US 20070073154A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2007/0073154 A1

Karasawa (43) Pub. Date: Mar. 29, 2007

(54) ULTRASONIC PROBE AND ULTRASONIC DIAGNOSTIC APPARATUS

(75) Inventor: **Hiroyuki Karasawa**, Kanagawa (JP)

Correspondence Address:
**SUGHRUE MION, PLLC**
**2100 PENNSYLVANIA AVENUE, N.W.**
**SUITE 800**
**WASHINGTON, DC 20037 (US)**

(73) Assignee: **FUJI PHOTO FILM CO., LTD.**

(21) Appl. No.: **11/518,272**

(22) Filed: **Sep. 11, 2006**

(30) **Foreign Application Priority Data**

Sep. 9, 2005 (JP) ..................................... 2005-262363

**Publication Classification**

(51) **Int. Cl.**
*A61B 8/14* (2006.01)

(52) **U.S. Cl.** ............................................................. **600/459**

(57) **ABSTRACT**

An ultrasonic diagnostic apparatus is provided with an ultrasonic probe that has at its end a low frequency ultrasonic transducer group and a high frequency ultrasonic transducer group, and a selection switch for selecting one of these transducer groups. According to the selection at the selection switch, a switching device of the ultrasonic probe connects either the low frequency ultrasonic transducer group or the high frequency ultrasonic transducer group to a multiplexer. The multiplexer selects from among ultrasonic transducers of the selected group ones to be driven at the same time, while shifting the driven transducers of the same group step by step.

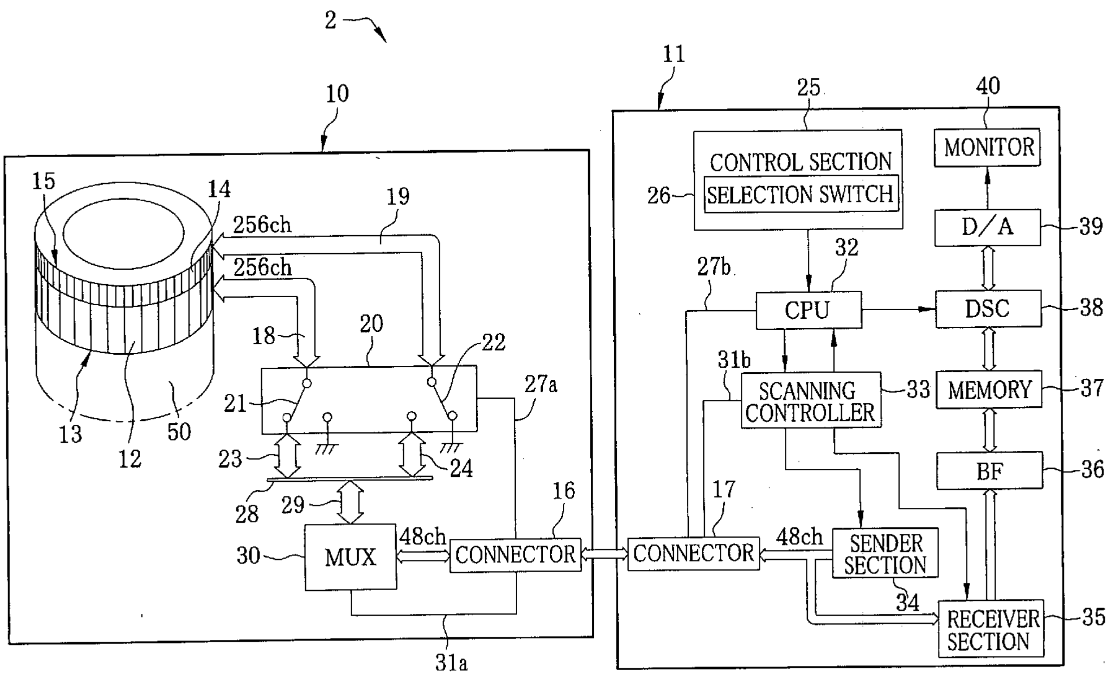
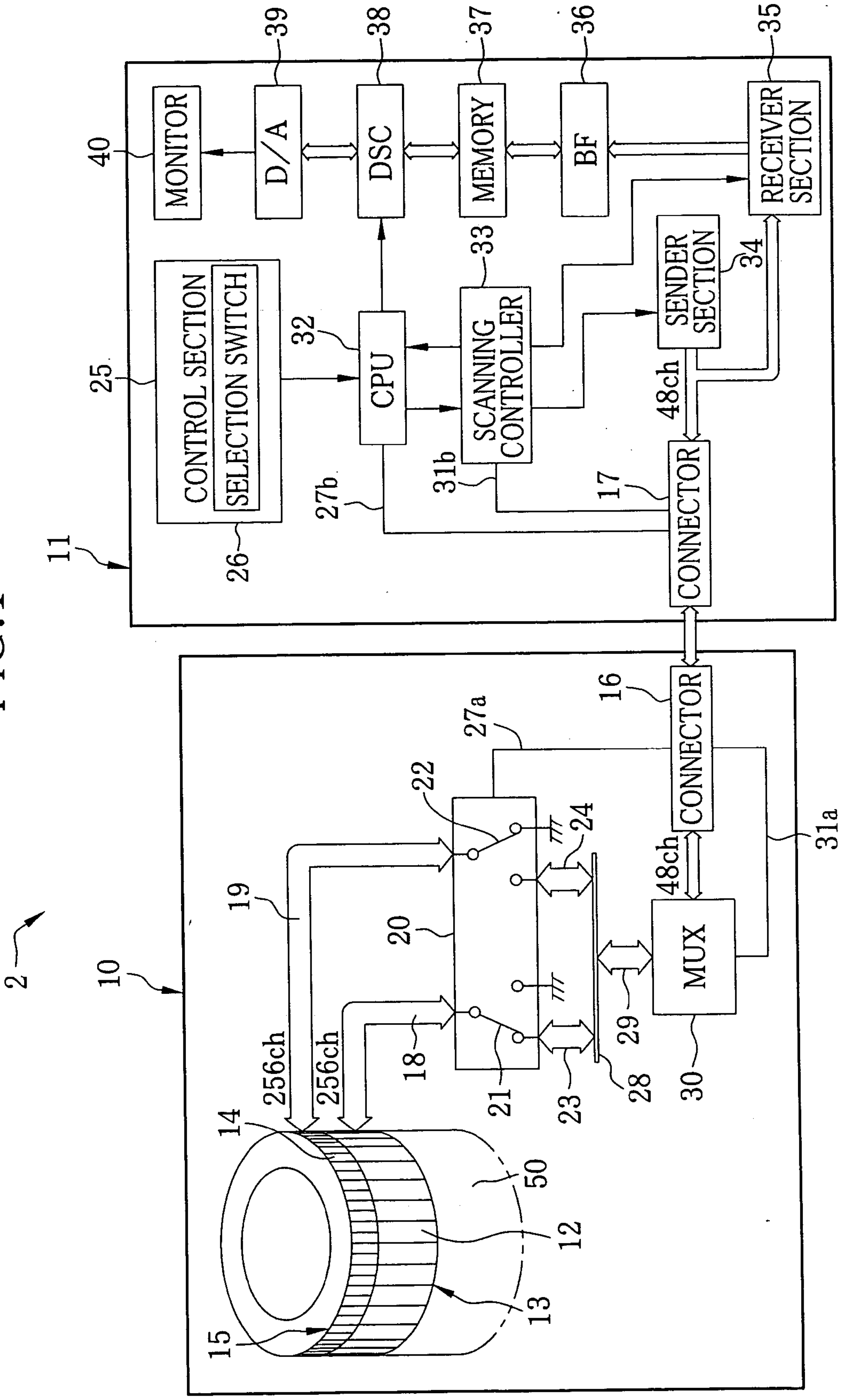


