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(54) **ULTRASONIC PROBE AND ULTRASONIC DIAGNOSTIC APPARATUS**

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(57) **ABSTRACT**

An ultrasonic probe includes: a support base; a rotation body which rotates while being supported by the support base; an ultrasonic oscillator which is disposed on an outer peripheral surface of the rotation body; and a rotary electric connector which is disposed to axially support the rotation body by the support base and exchanges electric signals with the ultrasonic oscillator, wherein the rotary electric connector includes: a rotary electrode which is bonded to the rotation body and rotates along with the rotation body, a fixed electrode which is bonded to the support base to face the rotary electrode and forms an annular guide groove in a rotation axis rotation in a region facing the rotary electrode, and a rotary contact member that is disposed inside the guide groove and rolls along the guide groove while contacting both the rotary electrode and the fixed electrode.

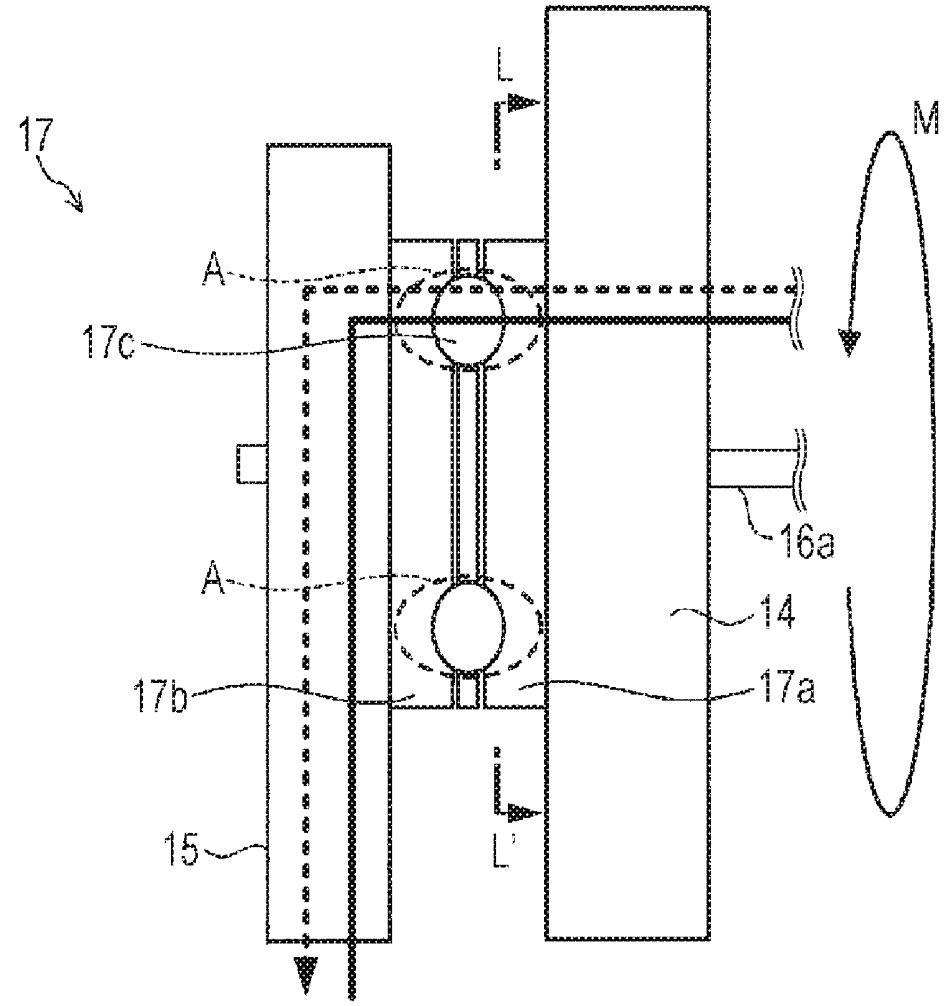


FIG. 1

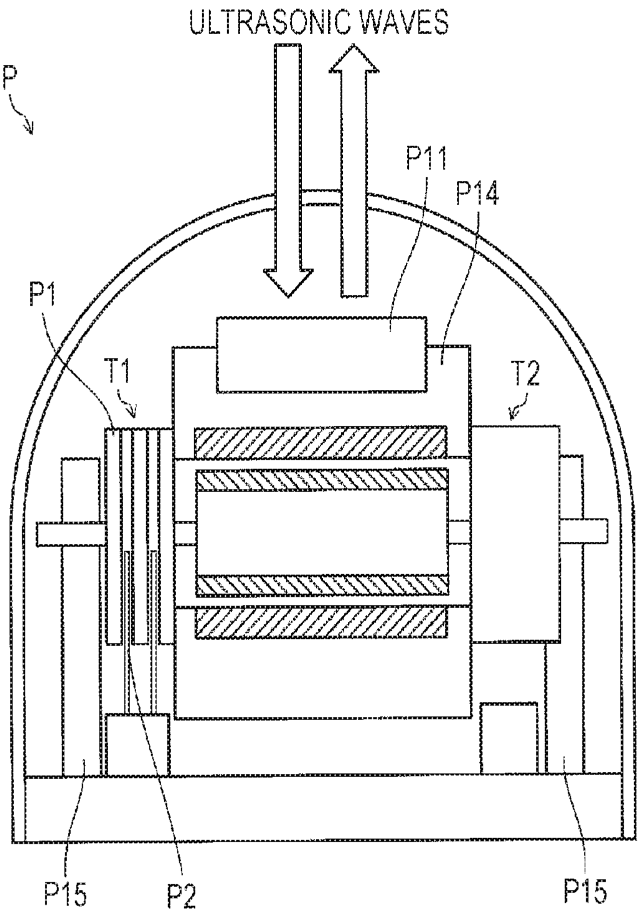


FIG. 2

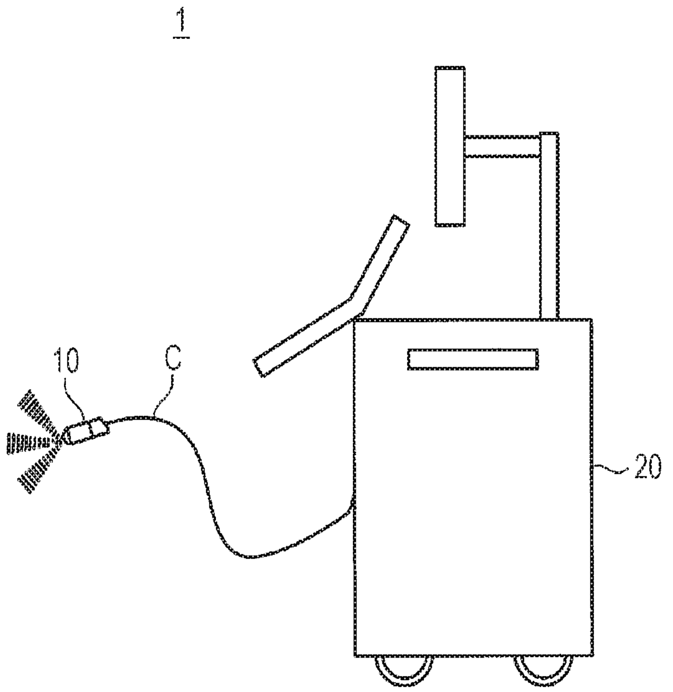


FIG. 3

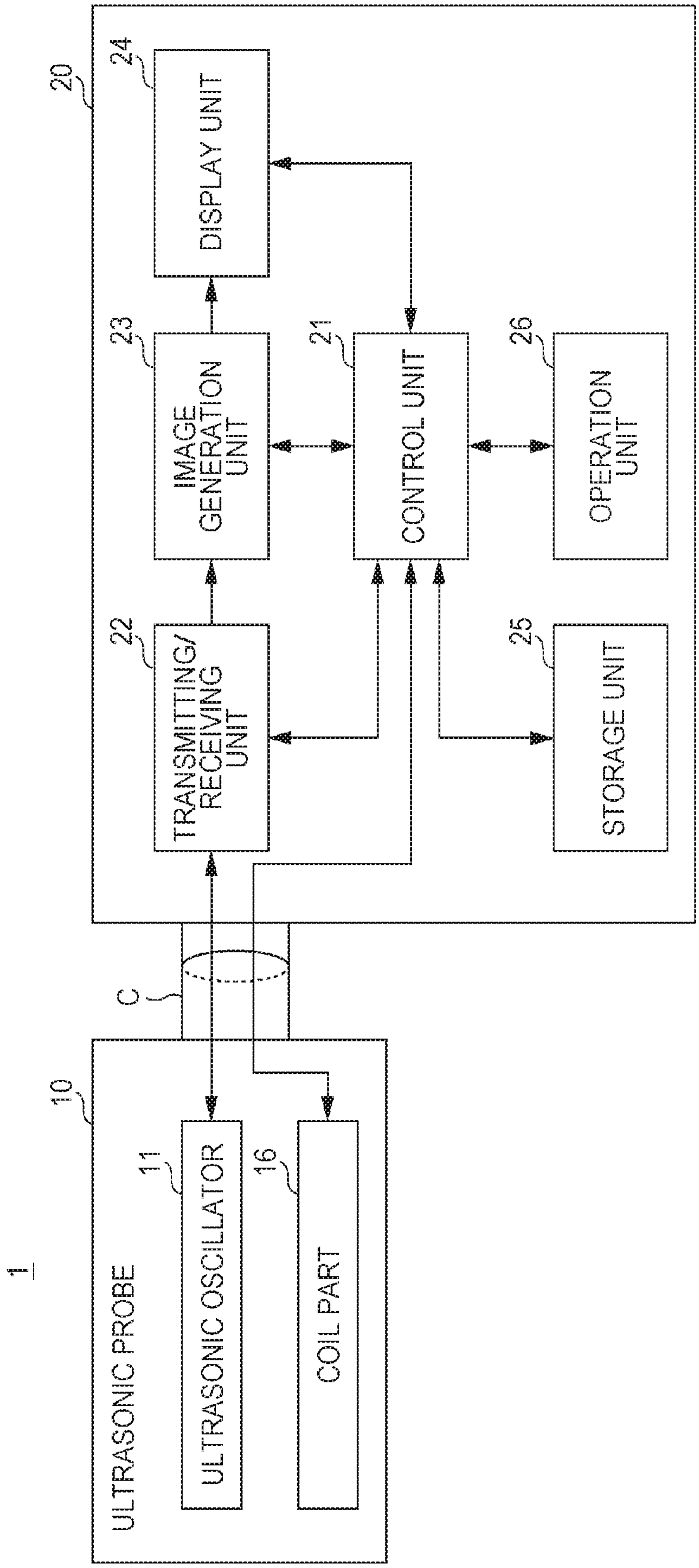

1
ULTRASONIC PROBE
10
ULTRASONIC OSCILLATOR
11
COIL PART
16
C
20
TRANSMITTING/ RECEIVING UNIT
22
IMAGE GENERATION UNIT
23
DISPLAY UNIT
24
CONTROL UNIT
21
OPERATION UNIT
26
STORAGE UNIT
25

