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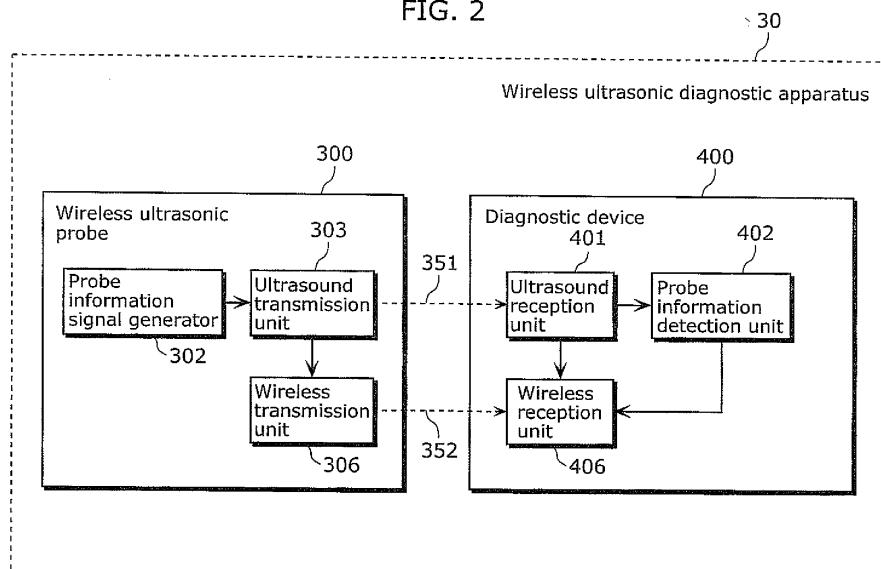
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(54) **WIRELESS ULTRASONIC DIAGNOSTIC DEVICE, WIRELESS ULTRASONIC PROBE, AND PROBE CERTIFICATION METHOD**

(57) A wireless ultrasonic diagnostic apparatus (30) including a wireless ultrasonic probe (300) and a diagnostic device (400). The wireless ultrasonic probe (300) includes: a wireless transmission unit (306) which wirelessly transmits echo data (352); and an ultrasound transmission unit (303) which transmits pairing ultrasound (351) including probe information for identifying the wireless ultrasonic probe (300). The diagnostic device (400)

includes: an ultrasound reception unit (401) which receives the pairing ultrasound (351); a probe information detection unit (402) which detects the probe information (452) from the pairing ultrasound (351); and a wireless reception unit (406) which determines, using the probe information (452), whether or not received data is the echo data (352) wirelessly transmitted by the wireless ultrasonic probe (300).

FIG. 2



**Description**

[Technical Field]

5 **[0001]** The present invention relates to wireless ultrasonic diagnostic apparatuses, wireless ultrasonic probes, and probe authentication methods, and relates particularly to a wireless ultrasonic diagnostic apparatus that includes a wireless ultrasonic probe which wirelessly transmits echo data and a diagnostic device which receives the echo data wirelessly transmitted by the wireless ultrasonic probe.

10 [Background Art]

**[0002]** Some of conventional wireless ultrasonic diagnostic apparatuses wirelessly transmit echo data obtained by an ultrasonic probe to the main device (see Patent Literature 1, for example).

15 **[0003]** FIG. 1 shows a structure of a conventional wireless ultrasonic diagnostic apparatus 10 disclosed in Patent Literature 1. A scrambler 112 shown in FIG. 1 scrambles echo data using either unique data identifying a main device 200 or unique data identifying an ultrasonic probe 100. More specifically, the scrambler 112 scrambles serial data provided by a PS conversion unit 110, using either a code signal provided by a code signal generator 114 for identifying the main device 200 or a code signal provided by the code signal generator 114 for identifying the ultrasonic probe 100. Then, the scrambler 112 provides the scrambled data to a modulator 116.

