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

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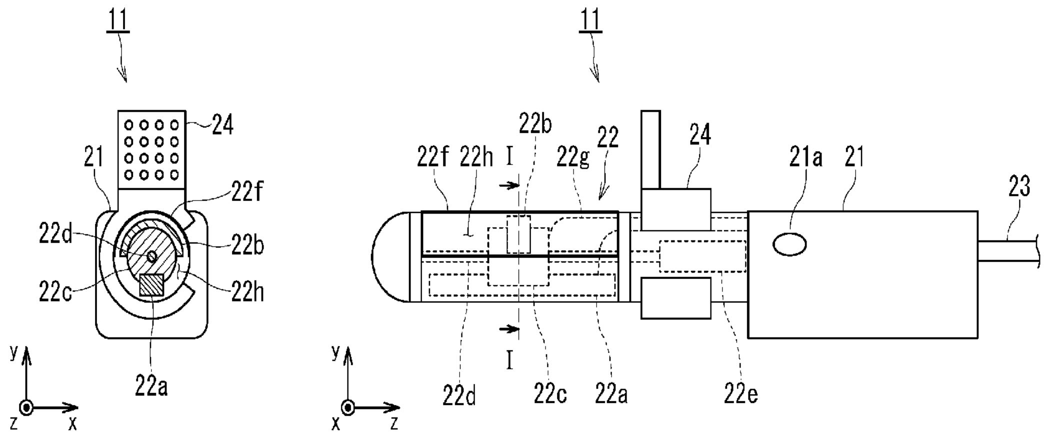
(57) **ABSTRACT**

The ultrasonic probe according to the present embodiment includes a first transducer set, a second transducer set and a transducer set supporter. The first transducer set arranges transducers in a direction parallel with an axis of the ultrasonic probe. The second transducer set arranges transducers on a plane substantially orthogonal to the axis. The transducer set supporter supports the first transducer set and the second transducer set, and is configured to pivot around the axis.



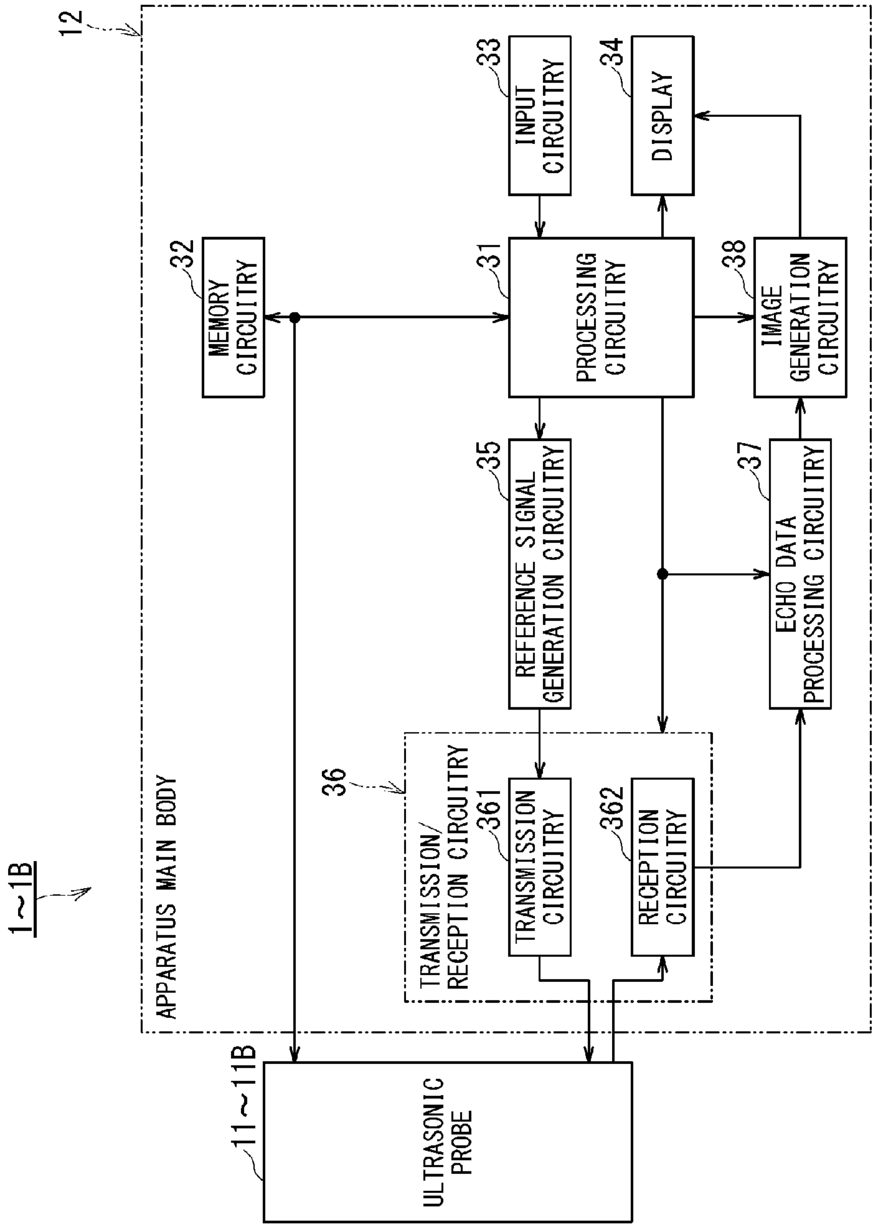
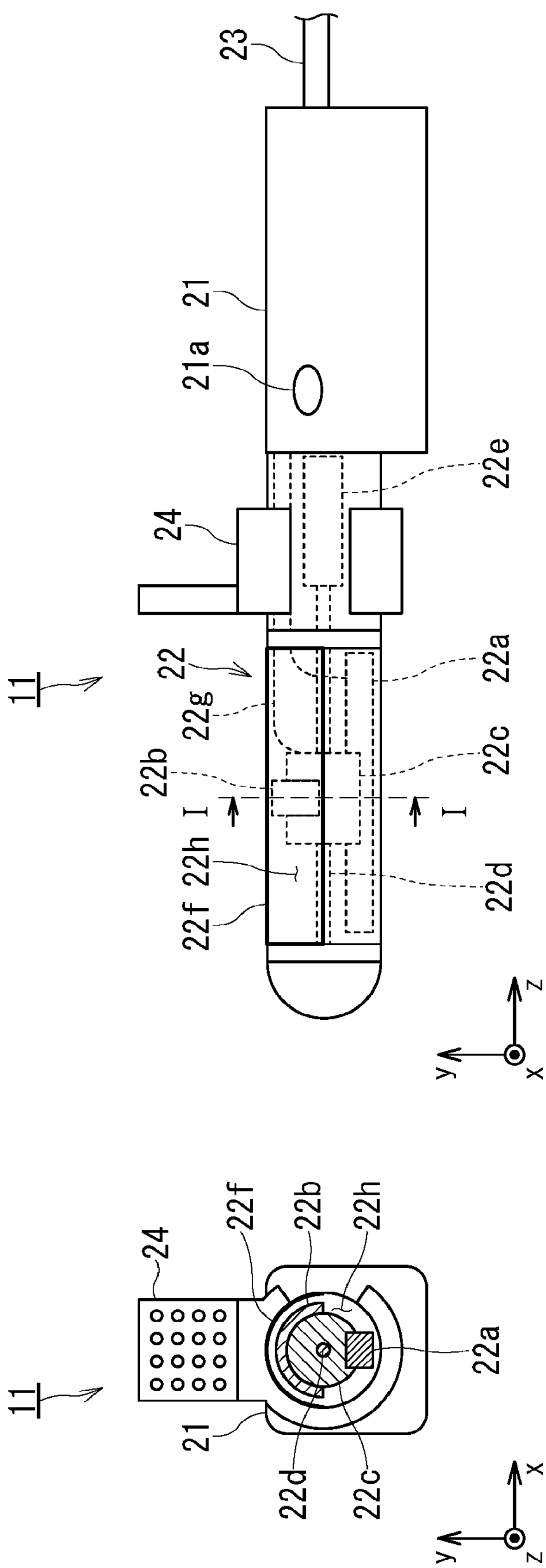

1~1B
12
APPARATUS MAIN BODY
11~11B
ULTRASONIC PROBE
32
MEMORY CIRCUITRY
31
PROCESSING CIRCUITRY
33
INPUT CIRCUITRY
34
DISPLAY
38
IMAGE GENERATION CIRCUITRY
35
REFERENCE SIGNAL GENERATION CIRCUITRY
37
ECHO DATA PROCESSING CIRCUITRY
36
TRANSMISSION/ RECEPTION CIRCUITRY
361
TRANSMISSION CIRCUITRY
362
RECEPTION CIRCUITRY

FIG. 1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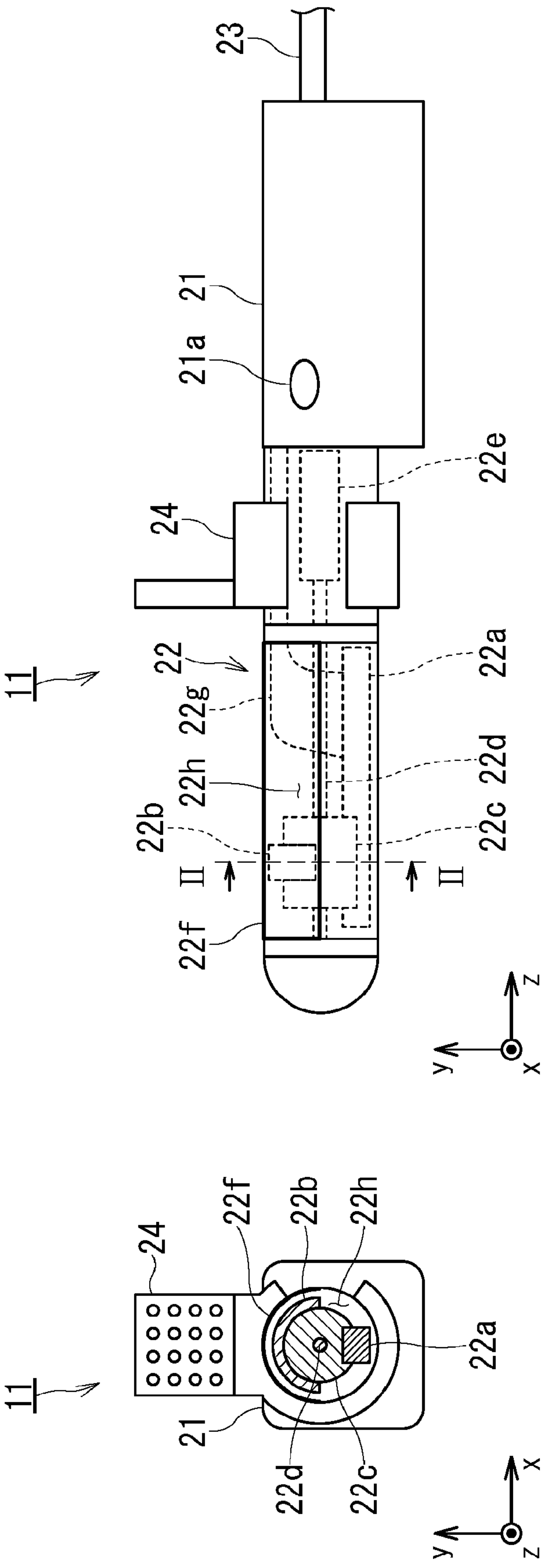
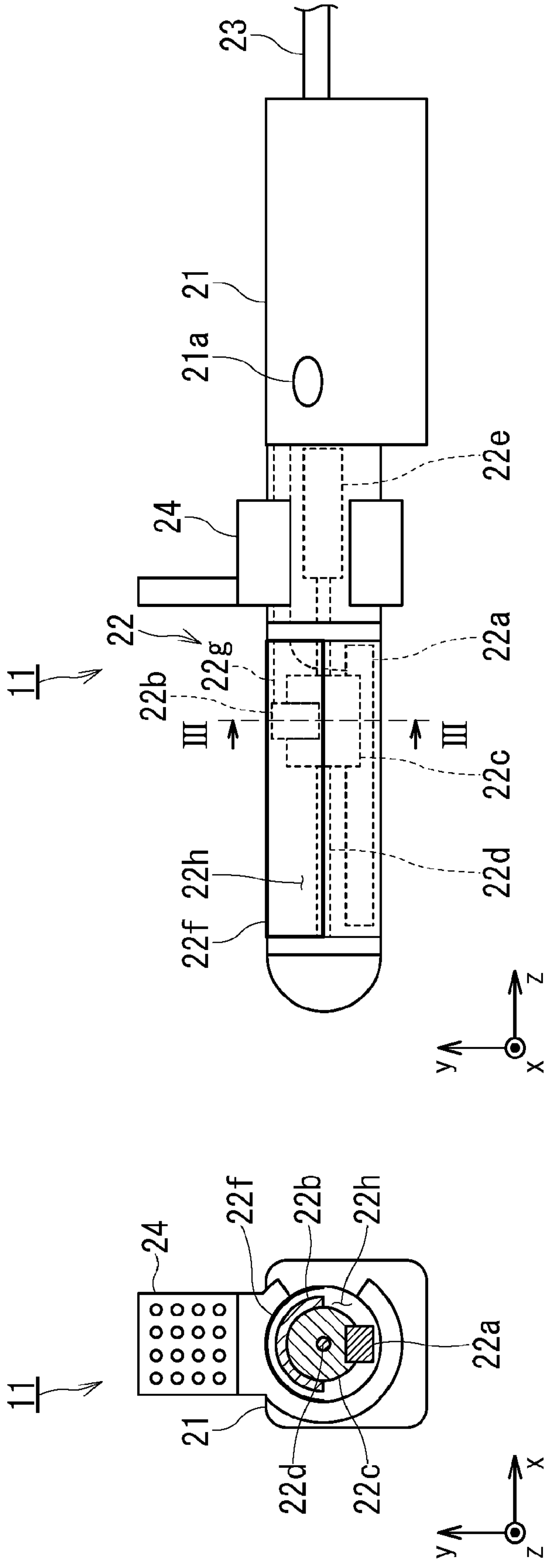
21
21a
22e
24
11
22
22a
22g
22c
22b
I
I
22h
22d
22f
y
z
x
24
22f
22b
22h
22a
11
21
22d
22c
y
x
z

