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(54) **REPOLARIZATION SYSTEM WHICH
REPOLARIZES TRANSDUCER USED IN
ULTRASONIC PROBE**

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(57) **ABSTRACT**

A repolarization system including an ultrasonic probe includes a plurality of transducers, a voltage generator, a switch, a connector, an interface, and a controller. The plurality of transducers are provided in the ultrasonic probe. Each one or more of the transducers is provided with a pair of electrodes. The voltage generator is configured to generate a predetermined voltage high enough to repolarize the transducers. The switch is configured to switch to supply the voltage to the pair of electrodes. The connector is configured to connect the pair of electrodes to the switch through a plurality of lands. Each of the plurality of lands corresponds to the pair of electrodes. The lands are provided to keep insulation enough to repolarize the transducers among the lands. The interface is configured to give an instruction. The controller is configured to control the voltage generator to generate the predetermined voltage. The controller is further configured to control the switch to supply the predetermined voltage to the pair of electrodes in accordance with the instruction.

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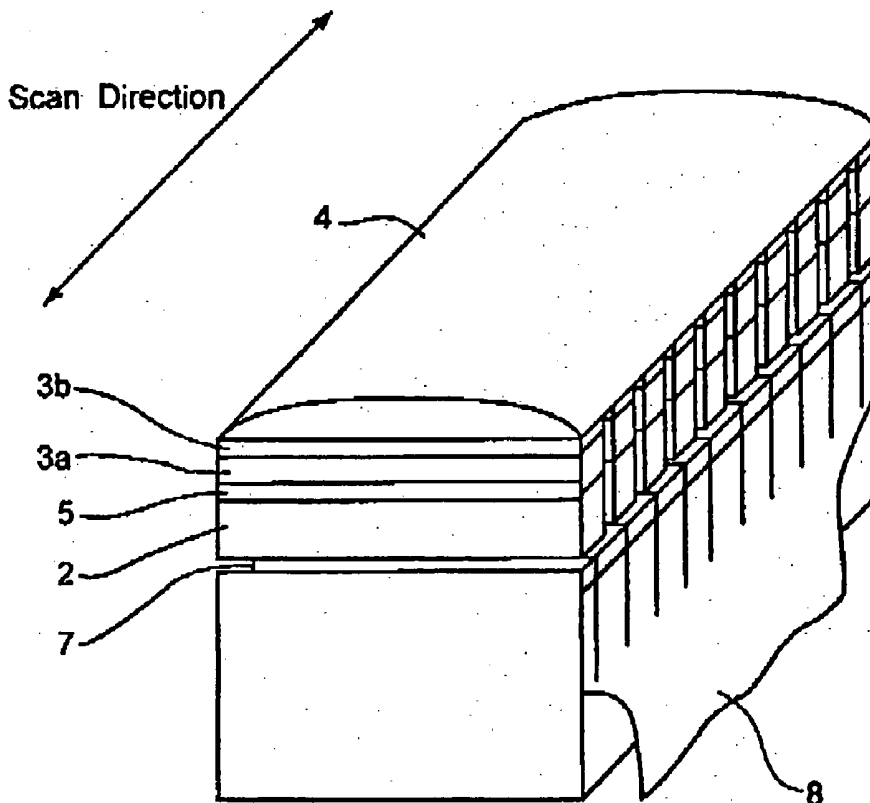
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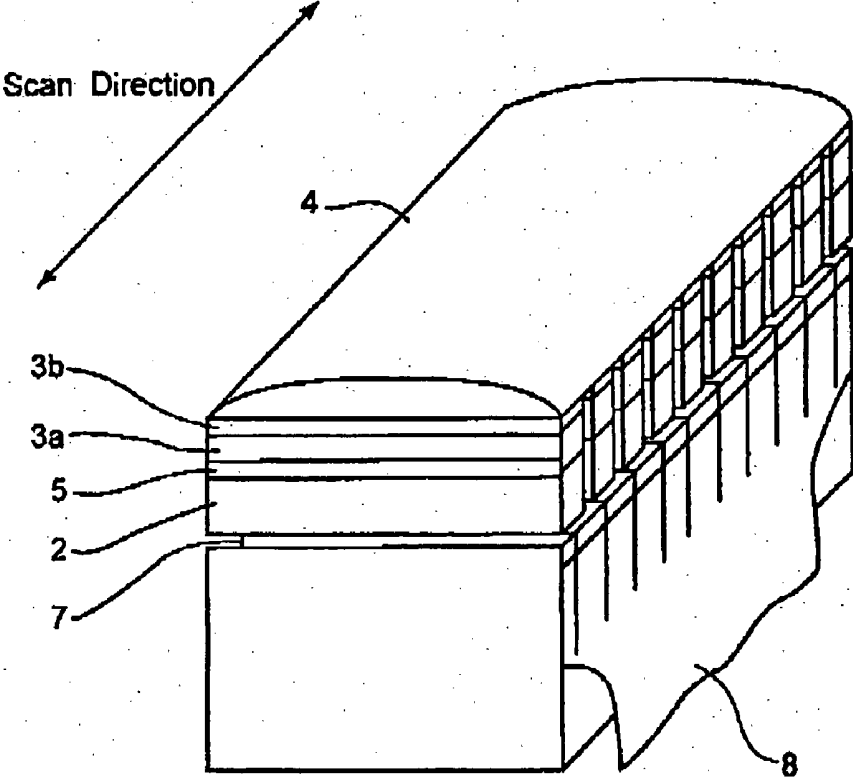


FIG.1

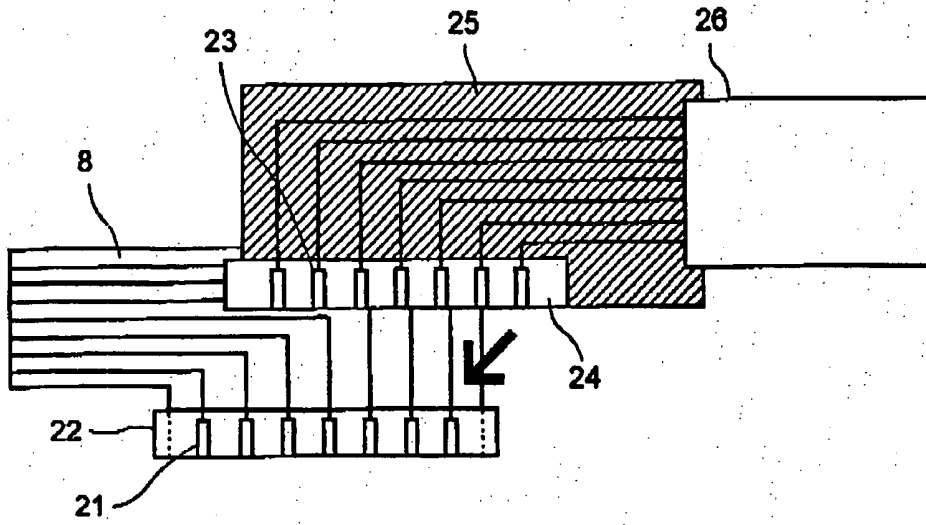


FIG. 2A

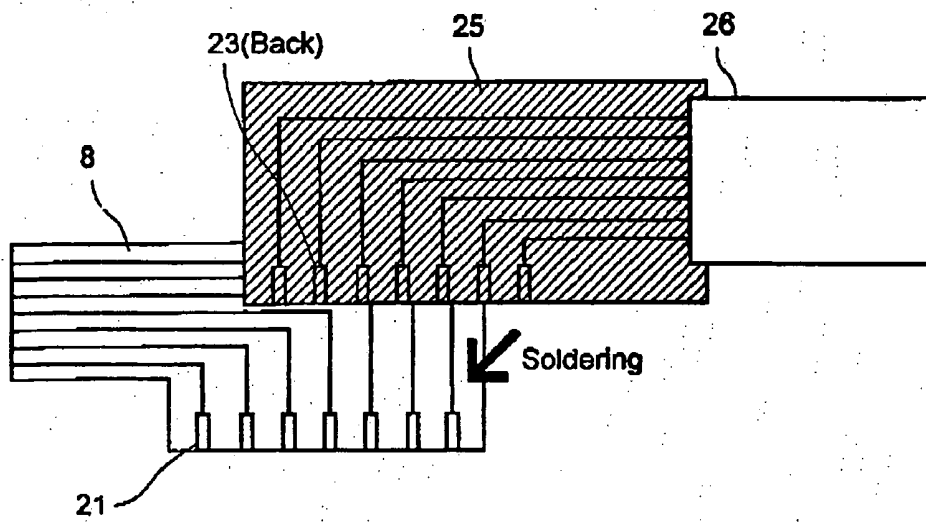


FIG. 2B

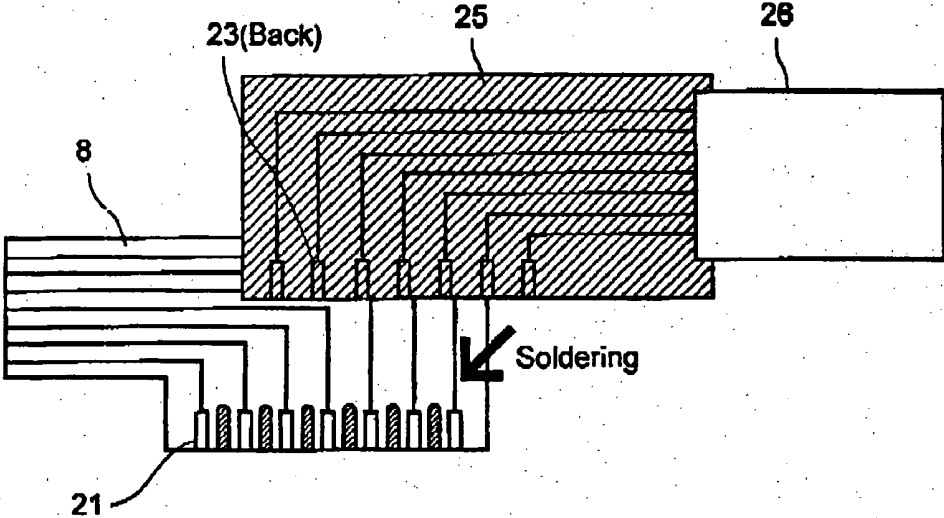


FIG.3

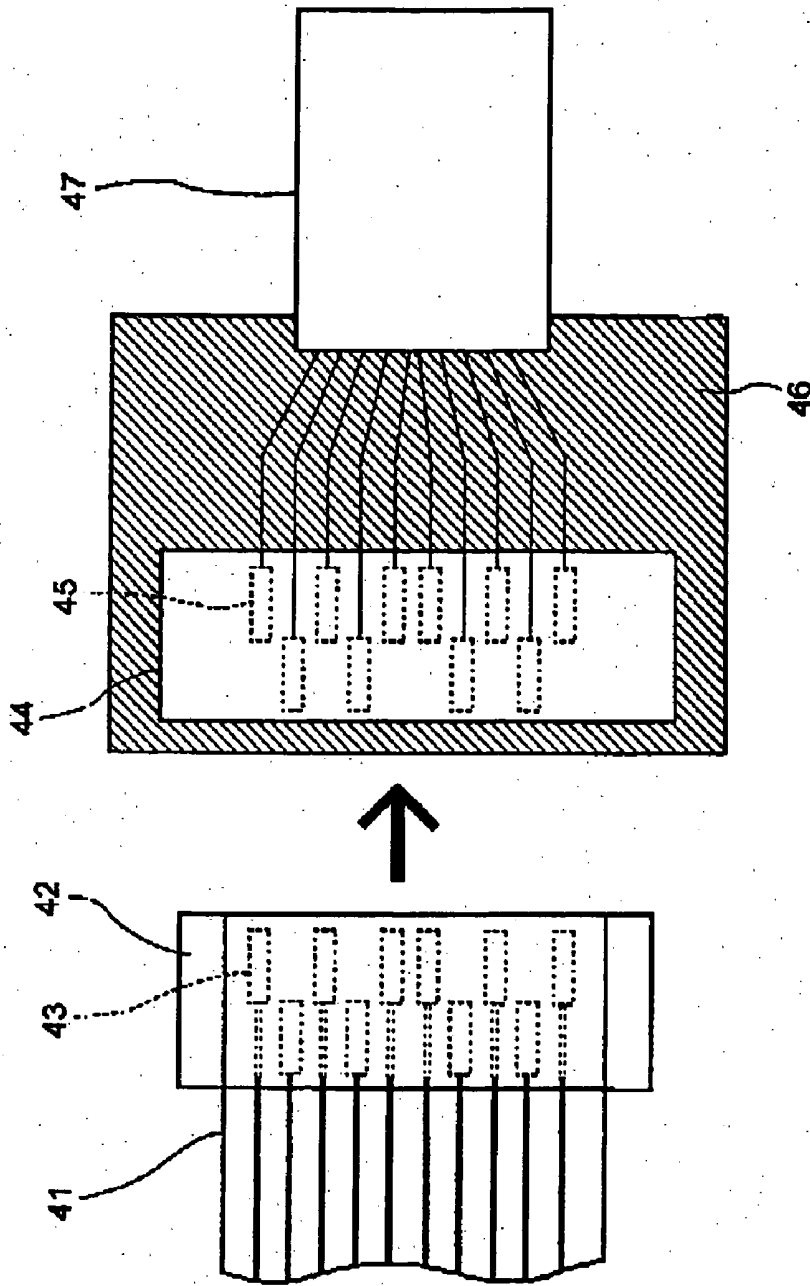


FIG. 4(PRIOR ART)