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[Citation List]

[Patent Literature]

25 **[0004]**

[PTL 1] Japanese Unexamined Patent Application Publication No. 2007-244579

[Summary of Invention]

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[Technical Problem]

35 **[0005]** The conventional structure disclosed in Patent Literature 1 enables identification of a specific diagnostic device and a specific wireless ultrasonic probe in one-to-one correspondence using a code signal. However, in some cases, the probe is used with more than one diagnostic device. Thus, if the code signal of the wireless ultrasonic probe corresponds to more than one diagnostic device, plural diagnostic devices respond to one wireless ultrasonic probe. This results in interference.

**[0006]** That is to say, the conventional structure disclosed in Patent Literature 1 does not mention how a plurality of wireless ultrasonic probes are to be concurrently used.

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**[0007]** The present invention, conceived to solve the above conventional problem, aims to provide a wireless ultrasonic diagnostic apparatus capable of easily and reliably establishing wireless communication between a diagnostic device and a wireless ultrasonic probe in the case of concurrently using a plurality of wireless ultrasonic probes.

[Solution to Problem]

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**[0008]** In order to solve the conventional problem, the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention is a wireless ultrasonic diagnostic apparatus including: a wireless ultrasonic probe which generates echo data and wirelessly transmits the echo data; and a diagnostic device which receives the echo data wirelessly transmitted by the wireless ultrasonic probe, the wireless ultrasonic probe including: a first signal generator which generates a first signal including probe information for identifying the wireless ultrasonic probe; an ultrasound transmission unit configured to transmit the first signal as first ultrasound; and a wireless transmission unit configured to wirelessly transmit the echo data associated with the probe information, and the diagnostic device including: an ultrasound reception unit configured to receive the first ultrasound transmitted by the wireless ultrasonic probe; a probe information detection unit configured to detect the probe information from the first ultrasound received; and a wireless reception unit configured to receive data that is wirelessly transmitted, and determine, using the probe information detected by the probe information detection unit, whether or not the received data is the echo data wirelessly transmitted by the wireless ultrasonic probe.

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**[0009]** With this structure, the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention performs processing (hereinafter referred to as "pairing") to establish wireless communication between the diagnostic

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device and the wireless ultrasonic probe. Here, the ultrasound does not reach a long distance. Therefore, the wireless ultrasonic probe can transmit the first ultrasound to only the desired diagnostic device even when there is a plurality of diagnostic devices. This enables the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention to easily and reliably establish wireless communication between the diagnostic device and the wireless ultrasonic probe.

5 [0010] In addition, the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention uses, for the purpose of pairing, the ultrasound used for diagnosis, thereby suppressing an increase in cost necessary for adding the above functions.

10 [0011] Furthermore, the wireless ultrasonic probe may further include an operating switch operable by an operator, and when the operating switch is pressed, the first signal generator may generate the first signal, and the ultrasound transmission unit may transmit the first signal as the first ultrasound.

[0012] With this structure of the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention, the operator can perform the pairing through a simple operation of pressing the operating switch provided on the wireless ultrasonic probe.

15 [0013] In addition, the first signal generator may generate the first signal including a synchronizing signal, and the probe information detection unit may be configured to detect the probe information from the first ultrasound by detecting the synchronizing signal included in the first ultrasound received.

[0014] This structure enables the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention to easily detect the probe information included in the first ultrasound.

20 [0015] Moreover, the ultrasound transmission unit may be further configured to emit second ultrasound for generating the echo data.

[0016] Furthermore, the ultrasound transmission unit may include: a first transducer which transmits the first ultrasound according to the first signal; and a second transducer which emits the second ultrasound, the second transducer being different from the first transducer.

25 [0017] With this structure, the frequency of the first transducer can differ from that of the second transducer. Thus, the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention can set an optimal frequency for the first ultrasound.

[0018] Furthermore, the first transducer may have a transmission frequency lower than a transmission frequency of the second transducer.

30 [0019] This structure enables the diagnostic device to receive the first ultrasound transmitted from the wireless ultrasonic probe, even when the diagnostic device and the wireless ultrasonic probe are distant from each other.

[0020] In addition, the ultrasound transmission unit may include a transducer which transmits the first ultrasound according to the first signal and emits the second ultrasound.

