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(54) ULTRASOUND TRANSDUCER, ULTRASOUND PROBE INCLUDING THE SAME, AND ULTRASOUND DIAGNOSTIC EQUIPMENT INCLUDING THE ULTRASOUND PROBE

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(57) **ABSTRACT**

Provided are an ultrasound transducer, an ultrasound probe including the ultrasound transducer, and ultrasound diagnostic equipment including the ultrasound probe. The ultrasound transducer includes a piezoelectric unit including a plurality of piezoelectric elements which vibrate to convert ultrasound waves into electrical signals and electrical signals back into ultrasound waves, and a dummy piezoelectric unit which is disposed at edges of the effective piezoelectric unit and includes a plurality of dummy piezoelectric elements which vibrate due to vibration of the piezoelectric unit.

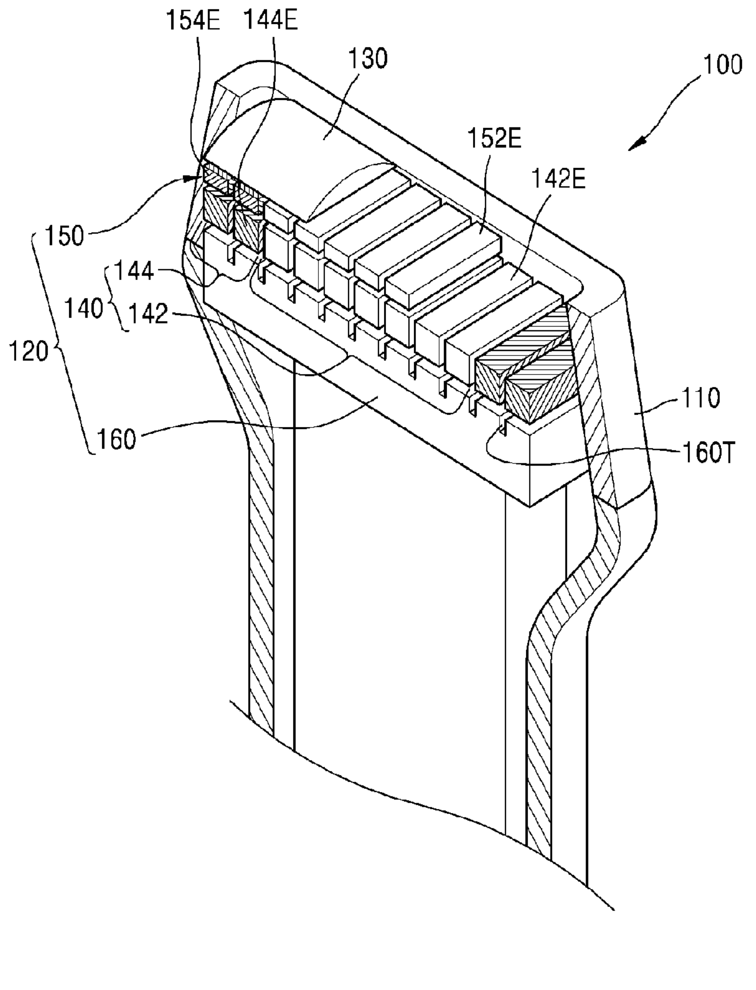


FIG. 1

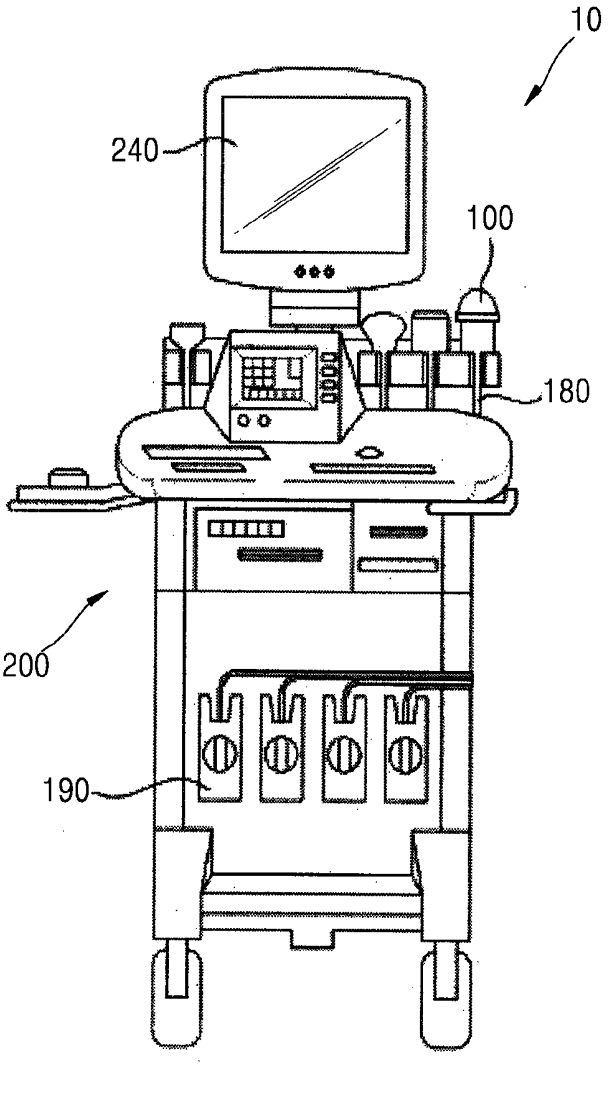


FIG. 2

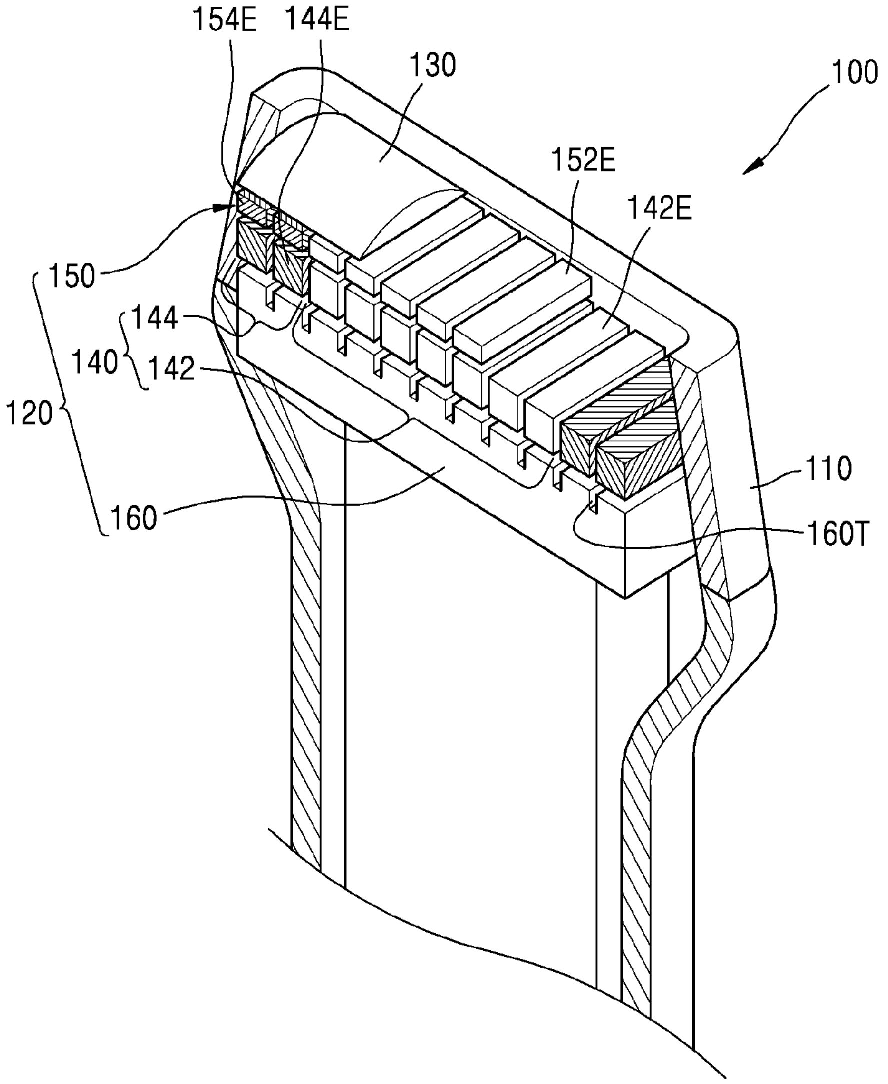


FIG. 3A

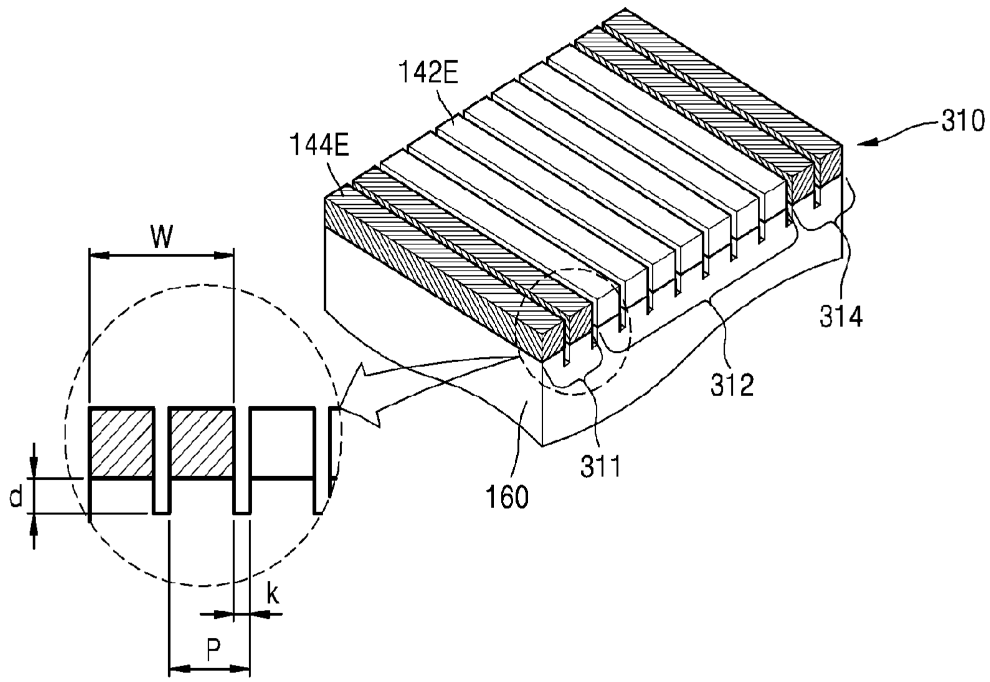

142E
144E
310
314
312
311
160
W
d
k
P

FIG. 3B

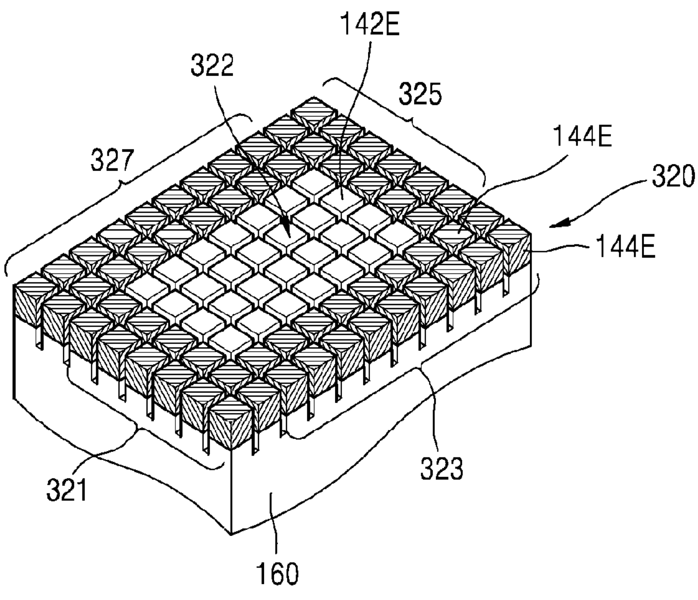

142E
322
325
327
144E
320
144E
321
323
160

FIG. 4

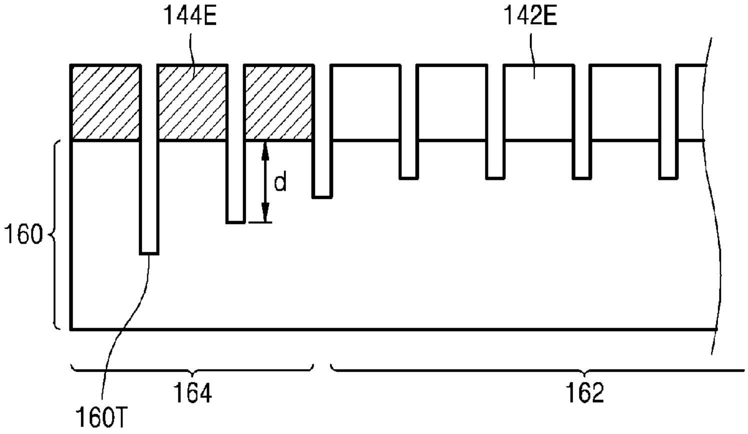

144E
142E
d
160
160T
164
162

FIG. 5

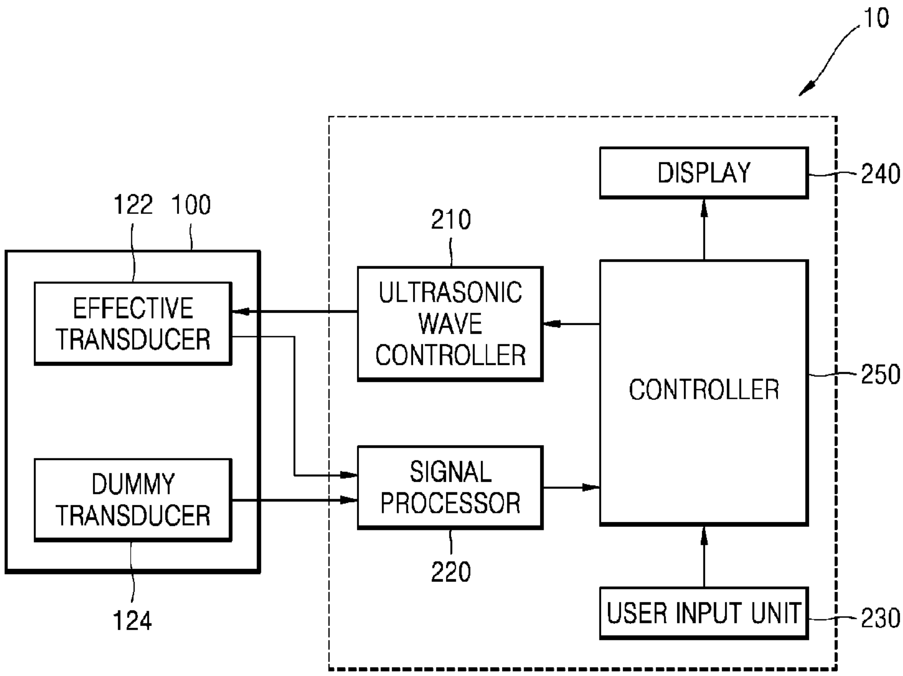

10
DISPLAY
240
122
100
210
ULTRASONIC
WAVE
CONTROLLER
EFFECTIVE
TRANSDUCER
CONTROLLER
250
DUMMY
TRANSDUCER
SIGNAL
PROCESSOR
220
124
USER INPUT UNIT
230