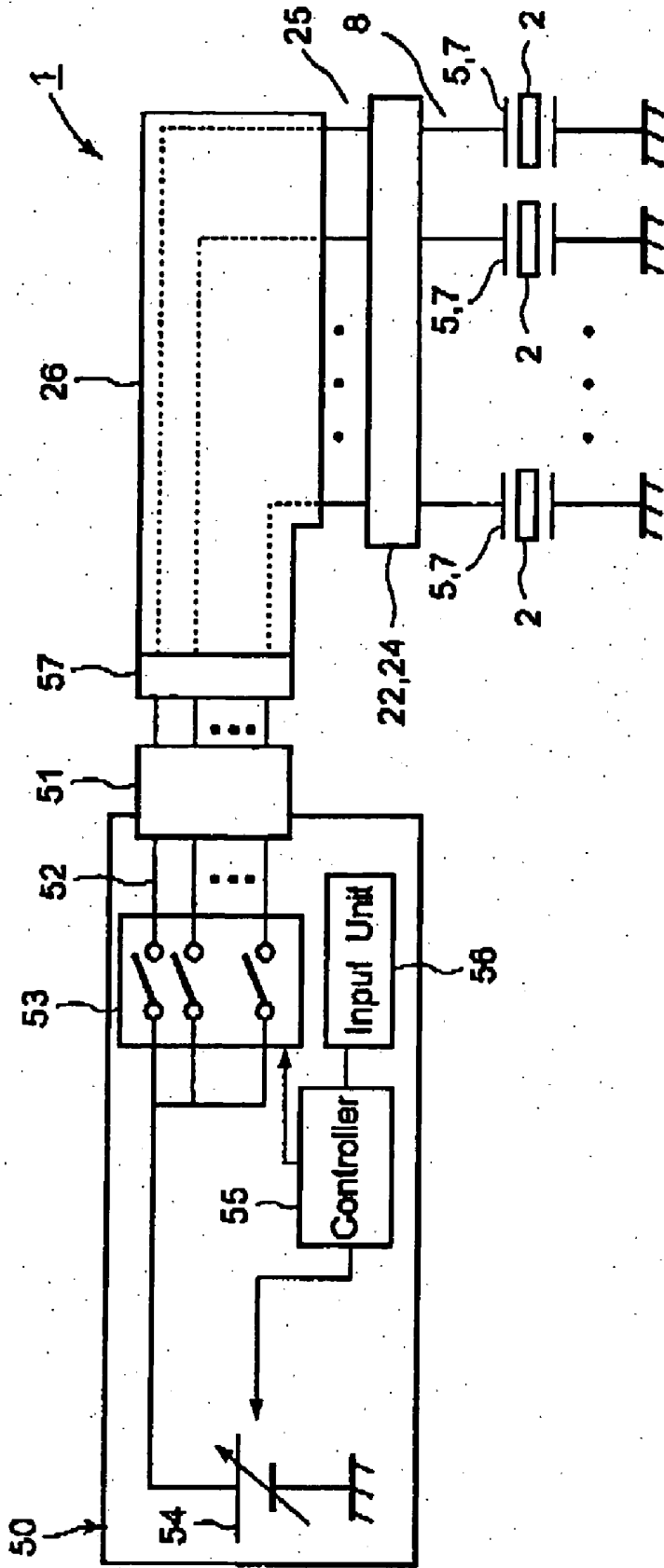


FIG. 5

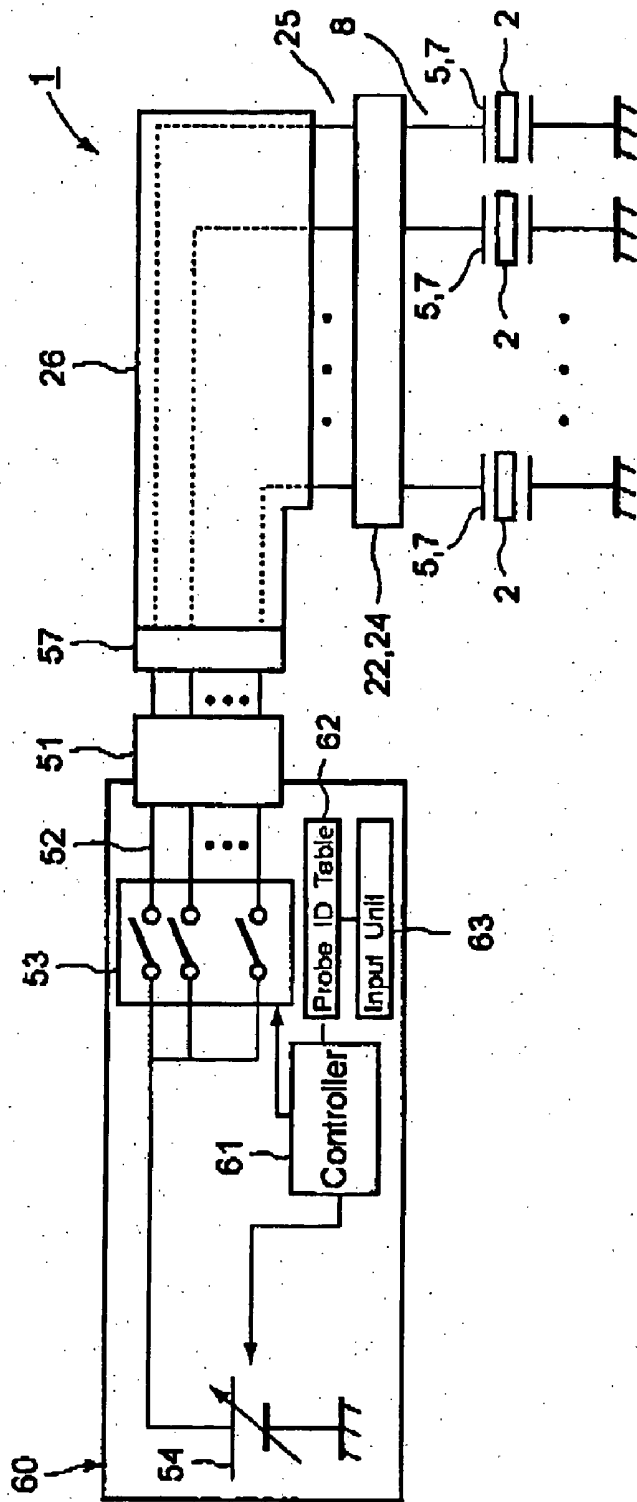


FIG. 6

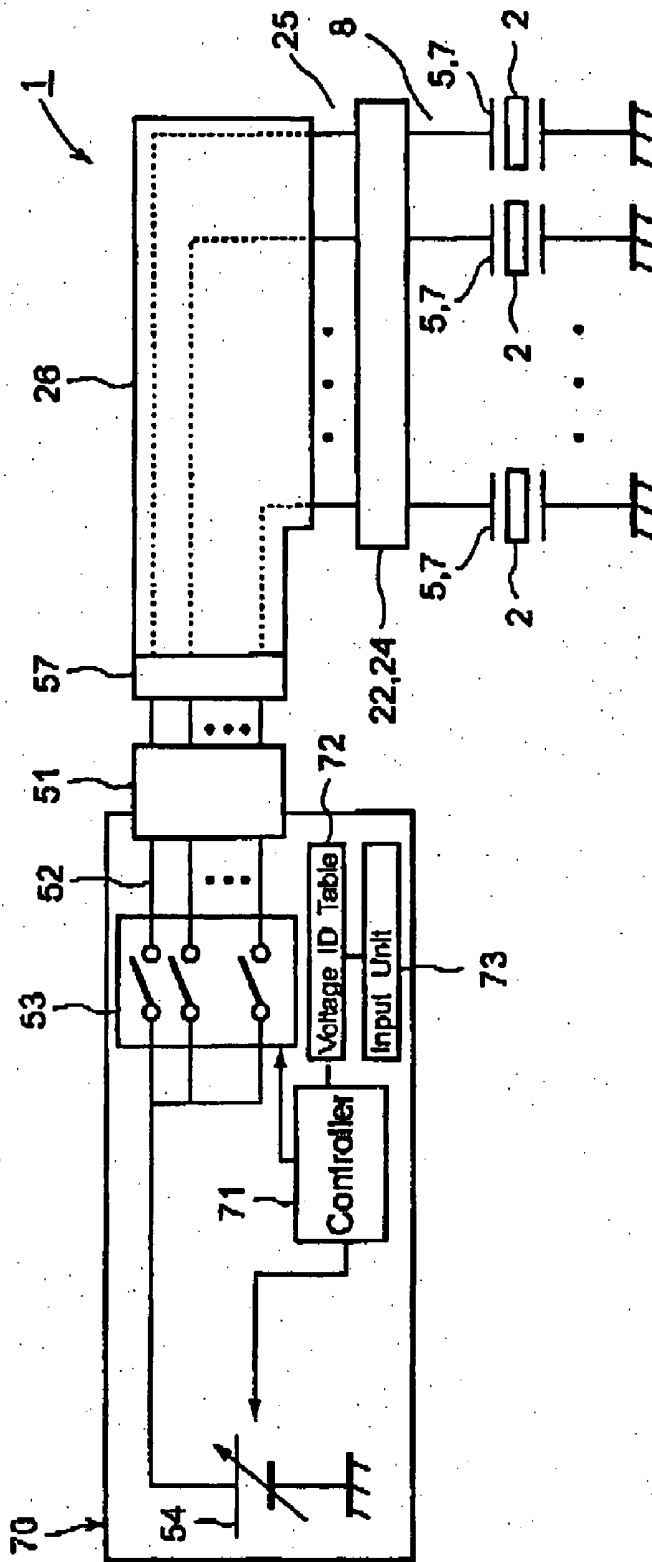


FIG. 7

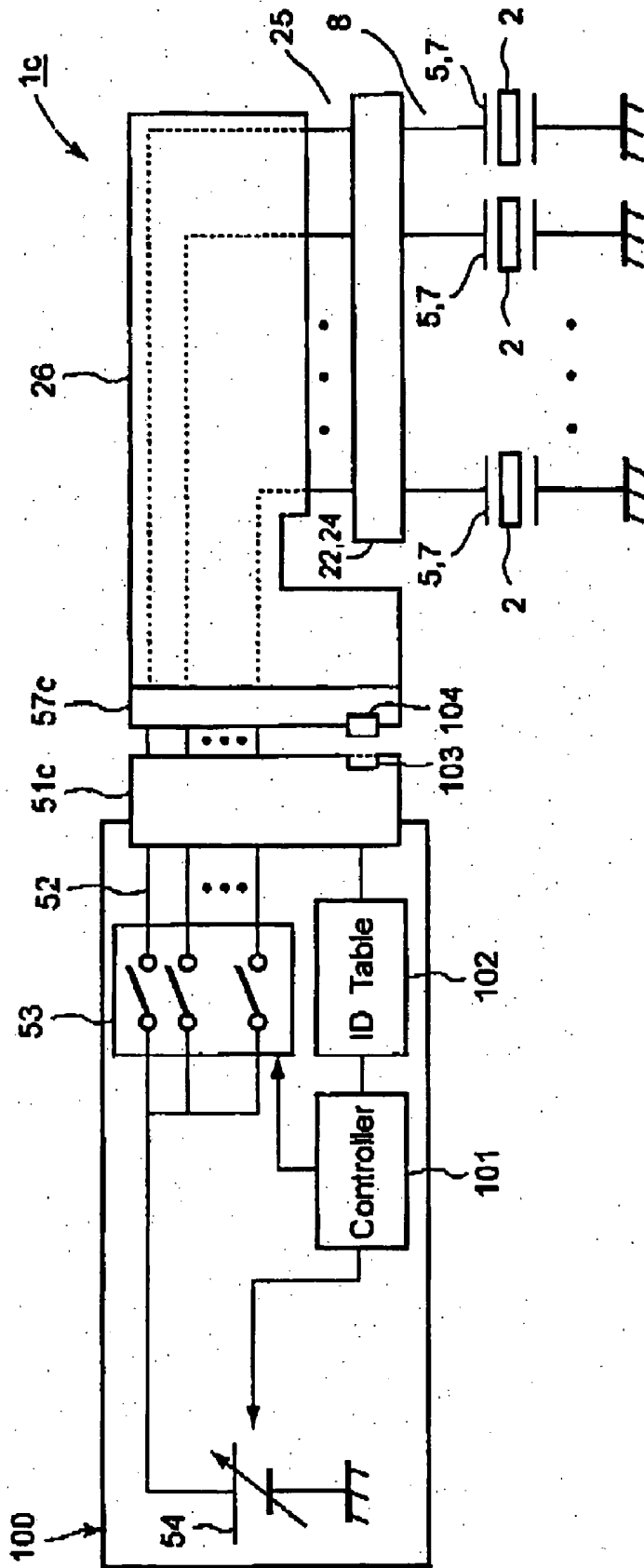


FIG.10

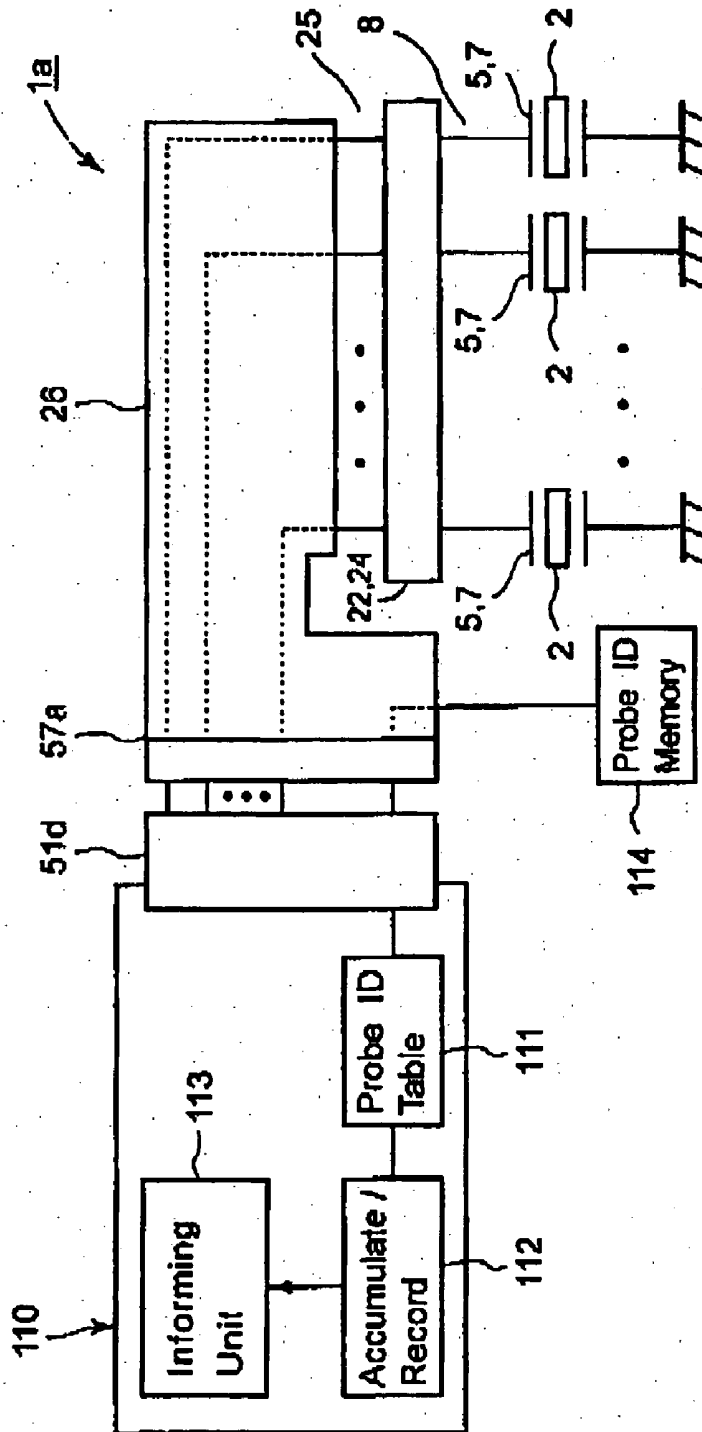


FIG.11

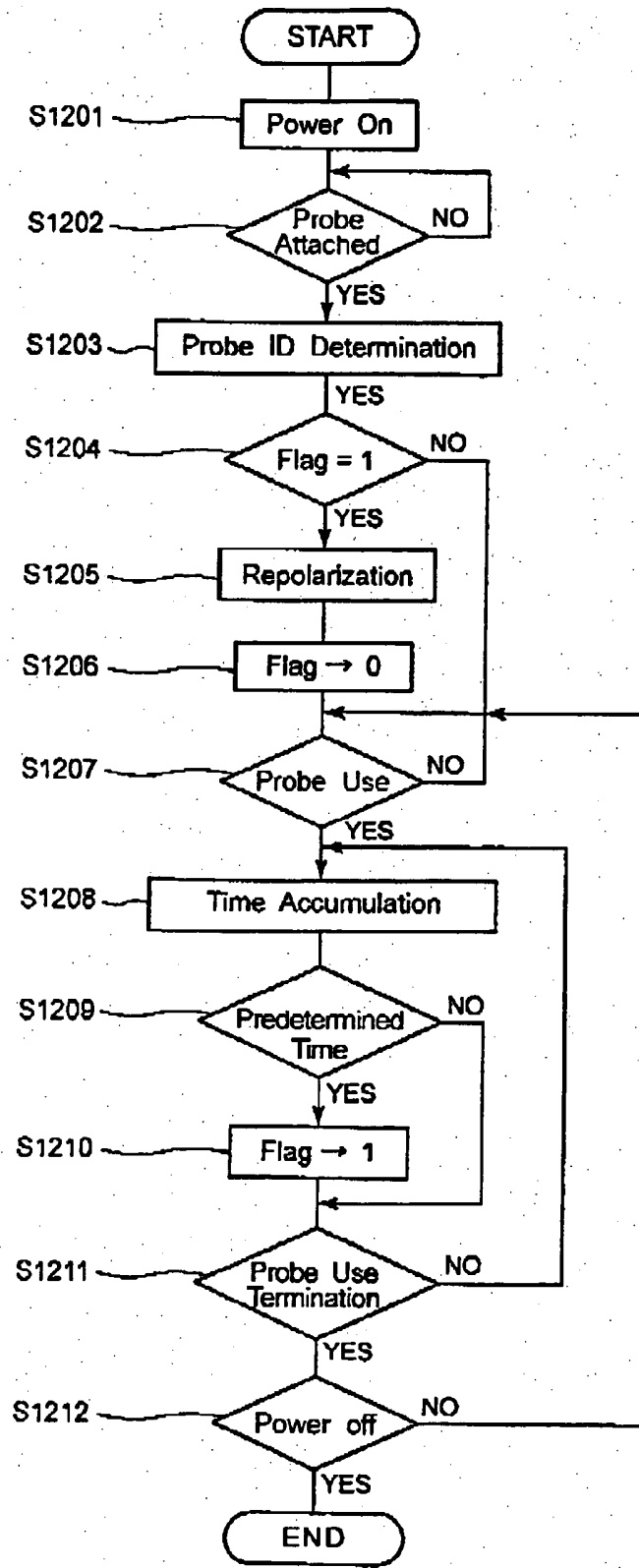


FIG.12

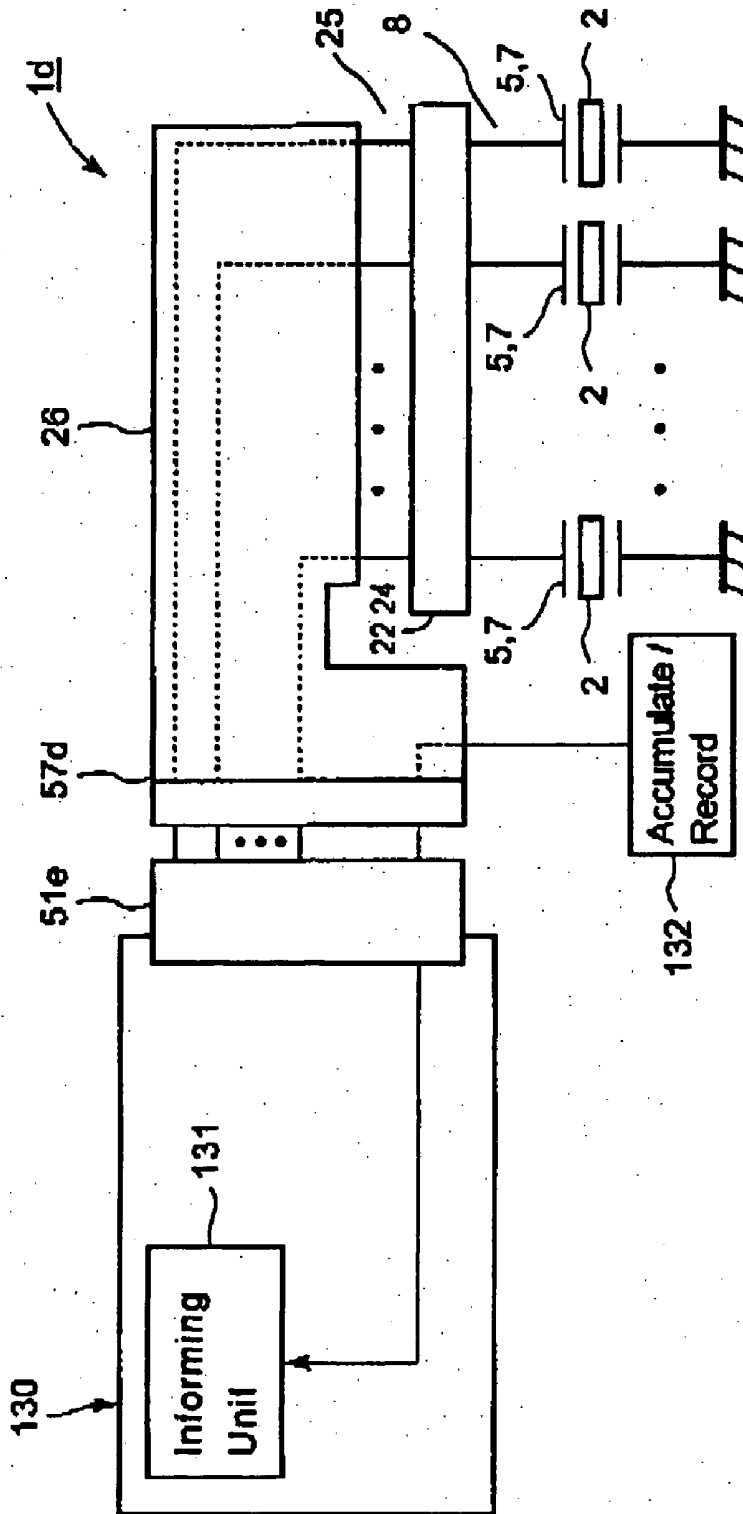


FIG.13

REPOLARIZATION SYSTEM WHICH REPOLARIZES TRANSDUCER USED IN ULTRASONIC PROBE

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. P2003-24554, filed on Jan. 31, 2003, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a repolarization system which repolarizes transducers used in an ultrasonic probe for generating an ultrasound. The present invention further relates to the ultrasonic probe and to an ultrasound imaging apparatus using the repolarization system.