35 [0021] This structure enables the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention to suppress an increase in cost by using the same transducer for both the transmission of the first ultrasound and the transmission and reception of the second ultrasound.

[0022] Moreover, the ultrasound transmission unit may include a plurality of transducers which synchronously transmit the first ultrasound according to the first signal.

40 [0023] This structure increases the signal level of the first ultrasound transmitted from the wireless ultrasonic probe, thereby increasing the possibility of successful communication between the wireless ultrasonic probe and the diagnostic device even when the wireless ultrasonic probe and the diagnostic device are distant from each other.

[0024] Furthermore, the ultrasound transmission unit may include a delay circuit which delays, according to a shape of a surface of the wireless ultrasonic probe from which the first ultrasound is emitted, the first signal provided to the transducers so that the first ultrasound synchronously transmitted by the transducers becomes plane waves.

45 [0025] This structure enables the wireless ultrasonic probe according to an aspect of the present invention to transmit data without data turbulence even in the case of using a probe having a curved emitting surface, such as a convex wireless ultrasonic probe.

50 [0026] Moreover, the wireless ultrasonic probe may further include a second signal generator which generates a second signal, the transducers may generate the second ultrasound according to the second signal, and the delay circuit may further delay the second signal to adjust a focal position of the second ultrasound, and provide the delayed second signal to the transducers.

[0027] This structure enables the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention to enhance the communication quality while suppressing an increase in cost.

55 [0028] In addition, the wireless ultrasonic probe may include a scan unit configured to perform, when the ultrasound transmission unit emits the second ultrasound, sector scanning in directions in which the second ultrasound is emitted, and when the ultrasound transmission unit emits the first ultrasound, the scan unit may fix a direction in which the first ultrasound is emitted.

[0029] This structure enables a sector-scanning wireless ultrasonic probe to reliably perform the pairing.

[0030] The ultrasound reception unit may have an acoustic impedance in a range of 1.5 to 2.0 inclusive.

[0031] This structure enables the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention to receive the first ultrasound with high sensitivity.

5 [0032] Furthermore, the ultrasound reception unit may include an acoustic lens which adjusts a focal position of the first ultrasound.

[0033] This structure enables the wireless ultrasonic diagnostic apparatus according to an aspect of the present invention to receive the first ultrasound with high sensitivity.

[0034] Moreover, the diagnostic device may include an error processing unit configured to notify an operator of error occurrence when an error occurs with the probe information transmitted by the wireless ultrasonic probe.

10 [0035] This structure allows the operator to easily recognize a failure in connection between the wireless ultrasonic probe and the diagnostic device.

[0036] The error processing unit may be configured to notify the operator of the error occurrence by causing an LED to flash or by changing a color of the LED.

[0037] This structure allows the operator to recognize a connection error more quickly.

15 [0038] Furthermore, the error processing unit may be configured to notify the operator of the error occurrence by beeping.

[0039] This structure allows the operator to recognize a connection error by a sound, enabling a more quick recognition of the connection error.

20 [0040] Note that the present invention can be realized not only as the above wireless ultrasonic diagnostic apparatus, but also as: a probe authentication method which includes, as steps, the characteristic elements included in the wireless ultrasonic diagnostic apparatus; and a program which causes a computer to execute such characteristic steps. It is apparent that such a program can be distributed via a recording medium such as a CD-ROM and a transmission medium such as the Internet.

25 [0041] In addition, the present invention may also be realized as a wireless ultrasonic probe or a diagnostic device included in the wireless ultrasonic diagnostic apparatus.

[0042] Furthermore, the present invention can also be realized as a semiconductor integrated circuit (LSI) which achieves some or all of the functions of the wireless ultrasonic diagnostic apparatus.

[Advantageous Effects of Invention]

30 [0043] The present invention provides a wireless ultrasonic diagnostic apparatus capable of easily and reliably establishing wireless communication between a diagnostic device and a wireless ultrasonic probe in the case of concurrently using a plurality of wireless ultrasonic probes.