FIG.1


MONITOR
D/A
DSC
MEMORY
BF
RECEIVER SECTION
CONTROL SECTION
SELECTION SWITCH
CPU
SCANNING CONTROLLER
SENDER SECTION
48ch
CONNECTOR
CONNECTOR
48ch
MUX
256ch
256ch
2
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27a
27b
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29
30
31a
31b
32
33
34
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36
37
38
39
40
50

FIG.2

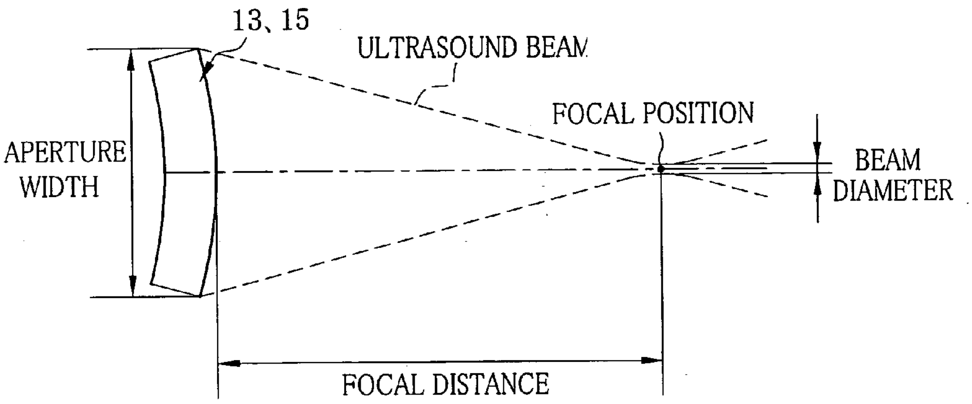

13、15
ULTRASOUND BEAM
FOCAL POSITION
APERTURE WIDTH
BEAM DIAMETER
FOCAL DISTANCE

FIG.4

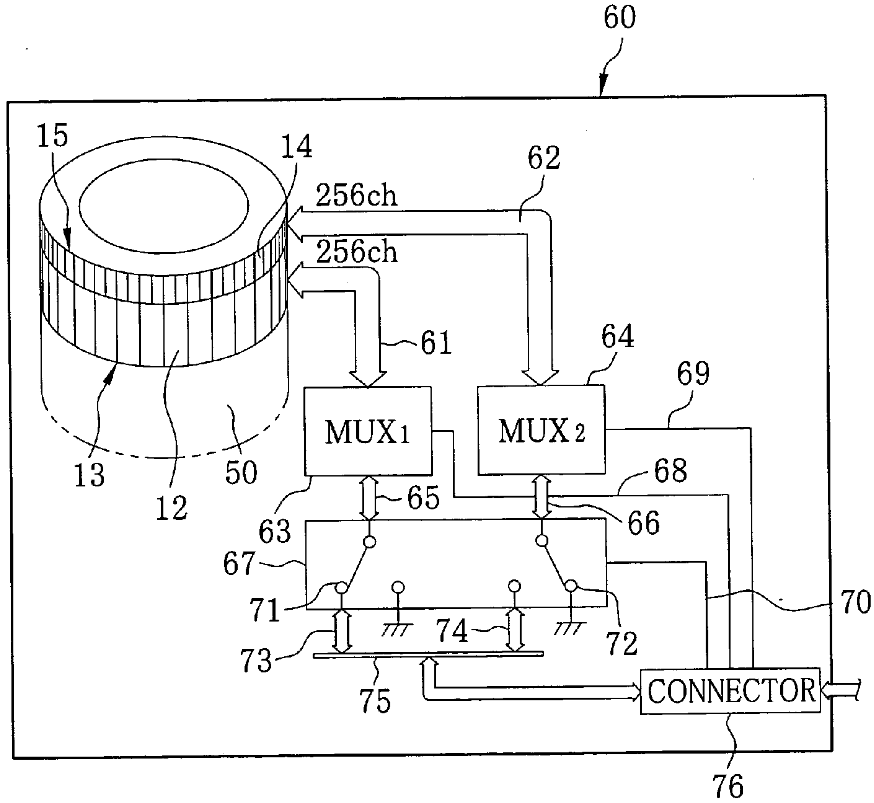

60
15
14
256ch
62
256ch
61
64
69
MUX1
MUX2
68
13
50
12
63
65
66
67
71
74
72
70
73
75
CONNECTOR
76