FIG. 2



11
23
21
21a
22e
24
22
22a
22g
22d
22h
22c
22b
II
II
22f
z
y
x
11
24
22f
22b
22h
22a
21
22d
22c
x
y
z

FIG. 3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21
21a
22e
24
22
22a
22g
22b
11
III
III
22c
22d
22h
22f
z
y
x
24
22f
22b
22h
22a
11
21
22d
22c
x
y
z

FIG. 4

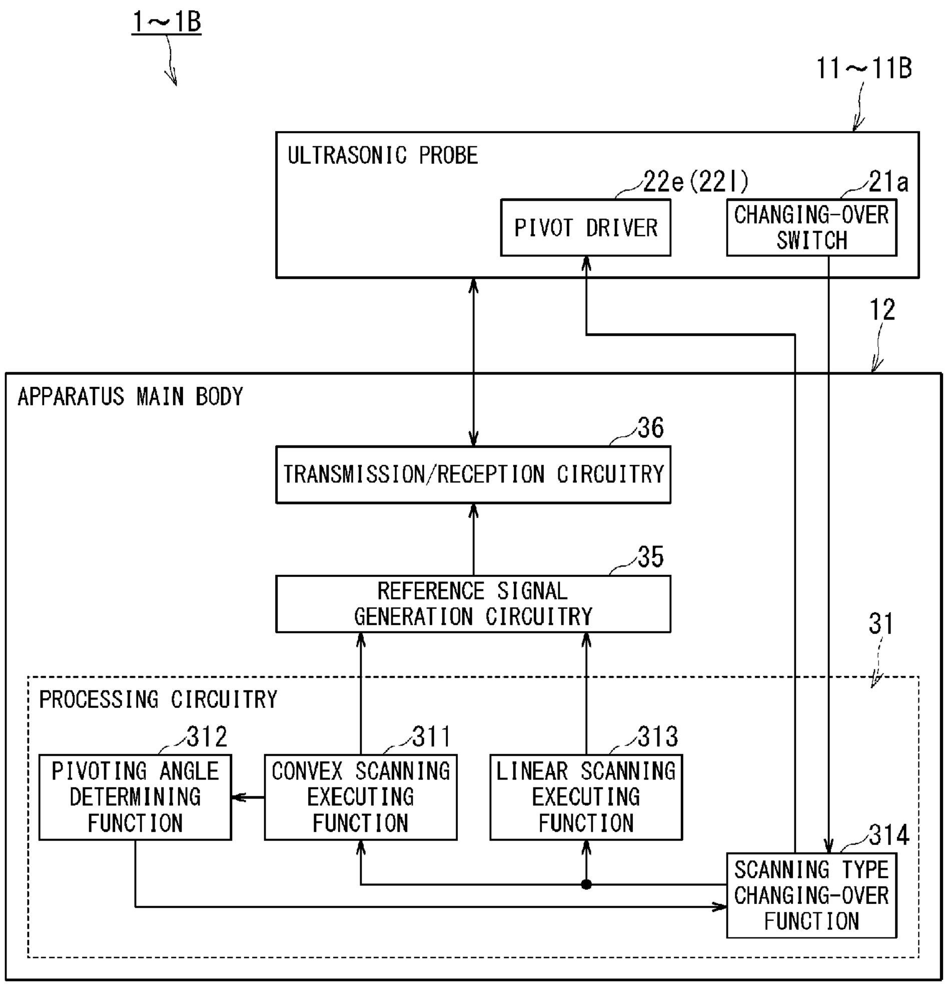
1~1B
11~11B
ULTRASONIC PROBE
22e (22l)
PIVOT DRIVER
21a
CHANGING-OVER SWITCH
12
APPARATUS MAIN BODY
36
TRANSMISSION/RECEPTION CIRCUITRY
35
REFERENCE SIGNAL GENERATION CIRCUITRY
31
PROCESSING CIRCUITRY
312
PIVOTING ANGLE DETERMINING FUNCTION
311
CONVEX SCANNING EXECUTING FUNCTION
313
LINEAR SCANNING EXECUTING FUNCTION
314
SCANNING TYPE CHANGING-OVER FUNCTION

FIG. 5

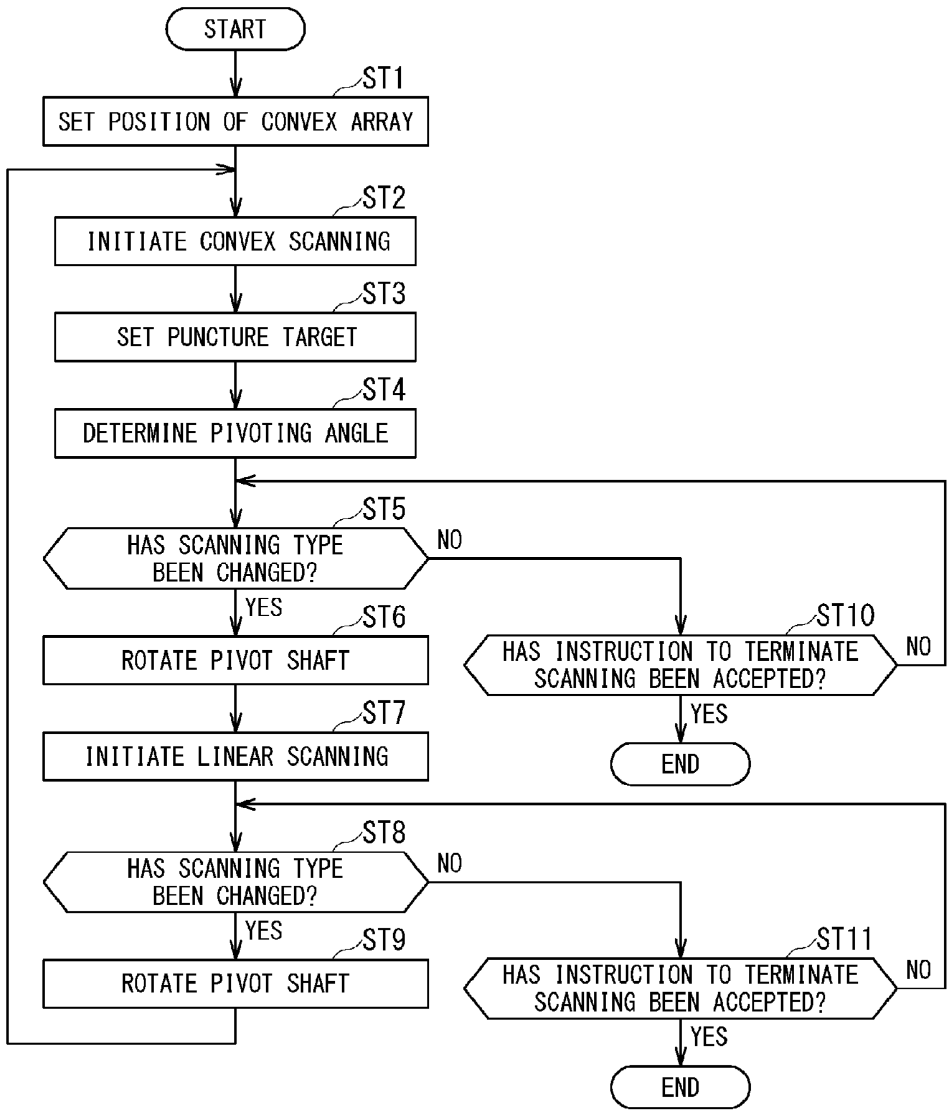
START
ST1
SET POSITION OF CONVEX ARRAY
ST2
INITIATE CONVEX SCANNING
ST3
SET PUNCTURE TARGET
ST4
DETERMINE PIVOTING ANGLE
ST5
HAS SCANNING TYPE BEEN CHANGED?
NO
YES
ST6
ROTATE PIVOT SHAFT
ST10
HAS INSTRUCTION TO TERMINATE SCANNING BEEN ACCEPTED?
NO
YES
END
ST7
INITIATE LINEAR SCANNING
ST8
HAS SCANNING TYPE BEEN CHANGED?
NO
YES
ST9
ROTATE PIVOT SHAFT
ST11
HAS INSTRUCTION TO TERMINATE SCANNING BEEN ACCEPTED?
NO
YES
END