[0004] 2. Discussion of the Background

[0005] As known in the field of an ultrasound imaging apparatus, an ultrasonic probe used as a part of the ultrasound imaging apparatus includes a plurality of transducers. The transducers are supplied with a high voltage and accordingly generate an ultrasound. The generated ultrasound is insonified towards an object or a patient. The insonified ultrasound returns from the object or the patient as an echo signal. The echo signal is converted into an electronic signal so as to obtain an ultrasound image. The obtained ultrasound image is displayed for observation. Such an ultrasound imaging apparatus is used, for example, as an ultrasound flaw detector (or a reflectoscope) for detecting flaws caused inside a welded part of metals. Further, such an ultrasound imaging apparatus is also used as an ultrasound diagnosis apparatus for diagnosing the inside of a patient. The metal, the patient, or any other object to be insonified by the ultrasound imaging apparatus is hereinafter referred to as a specimen.

[0006] An ultrasonic probe used for an ultrasound diagnosis apparatus typically includes tens to hundreds of transducers arranged in an array. The number of the transducers tends to increase as a higher resolution is required for images.

[0007] Each one or more of transducers are provided with a pair of electrodes in the ultrasound imaging apparatus. When the pair of electrodes is supplied (or impressed) with a predetermined high voltage, the transducer generates an ultrasound. A polarization characteristic of the electrodes, however, usually deteriorates during a manufacture of the transducer and/or after a use for a predetermined time. As a result of the deterioration, an acoustic characteristic deteriorates in the ultrasonic probe. Accordingly, image quality deterioration is caused in a displayed ultrasound image.

[0008] In order to solve the above issue, various techniques have been introduced to restrain a depolarization in the transducer (i.e., the deterioration of a polarization characteristic in a transducer). For example, Japanese Patent Application Publication No. PH7-99348 describes a piezoelectric monocrystal, an ultrasonic probe, and an array-type ultrasonic probe. Each of those can be restrained the depolarization during the manufacture and acoustic characteristic

deterioration due to its long time use. According to the description, the depolarization is restrained by giving a specific condition to a monocrystal included in a transducer.

[0009] Another exemplary technique is described in Japanese Patent Application Publication No. PH10-93154. According to the description, it is possible to obtain a transducer having a high electromechanical coupling factor (or an acoustic characteristic) by restraining the depolarization of the transducer during a manufacture of the transducer. The restraint is accomplished by preparing the transducer with a Perovskite-type lead compound oxide monocrystal and giving a specific condition to a cutting surface shape of the transducer.

[0010] The techniques described above can be useful to restrain the depolarization of transducers and accordingly to postpone a time of the depolarization. Once, however, the transducers are so depolarized that a preferable image quality cannot be kept any more, the techniques cannot cope with this problem. Since there is no technique of appropriately solving this problem, an ultrasonic probe including the transducers is required to be replaced with a new one.

[0011] Meanwhile, it is generally known that a depolarized transducer can be repolarized by supplying (or impressing) a predetermined high voltage to its pair of electrodes. That is, it is possible to recover an acoustic characteristic of the transducer. A conventional ultrasonic probe is, however, not configured from a point of view of reusing its transducers by repolarization. Therefore, it is not possible to directly supply a predetermined high voltage to transducers due to the configuration of the conventional ultrasonic probe. In order to supply the predetermined high voltage for the repolarization, it is necessary to disassemble the ultrasonic probe, pick up the transducers, and then supply the predetermined high voltage to the transducers (or to the pair of electrodes of each transducer). Such a configuration will be compared to an embodiment of the present invention in 'DESCRIPTION OF THE PREFERRED EMBODIMENTS' of the present invention.

[0012] Since the above repolarization requires a lot of work and even reassembling the ultrasonic probe after the repolarization, it is not implemented in practice. In addition, a conventional ultrasound imaging apparatus has no means of informing of (or giving a notice of) when the depolarization will be estimated to occur. Therefore, an operator has to determine a replacement time in accordance with image quality deterioration based on displayed images.

SUMMARY OF THE INVENTION

[0013] According to a first aspect of the present invention, there is provided a repolarization system including an ultrasonic probe. The system includes a plurality of transducers, a voltage generator, a switch, a connector, an interface, and a controller. The plurality of transducers are provided in the ultrasonic probe. Each one or more of the transducers is provided with a pair of electrodes. The voltage generator is configured to generate a predetermined voltage high enough to repolarize the transducers. The switch is configured to switch to supply the voltage to the pair of electrodes. The connector is configured to connect the pair of electrodes to the switch through a plurality of lands. Each of the plurality of lands corresponds to the pair of electrodes. The lands are provided to keep insulation enough to repolarize the trans-

ducers among the lands. The interface is configured to give an instruction. The controller is configured to control the voltage generator to generate the predetermined voltage. The controller is further configured to control the switch to supply the predetermined voltage to the pair of electrodes in accordance with the instruction.

[0014] According to a second aspect of the present invention, there is provided an ultrasound imaging apparatus for obtaining an ultrasound image through an ultrasonic probe. The apparatus includes a plurality of transducers, a voltage generator, a switch, a connector, an interface, and a controller. The plurality of transducers are provided in the ultrasonic probe. The plurality of transducers are configured to generate an ultrasound so as to obtain the ultrasound image. Each one or more of the transducers is provided with a pair of electrodes. The voltage generator is configured to generate a predetermined voltage high enough to repolarize the transducers. The switch is configured to switch to supply the voltage to the pair of electrodes. The connector is configured to connect the pair of electrodes to the switch through a plurality of lands. Each of the plurality of lands corresponds to the pair of electrodes. The lands are provided to keep insulation enough to repolarize the transducers among the lands. The interface is configured to give an instruction. The controller is configured to control the voltage generator to generate the predetermined voltage. The controller is further configured to control the switch to supply the predetermined voltage to the pair of electrodes in accordance with the instruction.

[0015] According to a third aspect of the present invention, there is provided an ultrasonic probe which is connectable to a voltage, supply apparatus. The probe includes a plurality of transducers, a plurality of lands, a cable, and a connector. Each one or more of the plurality of transducers is provided with a pair of electrodes. Each of the plurality of lands is configured to correspond to the pair of electrodes. The plurality of lands are provided to keep insulation enough to repolarize the transducers among the lands. The cable is configured to include a plurality of voltage supply lines connected to the lands, respectively. The connector is configured to connect the cable to the voltage supply apparatus. A predetermined voltage is supplied to the transducers through the lands.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] A more complete appreciation of embodiments of the present invention and many of its attendant advantages will be readily obtained by reference to the following detailed description considered in connection with the accompanying drawings, in which:

[0017] FIG. 1 is an illustration showing an exemplary configuration of an ultrasonic probe according to embodiments of the present invention;

[0018] FIGS. 2A and 2B are illustrations showing a first exemplary configuration for explaining a land connection according to embodiments of the present invention;

[0019] FIG. 3 is an illustration showing a second exemplary configuration for explaining the land connection according to embodiments of the present invention;

[0020] FIG. 4 is an illustration showing an exemplary configuration for explaining a conventional land connection according to a prior art of the present invention;

[0021] FIG. 5 is a block diagram showing a first exemplary configuration of a repolarization system according to a first embodiment of the present invention;

[0022] FIG. 6 is a block diagram showing a second exemplary configuration of the repolarization system according to a second embodiment of the present invention;

[0023] FIG. 7 is a block diagram showing a third exemplary configuration of the repolarization system according to a third embodiment of the present invention;

[0024] FIG. 8 is a block diagram showing a fourth exemplary configuration of the repolarization system according to a fourth embodiment of the present invention;

[0025] FIG. 9 is a block diagram showing a fifth exemplary configuration of the repolarization system according to a fifth embodiment of the present invention;

[0026] FIG. 10 is a block diagram showing a sixth exemplary configuration of the repolarization system according to a sixth embodiment of the present invention;

[0027] FIG. 11 is a block diagram showing a first exemplary configuration of an ultrasound imaging apparatus according to a seventh embodiment of the present invention;

[0028] FIG. 12 is a flowchart showing an example of operations of an ultrasound imaging apparatus according to an eighth embodiment of the present invention; and

[0029] FIG. 13 is a block diagram showing a second exemplary configuration of the ultrasound imaging apparatus according to a ninth embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0030] Embodiments of the present invention will be described with reference to the accompanying drawings.

[0031] FIG. 1 is an illustration showing an exemplary configuration of an ultrasonic probe according to embodiments of the present invention. The ultrasonic probe can be used for an ultrasound imaging apparatus, such as, for example, an ultrasound flaw detector (or a reflectoscope) for detecting flaws caused inside a welded part of metals or an ultrasound diagnosis apparatus for the purpose of medical diagnoses.

[0032] As shown in FIG. 1, an ultrasonic probe 1 includes a plurality of transducers 2, acoustic matching layers 3a and 3b, an acoustic lens 4, electrodes 5 and 7, and a flexible printed wiring board 8. The transducers 2 are arranged in an array form and reversibly convert between ultrasound signals and electronic signals. The transducers 2 are aligned along a scan direction of ultrasound generated from the transducers 2. The acoustic matching layers 3a and 3b are formed on an ultrasound reception surface side of the ultrasonic probe 1. Although the acoustic matching layers 3a and 3b are provided as a bilayer configuration in FIG. 1, a single layer or more than two layers may be applicable as an acoustic matching layer configuration. The acoustic matching layers 3a and 3b are provided over the transducers 2 along the scan direction. The acoustic matching layers 3a and 3b are covered by the acoustic lens 4.

[0033] The electrodes 5 are provided to the transducers 2, respectively and are individual electrodes for supplying or impressing (hereinafter referred to as supplying) a predetermined high voltage to the transducers 2, respectively. Further, the electrodes 7 are also provided to the transducers 2, respectively and are individual electrodes for taking out electronic signals from the transducers 2, respectively. Each one of the transducers 2 is provided with one of the electrodes 5 and one of the electrodes 7. The one electrode 5 and the one electrode 7 can be in pairs. Alternatively, each adjacent two or more of the transducers 2 may be provided with one of the electrodes 5 and one of the electrodes 7. The one electrode 5 and the one electrode 7 can be in pairs. In this alternative case, the adjacent two or more transducers 2 commonly provided with the pair of the one electrode 5 and the one electrode 7 are operative in the same manner as if they constituted one transducer.

[0034] Lead wires from the electrodes 7 are connected to the flexible printed wiring board 8 by soldering or conductive paste, for example. Lead wires from the electrodes 5 are also connected to the flexible printed wiring board 8 by soldering or conductive paste, for example. Alternatively, the electrodes 5 may be connected to an earth board while the lead wires from the electrodes 7 are connected to the flexible printed wiring board 8. The earth board may be connected to the flexible printed wiring board 8.

[0035] FIGS. 2A and 2B are illustrations showing a first exemplary configuration for explaining a land connection according to embodiments of the present invention. The land connection is implemented so as to connect the electrodes 5 and 7 (or transducers 2) and a cable of the ultrasonic probe 1.

[0036] As shown in FIG. 2A, the flexible printed wiring board 8 connected to the electrodes 5 and 7 has a connector 22. The connector 22 includes a plurality of lands 21. The lands 21 are connected to the electrodes 5 and 7 through voltage supply lines provided in the flexible printed wiring board 8. The lands 21 include signal lands and ground lands. Each of the signal lands is connected to each of the electrodes 7. Each of the ground lands is connected to one or more of the electrodes 5. In other words, one ground land can be used in common with a plurality of the electrodes 5.