FIG.3A

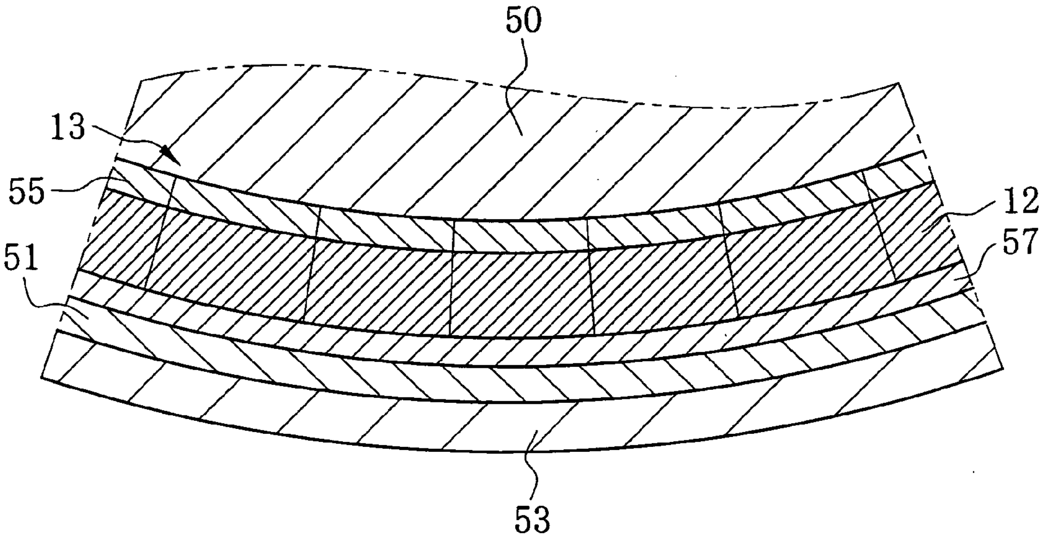



FIG.3B

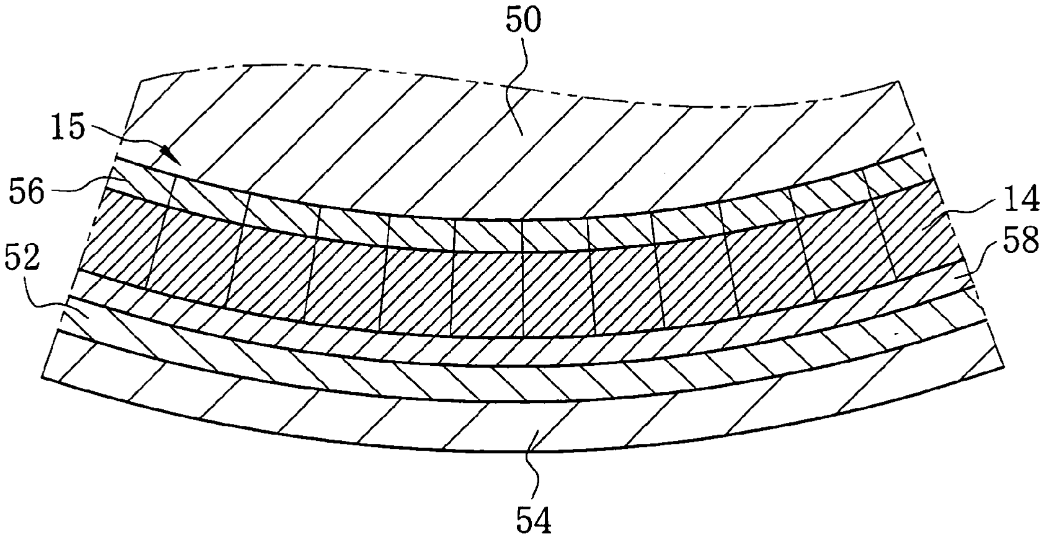


FIG.5

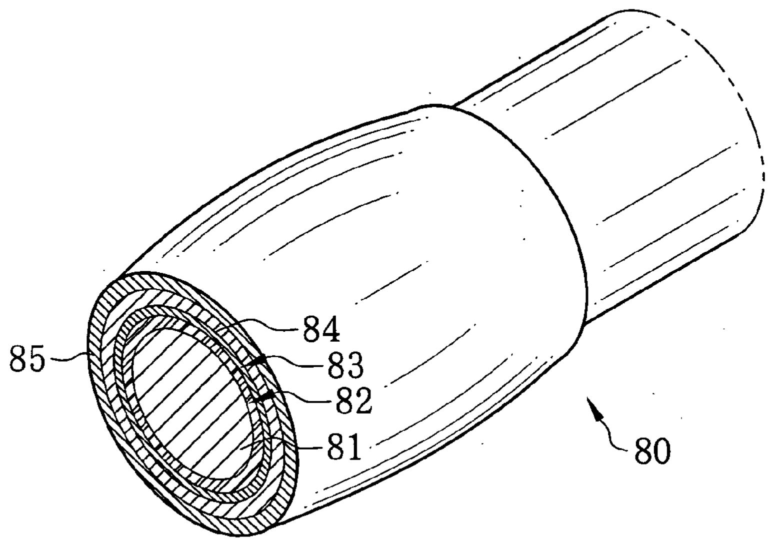
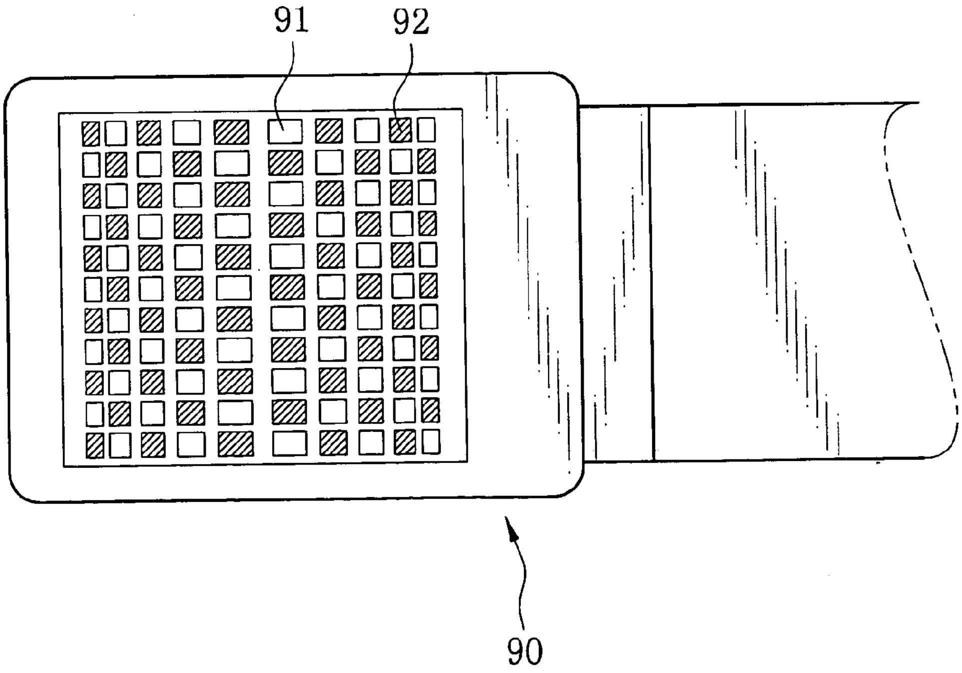