FIG. 6

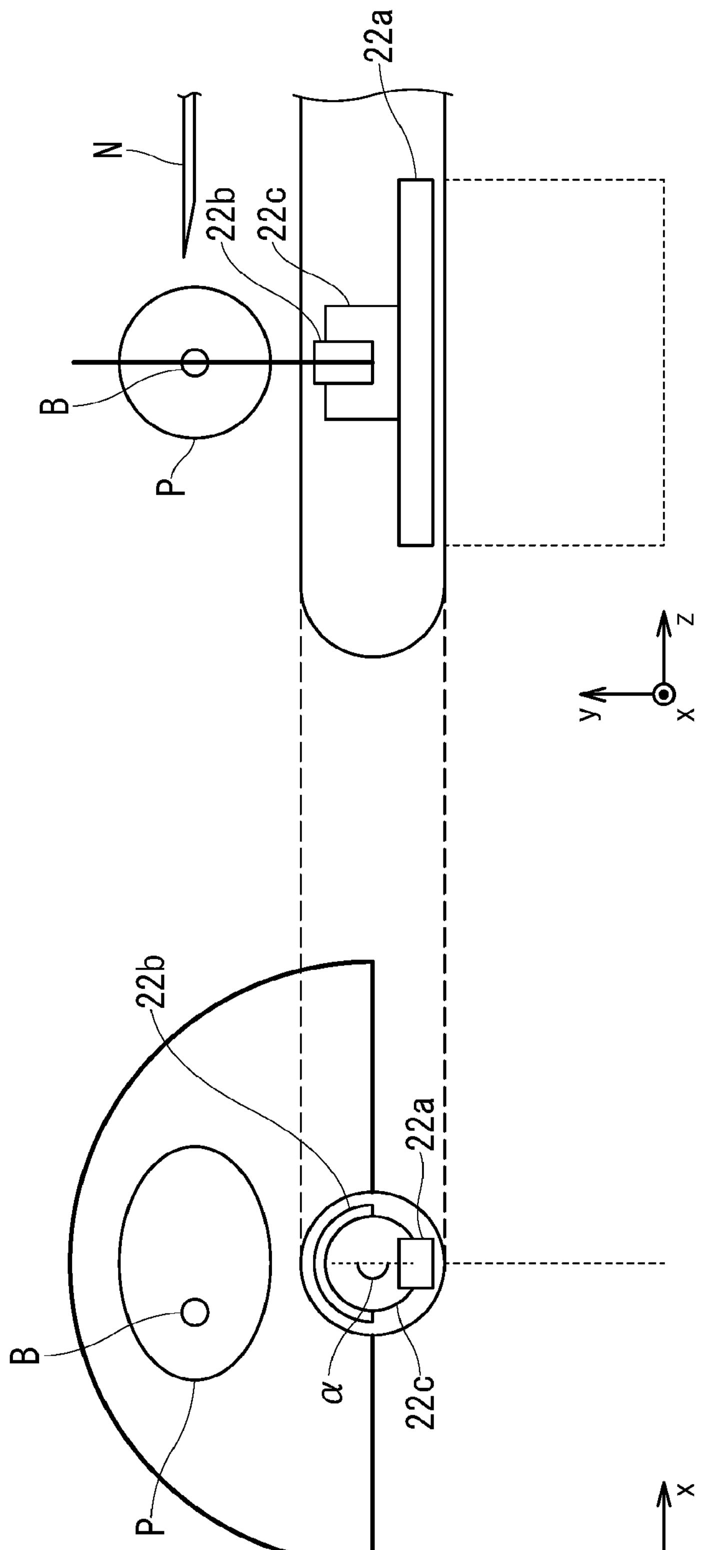

FIG. 7

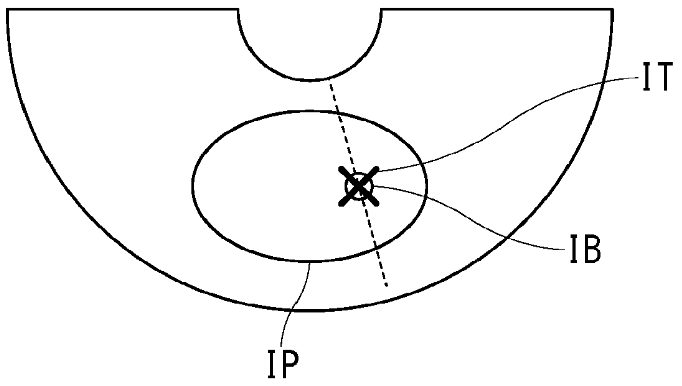

FIG. 8

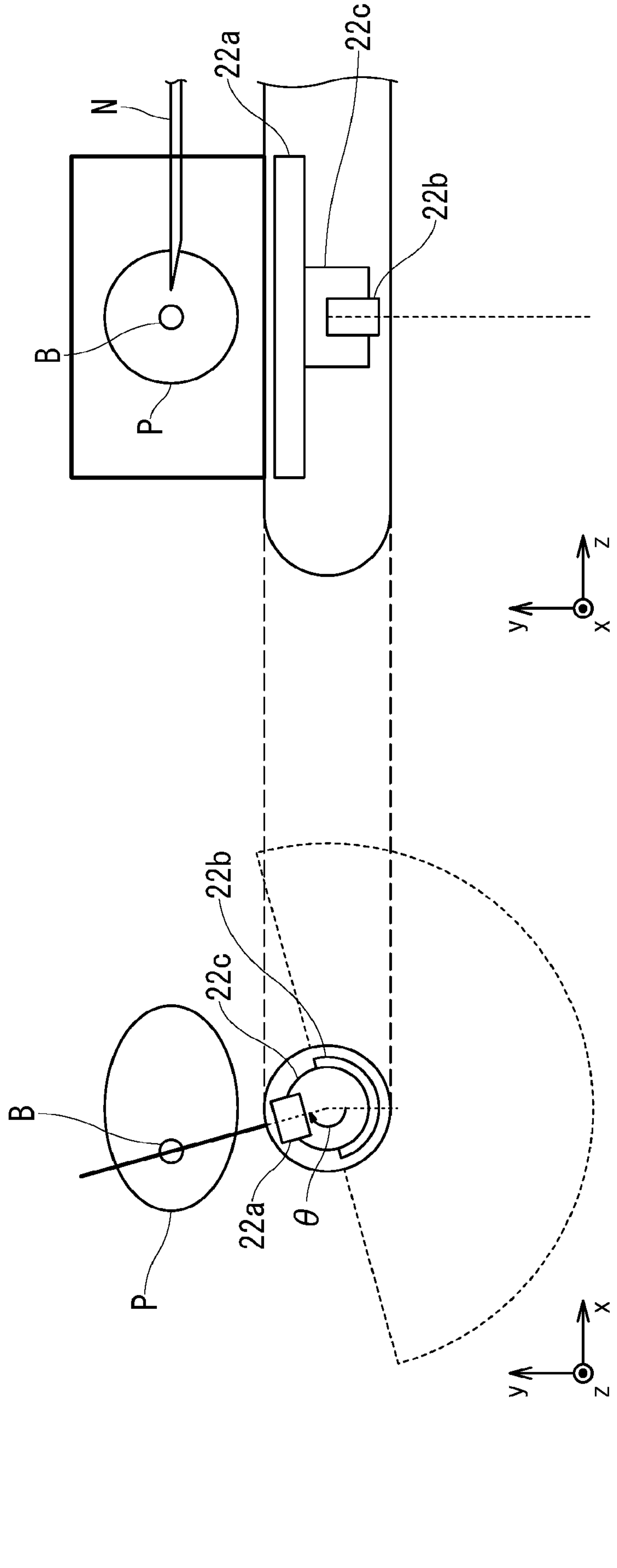

FIG. 9

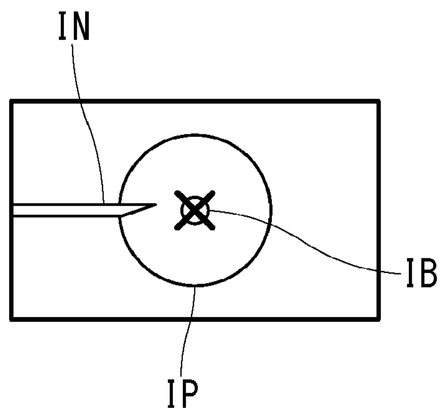

FIG. 10

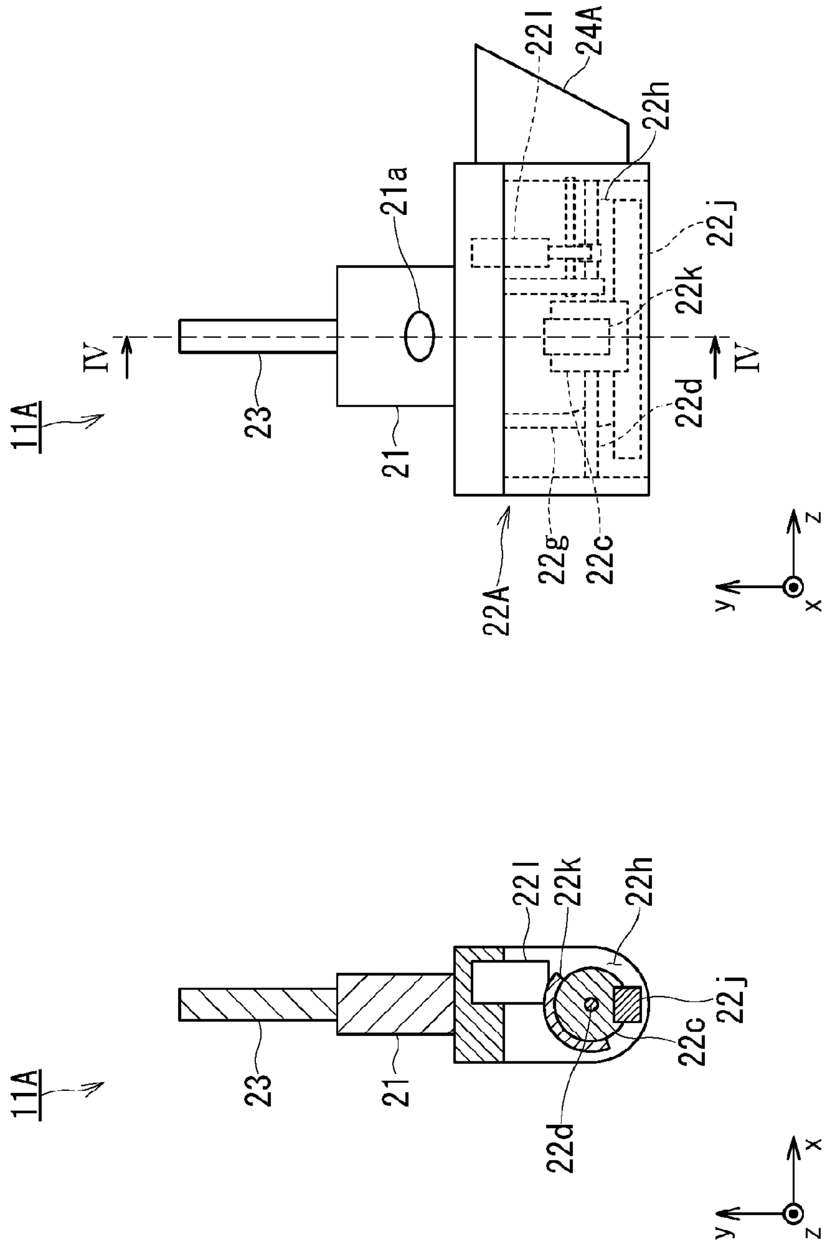
11A
23
21
21a
22A
22g
22c
22d
22k
22j
22h
22l
24A
IV
x
y
z
11A
23
21
22l
22k
22h
22j
22c
22d
y
x
z