FIG. 6A

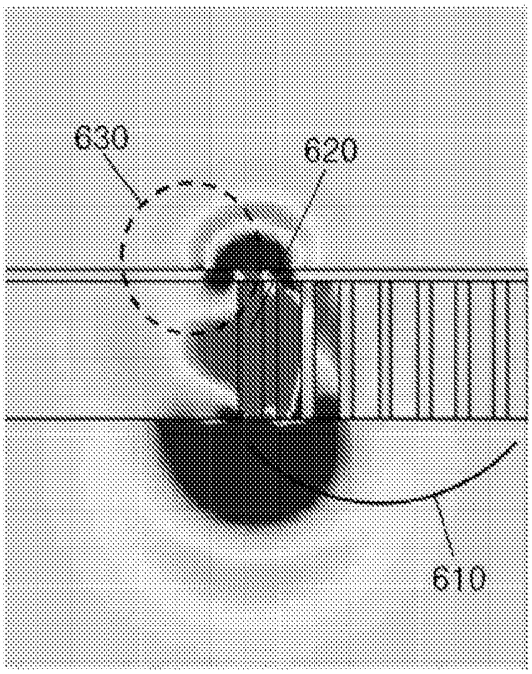


FIG. 6B

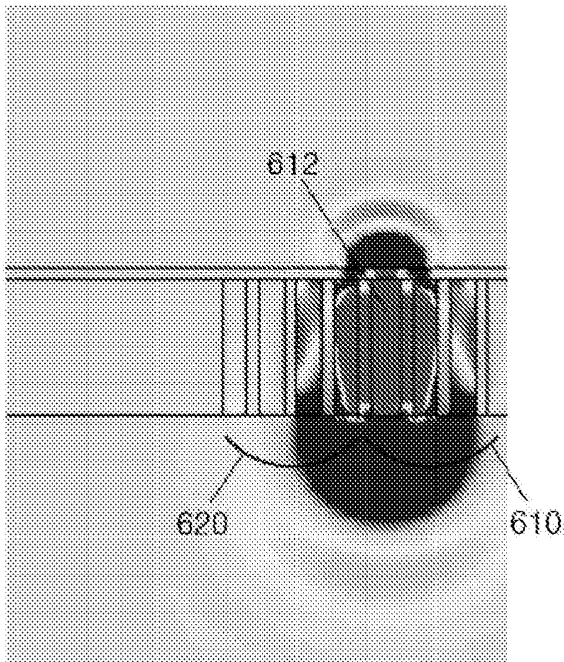


FIG. 7

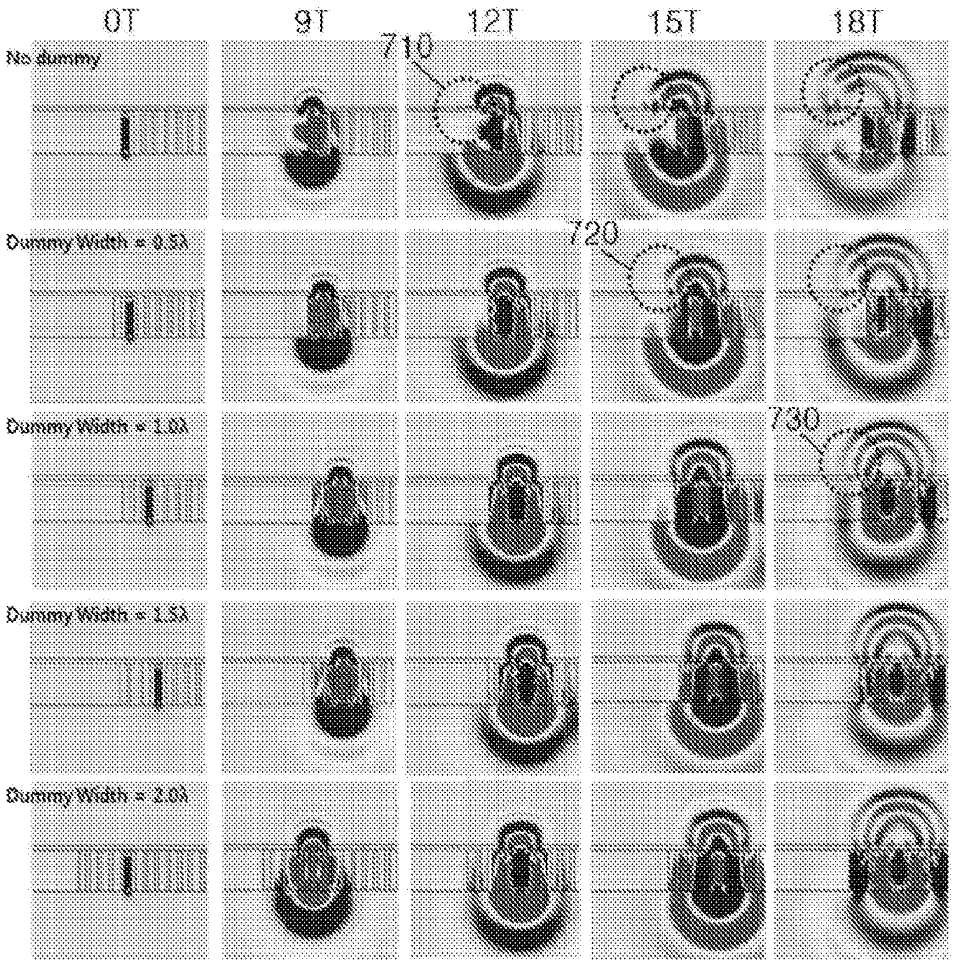

0T
9T
12T
15T
18T
No dummy
Dummy Width = 0.5λ
Dummy Width = 1.0λ
Dummy Width = 1.5λ
Dummy Width = 2.0λ
710
720
730