35 [Brief Description of Drawings]

[0044]

[Fig. 1] FIG. 1 is a block diagram of a conventional wireless ultrasonic diagnostic apparatus.

40 [Fig. 2] FIG. 2 is a block diagram of a wireless ultrasonic diagnostic apparatus according to Embodiment 1 of the present invention.

[Fig. 3] FIG. 3 is a block diagram of a wireless ultrasonic probe according to Embodiment 1 of the present invention.

[Fig. 4] FIG. 4 is an external view of a wireless ultrasonic probe according to Embodiment 1 of the present invention.

[Fig. 5] FIG. 5 shows a structural example of pairing ultrasound according to Embodiment 1 of the present invention.

45 [Fig. 6] FIG. 6 shows a data example of pairing ultrasound according to Embodiment 1 of the present invention.

[Fig. 7] FIG. 7 is a block diagram of a diagnostic device according to Embodiment 1 of the present invention.

[Fig. 8] FIG. 8 is an external view of a diagnostic device according to Embodiment 1 of the present invention.

[Fig. 9] FIG. 9 shows pairing performed in a wireless ultrasonic diagnostic apparatus according to Embodiment 1 of the present invention.

50 [Fig. 10] FIG. 10 is a flowchart showing a processing flow of a wireless ultrasonic probe according to Embodiment 1 of the present invention.

[Fig. 11] FIG. 11 is a flowchart showing a processing flow of a diagnostic device according to Embodiment 1 of the present invention.

55 [Fig. 12] FIG. 12 shows a structure of an ultrasound transmission unit according to Embodiment 1 of the present invention.

[Fig. 13] FIG. 13 shows a structure of an ultrasound transmission unit according to Embodiment 1 of the present invention.

[Fig. 14] FIG. 14 is a block diagram of a wireless ultrasonic probe according to Embodiment 2 of the present invention.

[Fig. 15] FIG. 15 shows pairing ultrasound according to Embodiment 2 of the present invention.

[Fig. 16] FIG. 16 shows echo ultrasound according to Embodiment 2 of the present invention.

[Fig. 17] FIG. 17 shows a structure of an ultrasound reception unit according to Embodiment 2 of the present invention.

[Fig. 18] FIG. 18 is a flowchart showing a processing flow of a wireless ultrasonic probe according to Embodiment 2 of the present invention.

[Fig. 19] FIG. 19 is a block diagram of a wireless ultrasonic probe according to Embodiment 3 of the present invention.

[Fig. 20] FIG. 20 is a flowchart showing a processing flow of a wireless ultrasonic probe according to Embodiment 3 of the present invention.

[Fig. 21] FIG. 21 is a block diagram of a wireless ultrasonic probe according to a variation of the present invention.

[Description of Embodiments]

**[0045]** Hereinafter, Embodiment 1 of the present invention is described with reference to the drawings.

(Embodiment 1)

**[0046]** The wireless ultrasonic diagnostic apparatus according to Embodiment 1 of the present invention pairs a wireless ultrasonic probe with a diagnostic device using ultrasound. By doing so, the wireless ultrasonic diagnostic apparatus according to Embodiment 1 of the present invention can easily and reliably establish wireless communication between the wireless ultrasonic probe and the diagnostic device.

**[0047]** First, an overall structure of the wireless ultrasonic diagnostic apparatus according to Embodiment 1 of the present invention is described.

**[0048]** FIG. 2 is a block diagram of a wireless ultrasonic diagnostic apparatus 30 according to Embodiment 1 of the present invention. The wireless ultrasonic diagnostic apparatus 30 shown in FIG. 2 includes a wireless ultrasonic probe 300 and a diagnostic device 400.

**[0049]** The wireless ultrasonic probe 300 shown in FIG. 2 wirelessly transmits echo data 352 to the diagnostic device 400. The wireless ultrasonic probe 300 includes: a wireless transmission unit 306 which wirelessly transmits the echo data 352; a probe information signal generator 302 (a first signal generator) which generates a probe information signal including probe information for identifying the wireless ultrasonic probe 300; and an ultrasound transmission unit 303 which transmits the probe information signal as pairing ultrasound 351 (first ultrasound).