FIG.6



# ULTRASONIC PROBE AND ULTRASONIC DIAGNOSTIC APPARATUS

## FIELD OF THE INVENTION

[0001] The present invention relates an ultrasonic probe that is provided with plural kinds of ultrasonic transducer groups, each group consists of a plurality of ultrasonic transducers having the same frequency bandwidth. The present invention also relates to an ultrasonic diagnostic apparatus using the ultrasonic probe.

## BACKGROUND OF THE INVENTION

[0002] Recently, medical diagnoses utilizing ultrasonic images have been put into practice in the medical field. To take an ultrasonic image, ultrasonic waves are radiated from an ultrasonic probe toward a certain region of a living body, and thereafter an echo signal is detected electrically from the living body. Based on the echo signal, the ultrasonic image is produced and displayed on an ultrasonic observer that is connected to the ultrasonic probe through connecters.

[0003] Scanning a region with ultrasonic waves can take an ultrasonotomographic image. Ultrasonic probes of mechanical scanning type turn or swing mechanically an ultrasonic transducer that sends and receives the ultrasonic waves. Ultrasonic probes of electronic scanning type have an array of ultrasonic transducers, which are switched on and off by electronic switches, to drive selected ones of these transducers.

[0004] However, in order to obtain adequate ultrasonotomographic images for exact medical diagnoses, it is necessary to adjust frequency of the ultrasonic waves in accordance with the depth of region to be scanned, because there are differences between individual living bodies, e.g. a difference in fat amount, and a difference in ultrasound propagation characteristics between tissues. In addition to that, high frequency ultrasonic waves can provide high-resolution images but cannot provide images of deep site. To cope with this problem, there is a method wherein low frequency ultrasonic waves are first radiated to observe a rough image of the whole region including the deep sites, and then high frequency ultrasonic waves are radiated to observe details of a suspected lesion on a high-resolution image.

[0005] For this purpose, a plurality of ultrasonic endoscopes or ultrasonic probes, which are loaded with ultrasonic transducers of different frequency bands, have conventionally been prepared, so that the operator can use some of them according to the site to be observed. Since it is necessary for intra-cavity diagnosis to introduce the ultrasonic probe through a channel of forceps into the patient body, the use of plural kinds of ultrasonic probes has been a main factor of increasing the load on the patient. To solve this problem, an ultrasonic probe has been suggested in Japanese Laid-open Patent Application No. 2005-103193, which has different kinds of ultrasonic transducer groups, each group consisting of a plurality of ultrasonic transducers of the same frequency band. According to this prior art, the single ultrasonic probe can radiate ultrasonic waves of different frequency bands.

[0006] More specifically, the ultrasonic probe of this prior art has a laminated structure having at least two layers of ultrasonic transducers, each layer consisting of a plurality of electric/ultrasound transducer elements. The individual layers are driven independently at the different frequencies. So the ultrasonic probe of this prior art is usable both for transcranial ultrasound Doppler monitoring, using a frequency of about 2 MHz, and for thrombolytic treatment, using a frequency of about 500 MHz.

[0007] Japanese Laid-open Patent Application No. 2003-169800 also suggests an ultrasonic probe having a plurality of ultrasonic transducers, which are arranged in a plane and consist of groups of different frequency characteristic curves from each other. The ultrasonic probe of the latter prior art widens the usable frequency bandwidth and thus facilitates modulations, such as harmonic imaging for producing adequate three-dimensional ultrasonic images.

[0008] However, the ultrasonic probe of the former prior art is automatically switched over between the transcranial ultrasound Doppler monitoring mode and the thrombolytic treatment mode at constant time intervals. The ultrasonic probe of the latter prior art just connects one or both of the two kinds of ultrasonic transducer groups to a sender section for sending a drive signal to excite the ultrasonic transducers, or a receiver section for receiving an echo signal from the living body. That is, the combinations of sending and receiving signals are fixed, so the operator cannot switch or select the frequency band of the ultrasonic wave. Accordingly, the prior arts cannot satisfy the demand of the operators for selecting the frequency of ultrasonic wave from the ultrasonic probe appropriately in accordance with required image resolution and depth of observation, which vary depending upon the diagnostic purpose.

[0009] Furthermore, according to the above prior arts, the number of wires to the ultrasonic transducers increases with the number of kinds of ultrasonic transducers. Correspondingly, the diameters of the ultrasonic probes of the prior arts come to be larger than a conventional one using a single kind of ultrasonic transducers. So the load on the patients at the time of introducing the ultrasonic probe into a body cavity gets heavier.

## SUMMARY OF THE INVENTION

[0010] In view of the foregoing, a primary object of the present invention is to provide an ultrasonic probe, which allows the operator to change the frequency of ultrasonic wave promptly in accordance with the intension of the operator without the need for replacing the probe, or without enlarging the diameter of the probe. Another object is to provide an ultrasonic diagnostic apparatus using the inventive ultrasonic probe.

[0011] According to the present invention, in an ultrasonic probe and an ultrasonic diagnostic apparatus using the ultrasonic probe, a plural kinds of groups of ultrasonic transducers are arranged at an end of the ultrasonic probe for radiating ultrasonic waves toward a living body and receiving echo signal from the living body, each group consisting of a plurality of ultrasonic transducers having the same frequency band that is different from another group, and one group to use is selected from among the plural kinds of groups in accordance with a control device that is entered by operating a control device.