FIG. 8

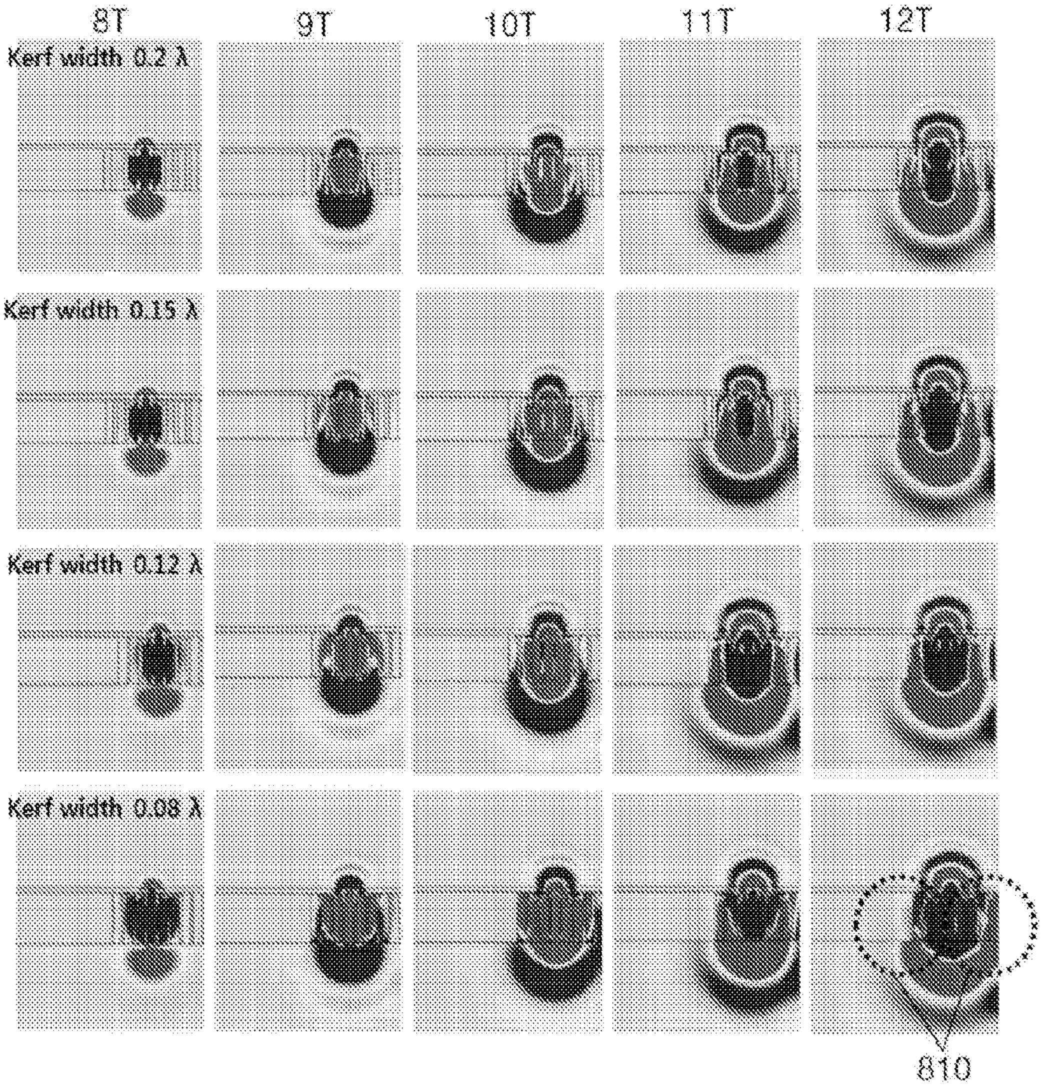
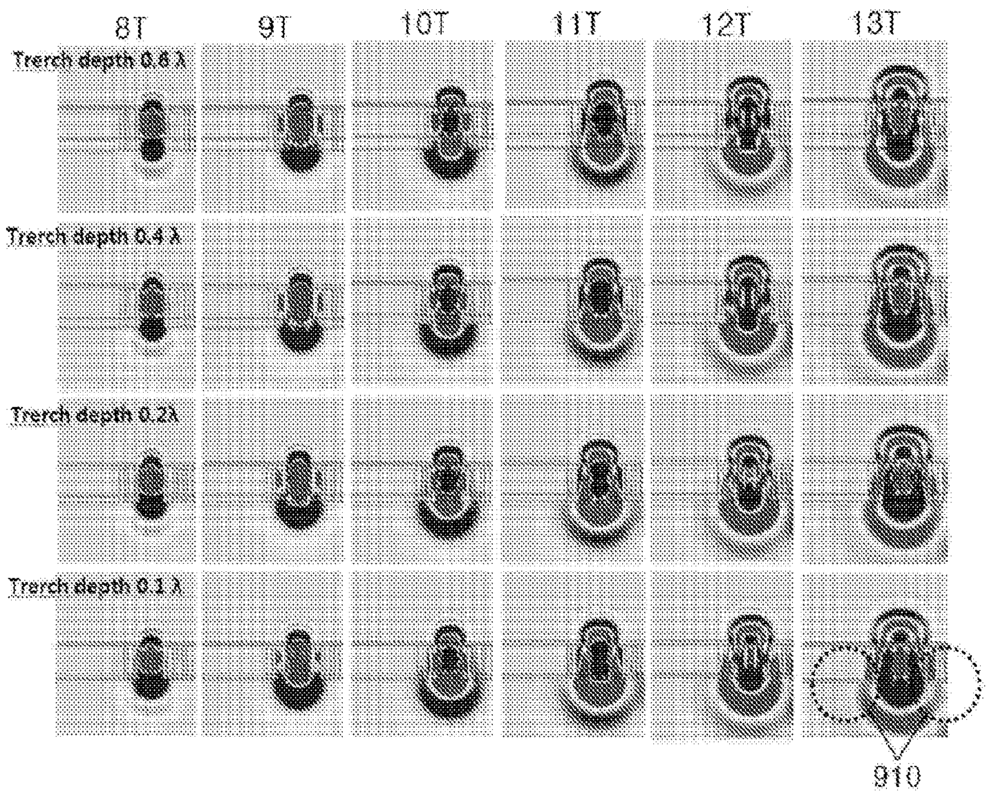

8T
9T
10T
11T
12T
Kerf width 0.2 λ
Kerf width 0.15 λ
Kerf width 0.12 λ
Kerf width 0.08 λ
810

FIG. 9


8T
9T
10T
11T
12T
13T
Trerch depth 0.8 λ
Trerch depth 0.4 λ
Trerch depth 0.2λ
Trerch depth 0.1 λ
910

ULTRASOUND TRANSDUCER, ULTRASOUND PROBE INCLUDING THE SAME, AND ULTRASOUND DIAGNOSTIC EQUIPMENT INCLUDING THE ULTRASOUND PROBE

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 10-2013-0012943, filed on Feb. 5, 2013, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to an ultrasound transducer including dummy piezoelectric elements, an ultrasound probe including the ultrasound transducer, and ultrasound diagnostic equipment including the ultrasound probe.

[0004] 2. Description of the Related Art

[0005] In general, ultrasound diagnostic equipment is used to diagnose a disease by sending ultrasound waves to an organ within a human body or an animal body, detecting an echo signal reflected from the organ, displaying a cross-sectional image of the organ on a monitor, and providing information necessary for diagnosing the disease.

[0006] For this purpose, the ultrasound diagnostic equipment includes an ultrasound probe for transmitting ultrasound waves to the organ and receiving an echo signal from the organ.

[0007] The ultrasound probe includes an ultrasound transducer that converts an ultrasound signal into an electrical signal and vice versa. A typical ultrasound transducer includes a plurality of piezoelectric elements.

[0008] Thus, the ultrasound diagnostic equipment configured as described above radiates an ultrasound wave into the object and converts the reflected ultrasound signal into an electrical signal, and generates an ultrasound image in response to the electrical signal.

[0009] According to this process, such ultrasound diagnostic equipment including the ultrasound probe is used in a wide variety of medical applications, such as detection of foreign materials within a human body, measurement of a degree of a lesion, observation of tumors and fetuses, etc.

[0010] In this regard, since the piezoelectric elements are arranged adjacent to one another, crosstalk is caused between neighboring piezoelectric elements due to vibrations thereof. In particular, since an acoustic crosstalk between central piezoelectric elements is different from crosstalk between lateral piezoelectric elements, it may be difficult to create an accurate ultrasound image of the investigated organ. Accordingly, there is a need for an ultrasound transducer, an ultrasound probe, and ultrasound medical equipment that can produce accurate ultrasound images to facilitate medical diagnosis and other various purposes.

SUMMARY OF THE INVENTION

[0011] The present invention provides an ultrasound transducer having a dummy piezoelectric element, an ultrasound probe including the ultrasound transducer, and ultrasound diagnostic equipment including the ultrasound probe.