FIG. 4

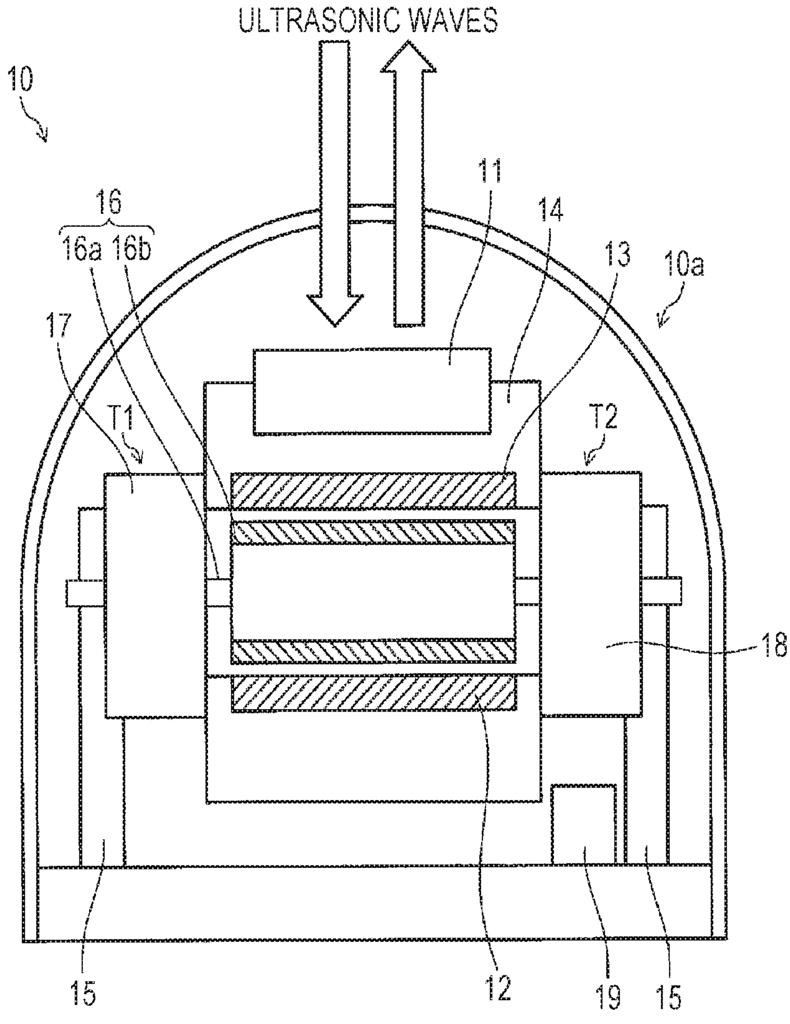

ULTRASONIC WAVES
10
16
16a
16b
11
14
13
10a
17
T1
T2
18
12
15
19
15

FIG. 5

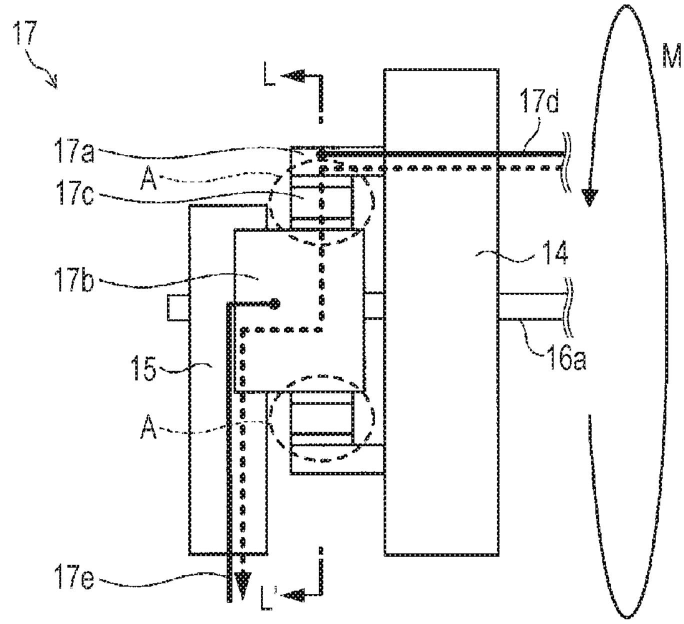


FIG. 6

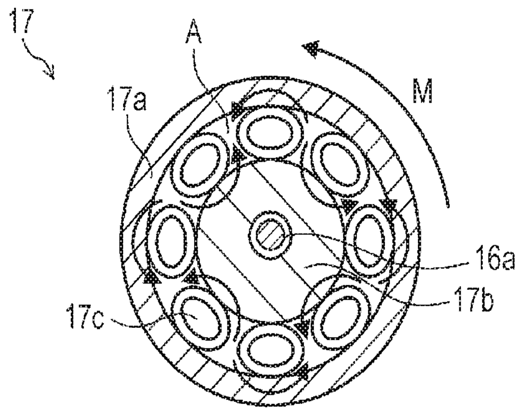


FIG. 7

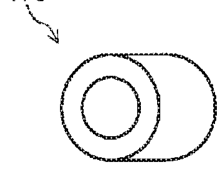


FIG. 8

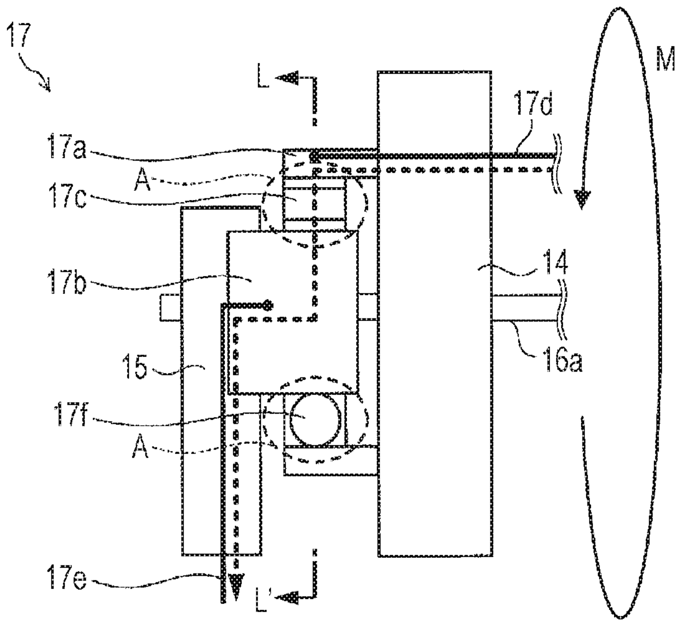

17
L
M
17d
17a
A
17c
14
17b
16a
15
17f
A
17e
L'

FIG. 9

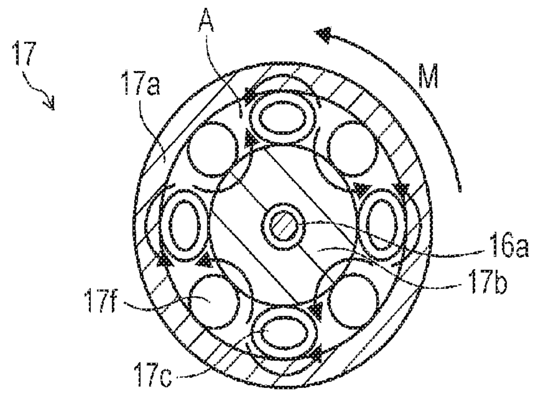

A
M
17
17a
16a
17b
17f
17c

FIG. 10

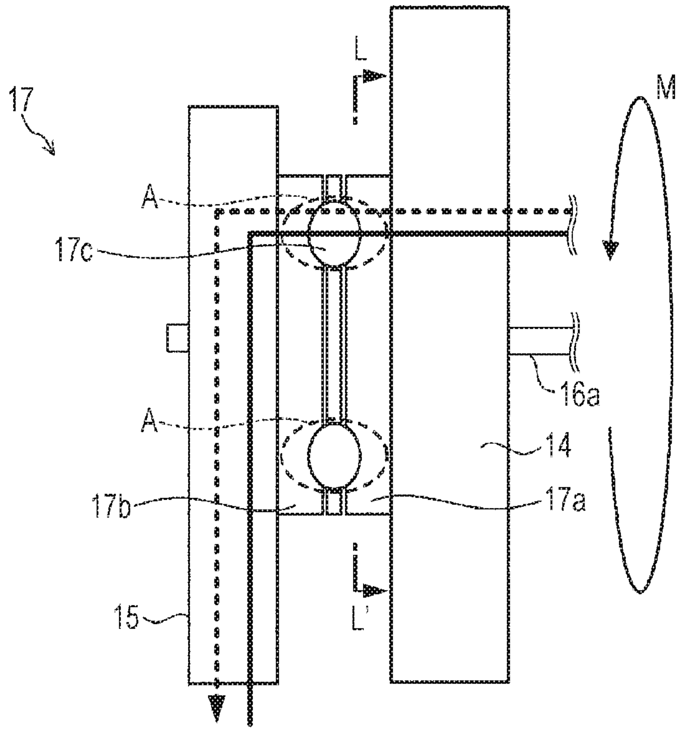


FIG. 11

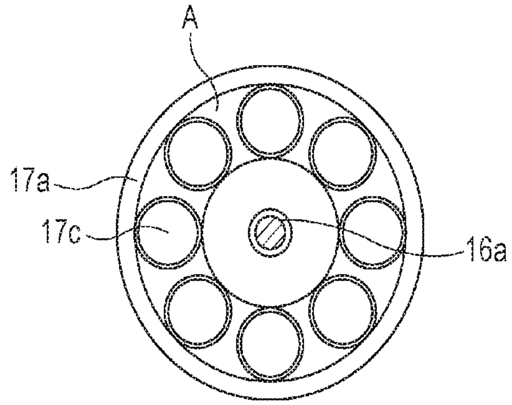


FIG. 12

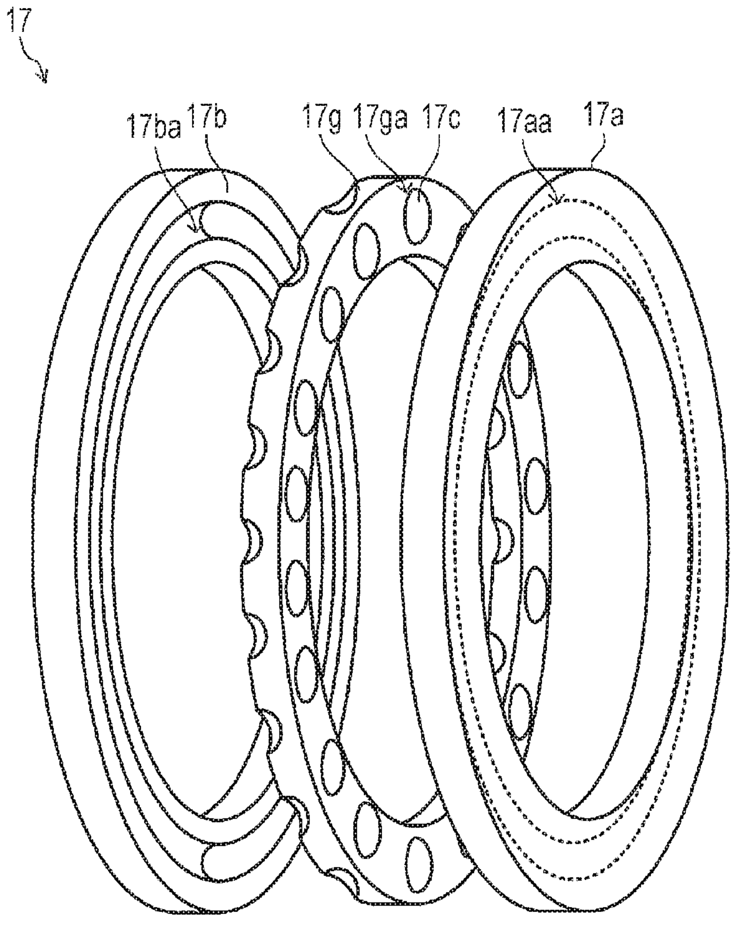


FIG. 13

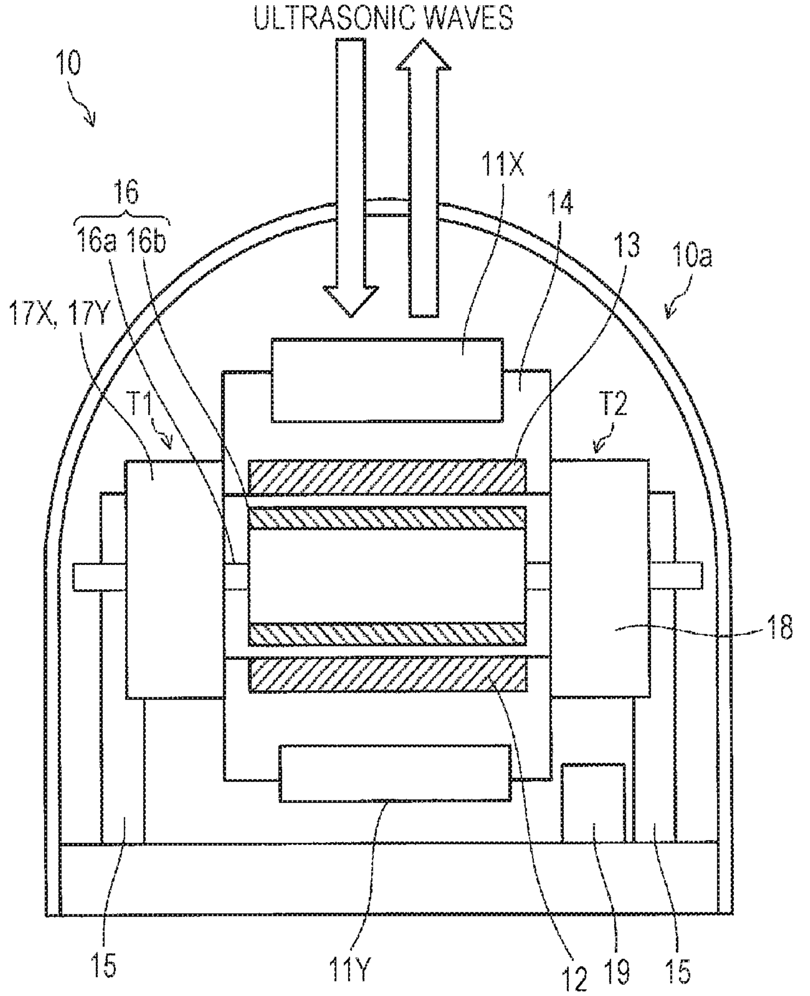

ULTRASONIC WAVES
10
11X
16
16a 16b
14
13
10a
17X, 17Y
T1
T2
18
15
11Y
12
19
15

FIG. 14

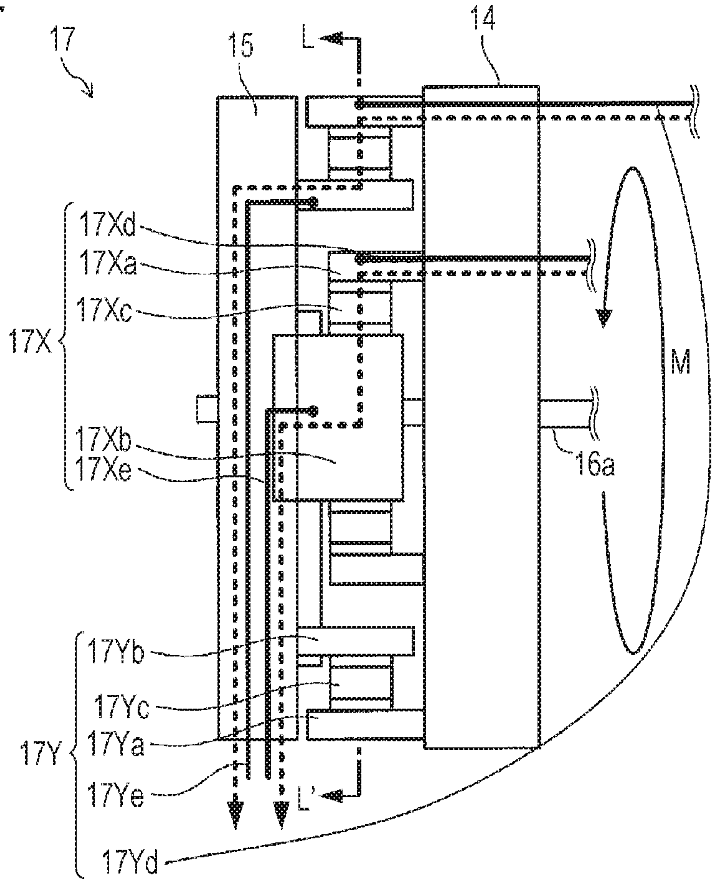

17
15
14
L
17Xd
17Xa
17Xc
17X
17Xb
17Xe
M
16a
17Yb
17Yc
17Ya
17Y
17Ye
L'
17Yd

FIG. 15

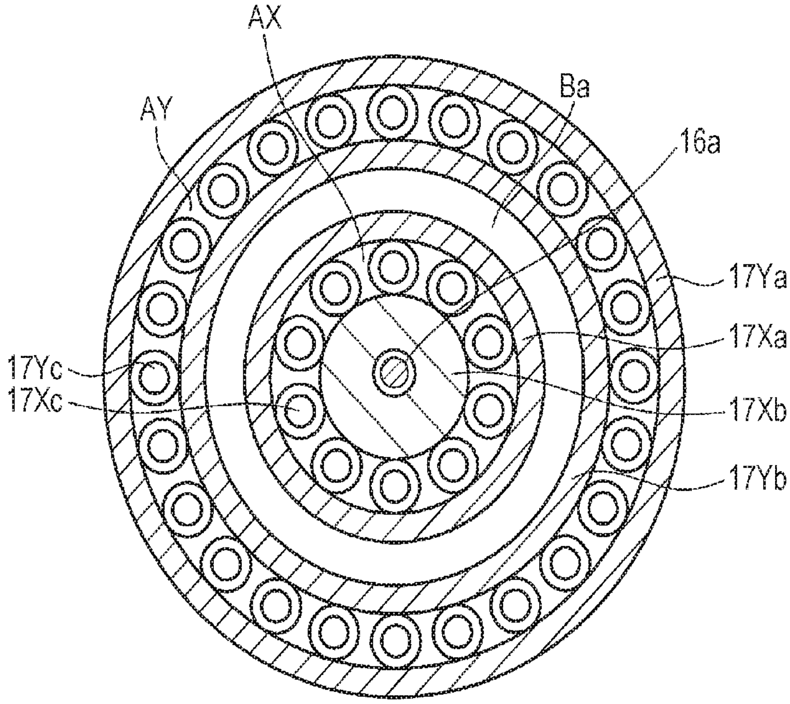

AX
Ba
AY
16a
17Ya
17Xa
17Yc
17Xc
17Xb
17Yb

FIG. 16

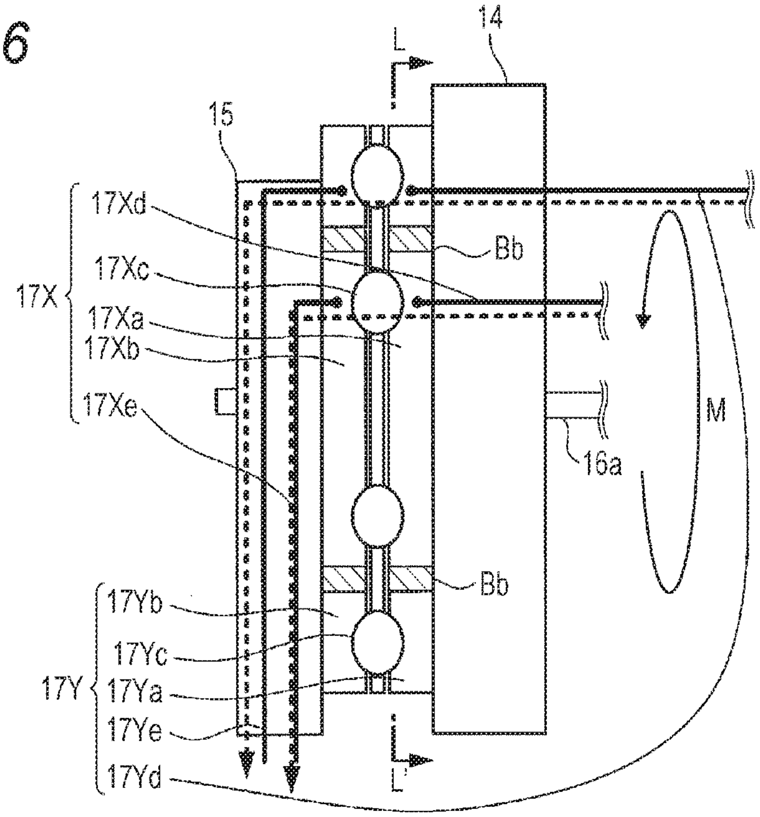
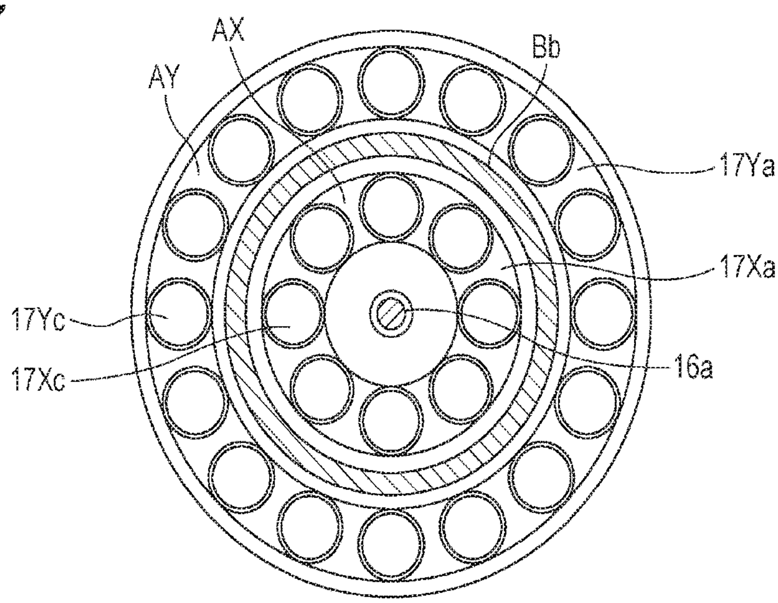

14
L
15
17Xd
Bb
17Xc
17X
17Xa
17Xb
17Xe
M
16a
Bb
17Yb
17Yc
17Y
17Ya
17Ye
L'
17Yd

FIG. 17


AX
Bb
AY
17Ya
17Xa
17Yc
16a
17Xc

ULTRASONIC PROBE AND ULTRASONIC DIAGNOSTIC APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application claims priority under 35 U.S.C. § 119 to Japanese Patent Application No. 2017-051265, filed on Mar. 16, 2017, the entire disclosure of which are incorporated herein by reference.

BACKGROUND

Technological Field

[0002] The present disclosure relates to an ultrasonic probe and an ultrasonic diagnostic apparatus.

Description of the Related Art

[0003] An ultrasonic probe capable of oscillating an ultrasonic oscillator using a motor is known (for example, see JP 2013-048802 A).