[0037] In the connector 22, the lands 21 are provided to keep a predetermined interval between adjacent two of the lands 21 (i.e., between one of the lands 21 and a next of the one land 21). The predetermined interval is determined to be long enough to keep insulation between the adjacent two lands 21. This is because a predetermined high voltage is supplied to the lands 21 so that the acoustic characteristic of the transducers 2 is recovered. The predetermined high voltage may be six to seven times larger than a voltage to be supplied to the transducers 2 for ultrasound generation. Therefore, if a creepage distance for insulation is not kept as a land interval, a dielectric breakdown is caused in the land interval. Such a dielectric breakdown leads to a breakage of the ultrasonic probe 1.

[0038] The electrodes 5 and 7 are supplied with the predetermined high voltage through the flexible printed wiring board 8, the lands 21 (the connector 22), lands 23 (a connector 24), a printed wiring board 25, and a cable 26. The connector 22 is connected to the connector 24. When the connectors 22 and 24 are connected to each other, the lands

21 are connected to the lands 23. The lands 23 are prepared in a similar manner to the lands 21 so that each of the lands 21 is connected to corresponding one of the lands 23. Each of the lands 23 is also connected to each of voltage supply lines provided in the printed wiring board 25. The printed wiring board 25 is connected to the cable 26 which is also connected to an ultrasonic probe repolarization apparatus to be described later. The connection between the connector 22 and the connector 24 may be accomplished by soldering as shown in FIG. 2B so as to ensure the insulation between the adjacent two lands 21 and also between correspondingly adjacent two of the lands 23.

[0039] For avoiding the dielectric breakdown, an insulator may be provided between the adjacent two lands 21 as shown in FIG. 3, instead of keeping the predetermined interval. Any other possible way can be applied for avoiding the dielectric breakdown between the adjacent two lands 21.

[0040] Compared to the above described land connection according to embodiments of the present invention, a conventional land connection will be described briefly with reference to FIG. 4. FIG. 4 is an illustration showing an exemplary configuration for explaining the conventional land connection according to a prior art of the present invention. Similar to FIG. 2A, a flexible printed wiring board 41 is connected to a connector 42 including a plurality of lands 43. Further, the connector 42 is connected to a connector 44 including a plurality of lands 45. The connector 44 provided in a printed wiring board 46 is also connected to a cable 47. The lands 43 provided in the connector 42 are connected to lands 45 provided in the connector 44. A typical feature of the lands 43 and 45 is a close-packed placement. In the connector 42, for example, adjacent two lands 43 are very close to each other. Consequently, if the predetermined high voltage is supplied to the lands 43, a dielectric breakdown is caused between the lands 43.

First Embodiment

[0041] FIG. 5 is a block diagram showing a first exemplary configuration of a repolarization system according to a first embodiment of the present invention. As shown in FIG. 5, the repolarization system includes an ultrasonic probe repolarization apparatus 50 and the ultrasonic probe 1. The ultrasonic probe repolarization apparatus 50 includes a connector 51, connection lines 52, a switch unit 53, a high voltage power source 54, a controller 55, and an input unit 56. The connector 51 is detachably connected to a connector 57 of the ultrasonic probe 1. The connector 57 is connected to the cable 26. Other configuration of the ultrasonic probe 1 is similar to that described before. Therefore, explanations for the ultrasonic probe 1 are omitted herein.

[0042] The switch unit 53 includes a plurality of switching elements. The switching elements are switched on/off by the controller 55. At least a part of the switching elements corresponds to the lands 21 (23) one by one, respectively. In other words, all the switching elements may not always be used since the number of the lands 21 (23) depends on a type of the ultrasonic probe 1. Each of the corresponding switching elements is selected to switch on for supplying a predetermined high voltage to a corresponding land 21 (23). The switch unit 53 is connected to the connector 51 through the connection lines 52. The predetermined high voltage is generated by the high voltage power source 54. The con-

troller 55 controls the switch unit 53 to switch on for a switch-on period of the switching elements. In addition, the controller 55 also controls the high voltage power source 54 so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe 1. The input unit 56 is used for inputting the predetermined voltage value and/or the switch-on period through an interface of the input unit 56. The controller 55 may further control the switch unit 53 and designate which switching elements to switch on (or which lands to be supplied with the predetermined high voltage). The controller 55 implements the above-described controls in accordance with the information input from the input unit 56.

[0043] The repolarization system configured as above will operate as follows.

[0044] An operator of the repolarization system inputs information of, for example, the predetermined high voltage and the switch-on period, from the input unit 56. The controller 55 receives the information and controls the high voltage power source 54 to generate the predetermined high voltage. The controller 55 also controls the switch unit 53 to switch on the switching elements for the input switch-on period.

[0045] The input unit 56 may alternatively include various buttons corresponding to various predetermined high voltages. Similarly, the input unit 56 may also include various buttons corresponding to various switch-on periods which may be appropriate for the repolarization. In such cases, the operator only needs to press one of the buttons appropriate for each case. The buttons may alternatively be provided as icons in a display window if provided in the ultrasonic probe repolarization apparatus 50. The operator may click one of the icons. Any of these inputs is construed as an instruction to the controller 55.

[0046] When the lands 21 (23) are supplied with the predetermined high voltage, the supplied voltage is applied to the electrodes 5 and 7. Since appropriate insulation is kept between one and the next of the lands 21 (23), the supplied high voltage is properly applied to the electrodes 5 and 7 for the switch-on period. Therefore, the transducers 2 are repolarized, which results in a recovery of the acoustic characteristic in the transducers 2. In response to the repolarization, the ultrasonic probe 1 can become reusable as an ultrasonic probe.

[0047] The predetermined high voltage maybe determined according to thickness of the transducers 2. The thickness of 1 [mm] may require a voltage 1 [kV]. For example, 2 millimeter-thick transducers may need to be supplied with a 2-kilovolt voltage. In addition, a voltage supply period (i.e., the switch-on period) may be approximately 30 to 60 seconds whatever the thickness is, for example.

Second Embodiment

[0048] FIG. 6 is a block diagram showing a second exemplary configuration of the repolarization system according to a second embodiment of the present invention. In FIG. 6, components given the same reference numbers as those shown in FIGS. 1, 2A, and 5 will be operative in similar manners. Therefore, detailed explanations of such components are omitted herein.

[0049] In the repolarization system according to the second embodiment, an ultrasonic probe repolarization appa-

ratus 60 includes a controller 61 instead of the controller 55, an ultrasonic probe identification table memory 62, and an input unit 63 instead of the input unit 56. The controller 61 controls the switch unit 53 and designates which switching elements to switch on (or which lands to be supplied with the predetermined high voltage). The controller 61 further controls the switch unit 53 to switch on for a switch-on period of the switching elements. In addition, the controller 61 also controls the high voltage power source 54 so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe 1. The input unit 63 is used for inputting information identifying a type of the ultrasonic probe 1 through an interface of the input unit 63.

[0050] The ultrasonic probe identification table memory 62 stores a first table showing a relationship between ultrasonic probe type identification information and supply voltage information. The supply voltage information shows various voltages high enough to polarize the electrodes 5 and 7. Which of the voltages to supply depends on a type of the ultrasonic probe 1. Further, the ultrasonic probe identification table memory 62 also stores a second table showing a relationship between ultrasonic probe type identification information and switching condition information. The switching condition information may include switch-on periods of the switch unit 53 and information of designating which switching elements to switch on. The switch-on period is determined to be long enough to polarize the electrodes 5 and 7. Which of the switch-on periods to apply depends on a type of the ultrasonic probe 1. It is necessary to determine the number of switching elements to switch on and/or to determine which switching elements to switch on since the number and relative positions of the lands 21 (23) are different among types of the ultrasonic probe 1. The first table and the second table may be combined to use as one table. The ultrasonic probe repolarization apparatus 60 may alternatively include only one of the first and second tables. In this case, the input according to the first embodiment may be combined in the input operation. Still further, the ultrasonic probe identification table memory 62 may be provided in the controller 61 as a part of features of the controller 61. In this case, the controller 61 refers to the ultrasonic probe identification table memory 62 for the controls.

[0051] The controller 61 implements the above-described controls in accordance with information supplied from the ultrasonic probe identification table memory 62 based on the information input by the input unit 63.

[0052] The repolarization system configured as above will operate as follows.

[0053] An operator of the repolarization system inputs information identifying a type of the ultrasonic probe 1 from the input unit 63. The ultrasonic probe identification table memory 62 receives the input information and compares the received information to the ultrasonic probe type identification information in the first table. As a result of the comparison, the supply voltage information corresponding to the ultrasonic probe type identification information identical to the received information is obtained and supplied to the controller 61. Similarly, the ultrasonic probe identification table memory 62 compares the received information to the ultrasonic probe type identification information in the second table. As a result of the comparison, the switching

condition information corresponding to the ultrasonic probe type identification information identical to the received information is obtained and supplied to the controller 61. The controller 61 receives the supply voltage information and the switching condition information. The controller 61 controls the high voltage power source 54 to generate the predetermined high voltage based on the supply voltage information. Also based on the switching condition information, the controller 61 controls the switch unit 53 to switch on switching elements designated in the switching condition information for the switch-on period designated in the switching condition information. In case that the switch-on period is fixed for any case, the switch-on period is not required in the switching condition information.

[0054] The input unit 63 may alternatively include various buttons corresponding to various predetermined ultrasonic probe types. In such a case, the operator only needs to press one of the buttons appropriate for a type of the ultrasonic probe 1. The buttons may alternatively be provided as icons in a display window if provided in the ultrasonic probe repolarization apparatus 60. The operator may click one of the icons. Any of these inputs or information to be supplied from the ultrasonic probe identification table memory 62 is construed as an instruction to the controller 61.

[0055] Operations of the repolarization in the ultrasonic probe 1 are similar to those described in the first embodiment.

Third Embodiment

[0056] When it is possible to categorize various types of the ultrasonic probe 1 into less number of types (or groups) in accordance with a supply voltage necessary for the repolarization, such categorized voltage types may be input to the controller of the ultrasonic probe repolarization apparatus so as to control the repolarization. This categorization is based on a fact that some types of ultrasonic probes can be repolarized with a similar voltage. Application of the controls according to such supply voltages may simplify operations by the operator and controls of the ultrasonic probe repolarization apparatus. One type of a supply voltage corresponds to one predetermined voltage to be supplied for the repolarization.

[0057] FIG. 7 is a block diagram showing a third exemplary configuration of the repolarization system according to a third embodiment of the present invention. In FIG. 7, components given the same reference numbers as those shown in FIGS. 1, 2A, and 5 will be operative in similar manners. Therefore, detailed explanations of such components are omitted herein.

[0058] In the repolarization system according to the third embodiment, an ultrasonic probe repolarization apparatus 70 includes a controller 71 instead of the controller 61, a supply voltage identification table memory 72, and an input unit 73 instead of the input unit 63. The controller 71 controls the switch unit 53 to switch on for a switch-on period of the switching elements. In addition, the controller 71 also controls the high voltage power source 54 so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe 1. The controller 71 may further control the switch unit 53 and designate which switching elements to switch on (or which lands to be supplied with the predetermined high voltage).

The input unit 73 is used for inputting information identifying a supply voltage type of the predetermined high voltage for the ultrasonic probe 1 through an interface of the input unit 73.

[0059] The supply voltage identification table memory 72 stores a third table showing a relationship between supply voltage type identification information and supply voltage information. The supply voltage information shows various voltages high enough to polarize the electrodes 5 and 7. Which of the voltages to supply depends on a type of the ultrasonic probe 1. Further, the supply voltage identification table memory 72 also stores a fourth table showing a relationship between supply voltage type identification information and switching condition information. The switching condition information may include switch-on periods of the switch unit 53 and information of designating which switching elements to switch on. The switch-on period is determined to be long enough to polarize the electrodes 5 and 7. Which of the switch-on periods to apply depends on a type of the ultrasonic probe 1. It is necessary to determine the number of switching elements to switch on and/or to determine which switching elements to switch on since the number and relative positions of the lands 21 (23) are different among types of the ultrasonic probe 1. The third table and the fourth table may be combined to use as one table. The ultrasonic probe repolarization apparatus 70 may alternatively include only one of the third and fourth tables. In this case, the input according to the first embodiment may be combined in the input operation. Still further, the supply voltage identification table memory 72 may be provided in the controller 71 as a part of features of the controller 71. In this case, the controller 71 refers to the supply voltage identification table memory 72 for the controls.