FIG. 11

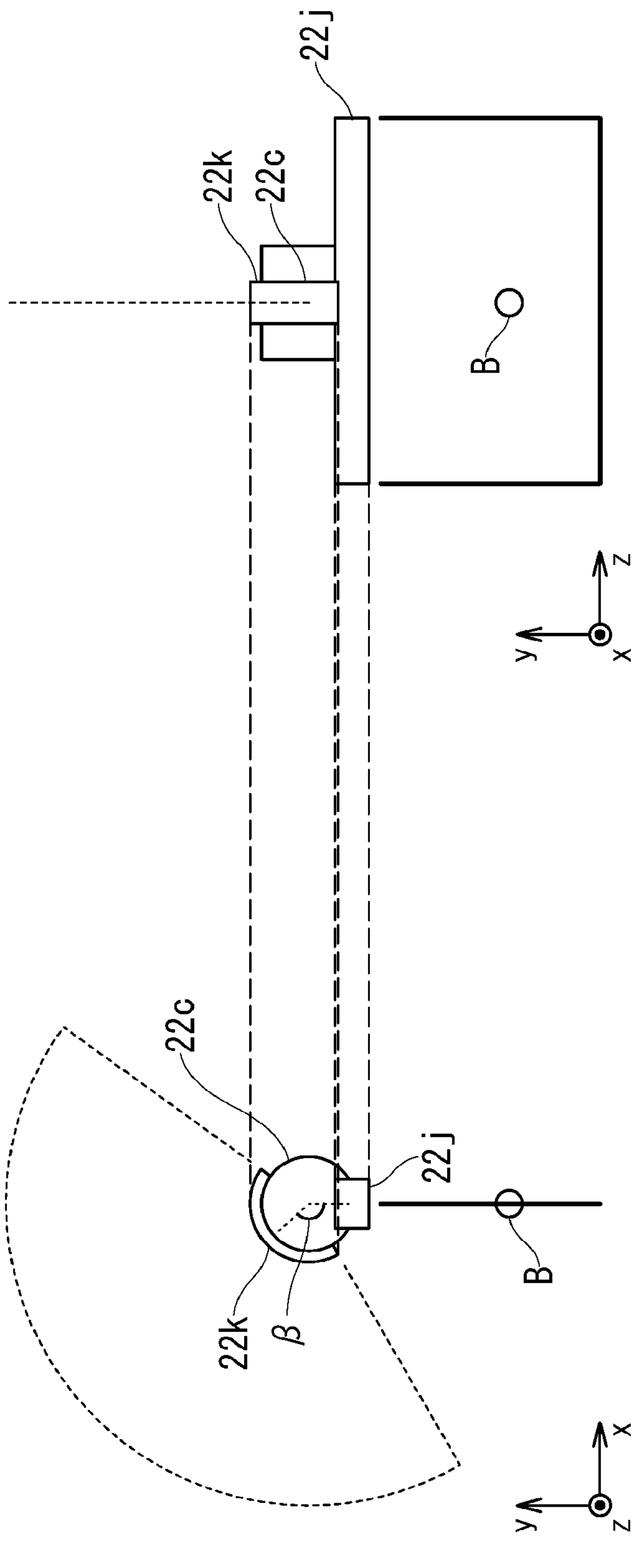

FIG. 12

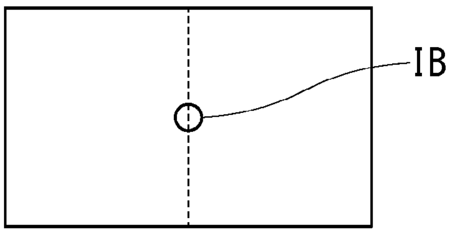

FIG. 13

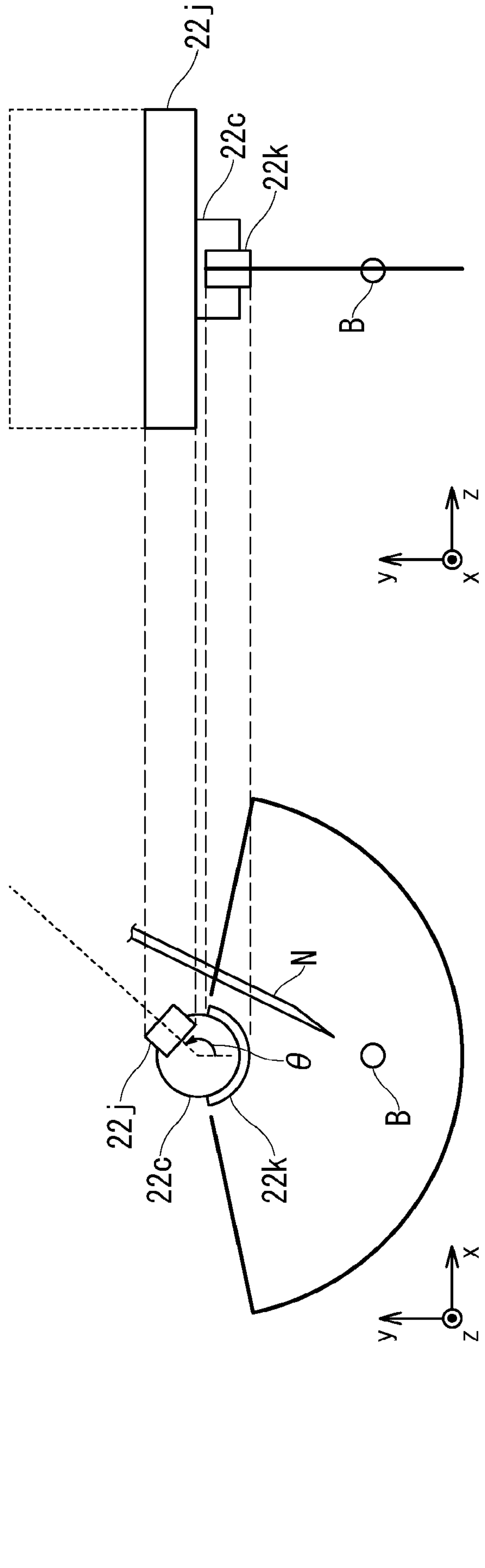

FIG. 14

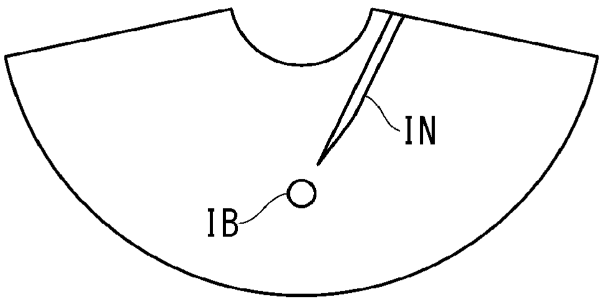

FIG. 15

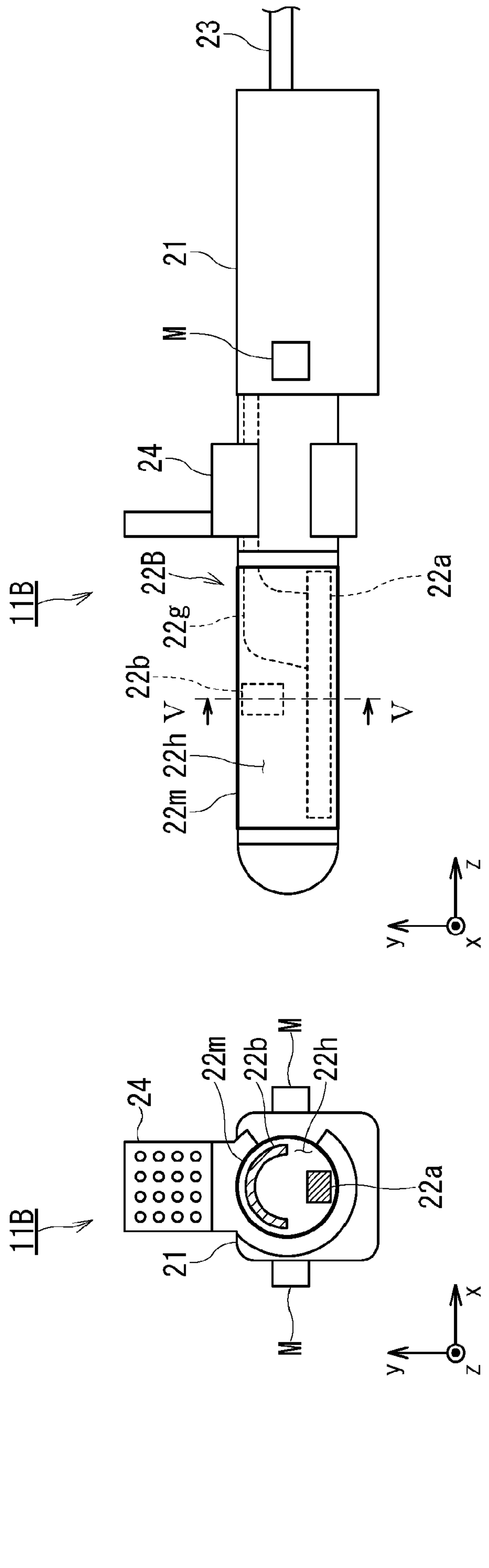
23
21
M
24
11B
22B
22a
22g
22b
V
V
22h
22m
z
y
x
24
22m
22b
22h
M
11B
22a
21
M
x
y
z

FIG. 16

ULTRASONIC PROBE AND ULTRASONIC DIAGNOSTIC APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2015-100895, filed on May 18, 2015, the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments as an aspect of the present invention relate to an ultrasonic probe and an ultrasonic diagnostic apparatus.

BACKGROUND

[0003] In the field of medical applications, ultrasonic diagnostic apparatuses have been used which utilize ultrasound generated by using transducers (piezoelectric devices) of an ultrasonic probe to perform imaging of the interior of an object. An ultrasonic diagnostic apparatus transmits ultrasound into an object from an ultrasonic probe connected to the ultrasonic diagnostic apparatus, and receives reflected waves, which are caused by inconsistencies of acoustic impedance in the interior of the object, with an ultrasonic probe. The ultrasonic diagnostic apparatus creates a received signal based on a reflected wave received at the ultrasonic probe, and obtains a desired ultrasonic image through image processing.

[0004] As a prior art for the structure of ultrasonic probe, there has been disclosed an ultrasonic probe for use inside a body cavity, which includes a first transducer set in which transducers are arranged on an outer peripheral surface of the probe body so as to be parallel with the axis of the probe, and a second transducer set in which transducers are arranged along a direction orthogonal to the axis of the probe.

[0005] According to the prior art ultrasonic probe, change-over between the first transducer set and the second transducer set is performed by manually rotating the ultrasonic probe around its axis. Therefore, such a rotating operation during manipulation is a burden for the operator.

[0006] Moreover, it is difficult to perform the rotating operation so as to cause a puncture target, which has appeared on a scanning plane by either of the transducer sets, to appear on a scanning plane by another of the transducer sets after change-over.

[0007] Further, when a puncture adaptor for guiding a puncture needle has be attached to the ultrasonic probe, a rotation support mechanism is provided in the ultrasonic probe and the puncture adaptor to make the ultrasonic probe rotatable while holding the position of the puncture adaptor. As a result, due to the effect of operations such as rotating of the ultrasonic probe, the operation to hold the puncture adaptor so as to prevent fluctuation of its position becomes a burden for the operator.