[0004] In general, an ultrasonic diagnostic apparatus transmits an ultrasonic beam from an ultrasonic oscillator disposed in an ultrasonic probe to a subject and forms an ultrasonic image based on receiving signals which are ultrasonic echoes. Then, when the ultrasonic oscillator is oscillated by using the motor as described above, a three-dimensional ultrasonic image can be generated or a two-dimensional ultrasonic image can be generated at various angles or positions.

[0005] FIG. **1** is a diagram showing a configuration of an ultrasonic probe P according to the related art.

[0006] A distal end of the ultrasonic probe P is liquid-tightly filled with a coupling liquid which is an audio transfer medium and an ultrasonic oscillator P**11** is disposed in the coupling liquid. Further, the ultrasonic oscillator P**11** is attached to a rotation body P**14** driven by a motor or the like in order to scan an interest region. Then, at the time of generating an ultrasonic image, the ultrasonic oscillator P**11** exchanges electric signals (for example, a receiving signal of an ultrasonic echo or a drive signal for transmitting an ultrasonic beam) with a main body of an ultrasonic diagnostic apparatus while rotating together with the rotation body P**14**.

[0007] In the ultrasonic probe P according to the related art, as a configuration for exchanging electric signals between the ultrasonic oscillator P**11** and a main body (not illustrated) of the ultrasonic diagnostic apparatus, a slip ring P**1** rotating together with the rotation body P**14** and a brush P**2** fixed to a support body P**15** are used.