[0060] The controller 71 implements the above-described controls in accordance with information supplied from the supply voltage identification table memory 72 based on the information input by the input unit 73.

[0061] The repolarization system configured as above will operate as follows.

[0062] An operator of the repolarization system inputs information identifying a supply voltage type of the predetermined high voltage for the ultrasonic probe 1 from the input unit 73. The supply voltage identification table memory 72 receives the input information and compares the received information to the supply voltage type identification information in the third table. As a result of the comparison, the supply voltage information corresponding to the supply voltage type identification information identical to the received information is obtained and supplied to the controller 71. Similarly, the supply voltage identification table memory 72 compares the received information to the supply voltage type identification information in the fourth table. As a result of the comparison, the switching condition information corresponding to the supply voltage type identification information identical to the received information is obtained and supplied to the controller 71. The controller 71 receives the supply voltage information and the switching condition information. The controller 71 controls the high voltage power source 54 to generate the predetermined high voltage based on the supply voltage information. Also based on the switching condition information, the controller 71 controls the switch unit 53 to switch on switching elements

designated in the switching condition information for the switch-on period designated in the switching condition information. In case that the switch-on period is fixed for any case, the switch-on period is not required in the switching condition information.

[0063] The input unit **73** may alternatively include various buttons corresponding to various predetermined supply voltage types. In such a case, the operator only needs to press one of the buttons appropriate for a type of the supply voltage. The buttons may alternatively be provided as icons in a display window if provided in the ultrasonic probe repolarization apparatus **70**. The operator may click one of the icons. Any of these inputs or information to be supplied from the supply voltage identification table memory **72** is construed as an instruction to the controller **71**.

[0064] Operations of the repolarization in the ultrasonic probe **1** are similar to those described in the first embodiment.

Fourth Embodiment

[0065] FIG. 8 is a block diagram showing a fourth exemplary configuration of the repolarization system according to a fourth embodiment of the present invention. In FIG. 8, components given the same reference numbers as those shown in FIGS. 1, 2A, and 5 will be operative in similar manners. Therefore, detailed explanations of such components are omitted herein.

[0066] In the repolarization system according to the fourth embodiment, an ultrasonic probe repolarization apparatus **80** includes a controller **81** instead of the controller **61**, an ultrasonic probe identification table memory **82** instead of the ultrasonic probe identification table memory **62**, and a connector **51a** instead of the connector **51**. An ultrasonic probe **1a** includes a connector **57a** instead of the connector **57**, a cable **26a** instead of the cable **26**, and an ultrasonic probe identification memory **83**.

[0067] The connector **57a** is connected to the connector **51a**. The connector **57a** is also connected to the cable **26a**. The cable **26a** is similar to the cable **26**, except for a connection to the ultrasonic probe identification memory **83**. The ultrasonic probe identification memory **83** stores information identifying a type of the ultrasonic probe **1a**. The information can be transferred to the ultrasonic probe identification table memory **82** through the cable **26a**, the connector **57a**, and the connector **51a**.

[0068] In the ultrasonic probe repolarization apparatus **80**, the controller **81** controls the switch unit **53** and designates which switching elements to switch on (or which lands to be supplied with the predetermined high voltage). The controller **81** further controls the switch unit **53** to switch on for a switch-on period of the switching elements. In addition, the controller **81** also controls the high voltage power source **54** so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe **1a**.

[0069] The ultrasonic probe identification table memory **82** stores a fifth table showing a relationship between ultrasonic probe type identification information and supply voltage information. The supply voltage information shows various voltages high enough to polarize the electrodes **5** and **7**. Which of the voltages to supply depends on a type of

the ultrasonic probe **1a**. Further, the ultrasonic probe identification table memory **82** also stores a sixth table showing a relationship between ultrasonic probe type identification information and switching condition information. The switching condition information may include switch-on periods of the switch unit **53** and information of designating which switching elements to switch on. The switch-on period is determined to be long enough to polarize the electrodes **5** and **7**. Which of the switch-on periods to apply depends on a type of the ultrasonic probe **1a**. It is necessary to determine the number of switching elements to switch on and/or to determine which switching elements to switch on since the number and relative positions of the lands **21** (**23**) are different among types of the ultrasonic probe **1a**. The fifth table and the sixth table may be combined to use as one table. The ultrasonic probe repolarization apparatus **80** may alternatively include only one of the fifth and sixth tables. In this case, the input according to the first embodiment may be combined in the transferring operation as an input operation. Still further, the ultrasonic probe identification table memory **82** may be provided in the controller **81** as a part of features of the controller **81**. In this case, the controller **81** refers to the ultrasonic probe identification table memory **82** for the controls.

[0070] The controller **81** implements the above-described controls in accordance with information supplied from the ultrasonic probe identification table memory **82** based on the information transferred from the ultrasonic probe identification memory **83** through the cable **26a**, the connector **57a**, and the connector **51a** as interfaces.

[0071] According to the fourth embodiment of the present invention, the ultrasonic probe identification memory **83** may be provided in any part of the ultrasonic probe **1a**.

[0072] The repolarization system configured as above will operate as follows.

[0073] An operator of the repolarization system connects the ultrasonic probe **1a** to the ultrasonic probe repolarization apparatus **80** by putting the connector **57a** into the connector **51a**. In response to the connection or alternatively to a predetermined operation in the ultrasonic probe **1a** and/or the ultrasonic probe repolarization apparatus **80**, the information identifying a type of the ultrasonic probe **1a** stored in the ultrasonic probe identification memory **83** is transferred to the ultrasonic probe identification table memory **82** through the cable **26a** and the connectors **57a** and **51a**. The ultrasonic probe identification table memory **82** receives the transferred information and compares the received information to the ultrasonic probe type identification information in the first table. As a result of the comparison, the supply voltage information corresponding to the ultrasonic probe type identification information identical to the received information is obtained and supplied to the controller **81**. Similarly, the ultrasonic probe identification table memory **82** compares the received information to the ultrasonic probe type identification information in the second table. As a result of the comparison, the switching condition information corresponding to the ultrasonic probe type identification information identical to the received information is obtained and supplied to the controller **81**. The controller **81** receives the supply voltage information and the switching condition information. The controller **81** controls the high voltage power source **54** to generate the predetermined high voltage

based on the supply voltage information. Also based on the switching condition information, the controller **81** controls the switch unit **53** to switch on switching elements designated in the switching condition information for the switch-on period designated in the switching condition information. In case that the switch-on period is fixed for any case, the switch-on period is not required in the switching condition information.

[0074] Operations of the repolarization in the ultrasonic probe **1a** are similar to those described in the first embodiment.

Fifth Embodiment

[0075] FIG. 9 is a block diagram showing a fifth exemplary configuration of the repolarization system according to a fifth embodiment of the present invention. In FIG. 9, components given the same reference numbers as those shown in FIGS. 1, 2A, and 5 will be operative in similar manners. Therefore, detailed explanations of such components are omitted herein.

[0076] In the repolarization system according to the fifth embodiment, an ultrasonic probe repolarization apparatus **90** includes a controller **91** instead of the controller **81**, a supply voltage identification table memory **92** instead of the ultrasonic probe identification table memory **82**, and a connector **51b** instead of the connector **51a**. An ultrasonic probe **1b** includes a connector **57b** instead of the connector **57a**, a cable **26b** instead of the cable **26a**, and a supply voltage identification memory **93** instead of the ultrasonic probe identification memory **83**.

[0077] The connector **57b** is connected to the connector **51b**. The connector **57b** is also connected to the cable **26b**. The cable **26b** is similar to the cable **26a**, except for a connection to the supply voltage identification memory **93**. The supply voltage identification memory **93** stores information identifying a supply voltage type of the ultrasonic probe **1b**. The information can be transferred to the supply voltage identification table memory **92** through the cable **26b**, the connector **57b**, and the connector **51b**.

[0078] In the ultrasonic probe repolarization apparatus **90**, the controller **91** controls the switch unit **53** and designates which switching elements to switch on (or which lands to be supplied with the predetermined high voltage). The controller **91** further controls the switch unit **53** to switch on for a switch-on period of the switching elements. In addition, the controller **91** also controls the high voltage power source **54** so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe **1b**.

[0079] The supply voltage identification table memory **92** stores a seventh table showing a relationship between supply voltage type identification information and supply voltage information. The supply voltage information shows various voltages high enough to polarize the electrodes **5** and **7**. Which of the voltages to supply depends on a type of the ultrasonic probe **1b**. Further, the supply voltage identification table memory **92** also stores an eighth table showing a relationship between supply voltage type identification information and switching condition information. The switching condition information may include switch-on periods of the switch unit **53** and information of designating

which switching elements to switch on. The switch-on period is determined to be long enough to polarize the electrodes **5** and **7**. Which of the switch-on periods to apply depends on a type of the ultrasonic probe **1b**. It is necessary to determine the number of switching elements to switch on and/or to determine which switching elements to switch on since the number and relative positions of the lands **21** (**23**) are different among types of the ultrasonic probe **1b**. The seventh table and the eighth table may be combined to use as one table. The ultrasonic probe repolarization apparatus **90** may alternatively include only one of the seventh and eighth tables. In this case, the input according to the first embodiment may be combined in the transferring operation as an input operation. Still further, the supply voltage identification table memory **92** may be provided in the controller **91** as a part of features of the controller **91**. In this case, the controller **91** refers to the supply voltage identification table memory **92** for the controls.

[0080] The controller **91** implements the above-described controls in accordance with information supplied from the supply voltage identification table memory **92** based on the information transferred from the supply voltage identification memory **93** through the cable **26b**, the connector **57b**, and the connector **51b** as interfaces.

[0081] According to the fifth embodiment of the present invention, the supply voltage identification memory **93** may be provided in any part of the ultrasonic probe **1b**.

[0082] The repolarization system configured as above will operate as follows.

[0083] An operator of the repolarization system connects the ultrasonic probe **1b** to the ultrasonic probe repolarization apparatus **90** by putting the connector **57b** into the connector **51b**. In response to the connection or alternatively to a predetermined operation in the ultrasonic probe **1b** and/or the ultrasonic probe repolarization apparatus **90**, the information identifying a supply voltage type of the ultrasonic probe **1b** stored in the supply voltage identification memory **93** is transferred to the supply voltage identification table memory **92** through the cable **26b** and the connectors **57b** and **51b**. The supply voltage identification table memory **92** receives the transferred information and compares the received information to the supply voltage type identification information in the seventh table. As a result of the comparison, the supply voltage information corresponding to the supply voltage type identification information identical to the received information is obtained and supplied to the controller **91**. Similarly, the supply voltage identification table memory **92** compares the received information to the supply voltage type identification information in the eighth table. As a result of the comparison, the switching condition information corresponding to the supply voltage type identification information identical to the received information is obtained and supplied to the controller **91**. The controller **91** receives the supply voltage information and the switching condition information. The controller **91** controls the high voltage power source **54** to generate the predetermined high voltage based on the supply voltage information. Also based on the switching condition information, the controller **91** controls the switch unit **53** to switch on switching elements designated in the switching condition information for the switch-on period designated in the switching condition

information. In case that the switch-on period is fixed for any case, the switch-on period is not required in the switching condition information.

[0084] Operations of the repolarization in the ultrasonic probe **1b** are similar to those described in the first embodiment.

Sixth Embodiment

[0085] FIG. 10 is a block diagram showing a sixth exemplary configuration of the repolarization system according to a sixth embodiment of the present invention. In FIG. 10, components given the same reference numbers as those shown in FIGS. 1, 2A, and 5 will be operative in similar manners. Therefore, detailed explanations of such components are omitted herein.

[0086] In the repolarization system according to the sixth embodiment, an ultrasonic probe repolarization apparatus **100** includes a controller **101** instead of the controller **91**, an identification table memory **102** instead of the supply voltage identification table memory **92**, a first mechanism **103**, and a connector **51c** instead of the connector **51b**. An ultrasonic probe **1c** includes a connector **57c** instead of the connector **57b** and a second mechanism **104**.