[0008] Accordingly, it is an objective of the present invention to provide an ultrasonic probe and an ultrasonic diagnosis apparatus, which can improve operability by the operator.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] In accompanying drawings,

[0010] FIG. **1** is a schematic diagram showing a configuration of an ultrasonic probe and an ultrasonic diagnostic apparatus according to a first embodiment;

[0011] FIG. **2** is a diagram showing a first example structure of the ultrasonic probe according to the first embodiment;

[0012] FIG. **3** is a diagram showing a second example structure of the ultrasonic probe according to the first embodiment;

[0013] FIG. **4** is a diagram showing a third example structure of the ultrasonic probe according to the first embodiment;

[0014] FIG. **5** is a block diagram showing functions of the ultrasonic diagnostic apparatus according to the first embodiment;

[0015] FIG. **6** is a flowchart showing the operation of the ultrasonic diagnostic apparatus according to the first embodiment;

[0016] FIG. **7** is a diagram to illustrate a convex scanning;

[0017] FIG. **8** is a diagram showing an example of an ultrasonic image by the convex scanning;

[0018] FIG. **9** is a diagram to illustrate a linear scanning;

[0019] FIG. **10** is a diagram showing an example of an ultrasonic image by the linear scanning;

[0020] FIG. **11** is a diagram showing an example structure of an ultrasonic probe according to a second embodiment;

[0021] FIG. **12** is a diagram to illustrate a linear scanning;

[0022] FIG. **13** is a diagram showing an example of an ultrasonic image by the linear scanning;

[0023] FIG. **14** is a diagram to illustrate a convex scanning;

[0024] FIG. **15** is a diagram showing an example of an ultrasonic image by the convex scanning; and

[0025] FIG. **16** is a diagram showing an example structure of an ultrasonic probe according to a third embodiment.

DETAILED DESCRIPTION

[0026] An ultrasonic probe and an ultrasonic diagnostic apparatus according to the present embodiment will be described with reference to the appended drawings.

[0027] The ultrasonic probe according to the present embodiment includes a first transducer set, a second transducer set and a transducer set supporter. The first transducer set arranges transducers in a direction parallel with an axis of the ultrasonic probe. The second transducer set arranges transducers on a plane substantially orthogonal to the axis. The transducer set supporter supports the first transducer set and the second transducer set, and is configured to pivot around the axis.

First Embodiment

[0028] FIG. **1** is a schematic diagram showing a configuration of an ultrasonic probe and an ultrasonic diagnostic apparatus according to a first embodiment.

[0029] FIG. **1** shows an ultrasonic diagnostic apparatus **1** according to the first embodiment, and an ultrasonic probe **11** according to the first embodiment and an apparatus main body **12**, which are included in the ultrasonic diagnostic apparatus **1**.

[0030] The ultrasonic probe **11** is one principally for use inside a body cavity, which is suitable for being inserted through the rectum to image an internal organ. The ultrasonic probe **11** performs transmission/reception of ultrasound to and from an object according to control by the apparatus main body **12**.

[0031] FIG. **2** is a diagram showing a first example structure of the ultrasonic probe **11** according to the first embodiment.

[0032] Shown on the left-hand side of FIG. **2** is a I-I section (x-y section) of the ultrasonic probe **11** shown on the right-hand side of FIG. **2**, and shown on the right-hand side of FIG. **2** is a side view (viewed from a y-z plane) of the ultrasonic probe **11**.

[0033] The ultrasonic probe **11** includes a handle portion **21**, a probe body (distal end portion) **22**, and a cable **23**. The handle portion **21** includes a changing-over switch **21***a* for instructing changing-over of a scanning, that is, pivoting of a pivot shaft **22***d* to be described later. The pivoting of the pivot shaft **22***d* includes pivoting in positive direction and pivoting in negative direction. Note that the ultrasonic probe **11** may include a scale visually perceptible by the operator, which indicates a pivoting angle of the pivot shaft **22***d* to be described later.

[0034] Further, the ultrasonic probe **11** may be equipped with a puncture adaptor **24** for guiding a puncture needle. Through holes for guiding a puncture needle are formed at predetermined positions of the puncture adaptor **24**.

[0035] The probe body **22** includes a first transducer set **22***a*, a second transducer set **22***b*, a transducer set supporter **22***c*, a pivot shaft (pivot unit) **22***d*, a pivot driver (motor) **22***e*, an acoustic window **22***f*, a signal line **22***g*, and a solution layer **22***h*. It is supposed that scanning types by the first transducer set **22***a* and by the second transducer set **22***b* are different from each other.

[0036] A center position in a direction (z direction) parallel with an axis of the probe body **22**, of the second transducer set **22***b* of the ultrasonic probe **11** substantially corresponds to a center position in the z direction, of the first transducer set **22***a*. Moreover, in an orthogonal plane (x-y section) with respect to the z direction, an angle α (shown in FIG. **7**) formed between a scanning plane of the first transducer set **22***a* and a center line of the second transducer set **22***b* is preferably a straight angle (180°). This is because the puncture needle advances in parallel with the z direction when the ultrasonic probe **11** is used.

[0037] The first transducer set **22***a* has a structure in which transducers (piezoelectric devices) are arranged in a row along the z direction. The row along the z direction may be one or more rows. Each transducer is an electro-acoustic transducer, which has a function of converting an electric pulse into an ultrasonic pulse (transmission ultrasound) during transmission, and converting an ultrasonic reflected wave (reception ultrasound) into an electric signal (received signal) during reception. The first transducer set **22***a* is, for example, a linear array. Hereafter, description will be made by taking as an example a case in which the first transducer set **22***a* is a linear array.

[0038] When the transducers are arranged in 1 to about 3 rows in the linear array **22***a*, a lens member (not shown) for focusing ultrasound in the arrangement direction (x direction) is provided in a front side of the linear array **22***a*. On the other hand, when the transducers are arranged in a sufficient number of rows in the linear array **22***a*, electronic focusing is used to focus ultrasound in the x direction.

[0039] The second transducer set **22***b* has a structure in which transducers are arranged on a plane (x-y section) substantially orthogonal to the z direction. The second transducer set **22***b* includes the transducers arranged on the one plane substantially orthogonal to the z direction or on multiple planes substantially orthogonal to the z direction. The second transducer set **22***b* is, for example, a convex array in which the transducers are arranged on a plane substantially orthogonal to the z direction, and in a portion of a circumference whose radius of curvature substantially corresponds to a pivoting radius. Hereafter, description will be made taking as an example a case in which the second transducer set **22***b* is a convex array.

[0040] When the transducers are arranged in 1 to about 3 planes in the convex array **22***b*, a lens member (not shown) for focusing ultrasound in the z direction is provided in a front side of the convex array **22***b*. On the other hand, when the transducers are arranged in a sufficient number of planes in the convex array **22***b*, electronic focusing is used to focus ultrasound in the z direction.

[0041] Note that although it is supposed that a bucking for preventing back reflection is provided in a rear side of each of the arrays **22***a* and **22***b*, description thereof will be omitted.

[0042] The transducer set supporter **22***c* supports the arrays **22***a* and **22***b* such that the angle formed between the scanning plane of the linear array **22***a* and the center line of the convex array **22***b* is kept at constant in the x-y section.

[0043] The pivot shaft **22***d* supports the transducer set supporter **22***c* (arrays **22***a* and **22***b*) and pivots around an axis of the probe body **22** through the pivot driver **22***e*. That is, the pivot shaft **22***d* is provided on the axis of the probe body **22**.

[0044] The pivot driver **22***e* drives the pivot shaft **22***d* to pivot itself according to a pivoting angle instructed from the apparatus main body **12** upon depression of the changing-over switch **21***a*. Note that, upon depression of the changing-over switch **21***a*, the pivot driver **22***e* may drive the pivot shaft **22***d* to pivot itself according to a previously set, fixed pivoting angle.

[0045] The acoustic window **22***f* is provided in the whole or a part (a portion of transmission/reception opening) of the circumference around the axis of the probe body **22** out of the housing, which is in contact with the object, and is made of a material which easily transmits ultrasound. The housing, whose axial center substantially corresponds to the pivot shaft **22***d* (pivoting center), accommodates the linear array **22***a*, the convex array **22***b*, the transducer set supporter **22***c*, the pivot shaft **22***d*, the pivot driver **22***e*, and a part of the signal line **22***g*.

[0046] The signal line **22***g* is connected to each transducer of the arrays **22***a* and **22***b*. While the signal line **22***g* is drawn out to the cable **23**, for example, through inside a bucking (not shown), illustration and description of the drawn out signal lines **22***g* and a substrate to which the signal line **22***g* is connected will be omitted.

[0047] The solution layer **22***h* is provided inside the probe body **22**, and is a layer filled with a liquid or fluid matter (sound medium) which easily transmits an ultrasonic signal.

[0048] The cable **23** connects the probe body **22** with transmission circuitry **361** and reception circuitry **362** of transmission/reception circuitry **36**.

[0049] FIG. **3** is a diagram showing a second example structure of the ultrasonic probe **11** according to the first embodiment.

[0050] Shown on the left-hand side of FIG. **3** is a II-II section (x-y section) of the ultrasonic probe **11** shown on the right-hand side of FIG. **3**, and shown on the right-hand side of FIG. **3** is a side view (viewed from a y-z plane) of the ultrasonic probe **11**.

[0051] The ultrasonic probe **11** shown in FIG. **3** has a structure in which the center position in the z direction, of the convex array **22***b* is deviated toward a distal end side than the center position in the z direction, of the linear array **22***a*.

[0052] According to the ultrasonic probe **11** shown in FIG. **3**, it is possible to effectively support operator's manipulation to advance a puncture needle to an organ, such as the prostate while confirming an ultrasonic image by a convex scanning using the convex array **22***b*. Therefore, according to the ultrasonic probe **11** shown in FIG. **3**, it is possible to improve the accuracy of insertion into the prostate.

[0053] Moreover, since the distance from the convex array **22***b* to the distal end of the ultrasonic probe **11** can be made relatively short, it is possible to reduce the amount of insertion of the ultrasonic probe **11** into an object.

[0054] FIG. **4** is a diagram showing a third example structure of the ultrasonic probe **11** according to the first embodiment.

[0055] Shown on the left-hand side of FIG. **4** is a section (x-y section) of the ultrasonic probe **11** shown on the right-hand side of FIG. **4**, and shown on the right-hand side of FIG. **4** is a side view (viewed from a y-z plane) of the ultrasonic probe **11**.

[0056] The ultrasonic probe **11** shown in FIG. **4** has a structure in which the center position in the z direction, of the convex array **22***b* is deviated toward the handle portion **21** side than the center position in the z direction, of the linear array **22***a*.

[0057] According to the ultrasonic probe **11** shown in FIG. **4**, the distance between the convex array **22***b* and the puncture adaptor **24** can be made short. Therefore, according to the ultrasonic probe **11** shown in FIG. **4**, it is possible to improve the accuracy of puncturing into a puncture target when the puncture target is located in a shallow position in the object.

[0058] Note that the ultrasonic probe **11** may have a structure in which the convex array **22***b* is slidable in the z direction with respect to the linear array **22***a*. In that case, the arrangements of the convex array **22***b* shown in FIGS. **2** to **4** can be freely selected.

[0059] Referring back to description of FIG. **1**, the apparatus main body **12** includes processing circuitry **31**, memory circuitry (storage unit) **32**, input circuitry (input unit) **33**, a display (display unit) **34**, reference signal generation circuitry **35**, transmission/reception circuitry **36**, echo data processing circuitry **37**, and image generation circuitry **38**.

[0060] The processing circuitry **31** refers to, in addition to a special-purpose or general-purpose CPU (central processing unit) or MPU (micro processor unit), an application specific integrated circuit (ASIC), a programmable logic device, etc. Examples of the programmable logic device include a simple programmable logic device (SPLD), a complex programmable logic device (CPLD), and a field programmable gate array (FPGA). The processing circuitry **31** reads out and executes a program stored in the memory circuitry **32** or directly incorporated into the processing circuitry **31**, thereby implementing functions **311** to **314** shown in FIG. **5**.

[0061] Moreover, the processing circuitry **31** may be made up of a single circuit, or a combination of independent multiple circuits. In the latter case, a memory circuit that stores a program may be provided separately for each of the multiple circuits, or a single memory circuit may store programs corresponding to functions of the multiple circuits.