[0008] More specifically, the brush P**2** comes into slidable contact with the slip ring P**1** and electric signals from the ultrasonic oscillator P**11** are transmitted to the outside through the slip ring P**1** and the brush P**2**. In other words, since the brush P**2** and the slip ring P**1** come into slidable contact with each other at all times, electric signals can be exchanged between the ultrasonic oscillator P**11** and the main body.

[0009] However, there is a case in which a slidable contact between the brush P**2** and the slip ring P**1** breaks momentarily. In this case, since the electric signals are not exchanged between the brush P**2** and the slip ring P**1**, for example, noises are superimposed on the receiving signals of the ultrasonic echo. Particularly, since the brush P**2** and the slip ring P**1** are disposed while being immersed into the coupling liquid, the coupling liquid flows into the slidable contact in response to the rotation of the rotation body P**14** so that a contact error may easily occur.

[0010] In addition, since the ultrasonic probe P according to the related art is used in a slipping manner while the brush P**2** is pressed against the slip ring P**1**, the brush P**2** or the slip ring P**1** is abraded at the slidable contact between the brush P**2** and the slip ring P**1**. As a result, since contact resistance changes with time, there is concern that electric signals cannot be reliably exchanged between the ultrasonic oscillator P**11** and the main body.

SUMMARY

[0011] The present disclosure has been made in view of the above-described problems, and an object of the present disclosure is to provide an ultrasonic probe and an ultrasonic diagnostic apparatus capable of more reliably exchanging electric signals with an ultrasonic oscillator while rotating the ultrasonic oscillator.