[0087] The connector **57c** is connected to the connector **51c**. The connector **57c** is also connected to the cable **26**. The second mechanism **104** is provided in the connector **57c**. The second mechanism **104** is mechanically configured to have joint indicating predetermined information. The predetermined information is, for example, an ultrasonic probe type or a supply voltage type of the ultrasonic probe **1c**. The second mechanism **104** is detachably attached to the first mechanism **103**. The first mechanism **103** is provided in the connector **51c**. The first mechanism is configured to have joint operative to respond to and recognize the first mechanism **104** and supply the identification table memory **102** with the predetermined information in accordance with the recognized mechanism. That is, electronic signals representing the predetermined information are generated in response to the operation of the first mechanism **103**.

[0088] In the ultrasonic probe repolarization apparatus **100**, the controller **101** controls the switch unit **53** and designates which switching elements to switch on (or which lands to be supplied with the predetermined high voltage). The controller **101** further controls the switch unit **53** to switch on for a switch-on period of the switching elements. In addition, the controller **101** also controls the high voltage power source **54** so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe **1c**.

[0089] The identification table memory **102** stores a ninth table showing a relationship between identification information and supply voltage information. The supply voltage information shows voltages high enough to polarize the electrodes **5** and **7**. Which of the voltages to supply depends on a type of the ultrasonic probe **1c**. Further, the identification table memory **102** also stores a tenth table showing a relationship between identification information and switching condition information. The switching condition information may include switch-on periods of the switch unit **53** and information of designating which switching elements to switch on. The switch-on period is determined to be long

enough to polarize the electrodes **5** and **7**. Which of the switch-on periods to apply depends on a type of the ultrasonic probe **1c**. It is necessary to determine the number of switching elements to switch on and/or to determine which switching elements to switch on since the number and relative positions of the lands **21** (**23**) are different among types of the ultrasonic probe **1c**. The ninth table and the tenth table may be combined to use as one table. The ultrasonic probe repolarization apparatus **100** may alternatively include only one of the ninth and tenth tables. In this case, the input according to the first embodiment may be combined in the attachment operation as an input operation. Still further, the identification table memory **102** may be provided in the controller **101** as a part of features of the controller **101**. In this case, the controller **101** refers to the identification table memory **102** for the controls.

[0090] The controller **101** implements the above-described controls in accordance with information supplied from the identification table memory **102** based on the predetermined information recognized by the first mechanism **103** in response to the second mechanism **104**.

[0091] The repolarization system configured as above will operate as follows.

[0092] An operator of the repolarization system connects the ultrasonic probe **1c** to the ultrasonic probe repolarization apparatus **100** by putting the connector **57c** into the connector **51c**. In response to the connection, the second mechanism **104** is attached to the first mechanism **103**. Accordingly, the predetermined information based on the second mechanism **104** is recognized by the first mechanism **103**. Electronic signals representing the recognized predetermined information is supplied to the identification table memory **102**. The identification table memory **102** receives the supplied information and compares the received information to the identification information in the ninth table. As a result of the comparison, the supply voltage information corresponding to the identification information identical to the received information is obtained and supplied to the controller **101**. Similarly, the identification table memory **102** compares the received information to the identification information in the tenth table. As a result of the comparison, the switching condition information corresponding to the identification information identical to the received information is obtained and supplied to the controller **101**. The controller **101** receives the supply voltage information and the switching condition information. The controller **101** controls the high voltage power source **54** to generate the predetermined high voltage based on the supply voltage information. Also based on the switching condition information, the controller **101** controls the switch unit **53** to switch on switching elements designated in the switching condition information for the switch-on period designated in the switching condition information. In case that the switch-on period is fixed for any case, the switch-on period is not required in the switching condition information.

[0093] Operations of the repolarization in the ultrasonic probe **1c** are similar to those described in the first embodiment.

Seventh Embodiment

[0094] FIG. 11 is a block diagram showing a first exemplary configuration of an ultrasound imaging apparatus

according to a seventh embodiment of the present invention. The ultrasound imaging apparatus includes a main body **110** and the ultrasonic probe **1a**. Components of the ultrasonic probe **1a** are similar to those of the ultrasonic probe **1a** shown in **FIG. 8**. Therefore, explanations of such components will be omitted herein. The main body **110** includes an ultrasonic probe identification table memory **111**, an accumulator **112**, an informing unit **113**, and a connector **51d**. In addition, the main body **110** further includes a controller, a switch unit, a high voltage power source, and an input unit, which are not shown in **FIG. 11**. Needless to say, the main body **110** also includes components typically required for a conventional ultrasound imaging apparatus.

[**0095**] The ultrasonic probe **1a** is detachably connected (or attached) to the main body **110** through the connectors **57a** and **51d**. The ultrasonic probe identification memory **114** stores information identifying the ultrasonic probe **1a**. Information identifying the ultrasonic probe **1a** stored in the ultrasonic probe identification memory **114** can be transferred to the ultrasonic probe identification table memory **111** through the cable **26a**, the connector **57a**, and the connector **51d**.

[**0096**] In the main body **110**, the controller controls the switch unit and designates which switching elements to switch on (or which lands to be supplied with a predetermined high voltage). The controller further controls the switch unit to switch on for a switch-on period of the switching elements. In addition, the controller also controls the high voltage power source so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe **1a**.

[**0097**] The ultrasonic probe identification table memory **111** stores an eleventh table showing a relationship between ultrasonic probe identification information and supply voltage information. The supply voltage information shows various voltages high enough to polarize the electrodes **5** and **7**. Which of the voltages to supply depends on a type of the ultrasonic probe **1a**. Further, the ultrasonic probe identification table memory **111** also stores a twelfth table showing a relationship between ultrasonic probe identification information and switching condition information. The switching condition information may include switch-on periods of the switch unit and information of designating which switching elements to switch on. The switch-on period is determined to be long enough to polarize the electrodes **5** and **7**. Which of the switch-on periods to apply depends on a type of the ultrasonic probe **1a**. It is necessary to determine the number of switching elements to switch on and/or to determine which switching elements to switch on since the number and relative positions of the lands **21** (**23**) are different among types of the ultrasonic probe **1a**. The eleventh table and the twelfth table may be combined to use as one table. The main body **110** may alternatively include only one of the eleventh and twelfth tables. In this case, inputs in a manner similar to the first embodiment may be combined in the transferring operation as an input operation. Still further, the ultrasonic probe identification table memory **111** may be provided in the controller as a part of features of the controller. In this case, the controller refers to the ultrasonic probe identification table memory **111** for the controls.

[**0098**] The accumulator **112** accumulates time during a use of the ultrasonic probe **1a**. The use of the ultrasonic

probe **1a** may be defined, for example, that the ultrasonic probe **1a** is supplied with a power for generating an ultrasound. Further, for example, the use of the ultrasonic probe **1a** may indicate that the ultrasonic probe **1a** generates an ultrasound. The accumulated time is recorded (or stored) in a recorder provided in the accumulator **112**. The recorder may alternatively be provided independently or in the controller. The accumulation by the accumulator **112** is implemented every ultrasonic probe identification information. This is because the ultrasonic probe **1a** may often be changed to others among a plurality of ultrasonic probes in accordance with a requirement in an ultrasound imaging.

[**0099**] The informing unit **113** gives a notice to an operator when the accumulated time has reached a predetermined time. The notice may be a suggestion that the ultrasonic probe **1a** (i.e., the transducers **2**) should be repolarized. The informing unit **113** may alternatively give a notice as a warning in a predetermined time before the time that the ultrasonic probe **1a** should be repolarized. In this case, the notice may indicate when the ultrasonic probe **1a** should be repolarized. Such indication may be displayed as a message in a display provided for displaying ultrasound images as a typical component of the ultrasound imaging apparatus. The ultrasound imaging apparatus may alternatively warn it in a sound, such as, for example, beep sound or a voice message. Instead of when to repolarize, a remaining time until when the ultrasonic probe **1a** should be repolarized maybe calculated or estimated based on the accumulated time and be displayed in the display or warned in the sound.

[**0100**] Usually the predetermined time is determined based on an image quality of images displayed in the display. If the depolarization progresses to a certain extent, the image quality is deteriorated to become beyond the permissible quality range. The predetermined time may be a time that such deterioration is caused and may depend on a type of the ultrasonic probe **1a** or the transducers **2**. Typically, the predetermined time may be about one year.

[**0101**] When the operator inputs an instruction through the input unit in response to the notice given by the informing unit **113**, the controller controls the switch unit and the high voltage power source so that the repolarization is implemented as described before.

Eighth Embodiment

[**0102**] **FIG. 12** is a flowchart showing an example of operations of an ultrasound imaging apparatus according to an eighth embodiment of the present invention. The ultrasound imaging apparatus according to the eighth embodiment will be described with reference to **FIGS. 11 and 12**. The ultrasound imaging apparatus is, however, not necessarily required to incorporate the informing unit **113** according to the eighth embodiment.

[**0103**] The ultrasound imaging apparatus automatically implements the repolarization under a predetermined condition as shown in **FIG. 12**. Operations shown in steps of **FIG. 12** are implemented by the controller, the ultrasonic probe identification table memory **111**, the accumulator **112**, and so on.

[**0104**] When the ultrasound imaging apparatus is switched on for operations (step **S1201**), it is determined whether the ultrasonic probe **1a** is attached to the main body

110 or not (step **S1202**). In response to the determination of the attachment, ultrasonic probe identification information of the ultrasonic probe **1a** is transferred from the ultrasonic probe **1a** to the main body **110** and determined (or recognized) (step **S1203**). After the determination, a flag corresponding to the determined ultrasonic probe identification information is determined whether it is one or zero (step **S1204**). If the flag is one, the main body **110** of the ultrasound imaging apparatus automatically implements the repolarization on the ultrasonic probe **1a** (or the transducers **2**) (step **S1205**). The flag is changed to zero (step **S1206**).

[**0105**] After step **S1206** and when the flag is not one in step **S1204**, it is determined whether the ultrasonic probe **1a** is being used or not (step **S1207**). In the determination of the use of the ultrasonic probe **1a**, time accumulation is implemented (step **S1208**). The accumulated time is recorded in the recorder. When the accumulated time has reached a predetermined time (step **S1209**), the flag is changed to one (step **S1210**). The predetermined time may be set, taking into consideration, for example, average time estimated to be required for one day use of the ultrasonic probe **1a** as a margin. The time accumulation continues during the use of the ultrasonic probe **1a**. When the use of the ultrasonic probe **1a** is terminated (step **S1211**), the time accumulation is terminated. Further, in response to switching off the power supply to the ultrasound imaging apparatus, the operations are terminated (step **S1212**).

[**0106**] According to the operations described above, when the ultrasonic probe **1a** is used and accumulated time has reached the predetermined time, the repolarization is automatically implemented at the beginning of the next use of the ultrasonic probe **1a**. Therefore, the operator needs neither to pay attention to the time for the repolarization nor to perform a predetermined operation for the repolarization.

[**0107**] As a first alternative example, when it is determined that the accumulated time has reached a predetermined time in step **S1209**, the repolarization may be automatically implemented in response to the termination of the use of the ultrasonic probe **1a** in step **S1211**.

[**0108**] Still further, it can be a second alternative example that an operator's confirmation is requested by displaying such a confirmation request message in the display or by a voice message in advance of implementing the repolarization in step **S1205** or in the above first alternative example.

Ninth Embodiment

[**0109**] **FIG. 13** is a block diagram showing a second exemplary configuration of the ultrasound imaging apparatus according to a ninth embodiment of the present invention. In **FIG. 13**, components given the same reference numbers as those shown in **FIGS. 1 and 2A**, and **5** will be operative in similar manners. Therefore, detailed explanations of such components are omitted herein.

[**0110**] The ultrasound imaging apparatus includes a main body **130** and an ultrasonic probe **1d**. The main body **130** includes an informing unit **131** and a connector **51e**. In addition, the main body **130** further includes a controller, a switch unit, a high voltage power source, an ultrasonic probe identification table memory, and an input unit, which are not shown in **FIG. 13**. Needless to say, the main body **130** also includes components typically required for a conventional

ultrasound imaging apparatus. The ultrasonic probe **1d** includes a connector **57d**, a cable **26d**, and an accumulator **132**, in addition to the components shown in **FIGS. 1 and 2A**.