**[0050]** The diagnostic device 400 shown in FIG. 2 receives the echo data 352 wirelessly transmitted by the wireless ultrasonic probe 300. The diagnostic device 400 includes: an ultrasound reception unit 401 which receives the pairing ultrasound 351 transmitted by the wireless ultrasonic probe 300; a probe information detection unit 402 which detects the probe information from the pairing ultrasound 351; and a wireless reception unit 406 which identifies, using the probe information detected by the probe information detection unit 402, the echo data 352 wirelessly transmitted from the wireless ultrasonic probe 300.

**[0051]** Hereinafter, a structure of the wireless ultrasonic probe 300 is described in detail.

**[0052]** FIG. 3 is a block diagram showing a detailed structure of the wireless ultrasonic probe 300.

**[0053]** The wireless ultrasonic probe 300 transmits echo ultrasound 353 (second ultrasound) to a subject (a patient, for example), and receives reflected waves 354 (echo) which are the echo ultrasound 353 reflected from the subject. Furthermore, the wireless ultrasonic probe 300 wirelessly transmits, to the diagnostic device 400, the echo data 352 which is based on the reflected waves 354 received.

**[0054]** The wireless ultrasonic probe 300 shown in FIG. 3 includes an operating switch 301 operable by an operator, the probe information signal generator 302, the ultrasound transmission unit 303, a signal-for-echo generator 304 (a second signal generator), an echo data processing unit 305, the wireless transmission unit 306, and a wireless reception unit 309.

**[0055]** FIG. 4 is an external view of the wireless ultrasonic probe 300.

**[0056]** The operating switch 301 is a button, for example. When the operator presses the button, the pairing ultrasound 351 which is low in power is output from the wireless ultrasonic probe 300, and the pairing of the wireless ultrasonic probe 300 with the diagnostic device 400 starts.

**[0057]** The button of the operating switch 301 is desirably provided at a position out of the way of diagnosis. For example, as shown in FIG. 4, the button may be provided on a side opposite to an emitting surface 307 from which the pairing ultrasound 351 and the echo ultrasound 353 are emitted.

**[0058]** When the operating switch 301 is pressed, the probe information signal generator 302 generates a probe information signal 331 including the probe information for identifying the wireless ultrasonic probe 300.

**[0059]** The ultrasound transmission unit 303 transmits the probe information signal 331 as the pairing ultrasound 351.

**[0060]** FIG. 5 shows a structural example of the probe information signal 331 (the pairing ultrasound 351).

**[0061]** As shown in FIG. 5, the probe information signal 331 includes a header portion 602 which is a synchronizing

signal and a data portion 603 which is the probe information.

[0062] The header portion 602 is added so that the starting point of the data portion 603 can be searched. A data sequence not used in the data portion 603 (0xF in FIG. 5) is used in the header portion 602, so that the header can be distinguished.

5 [0063] The data portion 603 indicates, for example, at least one of information on the shape of the wireless ultrasonic probe 300, information on the compatible frequency band of the wireless ultrasonic probe 300, and information on the individual number of the wireless ultrasonic probe 300.

[0064] FIG. 6 shows an example of the data portion 603. FIG. 6 shows a case where the data portion 603 indicates the shape of the wireless ultrasonic probe 300.

10 [0065] More specifically, in FIG. 5, the data portion 603 following the header portion 602 indicates 0xA. The shape of the wireless ultrasonic probe corresponding to 0xA is sector, and thus the diagnostic device 400 recognizes that the wireless ultrasonic probe 300 to be connected with is of a sector type. Furthermore, by transmitting the individual number of the wireless ultrasonic probe 300, it is possible to make settings on a probe-by-probe basis even if there is more than one wireless ultrasonic probe of the same type (the sector type, for example).

15 [0066] While the operating switch 301 is pressed, the probe information signal generator 302 continuously outputs data signals 601 each of which includes one header portion 602 and one data portion 603 as shown in FIG. 5.