[0012] To achieve the abovementioned object, according to an aspect of the present invention, an ultrasonic probe reflecting one aspect of the present invention comprises:

[0013] a support base;

[0014] a rotation body which rotates while being supported by the support base;

[0015] an ultrasonic oscillator which is disposed on an outer peripheral surface of the rotation body; and

[0016] a rotary electric connector which is disposed to axially support the rotation body by the support base and exchanges electric signals with the ultrasonic oscillator,

[0017] wherein the rotary electric connector includes:

- **[0018]** a rotary electrode which is bonded to the rotation body and rotates along with the rotation body,
- **[0019]** a fixed electrode which is bonded to the support base to face the rotary electrode and forms an annular guide groove in a rotation axis rotation in a region facing the rotary electrode, and
- **[0020]** a rotary contact member that is disposed inside the guide groove and rolls along the guide groove while contacting both the rotary electrode and the fixed electrode in response to the rotation of the rotary electrode.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The advantages and features provided by one or more embodiments of the invention will become more fully understood from the detailed description given hereinbelow and the appended drawings which are given by way of illustration only, and thus are not intended as a definition of the limits of the present invention:

[0022] FIG. **1** is a diagram showing an example of a configuration of an ultrasonic probe according to the related art;

[0023] FIG. **2** is a diagram showing an appearance of an ultrasonic diagnostic apparatus according to a first embodiment;

[0024] FIG. **3** is a block diagram showing an example of an overall configuration of the ultrasonic diagnostic apparatus according to the first embodiment;

[0025] FIG. **4** is a diagram showing an example of a configuration of an ultrasonic probe according to the first embodiment;

[0026] FIG. **5** is a side view showing a rotary electric connector according to the first embodiment;

[0027] FIG. **6** is a cross-sectional view showing the rotary electric connector according to the first embodiment;

[0028] FIG. **7** is a diagram showing a rotary contact member of the rotary electric connector according to the first embodiment;

[0029] FIG. **8** is a side view showing a rotary electric connector according to a second embodiment;

[0030] FIG. **9** is a cross-sectional view showing the rotary electric connector according to the second embodiment;

[0031] FIG. **10** is a side view showing a rotary electric connector according to a third embodiment;

[0032] FIG. **11** is a cross-sectional view showing the rotary electric connector according to the third embodiment;

[0033] FIG. **12** is an exploded diagram showing the rotary electric connector according to the third embodiment;

[0034] FIG. **13** is a diagram showing an example of a configuration of an ultrasonic probe according to a fourth embodiment;

[0035] FIG. **14** is a side view showing a rotary electric connector according to the fourth embodiment;

[0036] FIG. **15** is a cross-sectional view showing the rotary electric connector according to the fourth embodiment;

[0037] FIG. **16** is a side view showing a rotary electric connector according to a fifth embodiment; and

[0038] FIG. **17** is a cross-sectional view showing the rotary electric connector according to the fifth embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

[0039] Hereinafter, one or more embodiments of the present invention will be described with reference to the drawings. However, the scope of the invention is not limited to the disclosed embodiments.

First Embodiment

[0040] Hereinafter, a configuration of an ultrasonic probe **10** according to a first embodiment will be described with reference to FIG. **2** to FIG. **6**. For example, as described above, the ultrasonic probe **10** according to the embodiment is applied to an ultrasonic diagnostic apparatus **1**.

[0041] [Configuration of Ultrasonic Diagnostic Apparatus]

[0042] FIG. **2** is a diagram showing an appearance of the ultrasonic diagnostic apparatus **1** according to the embodiment. FIG. **3** is a block diagram showing an example of an overall configuration of the ultrasonic diagnostic apparatus **1** according to the embodiment.

[0043] The ultrasonic diagnostic apparatus **1** according to the embodiment has a configuration in which the ultrasonic probe **10** is attached to a main body **20** of the ultrasonic diagnostic apparatus **1**. Further, the main body **20** and the ultrasonic probe **10** are electrically connected to each other via a cable C.

[0044] Further, the ultrasonic diagnostic apparatus **1** according to the embodiment may generate an arbitrary ultrasonic image such as a B-mode image, a color Doppler image, a three-dimensional ultrasonic image, or an M-mode image. Similarly, the ultrasonic probe **10** may be arbitrarily configured as a convex probe, a linear probe, a sector probe, or a three-dimensional probe.

[0045] The main body **20** of the ultrasonic diagnostic apparatus **1** includes a control unit **21**, a transmitting/receiving unit **22**, an image generation unit **23**, a display unit **24**, a storage unit **25**, and an operation unit **26**. Further, the ultrasonic probe **10** includes an ultrasonic oscillator **11**, a coil part **16**, and the like (a detailed configuration of the ultrasonic probe **10** will be described below).

[0046] The transmitting/receiving unit **22** is a drive circuit which transmits and receives ultrasonic waves by the ultrasonic oscillator **11** of the ultrasonic probe **10**. The transmitting/receiving unit **22** transmits a voltage pulse which is a drive signal to the ultrasonic oscillator **11** and receives an electric signal relating to an ultrasonic echo generated by the ultrasonic oscillator **11** under the control of the control unit **21**.

[0047] The image generation unit **23** generates an ultrasonic image (for example, a B-mode image, a color Doppler image, and a three-dimensional ultrasonic image) by performing predetermined signal processes (a logarithmic compression process, a detection process, an FFT analysis process, and the like) on the signal acquired from the transmitting/receiving unit **22**. Further, since the contents of the process for generating the ultrasonic image are known, a description thereof will be omitted.

[0048] The display unit **24** is, for example, a liquid crystal display or the like and displays the ultrasonic image generated by the image generation unit **23**.

[0049] The storage unit **25** is, for example, a memory such as a hard disk, a ROM, and a RAM and stores a control program or various data referred by the control unit **21** or image data generated by the image generation unit **23**.

[0050] The operation unit **26** is, for example, a keyboard or a mouse and acquires an operation signal input by an operator.

[0051] The control unit **21** generally controls all units by communicating with the units of the ultrasonic diagnostic apparatus **1**.

[0052] The control unit **21** controls, for example, the transmitting/receiving unit **22** and transmits and receives ultrasonic waves by the ultrasonic oscillator **11**. Further, the control unit **21** controls a drive motor by generating a three-phase AC current using an embedded inverter circuit or the like and supplying the current to the coil part **16** to rotate the ultrasonic oscillator **11**. In addition, the control unit **21** includes, for example, a central processing unit (CPU), a read only memory (ROM), and a random access memory (RAM) and performs each process under the control of a program.

[0053] Further, the main body **20** and the ultrasonic probe **10** of the ultrasonic diagnostic apparatus **1** are connected to each other via a cable C accommodating various wires therein. The cable C according to the embodiment accommodates a signal wire and a ground wire connected to the ultrasonic oscillator **11**, an electric control wire supplying electric power to the coil part **16**, and a signal wire transmitting a sensor signal of an encoder or the like and is connected to the main body **20**.

[0054] [Configuration of Ultrasonic Probe]

[0055] FIG. **4** is a diagram showing an example of a configuration of the ultrasonic probe **10** according to the embodiment. FIG. **4** shows a window portion **10*a*** at a distal end of the ultrasonic probe **10**.

[0056] The ultrasonic probe **10** includes the ultrasonic oscillator **11**, permanent magnets **12** and **13**, a rotation body

14, a support base 15, the coil part 16, rotary electric connectors 17 and 18, and a sensor unit 19 and accommodates these in a casing.

[0057] The window portion 10*a* of the ultrasonic probe 10 is attached to the distal end and keeps its inner space filled with a coupling liquid which is an audio transfer medium. Then, the ultrasonic oscillator 11 and the like (the ultrasonic oscillator 11, the permanent magnets 12 and 13, the rotation body 14, the support base 15, the coil part 16, the rotary electric connectors 17 and 18, and the sensor unit 19) are disposed inside the window portion 10*a* while being immersed into the coupling liquid. Further, a front surface of the window portion 10*a* is formed of a material that transmits ultrasonic waves in order to transmit and receive ultrasonic waves by the ultrasonic oscillator 11.

[0058] The ultrasonic oscillator 11 is a simple transducer or transducer array and includes, for example, one or a plurality of piezoelectric elements. The ultrasonic oscillator 11 converts a voltage pulse into an ultrasonic beam and transmits the ultrasonic beam to a subject. At the same time, an ultrasonic echo reflected inside the subject is acquired and is converted into an electric signal. Accordingly, the ultrasonic oscillator 11 performs such an operation while rotating along with the rotation body 14 and scans a target region inside the subject.

[0059] A signal wire 17*d* (see FIG. 5) and a ground wire (not illustrated) are connected to the ultrasonic oscillator 11 and the ultrasonic oscillator 11 exchanges electric signals with the transmitting/receiving unit 22 of the main body 20 via the signal wire 17*d* and is ground-connected to the main body 20 via a ground wire.

[0060] Further, the other end of the signal wire 17*d* connected to the ultrasonic oscillator 11 is connected to the rotary electrode of the rotary electric connector 17. Then, the ultrasonic oscillator 11 exchanges electric signals with the main body 20 via a signal wire, a rotary electric connector 17, and a lead wire from the rotary electric connector 17. Further, the other end of the ground wire connected to the ultrasonic oscillator 11 is connected to the rotary electrode of the rotary electric connector 18. Then, the ultrasonic oscillator 11 is ground-connected to the main body 20 via a ground wire, the rotary electric connector 18, and a lead wire from the rotary electric connector 18 (described later with reference to FIG. 5).

[0061] The ultrasonic oscillator 11 is disposed on the outer peripheral surface of the rotation body 14 and rotates along with the rotation body 14.

[0062] The rotation body 14 is rotated while being supported by the support base 15 by a drive force of a motor (here, the motor includes the permanent magnets 12 and 13 and the coil part 16).

[0063] The rotation body 14 is rotatably supported by bearing portions T1 and T2 (here, the rotary electric connectors 17 and 18) at both sides of the support base 15. The rotation body 14 has, for example, a cylindrical shape and the permanent magnets 12 and 13 are disposed on the cylindrical inner peripheral surface to face each other with a hollow region interposed therebetween. Further, the coil part 16 is disposed in the cylindrical hollow region of the rotation body 14.

[0064] The permanent magnets 12 and 13 are disposed so that both facing surfaces have opposite polarities, that is, one permanent magnet faces an N pole inside the cylindrical hollow region and the other permanent magnet faces an S pole inside the cylindrical hollow region.

[0065] The support base 15 rotatably supports the rotation body 14. The support base 15 is disposed to sandwich the rotation body 14 from both sides while being fixed to the casing of the ultrasonic probe 10. The rotary electric connectors 17 and 18 are respectively disposed at the bearing portions T1 and T2 on both sides of the support base 15 and the bearing portions T1 and T2 according to the embodiment are formed as the rotary electric connectors 17 and 18. Here, the bearing portions T1 and T2 may be additionally provided with other bearing mechanisms other than the rotary electric connectors 17 and 18.