[0062] The memory circuitry **32** may be made up of a RAM (random access memory), a semiconductor memory element such as a flash memory, a hard disk, an optical disk, etc. The memory circuitry **32** may also be made up of a portable medium such as a USB (universal serial bus) memory, a DVD (digital video disk), etc. The memory circuitry **32** stores various processing programs (including applications programs as well as OS (operating system), etc.) to be used in the processing circuitry **31**, data necessary for execution of programs, and medical images. Further, the OS may include GUI (graphical user interface) which heavily uses graphics for displaying information for the operator on the display **34**, and enables fundamental operations by using the input circuitry **33**.

[0063] The input circuitry **33** is a circuit that inputs signals from an input device such as a pointing device (mouse), a keyboard, etc., which can be operated by the operator, where it is supposed that the input device itself is included in the input circuitry **33**. When the input device is operated by the operator, the input circuitry **33** generates an input signal corresponding to the operation and outputs it to the processing circuitry **31**. Note that the apparatus main body **12** may include a touch panel in which the input device is integrally constructed with the display **34**.

[0064] The display **34** includes a common display output apparatus such as a liquid crystal display and an OLED (organic light emitting diode) display, and displays image data generated by the image generation circuitry **38** according to control by the processing circuitry **31**.

[0065] The reference signal generation circuitry **35** generates, for example, a continuous wave or a square wave, which has a frequency substantially equal to the center frequency of an ultrasonic pulse, to the transmission/reception circuitry **36** according to a control signal from the processing circuitry **31**.

[0066] The transmission/reception circuitry **36** causes the ultrasonic probe **11** to perform transmission/reception according to a control signal from the processing circuitry **31**. The transmission/reception circuitry **36** includes transmission circuitry **361** for creating a drive signal for causing transmission ultrasound to be radiated from the ultrasonic probe **11**, and reception circuitry **362** for performing phasing addition on a received signal from the ultrasonic probe **11**.

[0067] The transmission circuitry **361** includes a rate pulse generator, transmission delay circuitry, and a pulsar, which are not shown. The rate pulse generator creates a rate pulse for determining a repeating period of transmission ultrasound by frequency-dividing a continuous wave or square wave provided from the reference signal generation circuitry **35**, and provides the rate pulse to the transmission delay circuitry. The transmission delay circuitry includes independent delay circuitries of the same number (N channels) as that of the transducers used for transmission, and gives the rate pulse a delay time for focusing transmission ultrasound at a predetermined depth to obtain a narrow beam width, and a delay time for radiating transmission ultrasound in a predetermined direction during transmission, and provides the rate pulse to the pulsar. The pulsar includes N channels of independent drive circuitries, and generates drive pulses for driving the transducers built in the ultrasonic probe **11**, based on the rate pulse.

[0068] The reception circuitry **362** of the transmission/reception circuitry **36** includes a pre-amplifier, A/D (analog to digital) conversion circuitry, reception delay circuitry, and adding circuitry, which are not shown. The pre-amplifier includes N channels, and amplifies a minute signal which has been converted into a received electric signal by the transducer to ensure a sufficient S/N level. Each of the received signals of N channels, which has been amplified to a predetermined magnitude at the pre-amplifier, is converted into a digital signal at the A/D conversion circuitry, and is sent to the reception delay circuitry. The reception delay circuitry gives a focusing delay time for focusing ultrasound reflection wave from a predetermined depth, and a deflecting delay time for setting a reception directivity in a predetermined direction, to each of the received signals of N channels outputted from the A/D conversion circuitry. The adding circuitry performs phasing and adding of the received signals from the reception delay circuitry (matches the phases of received signals obtained from a predetermined direction and adds them together).

[0069] The echo data processing circuitry **37** performs processing to generate ultrasonic images on the echo data inputted from the reception circuitry **362**, according to a control signal from the processing circuitry **31**. For example, the echo data processing circuitry **37** performs B-mode processing such as logarithmic compression processing and envelope wave-detection processing, and Doppler processing such as orthogonal wave-detection processing and filtering processing.

[0070] The image generation circuitry **38** scans and converts data inputted from the echo data processing circuitry **37** with a scan converter according to a control signal from the processing circuitry **31**, to generate ultrasonic image data. Then, the image generation circuitry **38** causes an ultrasonic image based on the ultrasonic image data to be displayed on the display **34**. The ultrasonic image is, for example, a B-mode image and a color Doppler image.

[0071] Next, functions of the ultrasonic diagnostic apparatus **1** according to the first embodiment will be described.

[0072] FIG. **5** is a block diagram showing functions of the ultrasonic diagnostic apparatus **1** according to the first embodiment.

[0073] As a result of the processing circuitry **31** performing a program, the ultrasonic diagnostic apparatus **1** functions as a convex scanning executing function **311**, a pivoting angle determining function **312**, a linear scanning executing function **313**, and a scanning type changing-over function **314**. Note that although description will be made taking as an example a case in which the functions **311** to **314** function in a software fashion, the whole or part of those functions **311** to **314** may be installed in a hardware fashion, respectively in the ultrasonic diagnostic apparatus **1**.

[0074] The convex scanning executing function **311** is a function of controlling the convex array **22***b* of the ultrasonic probe **11**, thereby causing a convex scanning to be executed. The convex scanning is executed such that the operator can confirm the insertion position of the puncture needle into an organ, for example, the prostate, on an ultrasonic image. An ultrasonic image by the convex scanning is shown in FIG. **8**.

[0075] The pivoting angle determining function **312** is a function of determining a pivoting angle in a change-over of the scanning type by the scanning type changing-over function **314** based on the position of a puncture target to be set on an ultrasonic image by the convex scanning executing function **311**.

[0076] The linear scanning executing function **313** is a function of controlling the linear array **22***a* of the ultrasonic probe **11**, thereby causing a linear scanning to be performed. The linear scanning is performed such that the operator can confirm a puncture target and a puncture needle on an ultrasonic image viewed from a side of the puncture needle. An ultrasonic image by liner scanning is shown in FIG. **10**.

[0077] The scanning type changing-over function **314** includes a function of controlling a pivot driver **22***e* such that upon depression of the changing-over switch **21***a* of the ultrasonic probe **11** during execution of the convex scanning by the convex scanning executing function **311**, the pivot shaft **22***d* pivots (pivots in positive direction) according to a pivoting angle determined by the pivoting angle determining function **312**, and a function of changing over the scanning type from the convex scanning to the linear scanning. Moreover, the scanning type changing-over function **314** includes a function of controlling the pivot driver **22***e* such that upon depression of the changing-over switch **21***a* of the ultrasonic probe **11** during execution of the linear scanning by the linear scanning executing function **313**, the pivot shaft **22***d* pivots (pivots in a negative direction) according to a pivoting angle determined by the pivoting angle determining function **312**, and a function of changing over the scanning type from the linear scanning to the convex scanning.

[0078] For example, consider a case in which the pivot shaft **22***d* (arrays **22***a* and **22***b*) repeats puncturing to three puncture targets. In such a case, in puncturing to a first puncture target, the scanning type changing-over function **314** rotates the pivot shaft **22***d* by a first pivoting angle $\theta 1$ in a positive direction, and thereafter rotates the pivot shaft **22***d* by the same first pivoting angle $\theta 1$ in a negative direction. In the following puncturing to a second puncture target, the scanning type changing-over function **314** rotates the pivot shaft **22***d* by a second pivoting angle $\theta 2$ in a positive direction, and thereafter rotates the pivot shaft **22***d* by the same pivoting angle $\theta 2$ in a negative direction. In the following puncturing to a third puncture target, the scanning type changing-over function **314** rotates the pivot shaft **22***d* by a third pivoting angle $\theta 3$ in a positive direction, and thereafter rotates the pivot shaft **22***d* by the same third pivoting angle $\theta 3$ in a negative direction.

[0079] Where, the pivoting angle determining function **312** is not an essential function for the ultrasonic diagnostic apparatus **1**. When the pivoting angle determining function **312** is absent, and when the changing-over switch **21***a* of the ultrasonic probe **11** is depressed during execution of the convex scanning by the convex scanning executing function **311**, the pivot shaft **22***d* pivots (pivots in a positive direction) according to a previously set, fixed pivoting angle. Moreover, when the pivoting angle determining function **312** is absent, and when the changing-over switch **21***a* of the ultrasonic probe **11** is depressed during execution of the linear scanning by the linear scanning executing function

313, the pivot shaft 22*d* pivots (pivots in the negative direction) according to a previously set, fixed pivoting angle.

[0080] For example, consider a case in which the pivoting angle determining function 312 is absent, and the pivot shaft 22*d* (arrays 22*a* and 22*b*) repeats puncturing to three puncture targets. In such a case, the pivoting angle θ of the pivot shaft 22*d* is supposed to be a previously set angle α (shown in FIG. 7), and in the puncturing to the first puncture target, the pivot shaft 22*d* pivots by a pivoting angle α in the positive direction, and thereafter pivots by the same pivoting angle α in the negative direction. In the following puncturing to the second puncture target, the pivot shaft 22*d* pivots by the same pivoting angle α in the positive direction, and thereafter pivots by the same pivoting angle α in the negative direction. In the following puncturing to the third puncture target, the pivot shaft 22*d* pivots by the same pivoting angle α in the positive direction, and thereafter pivots by the same pivoting angle α in the negative direction.

[0081] Next, an operation of the ultrasonic diagnostic apparatus 1 according to the first embodiment will be described by using FIGS. 1 and 6.

[0082] FIG. 6 is a flowchart showing the operation of the ultrasonic diagnostic apparatus 1 according to the first embodiment.

[0083] The ultrasonic diagnostic apparatus 1 sets, when an instruction to initiate scanning via the input circuitry 33 is input, the position of the convex array 22*b* such that the scanning type of the ultrasonic probe 11 is the convex scanning (step ST1).

[0084] The ultrasonic diagnostic apparatus 1 controls the convex array 22*b* of the ultrasonic probe 11 such that the operator can confirm the insertion position of the puncture needle into an organ, for example, the prostate, on an ultrasonic image, and initiates the convex scanning (step ST2). The ultrasonic diagnostic apparatus 1 sets a puncture target on an ultrasonic image by the convex scanning initiated by step ST2 (step ST3).

[0085] FIG. 7 is a diagram to illustrate the convex scanning. FIG. 8 is a diagram showing an example of an ultrasonic image by the convex scanning.

[0086] FIG. 7 shows a prostate P as an organ, and a region of interest B which is a region where presence of a prostate cancer included in the prostate P is suspected. When the convex scanning is performed on the prostate P, an ultrasonic image of an x-y section shown in FIG. 8 is obtained. The ultrasonic image shown in FIG. 8 includes a prostate image IP which corresponds to the prostate P shown in FIG. 7, a region-of-interest image IB which corresponds to the region of interest B, and a puncture target IT as a target.

[0087] Where, the puncture target IT may be set on the region-of-interest image IB by the operator, or the position of a candidate, which is selected from predetermined candidates of puncture target which are superimposed on the ultrasonic image, may be set as the position of the puncture target. In such a case, candidates of puncture target are superimposed on an ultrasonic image generated through the convex scanning, at positions corresponding to the positions of through holes for guiding a puncture needle in the puncture adaptor 24 (shown in FIGS. 2 to 4).

[0088] The operator can advance the puncture needle N while viewing a substantially real-time ultrasonic image shown in FIG. 8.

[0089] Moreover, a marker of a scanning plane by the linear scanning may be superimposed on an ultrasonic image by the convex scanning. The marker is shown by a dotted line in FIG. 8.