[**0111**] The connector **57d** is connected to the connector **51e**. The connector **57d** is also connected to the cable **26d**. The cable **26d** is similar to the cable **26**, except for a connection to the accumulator **132**. Therefore, the ultrasonic probe **1d** is detachably connected (attached) to the main body **130** through the connectors **57d** and **51e**. The accumulator **132** accumulates time during a use of the ultrasonic probe **1d**. The accumulated time is recorded (or stored) in a recorder provided in the accumulator **132**. The recorder may alternatively be provided independently in the ultrasonic probe **1d** or in the main body **130**.

[**0112**] The accumulated time is transferred to the controller provided in the main body **130**. The controller determines whether the accumulated time has reached a predetermined time. Alternatively, when it is determined in the accumulator **132** that the accumulated time has reached the predetermined time, instruction signals may be sent to the informing unit **130** through the cable **26d**, the connector **57d**, and the connector **51e**.

[**0113**] In the main body **130**, the controller controls the switch unit and designates which switching elements to switch on (or which lands to be supplied with a predetermined high voltage). The controller further controls the switch unit to switch on for a switch-on period of the switching elements. In addition, the controller also controls the high voltage power source so that the predetermined high voltage is generated. The predetermined high voltage varies depending on a type of the ultrasonic probe **1d**.

[**0114**] The ultrasonic probe identification table memory stores a table showing a relationship between ultrasonic probe identification information and supply voltage information. The supply voltage information shows various voltages high enough to polarize the electrodes **5** and **7**. Which of the voltages to supply depends on a type of the ultrasonic probe **1d**. Further, the ultrasonic probe identification table memory also stores another table showing a relationship between ultrasonic probe identification information and switching condition information. The switching condition information may include switch-on periods of the switch unit and information of designating which switching elements to switch on. The switch-on period is determined to be long enough to polarize the electrodes **5** and **7**. Which of the switch-on periods to apply depends on a type of the ultrasonic probe **1d**. It is necessary to determine the number of switching elements to switch on and/or to determine which switching elements to switch on since the number and relative positions of the lands **21** (**23**) are different among types of the ultrasonic probe **1d**. The table and another table may be combined to use as one table. The main body **130** may alternatively include only one of the table and another table. In this case, inputs in a manner similar to the first embodiment may be combined as an input operation. Still further, the ultrasonic probe identification table memory may be provided in the controller as a part of features of the controller. In this case, the controller refers to the ultrasonic probe identification table memory for the controls.

[**0115**] The informing unit **130** gives a notice to an operator when the accumulated time has reached the predeter-

mined time. As described above, the informing unit **130** is operative in response to the instruction signals from the accumulator **132** or the controls by the controller. The notice may be a suggestion that the ultrasonic probe id (i.e., the transducers **2**) should be repolarized. The informing unit **130** may alternatively give a notice as a warning in a predetermined time before the time that the ultrasonic probe id should be repolarized. In this case, the notice may indicate when the ultrasonic probe id should be repolarized. Such indication may be displayed as a message in a display provided for displaying ultrasound images as a typical component of the ultrasound imaging apparatus. The ultrasound imaging apparatus may alternatively warn it in a sound, such as, for example, beep sound or a voice message. Instead of when to repolarize, a remaining time until when the ultrasonic probe **1d** should be repolarized may be calculated and estimated based on the accumulated time and be displayed in the display or warned in the sound.

[**0116**] When the operator inputs an instruction through the input unit in response to the notice given by the informing unit **131**, the controller controls the switch unit and the high voltage power source so that the repolarization is implemented as described before.

[**0117**] Although the ultrasound imaging apparatus has been described only in the seventh to the ninth embodiments, any idea of the embodiments described for the repolarization system (i.e., the first to the sixth embodiments) can also be applied to the ultrasound imaging apparatus.

[**0118**] The embodiments of the present invention described above are examples described only for making it easier to understand the present invention, and are not described for the limitation of the present invention. Consequently, each component and element disclosed in the embodiments of the present invention may be redesigned or modified to its equivalent within a scope of the present invention. Furthermore, any possible combination of such components and elements may be included in a scope of the present invention as long as an advantage similar to those obtained according to the above disclosure in the embodiments of the present invention is obtained.

[**0119**] Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

1. A repolarization system including an ultrasonic probe, the system comprising:

- a plurality of transducers provided in the ultrasonic probe, each one or more of the transducers being provided with a pair of electrodes;
- a voltage generator configured to generate a predetermined voltage high enough to repolarize the transducers;
- a switch configured to switch to supply the voltage to the pair of electrodes;
- a connector configured to connect the pair of electrodes to the switch through a plurality of lands each of which corresponding to the pair of electrodes, the lands being

provided to keep insulation enough to repolarize the transducers among the lands;

an interface configured to give an instruction; and

a controller configured to control the voltage generator to generate the predetermined voltage and to control the switch to supply the predetermined voltage to the pair of electrodes in accordance with the instruction.

2. The system according to claim 1, wherein the ultrasonic probe is detachable from the system.

3. The system according to claim 1, wherein the system is incorporated in an ultrasound imaging apparatus.

4. The system according to claim 1, wherein the lands are provided at predetermined intervals so as to keep the insulation between each two of the lands.

5. The system according to claim 1, wherein there is an insulator between each two of the lands.

6. The system according to claim 1, further comprising a memory configured to store a table showing a relationship between ultrasonic probe type identification information and supply voltage information; and an input unit configured to input information identifying a type of the ultrasonic probe as the instruction, and wherein the controller determines the predetermined voltage based on the supply voltage information corresponding to the ultrasonic probe type identification information identical to the information input by the input unit.

7. The system according to claim 1, further comprising a memory configured to store a table showing a relationship between ultrasonic probe type identification information and switching condition information; and an input unit configured to input information identifying a type of the ultrasonic probe as the instruction, and wherein the controller controls the switch based on the switching condition information corresponding to the ultrasonic probe type identification information identical to the information input by the input unit.

8. The system according to claim 1, further comprising a memory configured to store a table showing a relationship between supply voltage type identification information and supply voltage information; and an input unit configured to input information identifying a supply voltage type of the ultrasonic probe as the instruction, and wherein the controller determines the predetermined voltage based on the supply voltage information corresponding to the supply voltage type identification information identical to the information input by the input unit.

9. The system according to claim 1, further comprising an input unit configured to input a value of the predetermined voltage as the instruction.

10. The system according to claim 1, further comprising an input unit configured to input a time period for which the predetermined voltage is supplied to the pair of the electrodes.

11. The system according to claim 1, further comprising a memory configured to store a table showing a relationship between ultrasonic probe type identification information and supply voltage information, wherein the ultrasonic probe is further configured to store information identifying a type of the ultrasonic probe, and wherein the controller determines the predetermined voltage based on the supply voltage information corresponding to the ultrasonic probe type identification information identical to the information provided from the ultrasonic probe as the instruction.

12. The system according to claim 1, further comprising a memory configured to store a table showing a relationship between ultrasonic probe type identification information and switching condition information, wherein the ultrasonic probe is further configured to store information identifying a type of the ultrasonic probe, and wherein the controller controls the switch based on the switching condition information corresponding to the ultrasonic probe type identification information identical to the information provided from the ultrasonic probe as the instruction.

13. The system according to claim 1, further comprising a memory configured to store a table showing a relationship between supply voltage type identification information and supply voltage information, wherein the ultrasonic probe is further configured to store information identifying a supply voltage type of the ultrasonic probe, and wherein the controller determines the predetermined voltage based on the supply voltage information corresponding to the supply voltage type identification information identical to the information provided from the ultrasonic probe as the instruction.

14. The system according to claim 1, further comprising a first mechanism configured to respond to a second mechanism provided in the ultrasonic probe so as to supply a predetermined information based on the second mechanism as the instruction; and a memory configured to store a table showing a relationship between the predetermined information and supply voltage information, wherein the controller determines the predetermined voltage based on the supply voltage information corresponding to the predetermined information supplied through the first mechanism.

15. The system according to claim 1, wherein the switch includes a plurality of switching elements and wherein the controller controls one or more of the switching elements to connect the voltage generator to the pair of electrodes provided for each of one or more of the transducers, the one or more of the transducers corresponding to the one or more of the switching elements.

16. The apparatus according to claim 1, wherein the controller is further configured to vary time to control the switch to supply the predetermined voltage in accordance with the instruction.

17. An ultrasound imaging apparatus for obtaining an ultrasound image through an ultrasonic probe, the apparatus comprising:

- a plurality of transducers provided in the ultrasonic probe and configured to generate an ultrasound so as to obtain the ultrasound image, each one or more of the transducers being provided with a pair of electrodes;
- a voltage generator configured to generate a predetermined voltage high enough to repolarize the transducers;
- a switch configured to switch to supply the voltage to the pair of electrodes;
- a connector configured to connect the pair of electrodes to the switch through a plurality of lands each of which corresponding to the pair of electrodes, the lands being provided to keep insulation enough to repolarize the transducers among the lands;
- an interface configured to give an instruction; and
- a controller configured to control the voltage generator to generate the predetermined voltage and to control the switch to supply the predetermined voltage to the pair of electrodes in accordance with the instruction.

18. The apparatus according to claim 17, further comprising an accumulator configured to accumulate a time when the transducers generate the ultrasound; a recorder configured to record the accumulated time; and a notice component configured to give a notice according to the accumulated time.

19. The apparatus according to claim 18, wherein the notice component gives the notice in response that the accumulated time has reached a predetermined time.

20. The apparatus according to claim 19, wherein the notice component gives the notice to suggest repolarizing the transducers.

21. The apparatus according to claim 18, wherein the notice component gives the notice to suggest when to repolarize the transducers.

22. The apparatus according to claim 18, wherein the notice component includes a display configured to display a remaining time estimated based on the accumulated time until repolarizing the transducers.

23. The apparatus according to claim 17, further comprising an accumulator configured to accumulate a time when the transducers generate the ultrasound; and a recorder configured to record the accumulated time, and wherein the controller is further configured to determine a power supply for the apparatus; and wherein the controller automatically controls the switch to supply the predetermined voltage to the pair of electrodes in response to determining the power supply when the accumulated time has reached a predetermined time at a time of a last termination of the power supply.

24. The apparatus according to claim 17, further comprising an accumulator configured to accumulate a time when the transducers generate the ultrasound; and a recorder configured to record the accumulated time, and wherein the controller is further configured to determine that the transducers terminate the ultrasound; and wherein the controller automatically controls the switch to supply the predetermined voltage to the pair of electrodes in response to determining the ultrasound termination when the accumulated time has reached a predetermined time at a time of the ultrasound termination.

25. The apparatus according to claim 18, wherein the accumulator and the recorder are provided in the ultrasonic probe.

26. The apparatus according to claim 17, wherein the ultrasonic probe is detachable from the apparatus.

27. An ultrasonic probe which is connectable to a voltage supply apparatus, the probe comprising:

- a plurality of transducers, each one or more of which being provided with a pair of electrodes;
- a plurality of lands each of which configured to correspond to the pair of electrodes and provided to keep insulation enough to repolarize the transducers among the lands;
- a cable configured to include a plurality of voltage supply lines connected to the lands, respectively; and
- a connector configured to connect the cable to the voltage supply apparatus, wherein a predetermined voltage is supplied to the transducers through the lands.

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摘要(译)

包括超声探头的复极系统包括多个换能器，电压发生器，开关，连接器，接口和控制器。多个换能器设置在超声波探头中。每个换能器中的每一个或多个设置有一对电极。电压发生器配置成产生足够高的预定电压以再次换能器。开关被配置为切换以向该对电极提供电压。连接器被配置为通过多个焊盘将该对电极连接到开关。多个焊盘中的每一个对应于该对电极。提供焊盘以保持绝缘足以在焊盘之间再次转换换能器。接口配置为提供指令。控制器配置成控制电压发生器以产生预定电压。控制器还被配置为根据指令控制开关将预定电压提供给电极对。