[0066] The coil part 16 includes a shaft 16*a* which is bonded to the bearing portions T1 and T2 on both sides of the support base 15 and a coil 16*b* for three phases (U, V, and W phases) wound on the shaft 16*a*. Then, the three-phase coil 16*b* is wound by shifting the positions around the shaft 16*a* in the extension direction and motor drive wires are respectively connected to the three-phase coils. Then, the three-phase coil 16*b* forms a rotation magnetic field around the shaft 16*a* in the extension direction by the three-phase AC power supplied thereto. In addition, the three-phase coil 16*b* is disposed to face the permanent magnets 12 and 13 with a gap interposed therebetween and applies a rotation magnetic field to the permanent magnets 12 and 13.

[0067] Further, the supply of the three-phase AC power to the coil part 16 is controlled by, for example, the control unit 21 of the main body 20. The control unit 21 servo-controls the rotation body 14 based on, for example, a sensor signal from the sensor unit 19.

[0068] The sensor unit 19 detects the rotation position of the rotation body 14. The sensor unit 19 is, for example, a rotary encoder and detects the rotation position of the rotation body 14 by detecting a magnetic field generated by a permanent magnet (not illustrated) for a sensor disposed on the rotation body 14 using a Hall element. The sensor signal of the sensor unit 19 is transmitted to, for example, the control unit 21 of the main body 20.

[0069] As described above, in the ultrasonic probe 10 according to the embodiment, an outer rotor rotation type brushless DC motor which rotates the rotation body 14 includes the permanent magnets 12 and 13 and the coil part 16. Here, a mechanism which rotates the rotation body 14 may be of an arbitrary drive type.

[0070] The rotary electric connectors 17 and 18 are connectors for exchanging electric signals with the ultrasonic oscillator 11 disposed on the rotation body 14. Further, the rotary electric connectors 17 and 18 according to the embodiment rotatably support the rotation body 14 in the bearing portions T1 and T2 on both sides of the support base 15.

[0071] Further, the left rotary electric connector 17 of FIG. 4 is provided to exchange electric signals between the ultrasonic oscillator 11 and the transmitting/receiving unit 22 of the main body 20 and the right rotary electric connector 18 of FIG. 4 is provided to ensure the ground of the ultrasonic oscillator 11. Since the rotary electric connector 17 and the rotary electric connector 18 have the same configuration, only the rotary electric connector 17 will be described below.

[0072] Here, the ground of the ultrasonic oscillator 11 may be formed at the rotation body 14 itself and in that case, the rotary electric connector 18 is not necessary. In that case, a bearing may be disposed at the bearing portion T**1** of the support base **15** instead of the rotary electric connector **18**. Meanwhile, a bearing may be provided at the bearing portions T**1** and T**2** on both sides of the support base **15** along with the rotary electric connectors **17** and **18** in order to smoothly rotate the rotation body **14**.

[0073] [Configuration of Rotary Electric Connector]

[0074] Next, a configuration of the rotary electric connector **17** according to the embodiment and a structure in which the ultrasonic oscillator **11** exchange electric signals with the main body **20** using the rotary electric connector **17** will be described with reference to FIG. **5** to FIG. **7**.

[0075] FIG. **5** is a diagram showing an example of a configuration of the rotary electric connector **17**. FIG. **6** is a cross-sectional view taken along a line L-L' of FIG. **5**. FIG. **7** is a diagram showing a rotary contact member **17***c* of the rotary electric connector **17**.

[0076] Hereinafter, a description will be made on the assumption that a coordinate axis which connects the rotation center position of the rotation body **14** in a linear shape will be referred to as a "rotation axis" and a direction in which the rotation body **14** rotates about the rotation axis will be referred to as a "rotation axis rotation M".

[0077] The rotary electric connector **17** includes the rotary electrode **17***a*, the fixed electrode **17***b*, and the rotary contact member **17***c*.

[0078] The rotary electrode **17***a* is an electrode member that is bonded to the rotation body **14** so that its rotation axis is the same as the rotation axis of the rotation body **14** and rotates along with the rotation body **14**. The rotary electrode **17***a* is formed in, for example, a cylindrical shape and is bonded to a disc surface at one end side of the cylindrical rotation body **14**.

[0079] The fixed electrode **17***b* is an electrode member that is bonded to the support base **15**. The fixed electrode **17***b* is disposed inside a hollow region of the rotary electrode **17***a*. The fixed electrode **17***b* is formed in, for example, a cylindrical shape having a diameter smaller than the diameter of the inner periphery of the rotary electrode **17***a*.

[0080] In other words, in the rotary electric connectors **17**, one rotary electric connector is a center member disposed at the inside in the radial direction in the rotation axis rotation M of the rotation body **14**, the other rotary electric connector is an outer peripheral member disposed at the outside in the radial direction in the rotation axis rotation M of the rotation body **14**, and the outer peripheral member at the other side surrounds the outer peripheral surface of the center member at one side. Additionally, in the embodiment, the fixed electrode **17***b* is set as the center member and the rotary electrode **17***a* is set as the outer peripheral member. In contrast, the fixed electrode **17***b* may be set as the outer peripheral member and the rotary electrode **17***a* may be set as the center member.

[0081] The outer peripheral surface of the fixed electrode **17***b* and the inner peripheral surface of the rotary electrode **17***a* face each other while being separated from each other to form an annular guide groove A in the rotation axis rotation M. Then, the rotary contact member **17***c* which electrically connects the rotary electrode **17***a* and the fixed electrode **17***b* to each other is disposed inside the annular guide groove A.

[0082] The rotary contact member **17***c* exchanges electric signals between the rotary electrode **17***a* and the fixed electrode **17***b*. The rotary contact member **17***c* is an electrode member having a columnar, spherical, or conical shape (in the embodiment, a columnar shape) and the rotary electrode **17***a* and the fixed electrode **17***b* are disposed in the annular guide groove A to rotate while contacting each other. In other words, the rotary contact member **17***c* serves as a rolling body of a roller bearing between the rotary electrode **17***a* and the fixed electrode **17***b*. In addition, the rotary contact member **17***c* is formed so that its diameter is larger than a groove width of the annular guide groove A.

[0083] The rotary contact member **17***c* according to the embodiment is formed by applying a conductive metal material onto a surface of an elastically deformable member (for example, a rubber member). Here, the rotary contact member **17***c* may be formed of an elastic conductive material (for example, a rubber member having a conductive particle). In this way, the rotary contact member **17***c* is formed as the elastic member. Thus, at the time of rotating the rotary electrode **17***a*, the rotary contact member **17***c* rolls while being elastically deformed inside the annular guide groove A to contact both the rotary electrode **17***a* and the fixed electrode **17***b* at all times. Accordingly, the rotary contact member **17***c* can ensure a large contact area with the rotary electrode **17***a* and the fixed electrode **17***b*.

[0084] Further, in the embodiment, a plurality of the rotary contact members **17***c* (in the embodiment, eight rotary contact members **17***c*) are laid in the annular guide groove A to be adjacent to each other.

[0085] If the rotary electric connector **17** includes only one rotary contact member **17***c*, the rotary contact member **17***c* is elastically deformed when rolling in the annular guide groove A. Accordingly, since the rotation axis of the rotation body **14** is displaced vertically and laterally, there is concern that the ultrasonic wave transmitting/receiving direction of the ultrasonic oscillator **11** may change. In this regard, since the plurality of rotary contact members **17***c* are disposed in the guide groove A, the rotary electrode **17***a* are urged toward the reference position of the fixed electrode **17***b*, that is, the reference position of the rotation axis of the rotation body **14** at all times by the elastic force of the plurality of rotary contact members **17***c*. As a result, the displacement of the rotation axis is suppressed.

[0086] Further, the rotary electrode **17***a* is connected to the ultrasonic oscillator **11** via the signal wire **17***d* and the fixed electrode **17***b* is connected to the main body **20** via the lead wire **17***e*. That is, an electric signal which is generated by the ultrasonic oscillator **11** is transmitted to the main body **20** via the signal wire **17***d*, the rotary electrode **17***a*, the rotary contact member **17***c*, the fixed electrode **17***b*, and the lead wire **17***e* in this order (which is indicated by a dotted line in FIG. **5**). On the contrary, the electric signal of the main body **20** is transmitted to the ultrasonic oscillator **11** via the lead wire **17***e*, the fixed electrode **17***b*, the rotary contact member **17***c*, the rotary electrode **17***a*, and the signal wire **17***d* in this order.

[0087] The rotary electric connector **17** is operated as below when the rotation body **14** rotates.

[0088] In the rotary electric connector **17**, the rotary electrode **17***a* first rotates along with the rotation of the rotation body **14** at the time of rotating the rotation body **14**. Then, the plurality of rotary contact members **17***c* revolve along the annular guide groove A while rotating at the corresponding position by the friction applied from the contact portion with the rotary electrode **17***a* in response to the rotation of the rotary electrode **17***a*. In other words, the plurality of rotary contact members **17***c* roll in the annular guide groove A to move in a planetary motion.

[0089] At this time, the plurality of rotary contact members **17***c* roll while urging the rotary electrode **17***a* toward the reference position of the rotation axis in an elastically deformed state so as to contact both electrode members of the rotary electrode **17***a* and the fixed electrode **17***b* at all times. Thus, the rotary electrode **17***a* and the fixed electrode **17***b* are electrically connected to each other at all times even when the rotation body **14** rotates. In addition, the rotation body **14** can rotate while the displacement of the rotation axis is suppressed.