[0067] When the pairing is established, the operator releases the operating switch 301 to stop the output of the pairing ultrasound 351. With such a structure by which the output of the pairing ultrasound 351 is automatically stopped when the operator releases the operating switch 301, it is possible to prevent the operating switch 301 from remaining on.

20 [0068] The pairing ultrasound 351 may be output when the operating switch 301 is pressed once, and stopped when the operating switch 301 is pressed once more. In that case, it is desirable to stop the pairing ultrasound 351 after a certain period of time (after the data signal 601 is output a certain number of times).

[0069] The signal-for-echo generator 304 generates a signal for echo 332 while the operating switch 301 is not pressed.

25 [0070] The ultrasound transmission unit 303 transmits the probe information signal 331 as the pairing ultrasound 351, and transmits the signal for echo 332 as the echo ultrasound 353. For example, the frequencies of the pairing ultrasound 351 and the echo ultrasound 353 are in a range of 1 M to 20 MHz inclusive.

[0071] The ultrasound transmission unit 303 receives the reflected waves 354 that are the echo ultrasound 353 reflected from the subject, and outputs the reflected waves 354 as an echo signal 333.

30 [0072] The echo data processing unit 305 first performs processing such as signal amplification and A/D conversion on the echo signal 333, and then associates the resultant signal with the probe information so as to generate echo data 334. For example, the echo data processing unit 305 generates the echo data 334 by adding to the echo signal 333 identification information corresponding to the probe information. Note that the echo data processing unit 305 may generate the echo data 334 by scrambling and compressing the echo signal 333 using a predetermined code corresponding to the probe information.

35 [0073] The wireless transmission unit 306 performs such processing as modulation and power amplification on the echo data 334, and wirelessly transmits the resultant data as the echo data 352. The frequency used for the wireless transmission of the echo data 352 is several GHz, for example.

40 [0074] The wireless reception unit 309 receives a control signal 359 wirelessly transmitted by the diagnostic device 400. According to the control signal 359 received by the wireless reception unit 309, the signal-for-echo generator 304 changes the signal for echo 332 to be generated.

[0075] Next, a detailed structure of the diagnostic device 400 is described.

[0076] FIG. 7 is a block diagram showing the detailed structure of the diagnostic device 400.

45 [0077] The diagnostic device 400 includes the ultrasound reception unit 401, the probe information detection unit 402, a probe information setting unit 405, the wireless reception unit 406, an echo data processing unit 407, a display unit 408, an error processing unit 409, and a wireless transmission unit 410. The probe information detection unit 402 includes a synchronizing signal detection unit 403 and a probe information determination unit 404.

[0078] The ultrasound reception unit 401 receives the pairing ultrasound 351 transmitted by the wireless ultrasonic probe 300, and outputs the pairing ultrasound 351 as a probe information signal 451.

50 [0079] FIG. 8 is an external view of the diagnostic device 400. As shown in FIG. 8, the diagnostic device 400 includes an LED 501 and a speaker 502.

[0080] Here, to perform the pairing, the operator presses the operating switch 301 while allowing the wireless ultrasonic probe 300 to contact the ultrasound reception unit 401 provided in the diagnostic device 400 as shown in FIG. 9. With this, the ultrasound reception unit 401 receives the pairing ultrasound 351 transmitted by the wireless ultrasonic probe 300.

55 [0081] The acoustic impedance of the ultrasound reception unit 401 is desirably similar to that of the body, water, or a gel applied to the tested area at the time of echo diagnosis. For example, the acoustic impedance of the ultrasound reception unit 401 is preferably in a range of 1 to 10 inclusive, more preferably in a range of 1.5 to 2.0 inclusive.

[0082] This reduces the difference between the acoustic impedance of the wireless ultrasonic probe 300 and that of the ultrasound reception unit 401, allowing the ultrasound reception unit 401 to reliably receive the pairing ultrasound

351 transmitted from the wireless ultrasonic probe 300.

**[0083]** The synchronizing signal detection unit 403 detects the synchronizing signal (the header portion 602) included in the probe information signal 451.