[0012] According to a preferred embodiment, the ultrasonic probe further comprises signal lines for sending drive signals to the ultrasonic transducers and transmitting the echo signals received from the living body; and a switching device for switching connections to the signal lines between the plural kinds of groups in accordance with the control signal.

[0013] Preferably, the ultrasonic probe further comprises multiplexers for selecting ones to be driven at the same time from among the ultrasonic transducers of the one group as selected through the control device.

[0014] The different frequency bands of the plural kinds of groups of ultrasonic transducers are preferably set to cover a bandwidth from about 3 MHz to 20 MHz.

[0015] It is preferable to short-circuit the ultrasonic transducers of not-selected ones of the groups electrically.

[0016] Because the control device is operated to enter the control signal for selecting one group from among the plural kinds of groups of ultrasonic transducers, the operator can change the frequency band of the ultrasonic wave appropriately at any timing.

[0017] The switching device, which switches connections to the signal lines between the plural kinds of groups of ultrasonic transducers in accordance with the operation on the control device, contributes to reducing the requisite number of wirings. The multiplexers, which select ones to be driven at the same time from among the ultrasonic transducers of the one group as selected through the control device, also contributes to reducing the requisite number of wirings. Thus, the ultrasonic probe of the present invention may have a smaller diameter even while it can radiate ultrasonic waves of different frequency bands.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The above and other objects and advantages of the present invention will be more apparent from the following detailed description of the preferred embodiments when read in connection with the accompanied drawings, wherein like reference numerals designate like or corresponding parts throughout the several views, and wherein:

[0019] FIG. **1** is a block diagram illustrating schematic structure of an ultrasonic diagnostic apparatus according to an embodiment of the invention;

[0020] FIG. **2** is a pattern diagram for explaining aperture width, focal length, focal position and beam diameter of an ultrasonic transducer;

[0021] FIG. **3**A is an enlarged sectional view of a low frequency ultrasonic transducer group at an end portion of an ultrasonic probe;

[0022] FIG. **3**B is an enlarged sectional view of a high frequency ultrasonic transducer group at an end portion of the ultrasonic probe;

[0023] FIG. **4** is a block diagram illustrating schematic structure of an ultrasonic probe according to another embodiment of the invention;

[0024] FIG. **5** is a perspective view, partly in section, of an ultrasonic probe according to a further embodiment of the invention; and

[0025] FIG. **6** is a top plan view illustrating an end portion of an ultrasonic probe according to another embodiment of the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0026] FIG. **1** shows an ultrasonic diagnostic apparatus **2** of the present invention, which consists of an ultrasonic probe **10** and an ultrasonic observer **11**. The ultrasonic probe **10** is provided with a low frequency ultrasonic transducer group **13** consisting of 256 low frequency ultrasonic transducers **12**, and a high frequency ultrasonic transducer group **15** consisting of 256 high frequency ultrasonic transducers **14**. The low frequency ultrasonic transducers **12** have an effective frequency band of 3.5 MHz to 8 MHz, whereas the high frequency ultrasonic transducers **14** have an effective frequency band of 8 MHz to 20 MHz. These transducer groups **13** and **15** are disposed at an end portion of a sheath of the ultrasonic probe **10**, the sheath being omitted from the drawings but made of a soft flexible material.

[0027] The ultrasonic transducers **12** and **14** have such properties as shown in TABLE 1, which permit executing diagnoses with the ultrasonic probe **10** while adjusting its ultrasonic frequency according to the purpose and application. Concretely, for the purpose of observing the whole image including deeper portions, the low frequency ultrasonic wave of 4 MHz or 7.5 MHz is usable. On the other hand, for the purpose of observing details of a suspected site of disease, the high frequency ultrasonic wave of 12 MHz or 20 MHz is usable. Note that "beam diameter" in TABLE 1 represents a diameter of an ultrasonic beam at a focal position, which is obtained when the aperture width and the focal length are set at the values shown in TABLE 1. "Depth" represents a depth of an observed site of a living body, at which an optimum image is obtainable when the frequency is set at the value shown in TABLE 1.

TABLE 1

| FREQUENCY (MHz) | APERTURE WIDTH (mm) | FOCAL LENGTH (cm) | DEPTH (cm) | BEAM DIAMETER (mm) |
|---|---|---|---|---|
| 4 | 6.4 | 8 | 6 or more | 4.8 |
| 7.5 | 4.8 | 4 | 6 or less | 1.7 |
| 12 | 3.2 | 2 | 3 | 0.8 |
| 20 | 2.4 | 0.5 | 1 or less | 0.16 |

[0028] As shown in FIG. **3**, the ultrasonic probe **10** is a so-called radial electronic scanning type, wherein the low frequency ultrasonic transducer group **13** and the high frequency ultrasonic transducer group **15** are arranged around a cylindrical backing material **50**, and an acoustic matching layer **51** or **52** and an acoustic lens **53** or **54** are laminated atop another on the transducer group **13** or **15**, respectively. The ultrasonic probe **10** is used as a fine probe that is introduced into an opening for forceps of an electronic endoscope, or as an ultrasonic endoscope that is integrated with an electronic endoscope. So the ultrasonic probe **10** is inserted in a cavity of a living body when it is used.

[0029] The ultrasonic transducers **12** and **14** are located between individual electrodes **55** and **56**, on one hand, and common electrodes **57** and **58**, on the other hand, respectively. The common electrodes **57** and **58** are grounded. The ultrasonic transducers **12** and **14** and the individual electrodes **55** and **56** are isolated from each other with a filling material that is not shown but implied by solid lines.

[0030] A voltage applied across from the individual electrodes **55** or **56** to the common electrode **57** or **58** excites the low or high frequency ultrasonic transducers **12** or **14** to oscillate, respectively. Thereby, the low or high frequency ultrasonic transducers **12** or **14** emit the ultrasonic wave toward the internal body site to be observed, and receive echo signals from the internal body site, to generate a voltage corresponding to the echo signals.