[0090] As described above, according to the ultrasonic probe **10** of the embodiment, it is possible to reliably exchange electric signals with the ultrasonic oscillator **11** while stably keeping the ultrasonic wave transmitting/receiving direction of the ultrasonic oscillator **11** using the rotary electric connector **17** to exchange electric signals with the ultrasonic oscillator **11**. Accordingly, since noises superimposed on the receiving signals of the ultrasonic echo decrease, the image quality of the ultrasonic image can be improved.

[0091] Further, since the rotary electric connector **17** according to the embodiment does not cause the abrasion of the members (for example, the rotary electrode **17***a*, the fixed electrode **17***b*, and the rotary contact member **17***c*) compared to an electric connection structure according to the related art using the brush and the slip ring, it is possible to suppress a change in electric connection state over time.

Second Embodiment

[0092] Hereinafter, an example of a configuration of an ultrasonic probe **10** according to a second embodiment will be described with reference to FIG. **8** and FIG. **9**.

[0093] The ultrasonic probe **10** according to the embodiment is different from that of the first embodiment in that a plurality of high-rigid rolling bodies **17***f* are disposed in the annular guide groove A of the rotary electric connector **17** along with the rotary contact member **17***c*. In addition, a description of the same configuration as that of the first embodiment will be omitted (hereinafter, the same applies to other embodiments).

[0094] FIG. **8** and FIG. **9** are diagrams (a side view and a cross-sectional view of the rotary electric connector **17**) respectively corresponding to FIG. **5** and FIG. **6** of the first embodiment and showing an example of a configuration of the rotary electric connector **17** according to the embodiment.

[0095] As described above, since the rotary contact member **17***c* is elastically deformable, the rotary contact member **17***c* is elastically deformed when rolling in the annular guide groove A. Accordingly, there is concern that the rotation axis of the rotation body **14** is displaced vertically and laterally.

[0096] In the rotary electric connector **17** according to the embodiment, a plurality of high-rigid rolling bodies **17***f* are disposed in the annular guide groove A along with the rotary contact member **17***c* in order to improve the concentricity of the rotation axis of the rotation body **14**.

[0097] Since the high-rigid rolling body **17***f* can be formed as a columnar, spherical, or conical member similarly to the rotary contact member **17***c*, a metal ball substantially having the same diameter as the diameter (here, the diameter of the column) of the rotary contact member **17***c* is typically used. In addition, the high-rigid rolling body **17***f* does not need to be formed of a metal material as long as the rigidity is higher than that of the rotary contact member **17***c*.

[0098] The plurality of high-rigid rolling bodies **17***f* contact the rotary electrode **17***a* and the fixed electrode **17***b* at a plurality of positions of the annular guide groove A and cause a reaction force against a force in which the rotary electrode **17***a* is displaced toward the outside from the reference position of the fixed electrode **17***b*, that is, the reference position of the rotation axis of the rotation body **14**. As a result, it is possible to further suppress the displacement of the rotation axis of the rotation body **14**.

[0099] More desirably, the high-rigid rolling bodies **17***f* are alternately arranged in the annular guide groove A along with the rotary contact members **17***c* as in FIG. **9**. Accordingly, since it is possible to suppress the displacement of the rotation axis of the rotation body **14** and to prevent the contact between the rotary contact members **17***c*, it is possible to also suppress the abrasion of the rotary contact member **17***c*. Additionally, FIG. **9** shows a state where four high-rigid rolling bodies **17***f* are alternately arranged in the annular guide groove A along with four rotary contact members **17***c*.

[0100] More desirably, the diameter of the high-rigid rolling body **17***f* is set to be substantially the same as the diameter (here, the diameter of the column) of the rotary contact member **17***c* and is more desirably slightly smaller than the diameter of the rotary contact member **17***c*. Accordingly, it is possible to reliably keep a state where the rotary contact member **17***c* contacts both the rotary electrode **17***a* and the fixed electrode **17***b*.

[0101] As described above, when the high-rigid rolling bodies **17***f* are disposed in the annular guide groove A of the rotary electric connector **17** along with the rotary contact members **17***c* as in the ultrasonic probe **10** according to the embodiment, it is possible to further suppress the displacement of the rotation axis of the rotation body **14**.

Third Embodiment

[0102] Hereinafter, an example of a configuration of an ultrasonic probe **10** according to a third embodiment will be described with reference to FIG. **10** to FIG. **12**.

[0103] The ultrasonic probe **10** according to the embodiment is different from that of the first embodiment in that the rotary electrode **17***a* and the fixed electrode **17***b* are disposed to face each other in the extension direction of the rotation axis and a track base **17***g* rotatably supporting the rotary contact member **17***c* is disposed in a region in which the rotary electrode **17***a* and the fixed electrode **17***b* face each other.

[0104] FIG. **10** and FIG. **11** are diagrams (a side view and a cross-sectional view of the rotary electric connector **17**) respectively corresponding to FIG. **5** and FIG. **6** of the first embodiment and are diagrams showing an example of a configuration of the rotary electric connector **17** according to the embodiment. FIG. **12** is an exploded diagram showing the rotary electric connector **17** according to the embodiment.

[0105] The rotary electric connector **17** according to the embodiment is formed as a thrust ball bearing.

[0106] More specifically, both the rotary electrode **17***a* and the fixed electrode **17***b* according to the embodiment are formed as plate-shaped members having annular track grooves **17***aa* and **17***ba*. Then, since the rotary electrode **17***a* and the fixed electrode **17***b* are disposed in the extension direction of the rotation axis so that the annular track grooves **17***aa* and **17***ba* face each other, the guide groove A on which the rotary contact member **17***c* rolls is formed.

[0107] Then, in the rotary electric connector **17** according to the embodiment, the track base **17***g* which regulates the rotation state of the rotary contact member **17***c* is disposed in a region in which the rotary electrode **17***a* and the fixed electrode **17***b* face each other.

[0108] The track base **17***g* is formed in an annular shape along the guide groove A. Further, the track base **17***g* includes a plurality of fitting grooves **17***ga* on which the rotary contact member **17***c* is disposed and is disposed along the guide groove A while the rotary contact member **17***c* is disposed in the fitting groove **17***ga*.

[0109] With such a configuration, the track base **17***g* is supported in a region in which the rotary electrode **17***a* and the fixed electrode **17***b* face each other by the rotary contact member **17***c* without contacting the rotary electrode **17***a* and the fixed electrode **17***b*. Then, the track base **17***g* performs the rotation axis rotation M in response to the rotation of the rotary contact member **17***c*. Further, since the plurality of rotary contact members **17***c* are respectively disposed in the fitting grooves **17***ga* of the track base **17***g*, the plurality of rotary contact members rotate along the guide groove A without contacting other rotary contact members **17***c*.

[0110] As described above, since the track base **17***g* is disposed as in the ultrasonic probe **10** according to the embodiment, it is possible to realize a more stable exchange of electric signals between the ultrasonic oscillator **11** and the main body **20** by stabilizing the rotation state of the rotary contact member **17***c*. In addition, since the track base **17***g* is disposed in the guide groove A, it is possible to prevent a problem in which the rotary contact member **17***c* is separated from the guide groove A.

[0111] Further, FIG. **10** to FIG. **12** show a case where the rotary contact member **17***c* has a spherical shape, but the rotary contact member may be, of course, formed in a columnar shape similarly to the first embodiment.

[0112] Similarly to the first embodiment, in the track bases **17***g*, one member may be a center member disposed at the inside in the radial direction of the rotation body **14** in the rotation axis rotation M and the other member may be an outer peripheral member disposed at the outside in the radial direction of the rotation body **14** in the rotation axis rotation M.

Fourth Embodiment

[0113] Hereinafter, an example of a configuration of an ultrasonic probe **10** according to a fourth embodiment will be described with reference to FIG. **13** to FIG. **15**.

[0114] The ultrasonic probe **10** according to the embodiment is different from that of the first embodiment in that two sets of rotary electric connectors **17** (referred to as a “first rotary electric connector **17**X” and a “second rotary electric connector **17**Y”) which are insulated and separated from each other are disposed at the inside and the outside in the radial direction of the rotation body **14** in the rotation axis rotation.

[0115] FIG. **13** is a diagram corresponding to FIG. **4** of the first embodiment and is a diagram showing an example of a configuration of the ultrasonic probe **10** according to the embodiment.

[0116] In the ultrasonic probe **10** according to the embodiment, two ultrasonic oscillators **11** (referred to as a “first ultrasonic oscillator **11**X” and a “second ultrasonic oscillator **11**Y”) are disposed on the outer peripheral surface of the rotation body **14**.

[0117] Here, the first ultrasonic oscillator **11**X and the second ultrasonic oscillator **11**Y have different signal transmission paths at the time of exchanging electric signals with the main body **20**. Then, the ultrasonic probe **10** according to the embodiment include two sets of rotary electric connectors **17** (the first rotary electric connector **17**X and the second rotary electric connector **17**Y) having different electric signal channels so as to individually exchange electric signals with the first ultrasonic oscillator **11**X and the second ultrasonic oscillator **11**Y.

[0118] FIG. **14** and FIG. **15** are diagrams (a side view and a cross-sectional view of the rotary electric connector **17**) respectively corresponding to FIG. **5** and FIG. **6** of the first embodiment and showing an example of a configuration of the rotary electric connector **17** according to the embodiment.

[0119] The first rotary electric connector **17**X is formed at the inner peripheral side of the rotation axis rotation M and the second rotary electric connector **17**Y is formed at the outer peripheral side of the rotation axis rotation M.