[0012] According to an aspect of the present invention, there is provided an ultrasound transducer including a piezoelectric unit including a plurality of piezoelectric elements which vibrate to convert ultrasound waves into electrical signals and electrical signals back into ultrasound waves, and a dummy piezoelectric unit which is disposed at edges of the effective piezoelectric unit and includes a plurality of dummy piezoelectric elements which vibrate due to vibration of the piezoelectric unit.

[0013] The piezoelectric elements may have the same shape as the dummy piezoelectric elements.

[0014] A kerf between adjacent dummy piezoelectric elements or the dummy piezoelectric elements and the corresponding piezoelectric elements may be greater than 0.12 times the wavelength of ultrasound waves.

[0015] A pitch between adjacent dummy piezoelectric elements or the dummy piezoelectric elements and the corresponding piezoelectric elements may be greater than 1.5 times the wavelength of ultrasound waves.

[0016] The dummy piezoelectric unit may have a width s greater than twice the wavelength of the ultrasound waves.

[0017] The plurality of piezoelectric elements may be arranged in a one-dimensional (1 D) array, and the plurality of dummy elements may be arranged in a 1D array with the plurality of piezoelectric elements interposed therebetween.

[0018] The plurality of piezoelectric elements may be arranged in a two-dimensional (2D) array, and the plurality of dummy elements may be arranged in a 2D array to surround the plurality of piezoelectric elements.

[0019] The transducer may further include a backing member which supports the piezoelectric units and the dummy piezoelectric units and absorbs the ultrasound waves.

[0020] The backing member may have a plurality of trenches formed in a region that is not in contact with the plurality of piezoelectric elements and the plurality of dummy piezoelectric elements.

[0021] A depth of the trenches formed in a region corresponding to the dummy piezoelectric unit may be greater than 0.1 times the wavelength of ultrasound waves.

[0022] The depth of the plurality of trenches may increase away from the piezoelectric unit.

[0023] The transducer may further include a matching unit for matching an acoustic impedance of the ultrasound waves produced by the piezoelectric unit with an acoustic impedance of an object under examination.

[0024] The matching unit may include a plurality of separate matching elements respectively disposed on at least one of the piezoelectric unit and the dummy piezoelectric unit corresponding thereto.

[0025] Crosstalk between the plurality of piezoelectric elements may be uniform.

[0026] According to another aspect of the present invention, there is provided an ultrasound probe including a housing and the ultrasound transducer described above, wherein the ultrasound transducer is accommodated in the housing.

[0027] According to another aspect of the present invention, there is provided ultrasound diagnostic equipment including the above-described ultrasound probe and a signal processor which creates an ultrasound image in response to an electrical signal corresponding to an ultrasound echo signal received by the ultrasound probe.

[0028] The ultrasound diagnostic equipment may further include an ultrasound controller for controlling the ultrasound probe so as to generate ultrasound waves. The ultrasound controller may apply an electrical signal only to the piezoelectric unit without applying the electrical signal to the dummy piezoelectric unit.

[0029] The signal processor may determine an electrical signal received from one of the piezoelectric elements in the effective piezoelectric unit as being an electrical signal corresponding to an ultrasound echo signal received by the piezoelectric element.

[0030] The signal processor may also determine an average of electrical signals received by a first piezoelectric element in the piezoelectric unit and at least one of a piezoelectric element and a dummy piezoelectric element adjacent to the first piezoelectric element as being an electrical signal corresponding to an ultrasound echo signal received by the first piezoelectric element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] The above and other features and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

[0032] FIG. **1** is a front view of ultrasound diagnostic equipment including an ultrasound probe according to an embodiment of the present invention;

[0033] FIG. **2** is a perspective view schematically illustrating an internal structure of an ultrasound probe according to an embodiment of the present invention;

[0034] FIGS. **3**A and **3**B illustrate arrangements of piezoelectric elements according to an embodiment of the present invention;

[0035] FIG. **4** illustrates an ultrasound transducer according to another embodiment of the present invention;

[0036] FIG. **5** is a block diagram of ultrasound diagnostic equipment according to an embodiment of the present invention;

[0037] FIGS. **6**A and **6**B illustrate experimental results showing changes in an acoustic signal according to the presence of a dummy piezoelectric unit;

[0038] FIG. **7** illustrates experimental results showing changes in an acoustic signal with respect to a width of a dummy piezoelectric unit;

[0039] FIG. **8** illustrates experimental results showing changes in an acoustic signal with respect to a kerf width of a dummy piezoelectric unit; and

[0040] FIG. **9** illustrates experimental results showing changes in an acoustic signal with respect to a depth of a trench of a dummy piezoelectric unit.

DETAILED DESCRIPTION OF THE INVENTION

[0041] A backing member, a transducer including the backing member, and an ultrasound probe including the transducer according to example embodiments will be described in detail with reference to the accompanying drawings. In the drawings, like reference numerals denote like elements. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0042] FIG. **1** is a front view of ultrasound diagnostic equipment **10** including an ultrasound probe **100** according to an embodiment of the present invention. The ultrasound probe **10** may be used in an ultrasound diagnostic system and other various ultrasound devices. Hereinafter, for convenience of explanation, it is assumed that the ultrasound probe **100** is used in ultrasound diagnostic equipment.

[0043] Referring to FIG. **1**, the ultrasound diagnostic equipment **10** includes a main body **200** including manipulation buttons and a display **240** whereon an image of an object under examination is displayed and the ultrasound probe **100** which emits ultrasound waves toward the object and receives an ultrasound echo signal from the object. The ultrasound probe **100** is connected to the main body **200** by a cable **180** and a connector **190**.

[0044] FIG. **2** is a partially broken away perspective view schematically illustrating an internal structure of the ultrasound probe **100** according to an embodiment of the present invention;

[0045] Referring to FIG. **2**, the ultrasound probe **100** includes a housing **110** and an ultrasound transducer **120** that is accommodated in the housing and generates ultrasound waves when a voltage is applied thereto from the ultrasound diagnostic equipment **10**. The ultrasound probe **100** may further include an acoustic lens **130** for focusing the ultrasound waves.

[0046] The ultrasound transducer **120** includes a piezoelectric unit **140** which converts an electrical signal into ultrasound waves and vice versa, a matching unit **150** which matches an acoustic impedance of the ultrasound waves produced by the piezoelectric unit **140** with an acoustic impedance of the object, and a backing member **160** which absorbs ultrasound waves transmitted in an opposite direction to the object.

[0047] When the piezoelectric unit **140** vibrates, an electrical signal is converted into ultrasound waves or ultrasound waves are converted back into an electrical signal. The piezoelectric unit **140** includes a plurality of piezoelectric elements **142**E and **144**E. The piezoelectric elements **142**E and **144**E may be formed by dividing a piezoelectric material into a plurality of elements. For example, a piezoelectric material elongated in a width direction may be subjected to a dicing process. However, the present invention is not limited thereto, and the plurality of piezoelectric elements **142**E and **144**E may be formed by using other various methods, e.g., by pressing a piezoelectric material into a metal mold. The piezoelectric material may be a material exhibiting a piezoelectric effect, such as a piezoelectric ceramic, a single crystal, or a piezoelectric composite material made by combining a piezoelectric ceramic or a single crystal with a polymer.

[0048] The piezoelectric unit **140** is divided into a piezoelectric region **142** and a dummy piezoelectric region **144**. The piezoelectric region **142** includes piezoelectric elements **142**E which vibrate so as to convert ultrasound waves into an electrical signal and vice versa. The dummy piezoelectric region **144** includes dummy piezoelectric elements **144**E that vibrate due to vibrations of the piezoelectric elements **142**E. The dummy piezoelectric region **144** is disposed at edges of the effective piezoelectric region **142**. The piezoelectric elements **142**E and the dummy piezoelectric elements **144**E are described in more detail below.