[0031] On scanning the ultrasonic wave across the internal body site to be observed, the ultrasonic transducers **12** and **14** are driven block by block. Each block consists of neighboring forty-eight pieces of the ultrasonic transducers **12** or **14**, and the forty-eight transducers of one block are driven at the same time. On receiving the echo signals from the observed site, the transducers of one block receive the echo signals simultaneously. Each time drive signals are sent to excite the low or high frequency ultrasonic transducers **12** or **14**, and the echo signals are received, the neighboring 48 ultrasonic transducers **12** or **14** to be driven at one time are shifted step by step, i.e. by one or several pieces. Thus, the ultrasonic transducers **12** or **14** to send the drive signals and receive the echo signals are switched over from one another. Note that the number of ultrasonic transducers to send and receive the signals is not necessarily equal. In that case, the control is carried out based on the bigger number of ultrasonic transducers of one block.

[0032] Referring back to FIG. **1**, the ultrasonic probe **10** is connected to the ultrasonic observer **11** by plugging a connector **16** of the ultrasonic probe **10** into a connector **17** of the ultrasonic observer **11**. The connector **16** is provided at a trailing end of a not-shown code that extends from the sheath.

[0033] The individual electrodes **55** and **56** of the ultrasonic transducers **12** and **14** are connected to one ends of first and second signal lines **18** and **19**, respectively. The first and second signal lines **18** and **19** provide 256 channels each, and are connected at the other ends to a switching device **20**. The switching device **20** consists of first switches **21** for 256 channels and second switches **22** for 256 channels, so the first signal lines **18** are connected to the first switches **21**, and the second signal lines **19** are connected the second switches **22**, in one-to-one relationships. The first and second switches **21** and **22** are made of semiconductor switching elements, such as MOSFETs.

[0034] The first and second switches **21** and **22** are connected at other ends to third and fourth signal lines **23** and **24** and the earth. In an initial position, the first switches **21** are connected to the third signal lines **23**, while the second switches **22** are connected to the earth. By operating a selection switch **26**, which is provided in an operating section **25** of the ultrasonic observer **11**, the first switches **21** are switched over between the third signal lines **23** and the earth, and the second switches **22** are switched over between the earth and the fourth signal lines **24** in cooperation with the first switches **21**. So the first switches **21** are connected to the third signal lines **23** while the second switches **22** are grounded and electrically short-circuited. While the second switches **22** are connected to the fourth signal lines **24**, the first switches **21** are grounded and electrically short-circuited.

[0035] The switching device **20** is connected to first control lines **27*a*** and **27*b*** that lead through the connectors **16** and **17** to a CPU **32** of the ultrasonic observer **11**. Each time the switching device **20** receives a first control signal of 1-bit from the CPU **32** through the first control lines **27*a*** and **27*b***, the switching device **20** switches the first and second switches **21** and **22** in the above-described manner.

[0036] The third and fourth signal lines **23** and **24** are connected to a switching port **28**, which is connected to fifth signal lines **29**. Corresponding to the selection by the selection switch **26**, the switching port **28** connects either the third signal lines **23** or the fourth signal lines **24** to the fifth signal lines **29**.

[0037] The fifth signal lines **29** are connected to a multiplexer (MUX) **30**. The multiplexer **30** switches the fifth signal lines **29** to select from among the fifth signal lines **29** ones to be used for transmitting the drive signals and the received echo signals. Each time the drive signals are sent to the 48 transducers of one block, and the echo signals are received, the 48 transducers to constitute one block are shifted by one or several pieces among the 256 ultrasonic transducers **12** or **14** of the selected group **13** or **15**.

[0038] The multiplexer **30** are connected to second control lines **31*a*** and **31*b*** that leads through the connectors **16** and **17** to a scanning controller **33** of the ultrasonic observer **11**. Upon receipt of a second control signal of 8-bits from the scanning controller **33** through the second control lines **31*a*** and **31*b***, the multiplexer **30** switches the fifth signal lines **29** in the above described manner. Note that the multiplexer **30** and the switching device **20** are built in a hollow inside the backing material **50**.

[0039] The ultrasonic observer **11** is totally controlled by the CPU **32**. The CPU **32** is connected to the scanning controller **33**, which is connected to a sender section **34** and a receiver section **35**, to send reference pulses for controlling operations of these sections.

[0040] Under the control of the scanning controller **33**, the sender section **34** sends the drive signals of 48 channels to those ultrasonic transducers **12** or **14** selected by the multiplexer **30**, while the receiver section **35** receives the echo signals of 48 channels from the site to be observed, which are taken by the ultrasonic transducers **12** or **14** selected by the multiplexer **30**. The receiver section **35** processes the echo signals for sensitivity time control (STC), whereby sensitivity is adjusted to time corresponding to propagation distance (depth) of the ultrasonic wave. The scanning controller **33** switches over the timing of sending the drive signals from the sender section **34** and the timing of receiving the echo signals on the receiver section **35**.

[0041] The echo signals received on the sender section **35** are input in a beam former (BF) **36**. The beam former **36** delays the 48-channel echo signals by a given time to adjust phases of all the echo signals into alignment with each other. Thereafter the beam former **36** sums up the echo signals.

[0042] After the echo signals are phase-aligned and summed in the beam former **36** and digitalized, the digital echo signal is stored in a memory **37**. Under the control of the CPU **32**, a digital scan converter (DSC) **38** reads out the digital echo signal from the memory **37** and converts it into an NTSC signal as a TV scanning signal. A digital/analog converter **39** converts the NTSC signal into an analog signal. The analog signal is sent from the D/A converter **39** to a monitor **40** for displaying an ultrasonic image.

[0043] The control section **25** is formed as a control panel that is provided with various operation buttons including the selection switch **26**. The CPU **32** controls the respective sections of the ultrasonic diagnostic apparatus **2** in response to operational signals entered through the control section **25**.

[0044] Now the operation of the ultrasonographic apparatus **2** will be described. First, the ultrasonic probe **10** is inserted into a body cavity till it reaches a site to be observed, and the control section **25** is operated to unfreeze. Then the sender section **34** sends out the 48-channel drive signals under the control of the scanning controller **33**. In this initial position, the first switches **21** are connected to the third signal lines **23**, whereas the second switches **22** are grounded. Accordingly, the low frequency ultrasonic transducers **12** are driven by the drive signals.