[0120] More specifically, the first rotary electric connector **17**X includes a first rotary electrode **17**Xa, a first fixed electrode **17**Xb, a first rotary contact member **17**Xc disposed in a guide groove AX formed by the first rotary electrode **17**Xa and the first fixed electrode **17**Xb, a first rotation-side signal wire **17**Xd, and a first fixed side lead wire **17**Xe and constitutes the same rotary electric connector as the rotary electric connector **17** of the first embodiment by these members.

[0121] Further, the second rotary electric connector **17**Y includes a second rotary electrode **17**Ya, a second fixed electrode **17**Yb, a second rotary contact member **17**Yc disposed in a guide groove AY formed by the second rotary electrode **17**Ya and the second fixed electrode **17**Yb, a second rotation-side signal wire **17**Yd, and a second fixed side lead wire **17**Ye and constitutes the same rotary electric connector as the rotary electric connector **17** of the first embodiment by these members.

[0122] The second rotary electrode **17**Ya and the second fixed electrode **17**Yb of the second rotary electric connector **17**Y are disposed at the outside in the radial direction of the rotation axis rotation M in relation to the first rotary electrode **17**Xa and the first fixed electrode **17**Xb of the first rotary electric connector **17**X. Then, the first rotary electric connector **17**X and the second rotary electric connector **17**Y are insulated and separated from each other by a space Ba therebetween.

[0123] As described above, according to the ultrasonic probe **10** of the embodiment, since a plurality of signal channels can be realized by two sets of rotary electric connectors **17**X and **17**Y, it is possible to individually exchange electric signals with the plurality of ultrasonic oscillators **11**X and **11**Y.

[0124] Further, three sets or more of the rotary electric connectors **17**X and **17**Y may be, of course, disposed in the radial direction of the rotation body **14** in the rotation axis rotation.

Fifth Embodiment

[0125] Hereinafter, an example of a configuration of an ultrasonic probe **10** according to a fifth embodiment will be described with reference to FIG. **16** and FIG. **17**.

[0126] The ultrasonic probe **10** according to the embodiment is different from that of the fourth embodiment in that the rotary electric connector according to the third embodiment is adopted to constitute two sets of rotary electric connectors **17**X and **17**Y.

[0127] FIG. **16** and FIG. **17** are diagrams (a side view and a cross-sectional view of the rotary electric connector **17**) respectively corresponding to FIG. **14** and FIG. **15** of the fourth embodiment and are diagrams showing an example of a configuration of the rotary electric connector **17** according to the embodiment.

[0128] Similarly to the ultrasonic probe **10** according to the fourth embodiment, the ultrasonic probe **10** according to the embodiment also includes two sets of the first rotary electric connector **17**X and the second rotary electric connector **17**Y having different electric signal channels and provided in the bearing portion T1 of the rotation body **14** of the support base **15** in order to individually exchange electric signals with two ultrasonic oscillators **11**.

[0129] The first rotary electric connector **17**X is formed at the inner peripheral side of the rotation axis rotation M and the second rotary electric connector **17**Y is formed at the outer peripheral side of the rotation axis rotation M.

[0130] More specifically, the first rotary electric connector **17**X includes the first rotary electrode **17**Xa, the first fixed electrode **17**Xb, the first rotary contact member **17**Xc disposed in a guide groove Aix formed by the first rotary electrode **17**Xa and the first fixed electrode **17**Xb, the first rotation-side signal wire **17**Xd, and the first fixed side lead wire **17**Xe and constitutes the same rotary electric connector as the rotary electric connector **17** of the first embodiment by these members.

[0131] Further, the second rotary electric connector **17**Y includes the second rotary electrode **17**Ya, the second fixed electrode **17**Yb, the second rotary contact member **17**Yc disposed in the guide groove AY formed by the second rotary electrode **17**Ya and the second fixed electrode **17**Yb, the second rotation-side signal wire **17**Yd, and the second fixed side lead wire **17**Ye and constitutes the same rotary electric connector as the rotary electric connector **17** of the first embodiment by these members.

[0132] The second rotary electrode **17**Ya and the second fixed electrode **17**Yb of the second rotary electric connector **17**Y are disposed at the outside in the radial direction in the rotation axis rotation M in relation to the first rotary electrode **17**Xa and the first fixed electrode **17**Xb of the first rotary electric connector **17**X. Then, the first rotary electric connector **17**X and the second rotary electric connector **17**Y are insulated and separated by an insulation region Bb therebetween.

[0133] As described above, according to the ultrasonic probe **10** of the embodiment, since it is possible to realize a plurality of signal channels by the rotary electric connectors **17**X and **17**Y, it is possible to individually exchange electric signals with the plurality of ultrasonic oscillators **11**.

Other Embodiments

[0134] The present invention is not limited to the above-described embodiments and various modifications can be considered.

[0135] In the above-described embodiments, an example of a configuration of the rotary electric connector **17** is shown variously. Here, various combinations of configurations in the embodiments may be used.

[0136] Further, in the above-described embodiments, as an example of a configuration of the rotary electric connector **17**, electric signals are exchanged between the ultrasonic oscillator **11** and the main body **20** using the lead wire **17***e* drawn to the main body **20**. Here, the lead wire **17***e* may be, of course, connected to a signal amplification relay circuit board disposed in the ultrasonic probe **10**.

[0137] Meanwhile, in the ultrasonic probes **10** according to the third embodiment and the fifth embodiment, the rotary electrode **17***a* and the fixed electrode **17***b* are disposed to face each other in the extension direction of the rotation axis, but from the viewpoint of preventing the separation of the rotary contact member **17***c*, a configuration in which the rotary electrode **17***a* and the fixed electrode **17***b* are disposed at the inside and the outside of the rotation axis in the radial direction to face each other as in the first embodiment is more desirable.

[0138] According to the ultrasonic probe of the present disclosure, it is possible to reliably exchange electric signals with the ultrasonic oscillator while rotating the ultrasonic oscillator.

[0139] Although embodiments of the present invention have been described and illustrated in detail, the disclosed embodiments are made for purposes of illustration and example only and not limitation. The scope of the present invention should be interpreted by terms of the appended claims. The technology described in the claims includes various modifications and changes of the above-described embodiments.

What is claimed is:

1. An ultrasonic probe comprising:

a support base;

a rotation body which rotates while being supported by the support base;

an ultrasonic oscillator which is disposed on an outer peripheral surface of the rotation body; and

a rotary electric connector which is disposed to axially support the rotation body by the support base and exchanges electric signals with the ultrasonic oscillator,

wherein the rotary electric connector includes:

a rotary electrode which is bonded to the rotation body and rotates along with the rotation body,

a fixed electrode which is bonded to the support base to face the rotary electrode and forms an annular guide groove in a rotation axis rotation in a region facing the rotary electrode, and

a rotary contact member that is disposed inside the guide groove and rolls along the guide groove while contacting both the rotary electrode and the fixed electrode in response to the rotation of the rotary electrode.

2. The ultrasonic probe according to claim **1**,

wherein in the rotary electrode and the fixed electrode of the rotary electric connector, one electrode is a center member disposed at the inside in the radial direction of the rotation body in the rotation axis rotation and the other electrode is an outer peripheral member disposed at the outside in the radial direction of the rotation body in the rotation axis rotation, and the outer peripheral member corresponding to the other electrode is disposed to surround the outer peripheral surface of the center member corresponding to one electrode.

3. The ultrasonic probe according to claim **1**,

wherein the rotary electrode and the fixed electrode of the rotary electric connector are all plate-shaped members having an annular track groove and are disposed to form the guide groove by allowing the track grooves to face each other along the extension direction of the rotation axis of the rotation body.

4. The ultrasonic probe according to claim **1**,

wherein the rotary contact member has a spherical, columnar, or conical shape.

5. The ultrasonic probe according to claim **1**,

wherein a plurality of the rotary contact members are disposed inside the guide groove.

6. The ultrasonic probe according to claim **1**,

wherein the rotary contact member is formed as an elastically deformable member.

7. The ultrasonic probe according to claim **1**,

wherein a plurality of high-rigid rolling bodies having a spherical shape, a columnar shape, or a conical shape are disposed inside the guide groove along with the rotary contact member.

8. The ultrasonic probe according to claim **1**,

wherein a track base having an annular shape along the guide groove and rotatably supporting the rotary contact member is disposed in a region in which the rotary electrode and the fixed electrode face each other.

9. The ultrasonic probe according to claim **1**,

wherein at least two sets of ultrasonic oscillators are disposed on the outer peripheral surface of the rotation body, and

at least two sets of the rotary electric connectors which are insulated and separated from each other are disposed at the inside and the outside in the radial direction of the rotation body in the rotation axis rotation to exchange electric signals with two sets of the ultrasonic oscillators.

10. The ultrasonic probe according to claim **1**,

wherein the rotation body includes a permanent magnet, and

the support base includes a coil part which generates a rotation force in the rotation body by applying a rotation magnetic field to the permanent magnet of the rotation body.

11. The ultrasonic probe according to claim **1**,

wherein the support base, the rotation body, the ultrasonic oscillator, and the rotary electric connector are disposed inside a window portion which keeps a coupling liquid in a liquid-tight state.

12. An ultrasonic diagnostic apparatus comprising:

the ultrasonic probe according to claim **1**.

* * * * *

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摘要(译)

超声波探头包括：支撑基座;旋转体，在由支撑基座支撑的同时旋转;超声波振荡器，设置在旋转体的外周表面上;旋转电连接器，设置成通过支撑基座轴向支撑旋转体并与超声波振荡器交换电信号，其中旋转电连接器包括：旋转电极，其与旋转体结合并随旋转而旋转本体，固定电极，其与支撑基座结合以面向旋转电极并且在面向旋转电极的区域中在旋转轴旋转中形成环形引导槽，以及设置在引导槽内并且设置在辊内的旋转接触构件沿着引导槽同时接触旋转电极和固定电极。