No.III of continuation of first sheet(2)

II. The invention of Claims 14, and 19 to 21 relates to an ultrasonic vibrator produced by forming a laminated body, integrally having a piezoelectric element and an acoustic matching layer, into a predetermined shape and then, with the laminated body rotating, feeding liquid-like resin including a filler.

The two groups of the inventions are not a group of the inventions so linked as to form a single general inventive concept set forth in PCT Rule 13.2. As a consequence, Claims 1 to 21 do not satisfy the requirement of unity of invention.

Form PCT/ISA/210 (extra sheet) (January 2004)

专利名称(译)	超声波振动器及其制造方法		
公开(公告)号	EP1614389A1	公开(公告)日	2006-01-11
申请号	EP2004725148	申请日	2004-04-01
[标]申请(专利权)人(译)	奥林巴斯株式会社		
申请(专利权)人(译)	OLYMPUS CORPORATION		
当前申请(专利权)人(译)	OLYMPUS CORPORATION		
[标]发明人	SAWADA YUKIHIKO		
发明人	SAWADA, YUKIHIKO		
IPC分类号	A61B8/12 B06B1/06		
CPC分类号	B06B1/0633		
优先权	2003098213 2003-04-01 JP 2003098214 2003-04-01 JP 2003098215 2003-04-01 JP		
其他公开文献	EP1614389A4		
外部链接	Espacenet		

摘要(译)

一种超声换能器，包括：声匹配层，至少包括由硬质材料制成的层;长度尺寸比该声匹配层短的压电元件，其被固定并设置在由构成声匹配层的硬质材料构成的层的预定位置，并被分成多个压电装置处于这种处置状态;以及由硬质材料制成的换能器形状形成构件，其中，在分割和形成的压电装置的表面设置在内周表面侧的状态下，多个压电装置排列成预定形状固定并设置在已经设置从压电装置突出的声匹配层的压电装置的表面上。

FIG.1