[0045] The drive signals from the sender section **34** are fed through the connectors **16** and **17** to the multiplexer **30**. The multiplexer **30** selects forty-eight lines for sending the drive signals from among the fifth signal lines **29**, based on the second control signal sent from the scanning controller **33** through the second control lines **31***a* and **31***b*. So the drive signals from the sender section **34** are sent through the fifth signal lines **29**, the third signal lines **23**, the first switches **21** and the first signal lines **18** to a designated block of the low frequency ultrasonic transducers **12**. Then the forty-eight ultrasonic transducers **12** of the designated block are excited by the drive signals to emit the low frequency ultrasonic wave toward the site to be observed.

[0046] After the drive signals are sent, the scanning controller **33** switches the sending operation of the sender section **34** to the receiving operation of the receiver section **35**. Then, the echo signals taken by the forty-eight low frequency ultrasonic transducers **12** of the designated block are fed through the first signal liens **18**, the first switches **21**, the third signal lines **23**, the fifth signal liens **29**, the multiplexer **30** and the connectors **16** and **17** to the receiver section **35**.

[0047] The receiver section **35** subjects the input echo signals to the STC processing. Thereafter, the echo signals are phase-aligned and summed in the beam former **36**, and are stored as a digital signal in the memory **37**. Thereafter, based on the second control signal, the multiplexer **30** shifts those to be driven among the low frequency ultrasonic transducers **12**, by one or several pieces, till the same process as above is executed on the last block of the low frequency ultrasonic transducers **12**.

[0048] When the scanning is accomplished with the 256 low frequency ultrasonic transducers **12** in this way, the digital scan converter **38** reads out the digital echo signals stored in the memory **37** and converts them into the NTSC signals. The NTSC signals are converted back to the analog signal through the D/A converter **39**, and are displayed as an ultrasonic image on the monitor **40**. The above-described sequential operation is repeated cyclically till a freeze command is given by operating the control section **25**.

[0049] Thereafter when the selection switch **26** is operated to cause the CPU **32** to send the first control signal through the first control lines **27***a* and **27***b* to the switching device **20**, the first switches **21** are switched from the third signal lines **23** to the earth side, whereas the second switches **22** are switched to the fourth signal lines **24**. Thereby, the drive signal from the sender section **34** are sent through the connectors **16** and **17**, the multiplexer **30**, the fifth signal lines **29**, the fourth signal lines **24**, the second switches **22** and the second signal lines **19** to a designated block of the high frequency ultrasonic transducers **14**.

[0050] The echo signals taken from the internal body site by these high frequency ultrasonic transducers **14** are sent through the second signal lines **19**, the second switches **22**, the fourth signal lines **24**, the fifth signal lines **29**, the multiplexer **30** and the connectors **16** and **17** to the receiver section **35**. Thereafter, the same process as described with respect to the low frequency ultrasonic transducers **12** is carried out, to display an ultrasonic image from the high frequency ultrasonic transducers **14** on the monitor **40**.

[0051] As described so far, the ultrasonic diagnostic apparatus **2** is provided with the selection switch **26** for selecting between the low frequency ultrasonic transducer group **13** and the high frequency ultrasonic transducer group **15**. So the operator can change the used frequency band of the ultrasonic wave according to the site to be observed.

[0052] Furthermore, the ultrasonic probe **10** is provided with the switching device **20** and the multiplexer **30**. The switching device **20** switches over the connection of the first and second signal lines **18** and **19** in response to the first control signal from the selection switch **26**, to drive either the low frequency ultrasonic transducer group **13** or the high frequency ultrasonic transducer group **15**. The multiplexer **30** switches the fifth signal lines **29** to select the ultrasonic transducers to be driven at the same time from among the ultrasonic transducers **12** or **14**. Thanks to the switching device and the multiplexer **30**, the requisite number of channels of the signal lines is reduced to 48, though 512 channels would otherwise be necessary for the transducer groups **13** and **15**. So the ultrasonic probe **10** can have a smaller diameter. Because being used for intra-cavity diagnosis, the ultrasonic probe **10** of a smaller diameter is effective especially for reducing the load on the patient.

[0053] Since the low and high frequency ultrasonic transducer groups **13** and **15** provide a frequency bandwidth ranging from about 3 MHz to 20 MHz, the ultrasonic diagnostic apparatus **2** of the present invention can produce ultrasonic images whose range of depth and resolution satisfy necessity for medical diagnoses, without the need for changing probes.

[0054] Since the first switches **21** are grounded alternately with the second switches **22**, while the other switches **22** or **21** are respectively connected to the signal lines **24** or **23**, unused one of the ultrasonic transducer groups is electrically short-circuited. Therefore, the ultrasonic transducers of the unused group do not unnecessarily oscillate to generate a noise, which damages quality of the subsequent ultrasonic image. That is, the present invention prevents image deterioration resulted from the noise caused by the unnecessary oscillation of the unused transducers.

[0055] FIG. **4** shows an ultrasonic probe **60** according to another embodiment of the present invention, wherein low frequency transducers **12** are connected through first signal lines **61** of 256 channels to first multiplexer (MUX**1**) **63**, whereas high frequency transducers **14** are connected through second signal lines **62** of 256 channels to second multiplexer (MUX**2**) **64** respectively. The first and second multiplexers **63** and **64** are connected through third and fourth signal lines **65** and **66**, each having 48 channels, to a switching device **67**, respectively.

[0056] The ultrasonic probe **60** may be used in combination with the ultrasonic observer **11**. Respectively based on second and third 8-bit control signals, which are sent from the scanning controller **33** through second and third control lines **68** and **69**, the first and second multiplexers **63** and **64** select from among the first and second signal lines **61** and **62** those signal lines to be used for sending the drive signals and receiving the echo signals. Also, based on the first control signal of 1-bit that is sent from the CPU **32** through a first control line **70**, the switching device **67** switches over first and second switches **71** and **72** in the same way as in the above-described embodiment. So either fifth signal lines **73** or sixth signal lines **77** are connected to the multiplexer **63** or **64**, to use ultrasonic transducer groups **13** and **15** alternatively. Reference numerals **75** and **76** designate a switching port and a connector **76** respectively.