[0090] Referring back to description of FIGS. 1 and 6, the ultrasonic diagnostic apparatus 1 determines a pivoting angle in the change-over of scanning type, based on the position of the puncture target set on the ultrasonic image by the convex scanning (step ST4). The ultrasonic diagnostic apparatus 1 judges whether or not the scanning type has been changed over from convex scanning to linear scanning via the changing-over switch 21*a* (shown in FIGS. 2 to 4) (step ST5).

[0091] When it is judged to be YES in step ST5, that is, that the scanning type has been changed over from the convex scanning to the linear scanning, the ultrasonic diagnostic apparatus 1 terminates the convex scanning, and rotates the pivot shaft 22*d* (rotates the pivot shaft 22*d* in the positive direction) according to a pivoting angle determined by step ST4 (step ST6). The pivoting angle in step ST6 is determined such that the scanning center by the linear scanning corresponds to the position of the puncture target set by step ST3.

[0092] The ultrasonic diagnostic apparatus 1 controls the linear array 22*a* of the ultrasonic probe 11 such that the operator can confirm the puncture target and the puncture needle on an ultrasonic image viewed from a side of the puncture needle, and initiates the linear scanning (step ST7).

[0093] FIG. 9 is a diagram to illustrate the linear scanning. FIG. 10 is a diagram showing an example of an ultrasonic image by the linear scanning.

[0094] FIG. 9 shows a state in which the arrays 22*a* and 22*b* shown in FIG. 7 are rotated by a pivoting angle θ around the axis of the pivot shaft 22*d*. FIG. 9 shows a prostate P as an organ and a region of interest B included in the prostate P. When the linear scanning on the prostate P is performed, an ultrasonic image of a y-z section shown in FIG. 10 will be obtained. The ultrasonic image shown in FIG. 10 includes a prostate image IP corresponding to the prostate P shown in FIG. 9, a region-of-interest image IB corresponding to the region of interest B, a puncture target IT, and a puncture needle IN.

[0095] The operator can advance the puncture needle N while viewing a substantially real-time ultrasonic image shown in FIG. 10.

[0096] Referring back to description of FIGS. 1 and 6, the ultrasonic diagnostic apparatus 1 judges whether or not the scanning type has been changed over from the linear scanning to the convex scanning through the changing-over switch 21*a* (shown in FIGS. 2 to 4) (step ST8).

[0097] When it is judged to be YES at step ST8, that is, that the scanning type has been changed over from the linear scanning to the convex scanning, the ultrasonic diagnostic apparatus 1 terminates the linear scanning, and rotates the pivot shaft 22*d* (rotates the pivot shaft 22*d* in the negative direction) according to a pivoting angle determined by step ST4 (or a previously set, fixed pivoting angle) (step ST9). The ultrasonic diagnostic apparatus 1 controls the convex array 22*b* of the ultrasonic probe 11 to initiate the convex scanning (step ST2).

[0098] The ultrasonic diagnostic apparatus 1 controls the linear array 22*a* of the ultrasonic probe 11 to initiate the linear scanning (step ST7), and controls the convex array **22**_b_ of the ultrasonic probe **11** to initiate the convex scanning (step ST**2**).

[0099] On the other hand, when it is judged to be NO at step ST**5**, that is, that the scanning type has not been changed over from the convex scanning to the linear scanning, the ultrasonic diagnostic apparatus **1** judges whether or not an instruction to terminate scanning has been accepted (step ST**10**). When it is judged to be YES at step ST**10**, that is, that an instruction to terminate scanning has been accepted, the ultrasonic diagnostic apparatus **1** terminates scanning. On the other hand, when it is judged to be NO at step ST**10**, that is, that no instruction to terminate scanning has been accepted, the ultrasonic diagnostic apparatus **1** returns to judgment at step ST**5**.

[0100] Moreover, when it is judged to be NO at step ST**8**, that is, that the scanning type has not been changed over from the linear scanning to the convex scanning, the ultrasonic diagnostic apparatus **1** judges whether or not an instruction to terminate scanning has been accepted (step ST**11**). When it is judged to be YES at step ST**11**, that is, that an instruction to terminate scanning has been accepted, the ultrasonic diagnostic apparatus **1** terminates scanning. On the other hand, when it is judged to be NO at step ST**11**, that is, that no instruction to terminate scanning has been accepted, the ultrasonic diagnostic apparatus **1** returns to judgment of step ST**8**.

[0101] For example, consider a case in which the ultrasonic diagnostic apparatus **1** repeats operations of steps ST**2** to ST**9** shown in FIG. **6** for three puncture targets (three pivoting angles θ**1** to θ**3**). In that case, the ultrasonic diagnostic apparatus **1** rotates the pivot shaft **22**_d_ (arrays **22**_a_ and **22**_b_) by a first pivoting angle θ**1** in the positive direction at step ST**6** of a first period, and thereafter rotates the pivot shaft **22**_d_ by the first pivoting angle θ**1** in the negative direction at step ST**9**. The ultrasonic diagnostic apparatus **1** rotates the pivot shaft **22**_d_ by a second pivoting angle θ**2** in the positive direction at step ST**6** in the following second period, and thereafter rotates the pivot shaft **22**_d_ by the second pivoting angle θ**2** in the negative direction at step ST**9**. The ultrasonic diagnostic apparatus **1** rotates the pivot shaft **22**_d_ by a third pivoting angle θ**3** in the positive direction at step ST**6** in the following third period, and thereafter rotates the pivot shaft **22**_d_ by the third pivoting angle θ**3** in the negative direction at step ST**9**.

[0102] Note that although description has been made using FIGS. **7** to **10** on a case in which the region of interest B is a prostate cancer (malignant tumor), and a target to be set on a region-of-interest image IB relating to the region of interest B is the puncture target, the present embodiment will not be limited in such a case. For example, the region of interest B may be a tumor of prostate, and a target to be set on a region-of-interest image IB may be a measurement target. In that case, an orthogonal section image, that is, an ultrasonic image by the convex scanning initiated by step ST**2**, and an ultrasonic image by the linear scanning initiated by step ST**7** may be displayed, and the size and dimensions etc. of the region-of-interest image IB are measured based on an orthogonal sectional image.

[0103] Moreover, the region of interest B is not limited to a tumor of prostate. For example, the region of interest B may be a tumor of ovarian.

[0104] According to the ultrasonic diagnostic apparatus **1** relating to the first embodiment, since change over between the first transducer set **22**_a_ and the second transducer set **22**_b_ is automatically performed, it is possible to improve operability by the operator.

[0105] Further, according to the ultrasonic diagnostic apparatus **1** relating to the first embodiment, it is possible to cause the puncture target, which has appeared on a scanning plane by either of the transducer sets, to appear on a scanning plane by another of the transducer sets after change over.

Second Embodiment

[0106] Since the configurations of the ultrasonic probe and the ultrasonic diagnostic apparatus according to the second embodiment are equal to those of the ultrasonic probe and the ultrasonic diagnostic apparatus according to the first embodiment shown in FIG. **1**, illustration and description thereof will be omitted.

[0107] FIG. **11** is a diagram showing an example structure of an ultrasonic probe according to a second embodiment.

[0108] FIG. **11** shows an ultrasonic probe **11**A according to the second embodiment. The ultrasonic probe **11**A is a probe for use on body surfaces. The ultrasonic probe **11**A performs transmission/reception of ultrasound to and from an object according to control by the apparatus main body **12**.

[0109] Shown on the left-hand side of FIG. **11** is a IV-IV section (x-y section) of the ultrasonic probe **11**A shown on the right-hand side of FIG. **11**, and shown on the right-hand side of FIG. **11** is a side view (viewed from a y-z plane) of the ultrasonic probe **11**A.

[0110] The ultrasonic probe **11**A includes a handle portion **21**, a probe body (distal end portion) **22**A, and a cable **23**.

[0111] Further, the ultrasonic probe **11**A may be equipped with a puncture adaptor **24**A for guiding a puncture needle. A through hole for guiding the puncture needle is formed at a predetermined position of the puncture adaptor **24**A.

[0112] The probe body **22**A includes a transducer set supporter **22**_c_, a pivot shaft **22**_d_, an acoustic window (not shown), a signal line **22**_g_, a solution layer **22**_h_, a first transducer set **22**_j_, a second transducer set **22**_k_, and a pivot driver (electromagnet) **221**. It is supposed that scanning types by the first transducer set **22**_j_ and by the second transducer set **22**_k_ are different from each other.

[0113] Note that in the ultrasonic probe **11**A shown in FIG. **11**, the same components as those of the ultrasonic probe **11** shown in FIG. **2** are given the same reference symbols, thereby omitting description thereof.

[0114] A center position, in a direction (z direction) orthogonal to an axis of the probe body **22**A, of the second transducer set **22**_k_ of the ultrasonic probe **11**A substantially corresponds to a center position in the z direction, of the first transducer set **22**_j_. Moreover, in an orthogonal plane (x-y section) with respect to the z direction, an angle (β shown in FIG. **12**) formed between a scanning plane of the first transducer set **22**_j_ and a center line of the second transducer set **22**_k_ is preferably not more than 180°. This is because the puncture needle advances obliquely to, not in parallel with, the z direction when the ultrasonic probe **11**A is used.

[0115] The first transducer set **22**_j_ has a structure in which transducers are arranged in a row along the z direction. The row along the z direction may be one or more rows. Each transducer is an electro-acoustic transducer, which has a function of converting an electric pulse into an ultrasonic pulse (transmission ultrasound) during transmission, and converting an ultrasonic reflected wave into an electric signal during reception. The first transducer set **22***j* is, for example, a linear array. Hereafter, description will be made taking as an example a case in which the first transducer set **22***j* is a linear array.

[0116] When transducers are arranged in 1 to about 3 rows in the linear array **22***j*, a lens member (not shown) for focusing ultrasound in the x direction is provided in a front side of the linear array **22***j*. On the other hand, when transducers are arranged in a sufficient number of rows in the linear array **22***j*, electronic focusing is used to focus ultrasound in the x direction.

[0117] The second transducer set **22***k* has a structure in which transducers are arranged on a plane (x-y section) substantially orthogonal to the z direction. The second transducer set **22***k* includes the transducers arranged on the one plane substantially orthogonal to the z direction or on multiple planes substantially orthogonal to the z direction. The second transducer set **22***k* is, for example, a convex array in which transducers are arranged on a plane substantially orthogonal to the z direction, and in a portion of a circumference whose radius of curvature substantially corresponds to the pivoting radius. Hereafter, description will be made taking as an example a case in which the second transducer set **22***k* is a convex array.

[0118] When the transducers are arranged in 1 to about 3 planes in the convex array **22***k*, a lens member (not shown) for focusing ultrasound in the z direction is provided in a front side of the convex array **22***k*. On the other hand, when the transducers are arranged in a sufficient number of planes in the convex array **22***k*, electronic focusing is used to focus ultrasound in the z direction.

[0119] Note that although it is supposed that a bucking for preventing back reflection is provided in a rear side of each of the arrays **22***j* and **22***k*, description thereof will be omitted.

[0120] The pivot driver **221** rotates the pivot shaft **22***d* according to a pivoting angle instructed from the apparatus main body **12** upon depression of the changing-over switch **21***a*. Note that, upon depression of the changing-over switch **21***a*, the pivot driver **221** may rotates the pivot shaft **22***d* according to a previously set, fixed pivoting angle.

[0121] Since the functions of the ultrasonic diagnostic apparatus **1**A according to the second embodiment are equal to those of the ultrasonic diagnostic apparatus **1** according to the first embodiment shown in FIG. **5**, description thereof will be omitted. Moreover, since the operations of the ultrasonic diagnostic apparatus **1**A according to the second embodiment are equal to those of the ultrasonic diagnostic apparatus **1** according to the first embodiment shown in FIG. **6**, description thereof will be omitted.