[0049] The matching unit **150** is disposed on a front surface of the piezoelectric unit **140** and gradually changes an acoustic impedance of the ultrasound waves generated by the piezoelectric unit **140** to approximately match an acoustic impedance of the object. In this case, the front surface of the piezoelectric unit **140** may be one of the surfaces of the piezoelectric unit **140** which is closest to the object, and a rear surface thereof may be a surface opposite the front surface.

[0050] The matching unit **150** may include a plurality of matching elements **152**E and **154**E disposed on the front surfaces of the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E corresponding thereto. However, the present invention is not limited thereto, and the matching unit **150** may be elongated along the front surface of the piezoelectric unit **140**. Although the matching unit **150** has a single layer structure in the present embodiment, the matching unit **150** may have a multilayer structure.

[0051] The backing member **160** is disposed on a rear surface of the piezoelectric unit **140** so as to support the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E and may absorb ultrasound waves which are transmitted to a back side of the piezoelectric unit **140** and not directly used for examination or diagnosis. The backing member **160** may have the same width in a width direction of the piezoelectric unit **140**. In this case, the width direction is a direction along a longer edge of the piezoelectric unit **140**. The backing member **160** has a plurality of electrodes (not shown) disposed therein for applying a voltage to the piezoelectric unit **140**. Since each of the plurality of electrodes is coupled to a corresponding one of the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E, the number of the plurality of electrodes may be equal to the number of the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E. The plurality of electrodes may be connected only to the piezoelectric elements **144**E or both of the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E.

[0052] The backing member **160** has a plurality of trenches **160**T formed in a region which is not in contact with the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E. The plurality of trenches **160**T are formed along an inward direction of the backing member **160**, which is opposite the direction of the piezoelectric unit **140**. The trenches **160**T serve to reduce the effect of vibrations of each of the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E on adjacent elements.

[0053] The acoustic lens **130** is disposed on a front surface of the ultrasound transducer **120** and condenses ultrasonic waves generated by the piezoelectric unit **140**. The acoustic lens **130** may be formed of a silicon rubber having an acoustic impedance close to that of the object. The acoustic lens **130** may have a central portion of a convex or flat shape or other various shapes according to design requirements.

[0054] FIGS. **3**A and **3**B illustrate arrangements of the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E according to an embodiment of the present invention.

[0055] Referring to FIG. **3**A, the plurality of piezoelectric elements **142**E and dummy piezoelectric elements **144**E are arranged on a front surface of the backing member **160** in a one-dimensional (1D) array in a width direction of a piezoelectric unit **310**. This is referred to as a 1D piezoelectric unit **310**. The 1D piezoelectric unit **310** may be a linear or curved array. The shape of the array may vary depending on design requirements. Although the cost of manufacturing the 1D piezoelectric unit **310** may be low, creating a 3D stereoscopic image by using the 1D piezoelectric unit **310** may be difficult.

[0056] More specifically, the plurality of piezoelectric elements **142**E are arranged in a 1D array. The plurality of dummy piezoelectric elements **144**E are divided into first and second dummy piezoelectric units **311** and **314** and arranged in a 1D array with the plurality of piezoelectric elements **142** being sandwiched between the first and second dummy piezoelectric units **311** and **314**. The first dummy piezoelectric unit **311** including one or more dummy piezoelectric elements **144**E, a piezoelectric unit **312** including one ore more piezoelectric elements **142**E, and the second dummy piezoelectric unit **314** including one or more dummy piezoelectric elements **144**E may be sequentially arranged in a 1D array in the width direction of the 1D piezoelectric unit **310**. The first and second dummy piezoelectric units **311** and **314** may be disposed with the piezoelectric unit **312** interposed therebetween, thereby making acoustic crosstalk between the effective piezoelectric elements **142**E uniform.

[0057] A kerf K between adjacent piezoelectric elements **142**E and dummy piezoelectric elements **144**E may be greater than 0.12 times the wavelength of an ultrasound wave generated by the 1D piezoelectric unit **310**. In particular, when the kerf K between adjacent piezoelectric elements **142**E and dummy piezoelectric elements **144**E is greater than 0.12 times the wavelength of an ultrasound wave, a difference in acoustic crosstalk between the piezoelectric elements **142**E at edges of the piezoelectric unit **142** and at a central portion thereof may be reduced.

[0058] A pitch P between the piezoelectric elements **142**E and dummy piezoelectric elements **144**E may be greater than 0.5 times the wavelength of an ultrasound wave generated by the 1D piezoelectric unit **310**. In particular, when a pitch P between the piezoelectric elements **142**E and dummy piezoelectric elements **144**E is greater than 0.5 times the wavelength of an ultrasound wave, a difference in acoustic crosstalk between the piezoelectric elements **142**E at edges of the piezoelectric unit **312** and at the central portion thereof may be reduced.

[0059] Furthermore, a width W of the dummy piezoelectric unit **311** or **314** may be 1.5 times the wavelength of an ultrasound wave generated by the piezoelectric unit **312**. In particular, when a width W of the dummy piezoelectric unit **311** or **314** is 1.5 times the wavelength of an ultrasound wave, a difference in acoustic crosstalk between the piezoelectric elements **142**E at edges of the piezoelectric unit **312** and at the central portion thereof may be reduced.

[0060] Referring to FIG. **3**B, a plurality of piezoelectric elements **142**E and dummy piezoelectric elements **144**E may be arranged in a two-dimensional (2D) array in a width direction as well as in a direction perpendicular to the width direction, which is referred to as a 2D piezoelectric unit **320**. The 2D piezoelectric unit **320** may be a linear or curved array. The shape of the array may vary depending on design requirements. In this case, the 2D piezoelectric unit **320** transmits ultrasonic waves to the object by appropriately delaying an input time for signals input to the respective piezoelectric elements **142**E and dummy piezoelectric elements **144**E and receives a plurality of echo signals from the object. The plurality of echo signals are used to form a 3D image.

[0061] If the number of the piezoelectric elements **142**E and dummy piezoelectric elements **144**E is increased, ultrasonic images of higher quality may be obtained. However, in order to increase the number of the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E, the size thereof has to be reduced, and thus, a large amount of crosstalk between piezoelectric elements disposed in a narrow region and a large difference in acoustic crosstalk between the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E disposed at edges and a central portion of the 2D piezoelectric unit **320** may be generated.

[0062] The plurality of piezoelectric elements **142**E are arranged in a 2D array while the plurality of dummy piezoelectric elements **144**E are arranged in a 2D array so as to surround the plurality of piezoelectric elements **142**E. For example, a piezoelectric unit **322** including a 2D array of the piezoelectric elements **142**E may be disposed at a central portion of the 2D piezoelectric unit **320**. First through fourth dummy piezoelectric units **321**, **323**, **325**, and **327** may be disposed along edges of the 2D piezoelectric unit so as to surround the piezoelectric unit **322**.

[0063] A kerf K between the piezoelectric elements **142**E and the dummy piezoelectric elements **144**E may be greater than 0.12 times the wavelength of an ultrasound wave generated by the 2D piezoelectric unit **320**. A pitch P between the piezoelectric elements **142**E and dummy piezoelectric elements **144**E may be greater than 0.5 times the wavelength of an ultrasound wave generated by the 2D piezoelectric unit **320**. A width W of the dummy piezoelectric unit **321**, **323**, **325**, or **327** may be greater than twice the wavelength of an ultrasound wave generated by the 2D piezoelectric unit **320**.