[0057] The present invention is not limited to the ultrasonic probes **10** and **60** as illustrated in the above embodiments. As shown for example in an ultrasonic probe **80** of FIG. **5**, it is possible to arrange a low frequency transducer group **82** around a cylindrical backing material **81**, and laminate a high frequency transducer group **83** on the low frequency transducer group **82**. Reference numerals **84** and **85** designate an acoustic matching layer and an acoustic lens respectively.

[0058] The present invention is not to be limited to the radial electronic scanning type ultrasonic probe, like the probes **10** and **80**, but also applicable to a convex electronic scanning type probe, e.g. an ultrasonic probe **90** as shown in FIG. **6**. In the convex electronic scanning type ultrasonic probe **90**, low frequency transducers **91** that are illustrated as blank quadrangles, and high frequency transducers **92** that are illustrated as hatched quadrangles are arranged alternately in a two-dimensional array.

[0059] Although the selection switch **26** is provided in the control section **25** of the ultrasonic observer **11**, a selection switch for selecting between the low frequency ultrasonic transducer group and the high frequency ultrasonic transducer group may be provided in a control section of the ultrasonic probe, together with an air sending button and a watering button.

[0060] It is to be noted that the number of ultrasonic transducers of one group, the number of ultrasonic transducers of one block to be driven at the same time, and the number of groups of the ultrasonic transducers are not limited to the above embodiments, but may be modified appropriately according to the specification of the ultrasonic diagnostic apparatus.

[0061] Thus, the present invention is not to be limited to the above embodiments but, on the contrary, various modifications will be possible without departing from the scope of claims appended hereto.

What is claimed is:

**1**. An ultrasonic probe comprising:

a plural kinds of groups of ultrasonic transducers arranged at an end of said ultrasonic probe for radiating ultrasonic waves toward a living body and receiving echo signal from the living body, each group consisting of a plurality of ultrasonic transducers having the same frequency band that is different from another group; and

a control device operated to enter a control signal for selecting one group to use from among said plural kinds of groups.

**2**. An ultrasonic probe as claimed in claim 1, further comprising:

signal lines for sending drive signals to said ultrasonic transducers and transmitting the echo signals received from the living body; and

a switching device for switching connections to said signal lines between said plural kinds of groups in accordance with said control signal.

**3**. An ultrasonic probe as claimed in claim 1, further comprising multiplexers for selecting ones to be driven at the same time from among the ultrasonic transducers of the one group as selected through said control device.

**4**. An ultrasonic probe as claimed in claim 1, wherein said ultrasonic probe is introduced into a cavity of the living body to use for intra-cavity diagnoses.

**5**. An ultrasonic probe as claimed in claim 1, wherein the different frequency bands of said plural kinds of groups of ultrasonic transducers are set to cover a bandwidth from about 3 MHz to 20 MHz.

**6**. An ultrasonic probe as claimed in claim 1, wherein the ultrasonic transducers of not-selected ones of said groups are electrically short-circuited.

**7**. An ultrasonic diagnostic apparatus using an ultrasonic probe, comprising:

a plural kinds of groups of ultrasonic transducers disposed at an end of said ultrasonic probe for radiating ultrasonic waves toward a living body and receiving echo signal from the living body, each group consisting of a plurality of ultrasonic transducers having the same frequency band that is different from another group; and

a control device operated to enter a control signal for selecting one group to use from among said plural kinds of groups.

**8**. An ultrasonic diagnostic apparatus as claimed in claim 7, wherein said ultrasonic probe comprises signal lines for sending drive signals to said ultrasonic transducers and transmitting the echo signals received from the living body, and a switching device for switching connections to said signal lines between said groups in accordance with said control signal, so that said drive signals are sent only to the ultrasonic transducers of the one group as selected through said control device.

**9**. An ultrasonic diagnostic apparatus as claimed in claim 7, wherein said ultrasonic probe comprises multiplexers for selecting ones to be driven at the same time from among the ultrasonic transducers of the one group as selected through said control device.

**10**. An ultrasonic diagnostic apparatus as claimed in claim 7, wherein said ultrasonic probe is introduced into a cavity of the living body to use for intra-cavity diagnoses.

**11**. An ultrasonic diagnostic apparatus as claimed in claim 7, wherein the different frequency bands of said plural kinds of groups of ultrasonic transducers are set to cover a bandwidth from about 3 MHz to 20 MHz.

**12**. An ultrasonic diagnostic apparatus as claimed in claim 7, wherein the ultrasonic transducers of not-selected ones of said groups are electrically short-circuited.

**13**. An ultrasonic diagnostic apparatus as claimed in claim 7, further comprising an ultrasonic observer having a device for displaying an ultrasonic image based on said echo signal, said ultrasonic observer sending said drive signals to and receiving said echo signals from said ultrasonic probe.

**14**. An ultrasonic diagnostic apparatus as claimed in claim 9, wherein said ultrasonic transducers are driven block by block in one group, each block consisting of a limited number of ultrasonic transducers, and said multiplexers select the block to drive, and wherein said drive signals and said echo signals are transmitted in channels of the limited number.

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|---|---|---|---|
| 专利名称(译) | 超声波探头和超声波诊断仪 | | |
| 公开(公告)号 | US20070073154A1 | 公开(公告)日 | 2007-03-29 |
| 申请号 | US11/518272 | 申请日 | 2006-09-11 |
| [标]申请(专利权)人(译) | 富士摄影胶片公司 | | |
| 申请(专利权)人(译) | 富士胶片有限公司. | | |
| 当前申请(专利权)人(译) | 富士胶片株式会社 | | |
| [标]发明人 | KARASAWA HIROYUKI | | |
| 发明人 | KARASAWA, HIROYUKI | | |
| IPC分类号 | A61B8/14 | | |
| CPC分类号 | A61B8/12 A61B8/4483 A61B8/4488 A61B8/445 B06B1/0269 B06B1/0633 A61B8/467 | | |
| 优先权 | 2005262363 2005-09-09 JP | | |
| 外部链接 | Espacenet USPTO | | |


摘要(译)

超声诊断设备具有超声探头，该超声探头在其端部具有低频超声换能器组和高频超声换能器组，以及用于选择这些换能器组之一的选择开关。根据选择开关的选择，超声波探头的开关装置将低频超声波换能器组或高频超声波换能器组连接到多路复用器。多路复用器从所选择的组中的超声换能器中选择要同时驱动的，同时逐步移动相同组的驱动换能器。