[0122] FIG. **12** is a diagram to illustrate the linear scanning. FIG. **13** is a diagram showing an example of an ultrasonic image by the linear scanning.

[0123] FIG. **12** shows a region of interest B. Performing the linear scanning from a body surface will result in an ultrasonic image of a y-z section shown in FIG. **13**. The ultrasonic image shown in FIG. **13** includes a region-of-interest image IB corresponding to the region of interest B shown in FIG. **12**. The operator can advance the puncture needle N while viewing a substantially real-time ultrasonic image shown in FIG. **13**.

[0124] Moreover, a marker of a scanning plane by the convex scanning may be superimposed on an ultrasonic image by the linear scanning. The marker is shown by a dotted line in FIG. **13**.

[0125] FIG. **14** is a diagram to illustrate the convex scanning. FIG. **15** is a diagram showing an example of an ultrasonic image by the convex scanning.

[0126] FIG. **14** shows a state in which the arrays **22***j* and **22***k* shown in FIG. **12** pivot by a pivoting angle θ around the axis of the pivot shaft **22***d*. FIG. **14** shows a region of interest B. Performing the linear scanning from a body surface will result in an ultrasonic image of an x-y section shown in FIG. **15**. The ultrasonic image shown in FIG. **15** includes a region-of-interest image IB corresponding to the region of interest B shown in FIG. **14**, and a puncture needle IN. The operator can advance the puncture needle N while viewing a substantially real-time ultrasonic image shown in FIG. **15**.

[0127] According to the ultrasonic diagnostic apparatus **1**A relating to the second embodiment, since change-over between the first transducer set **22***j* and the second transducer set **22***k* is automatically performed, it is possible to improve operability by the operator.

[0128] Further, according to the ultrasonic diagnostic apparatus **1**A relating to the second embodiment, it is possible to cause a puncture target, which has appeared on a scanning plane by either of the transducer sets, to appear on a scanning plane by another of the transducer sets after change over.

Third Embodiment

[0129] Since the configurations of the ultrasonic probe and the ultrasonic diagnostic apparatus according to a third embodiment are equal to those of the ultrasonic probe and the ultrasonic diagnostic apparatus according to the first embodiment shown in FIG. **1**, illustration and description thereof will be omitted.

[0130] FIG. **16** is a diagram to show an example structure of an ultrasonic probe according to the third embodiment.

[0131] FIG. **16** shows an ultrasonic probe **11**B according to the third embodiment. The ultrasonic probe **11**B is one principally for use inside a body cavity, which is suitable for being inserted through the rectum to image an internal organ. The ultrasonic probe **11**B performs transmission/reception of ultrasound to and from an object according to control by the apparatus main body **12**.

[0132] Shown on the left-hand side of FIG. **16** is a V-V section (x-y section) of the ultrasonic probe **11**B shown on the right-hand side of FIG. **16**, and shown on the right-hand side of FIG. **16** is a side view (viewed from a y-z plane) of the ultrasonic probe **11**B.

[0133] The ultrasonic probe **11**B includes a handle portion **21**, a probe body (distal end portion) **22**B, and a cable **23**.

[0134] Further, the ultrasonic probe **11**B may be equipped with a puncture adaptor **24** for guiding a puncture needle. Through holes for guiding a puncture needle are formed at predetermined positions of the puncture adaptor **24**. The ultrasonic probe **11**B can be equipped with two position sensors (magnetic sensors) M that measure a position of the ultrasonic probe **11**B, a direction of the axis of the ultrasonic probe **11**B, and a pivoting angle of the ultrasonic probe **11**B.

[0135] The probe body **22**B includes a first transducer set **22***a*, a second transducer set **22***b*, a signal line **22***g*, a solution layer **22***h*, and an acoustic window **22***m*. It is supposed that scanning types by the first transducer set **22**a and by the second transducer set **22**b are different from each other.

[0136] Note that in the ultrasonic probe **11**B shown in FIG. **16**, the same components as those of the ultrasonic probe **11** shown in FIG. **2** are given the same reference symbols, thereby omitting description thereof.

[0137] The acoustic window **22**m is provided in the whole or a part (a portion of transmission/reception opening) of a circumference around the axis of the probe body **22**B out of the housing, which is in direct contact with the object, and is made of a material which easily transmits ultrasound. The housing accommodates a linear array **22**a, a convex array **22**b, and part of signal line **22**g.

[0138] The ultrasonic diagnostic apparatus **1**B is configured such that when a manual rotating operation for changing-over the scanning type is performed by the operator, a scanning plane by the scanning type after the change-over is guided so as to include the position of the puncture target IT (shown in FIG. **8**) which has been set on an ultrasonic image by the scanning type before the change-over. When the scanning plane by the scanning type after the change-over includes the position of the puncture target IT, the ultrasonic diagnostic apparatus **1**B performs notification (by at least one of display and voice) of that fact.

[0139] A transmitter (magnetic transmitter) is disposed proximal to the ultrasonic diagnostic apparatus **1**B. Magnetic fields in three dimensional directions are temporally changed over and radiated from the transmitter and, in synchronous with that, the position sensor M detects the three-dimensional coordinates, making it possible that the ultrasonic diagnostic apparatus **1**B measures the pivoting angle of the ultrasonic probe **11**B.

[0140] Since the ultrasonic diagnostic apparatus **1**B can calculate the spatial position of the puncture target IT (shown in FIG. **8**) set on an ultrasonic image by the convex scanning, it can calculate a target pivoting angle when the scanning plane by the linear scanning includes the puncture target IT. Then, the ultrasonic diagnostic apparatus **1**B can perform notification of when a measured pivoting angle of the ultrasonic probe **11**B resulted from the manual rotating operation substantially corresponds to the target pivoting angle.

[0141] Note that as a result of the position sensor M detecting three dimensional coordinates, the ultrasonic diagnostic apparatus **1**B can also measure the spatial position of the ultrasonic probe **11**B and the direction of the axis of the ultrasonic probe **11**B. In that case, although, if the position of the ultrasonic probe **11**B and the direction of the axis of the ultrasonic probe **11**B change during the manual rotating operation of the ultrasonic probe **11**B, measured position of the ultrasonic probe **11**B, and measured direction of the axis of the ultrasonic probe **11**B will change, it is possible to comprehensively estimate such changes and perform notification when the scanning plane by the linear scanning includes a puncture target IT (shown in FIG. **8**).

[0142] According to the ultrasonic diagnostic apparatus **1**B relating to the third embodiment, it is possible to cause the puncture target, which has appeared on a scanning plane by either of the transducer sets, to appear on a scanning plane by another of the transducer sets after change over.

[0143] According to the ultrasonic probe and ultrasonic diagnostic apparatus relating to at least one of the above described embodiments, it is possible to improve operability by the operator.

[0144] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel methods and systems described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An ultrasonic probe, comprising:

a first transducer set in which transducers are arranged in a direction parallel with an axis of the ultrasonic probe;

a second transducer set in which transducers are arranged on a plane substantially orthogonal to the axis; and

a transducer set supporter supporting the first transducer set and the second transducer set, and configured to pivot around the axis.

2. The ultrasonic probe according to claim **1**, wherein scanning types by the first transducer set and by the second transducer set are different from each other.

3. The ultrasonic probe according to claim **2**, wherein the transducers of the first transducer set are arranged in a linear array whose scanning type is a linear scanning, and the transducers of the second transducer set are arranged in a convex array whose scanning type is a convex scanning.

4. The ultrasonic probe according to claim **1**, wherein center positions, in a direction of the axis, of the first transducer set and the second transducer set are different from each other.

5. The ultrasonic probe according to claim **1**, wherein scanning types by the first transducer set and by the second transducer set are different from each other, and center positions, in a direction of the axis, of the first transducer set and the second transducer set are different from each other.

6. The ultrasonic probe according to claim **1**, wherein the first transducer set and the second transducer set are covered by a housing, and an interior of the housing is filled with liquid or fluid matter.

7. The ultrasonic probe according to claim **6**, wherein a pivoting center of the transducer set supporter substantially corresponds to an axis of the housing.

8. The ultrasonic probe according to claim **1**, wherein the second transducer set is movable in the direction parallel with the axis.

9. The ultrasonic probe according to claim **1**, wherein pivoting radii of the first transducer set and the second transducer set substantially correspond to a radius of curvature of the second transducer set.

10. The ultrasonic probe according to claim **1**, wherein the transducer set supporter pivots through an electric motor or an electromagnet.

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

a scale indicating a pivoting angle of the transducer set supporter.

12. The ultrasonic probe according to claim **1**, further comprising

a changing-over switch for instructing the transducer set supporter to pivot.

13. The ultrasonic probe according to claim **1**, wherein

the second transducer set includes the transducers arranged on a circumference around the axis and arranged on a plane substantially orthogonal to the axis, and the second transducer set is insertable into a body cavity to collect an ultrasonic image of an inside of the body cavity.

14. An ultrasonic diagnostic apparatus, comprising:

the ultrasonic probe according to claim **1**; and

processing circuitry configured to:

perform a scanning through the ultrasonic probe to generate an ultrasonic image;

display the ultrasonic image on a display;

set, when a position of a target is set on an ultrasonic image generated through the scanning by the second transducer set, a pivoting angle such that a scanning center by the first transducer set corresponds to the position of the target on a basis of the position of the target; and

control a pivoting of the transducer set supporter according to the pivoting angle.

15. The ultrasonic diagnostic apparatus according to claim **14**, wherein

the processing circuitry is configured to superimpose a marker of a scanning plane of the scanning by the first transducer set on the ultrasonic image generated through the scanning by the second transducer set.

16. The ultrasonic diagnostic apparatus according to claim **14**, wherein

the processing circuitry is configured to:

superimpose candidates of target on the ultrasonic image generated through the scanning by the second transducer set; and

set a position of a candidate selected from the candidates of target as a position of the target.

17. The ultrasonic diagnostic apparatus according to claim **16**, wherein

the processing circuitry is configured to superimpose the candidates of target on the ultrasonic image generated through the scanning by the second transducer set, at positions corresponding to positions of through holes for guiding a puncture needle in a puncture adaptor equipped in the ultrasonic probe.

18. The ultrasonic diagnostic apparatus according to claim **14**, wherein

the processing circuitry is configured to set, when a position of a needle target is set as the target, a pivoting angle such that a scanning center by the first transducer set corresponds to a position of the puncture target on a basis of the position of the puncture target.

19. An ultrasonic diagnostic apparatus, comprising:

an ultrasonic probe including a first transducer set in which transducers are arranged in a direction parallel with an axis of the ultrasonic probe, a second transducer set in which transducers are arranged on a plane substantially orthogonal to the axis, and a sensor for detecting a position; and

processing circuitry configured to:

perform a scanning through the ultrasonic probe to generate an ultrasonic image;

display the ultrasonic image on a display;

calculate, when a position of a target is set on an ultrasonic image generated through scanning by the second transducer set, a target pivoting angle when the scanning plane through the scanning by the first transducer set includes the target on a basis of the position of the puncture target; and

perform notification when a pivoting angle of the ultrasonic probe based on the detected position substantially corresponds to the target pivoting angle.

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摘要(译)

根据本实施例的超声波探头包括第一换能器组，第二换能器组和换能器组支撑器。第一换能器组在与超声波探头的轴平行的方向上布置换能器。第二换能器组将换能器布置在基本垂直于轴的平面上。换能器组支撑件支撑第一换能器组和第二换能器组，并配置成绕轴枢转。