[0064] The trenches **160**T formed in the backing member **160** have a uniform depth d. However, the present invention is not limited thereto and the depth d of the trenches **160**T may vary depending on whether the backing member **160** supports dummy piezoelectric units. For example, the trenches **160**T in a dummy backing member have a depth greater than that of the trenches **160**T in a backing member. Alternatively, the trenches **160**T in the dummy backing member may have different depths according to their distances from the backing member.

[0065] FIG. **4** illustrates an ultrasound transducer according to another embodiment of the present invention. Referring to FIG. **4**, trenches **160**T formed in a backing member **162** have a uniform depth d. On the other hand, trenches **160**T formed in a dummy backing member **164** have a depth which increases away from the backing member **162**. Thus, the effect of vibrations of a dummy piezoelectric unit **144** on a piezoelectric unit **142** may be minimized.

[0066] FIG. **5** is a block diagram of ultrasound diagnostic equipment **10** of FIG. **1** according to an embodiment of the present invention. Referring to FIG. **5**, the ultrasound diagnostic equipment **10** includes an ultrasound probe **100** which sends ultrasound waves to a object under examination and receives echoes of the ultrasonic waves from the object and a main body **200** that uses signals received from the ultrasound probe **100** to create an ultrasound image of the object. The main body **200** may be connected to the ultrasound probe **100** in a wired or wireless manner.

[0067] The ultrasound probe **100** includes a transducer **122** which vibrates so as to convert ultrasound waves into electrical signals and electrical signals back into ultrasound waves and a dummy transducer **124** which vibrates due to the vibration of the transducer **122**.

[0068] The transducer **122** includes a piezoelectric unit (corresponding to the piezoelectric unit **142** in FIG. **2**), a portion of a matching unit (corresponding to the matching unit **150** in FIG. **2**) disposed above the effective piezoelectric unit, and a portion of a backing member (corresponding to the backing member **160** in FIG. **2**) disposed below the piezoelectric unit **142**. The dummy transducer **124** includes a dummy piezoelectric unit (corresponding to the dummy piezoelectric unit **144** in FIG. **2**), a portion of the matching unit disposed above the dummy piezoelectric unit, and a portion of the backing member disposed below the dummy piezoelectric unit.

[0069] The main body **200** includes an ultrasound controller **210** for controlling generation of ultrasound waves, a signal processor **220** which uses ultrasound echo signals to create an ultrasound image, a user input unit **230** which receives a user command for creating an ultrasound image, a display **240** for displaying an ultrasound image or a user command, and a controller **250** for controlling overall operations of the ultrasound diagnostic equipment **10** according to user commands.

[0070] The ultrasound controller **210** applies an electrical signal only to the piezoelectric unit in the transducer **122**, which then vibrates to convert the electrical signal into an ultrasound wave. The dummy piezoelectric unit may vibrate due to the vibration of the piezoelectric unit.

[0071] The signal processor **220** uses an electrical signal corresponding to an ultrasound echo signal to create an ultrasound image. More specifically, the ultrasound probe **100** receives an ultrasound echo signal and converts it to an electrical signal. The signal processor **220** uses only the electrical signal received from the effective transducer **122** to create an ultrasound image. For example, the signal processor **220** may determine the signal received from a piezoelectric element in the transducer **122** as being the electrical signal corresponding to the ultrasound echo signal received by the piezoelectric element. Alternatively, the signal processor **220** uses electrical signals received from the transducer **122** and dummy transducer **124** to create an ultrasound image. For example, an average of electrical signals received by a first piezoelectric element in the transducer **122** and the adjacent piezoelectric element or dummy piezoelectric element may be determined as being an electrical signal corresponding to an ultrasound echo signal received by the first piezoelectric element.

[0072] The ultrasound image may be at least one of a brightness (B) mode image representing the intensity of an ultrasound signal according to its brightness, a doppler mode image representing an image of a moving object via a Doppler spectra using the Doppler effect, a motion (M) mode image showing a movement of an object at a predetermined position over time, an elasticity mode image representing response differences between objects with and without compression, and a color (C) mode image representing velocities of moving objects as colors using the Doppler effect.

[0073] Since an ultrasound image is created by using a currently known approach, a detailed description thereof is omitted herein. An ultrasound image according to an embodiment of the present invention may include at least one of 1D, 2D, 3D, and 4D images.

[0074] The user input unit **230** allows a user to generate input data for controlling the operation of the ultrasound diagnostic equipment **10**. The user input unit **230** may include a key pad, a dome switch, a touch pad (resistive/capacitive), a jog wheel, and a jog switch. In particular, when the touch pad forms a layered structure with the display **240**, the layered structure may be referred to as a touch screen.

[0075] The display **240** displays and outputs information processed by the ultrasound diagnostic equipment **10**, such as ultrasound images. When the display **240** and a touch pad with a layer structure are integrated into a touch screen, the display **240** may be used as both output and input devices. The display **240** may include at least one of a liquid crystal display (LCD), a thin film transistor-LCD (TFT-LCD), an organic emitting diode (OLED), a flexible display, and a 3D display. The ultrasound diagnostic equipment **10** may include two or more displays **240** depending on the type of embodiment.

[0076] The touch screen may be configured to detect a touch input position, a touched area, and a touch input pressure. Furthermore, the touch screen may be configured to detect a real-touch and a proximity touch.

[0077] The components of the ultrasound diagnostic equipment **10** shown in FIG. **5** are not essential ones and are illustrated only for convenience of description. In other words, the ultrasound diagnostic equipment **10** may be realized by using a larger or smaller number of components.

[0078] Furthermore, the ultrasonic wave controller **210**, the signal processor **220**, the user input unit **230**, and the controller **250** in the main body **200** are not necessarily separated from the ultrasound probe **100**. At least one component in the main body **200** may be included in the ultrasound probe **100**. For example, the ultrasound controller **210** or user input unit **230** may be one component of the ultrasound probe **100**.

[0079] Experimental results showing changes in an acoustic signal according to the presence of a dummy piezoelectric unit are now described. The experiment described below was conducted by using a program called PZFlex.

[0080] FIGS. **6**A and **6**B illustrate experimental results showing changes in an acoustic signal according to the presence of a dummy piezoelectric unit.

[0081] A piezoelectric unit was designed with a kerf width and a pitch that were 0.16 times the wavelength of an ultrasound wave. An electrical signal was then applied to the piezoelectric unit in order to generate an ultrasound wave having frequency of 1.2 MHz and a velocity of 1,500 m/s. A piezoelectric unit included only the piezoelectric unit, and when an electrical signal was applied to a piezoelectric element disposed at an edge of the piezoelectric unit, the piezoelectric element vibrated to generate ultrasound waves. In this case, as apparent from FIG. **6**A, the generated ultrasound waves were not uniform.

[0082] On the other hand, a dummy piezoelectric unit was disposed at edges of the piezoelectric unit. The kerf width and pitch between the dummy piezoelectric elements and a depth of a trench were the same as those of the piezoelectric unit. When an electrical signal was applied to a piezoelectric element disposed at an edge of the piezoelectric unit in order to generate an ultrasound wave with frequency of 1.2 MHz and a velocity of 1500 m/s, the ultrasound wave generated at the edge of the piezoelectric unit was uniform as apparent from FIG. **6**B. The presence of the dummy piezoelectric unit may make the ultrasound wave uniform.

[0083] An experiment was conducted to observe changes in an acoustic signal over time by varying a width of a dummy piezoelectric unit while maintaining the same kerf width, pitch, and trench depth of the piezoelectric units and dummy piezoelectric units as described with reference to FIG. **6**B. FIG. **7** illustrates experimental results at time intervals of 217 ns after an electrical signal was applied to a piezoelectric element.

[0084] Referring to FIG. **7**, when a width of the dummy piezoelectric unit was less than 1.5 times the wavelength of an ultrasound wave, the ultrasound wave became uneven after a lapse of a predetermined time following the generation of ultrasound. Conversely, when the width of the dummy piezoelectric unit was greater than 1.5 times the wavelength of the ultrasound wave, the ultrasound wave remained uniform after a lapse of a predetermined time following the generation of ultrasound. Thus, as apparent from FIG. **7**, when the width of the dummy piezoelectric unit was greater than 1.5 times the wavelength of the ultrasound wave, acoustic crosstalk was uniform.

[0085] In another experiment, a width of the dummy piezoelectric unit was twice the wavelength of the ultrasound wave while maintaining the same pitch and trench depth as those described with reference to FIG. **6**B. The piezoelectric unit had the same kerf width, pitch, and trench depth as those described with reference to FIG. **6**B. Changes in an acoustic signal were then observed over time by varying a kerf width of the dummy piezoelectric unit. FIG. **8** illustrates experimental results at time intervals of 217 ns after an electrical signal was applied to a piezoelectric element.

[0086] Referring to FIG. **8**, when a kerf width of the dummy piezoelectric unit is 0.08 times the wavelength of an ultrasound wave, the ultrasound wave becomes uneven after a lapse of the predetermined time from the generation of the ultrasound. Conversely, when the kerf width of the dummy piezoelectric unit is greater than 0.12 times the wavelength of the ultrasound wave, the ultrasound wave remains uniform after a lapse of the predetermined time from the generation of the ultrasound. Thus, as apparent from FIG. **8**, when the kerf width of the dummy piezoelectric unit is greater than 0.12 times the wavelength of the ultrasound wave, acoustic crosstalk may be uniform.

[0087] In another experiment, the dummy piezoelectric unit was designed to have a width twice the wavelength of ultrasound wave while the kerf width and pitch were the same as described with reference to FIG. **6**B. Also, the piezoelectric unit had the same kerf width, pitch, and trench depth as described with reference to FIG. **6**B. Changes in an acoustic signal were then observed over time by varying a trench depth of the dummy piezoelectric unit. FIG. **9** illustrates experimental results obtained at time intervals of 217 ns after an electrical signal was applied to a piezoelectric element.

[0088] Referring to FIG. **9**, when a trench depth of the dummy piezoelectric unit is greater than 0.1 times the wavelength of an ultrasound wave, the ultrasound wave becomes uneven after a lapse of the predetermined time from the generation of the ultrasound. Conversely, when the trench depth of the dummy piezoelectric unit is greater than 0.1 times the wavelength of ultrasound wave, the ultrasound wave remains uniform after a lapse of the predetermined time from the generation of the ultrasound. Thus, as apparent from FIG. **9**, when the trench depth of the dummy piezoelectric unit is greater than 0.1 times the wavelength of ultrasound wave, acoustic crosstalk may be uniform.

[0089] As described above, the use of the dummy piezoelectric unit may reduce acoustic distortions.

[0090] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims. Thus, it should be understood that the exemplary embodiments described therein should be not considered for purposes of limitation, and the present invention should be construed as including all changes, equivalents, and substitutions covered by the spirit and scope thereof.

What is claimed is:

1. An ultrasound transducer comprising:

a piezoelectric unit including a plurality of piezoelectric elements which vibrate to convert ultrasound waves into electrical signals and electrical signals back into ultrasound waves; and

a dummy piezoelectric unit which is disposed at edges of the piezoelectric unit and includes a plurality of dummy piezoelectric elements which vibrate due to vibration of the piezoelectric unit.

2. The transducer of claim **1**, wherein the piezoelectric elements have the same shape as the dummy piezoelectric elements.

3. The transducer of claim **1**, wherein a kerf between adjacent dummy piezoelectric elements is greater than 0.12 times the wavelength of the ultrasound waves.

4. The transducer of claim **1**, wherein a pitch between adjacent dummy piezoelectric elements is greater than 1.5 times the wavelength of the ultrasound waves.

5. The transducer of claim **1**, wherein the plurality of piezoelectric elements are arranged in a one-dimensional (1D) array, and the plurality of dummy elements are arranged in a 1D array with the plurality of piezoelectric elements interposed therebetween.

6. The transducer of claim **1**, wherein the plurality of piezoelectric elements are arranged in a two-dimensional (2D) array, and the plurality of dummy elements are arranged in a 2D array that surrounds the plurality of piezoelectric elements.

7. The transducer of claim **1**, further comprising a backing member which supports the piezoelectric units and dummy piezoelectric units and absorbs the ultrasound waves.

8. The transducer of claim **7**, wherein the backing member has a plurality of trenches formed in a region that is not in contact with the plurality of piezoelectric elements and the plurality of dummy piezoelectric elements.

9. The transducer of claim **8**, wherein a depth of the trenches formed in a region corresponding to the dummy piezoelectric unit is greater than 0.2 times the wavelength of ultrasound waves.

10. The transducer of claim **8**, wherein the depth of the plurality of trenches increases away from the piezoelectric unit.

11. The transducer of claim **1**, further comprising a matching unit for matching an acoustic impedance of the ultrasound waves produced by the piezoelectric unit with an acoustic impedance of an object under examination.

12. The transducer of claim **11**, wherein the matching unit includes a plurality of separate matching elements respectively disposed on at least one of the piezoelectric unit and the dummy piezoelectric unit corresponding thereto.

13. The transducer of claim **1**, wherein crosstalk between the plurality of piezoelectric elements is uniform.

14. An ultrasound probe comprising a housing and the ultrasound transducer of one of claims **1** through **13**, wherein the ultrasound transducer is accommodated in the housing.

15. Ultrasound diagnostic equipment comprising the ultrasound probe of claim **14** and a signal processor which creates an ultrasound image in response to an electrical signal corresponding to an ultrasound echo signal received by the ultrasound probe.

16. The ultrasound diagnostic equipment of claim **15**, further comprising an ultrasound controller for controlling the ultrasound probe so as to generate ultrasound waves,

wherein the ultrasound controller applies an electrical signal only to the piezoelectric unit, without applying the electrical signal to the dummy piezoelectric unit.

17. The ultrasound diagnostic equipment of claim **15**, wherein the signal processor determines an electrical signal received from a piezoelectric element in the piezoelectric unit as being an electrical signal corresponding to an ultrasound echo signal received by the piezoelectric element.

18. The ultrasound diagnostic equipment of claim **15**, wherein the signal processor determines an average of electrical signals received by a first piezoelectric element in the piezoelectric unit and at least one of a piezoelectric element and a dummy piezoelectric element adjacent to the first piezoelectric element as being an electrical signal corresponding to an ultrasound echo signal received by the first piezoelectric element.

* * * * *

专利名称(译)	超声换能器，包括超声换能器的超声探头，以及包括超声探头的超声诊断设备		
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申请号	US14/037014	申请日	2013-09-25
[标]申请(专利权)人(译)	三星麦迪森株式会社		
申请(专利权)人(译)	三星MEDISON CO.，LTD.		
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摘要(译)

提供了一种超声换能器，包括超声换能器的超声探头，以及包括超声探头的超声诊断设备。超声换能器包括压电单元，该压电单元包括：多个压电元件，其振动以将超声波转换为电信号和电信号，将其转换回超声波;以及虚设压电单元，其设置在有效压电单元的边缘处并且包括多个由于压电单元的振动而振动的虚拟压电元件。