5 **[0084]** The probe information determination unit 404 obtains, based on the synchronizing signal detected by the synchronizing signal detection unit 403, probe information 452 (the data portion 603) included in the probe information signal 451. Furthermore, the probe information determination unit 404 determines whether or not an error has occurred with the probe information signal 451.

10 **[0085]** Based on the probe information 452 obtained by the probe information determination unit 404, the probe information setting unit 405 makes settings of the pairing of the wireless ultrasonic probe 300 with the diagnostic device 400, so as to enable identification of the echo data 352 transmitted from the wireless ultrasonic probe 300.

**[0086]** Based on the probe information 452 obtained by the probe information determination unit 404, the probe information setting unit 405 also makes settings of the operations of the wireless ultrasonic probe 300 and the diagnostic device 400. With this, connection is established between the wireless ultrasonic probe 300 and the diagnostic device 400, and the settings of the wireless ultrasonic probe 300 and the diagnostic device 400 are completed.

15 **[0087]** Note that when the connection is established, the diagnostic device 400 may notify the operator of the establishment of the connection by changing the color of the LED 501 (from red to blue, for instance). When the connection is established, the diagnostic device 400 may also notify the operator of the establishment of the connection by lighting up the LED 501, for example. Furthermore, the diagnostic device 400 may also notify the operator of the establishment of the connection by emitting, from the speaker 502, a sound indicating the connection establishment.

20 **[0088]** When an error has occurred with the probe information signal 451, the error processing unit 409 notifies the operator of the error occurrence. More specifically, the error processing unit 409 performs the error notification in such cases as where the synchronizing signal (the header portion 602) is not detected even though the ultrasound signal is detected or where the value of the data portion 603 is outside a specified value range even though the ultrasound signal is detected. In addition, the error processing unit 409 performs the error notification using either the LED 501 or the speaker 502. For example, the error processing unit 409 either causes the LED 501 to flash or changes the color of the LED 501. Specifically, the error processing unit 409 may cause the LED 501 to flash in red. Alternatively, the error processing unit 409 may beep through the speaker 502.

25 **[0089]** In such a manner, the wireless ultrasonic diagnostic apparatus 30 notifies the operator of the connection establishment and the error occurrence using either the LED 501 or the speaker 502. This allows the operator to recognize that the pairing has been reliably completed.

30 **[0090]** Note that the diagnostic device 400 may include both the LED 501 and the speaker 502, or only one of them.

**[0091]** The wireless reception unit 406 receives the echo data 352 wirelessly transmitted by the wireless ultrasonic probe 300. Furthermore, the wireless reception unit 406 determines, according to the probe information 452 set by the probe information setting unit 405, whether or not the received data is the echo data 352 transmitted by the wireless ultrasonic probe 300 corresponding to the probe information 452 set by the probe information setting unit 405. When the received data is the echo data 352 transmitted by the wireless ultrasonic probe 300 corresponding to the probe information 452 set by the probe information setting unit 405, the wireless reception unit 406 outputs the echo data 352 as echo data 453.

35 **[0092]** For example, when the wireless ultrasonic probe 300 transmits the echo data 352 including identification information corresponding to the probe information of the wireless ultrasonic probe 300, the wireless reception unit 406 generates the echo data 453 by performing power amplification and demodulation on the echo data 352. Furthermore, the wireless reception unit 406 extracts identification information included in the echo data 453. In addition, when the probe information corresponding to the extracted identification information matches the set probe information 452, the wireless reception unit 406 determines that the echo data 453 is the data transmitted by the paired wireless ultrasonic probe 300, and outputs the echo data 453 to the subsequently-provided echo data processing unit 407.

40 **[0093]** Furthermore, when the wireless ultrasonic probe 300 transmits the echo data 334 generated through the scrambling and the compression using a predetermined code corresponding to the probe information of the wireless ultrasonic probe 300, the wireless reception unit 406 generates the echo data 453 by performing power amplification and demodulation on the echo data 352 and then performing descrambling and decompression using a predetermined code corresponding to the probe information 452. In this case, the wireless reception unit 406 can correctly reconstruct only the echo data 352 transmitted by the paired wireless ultrasonic probe 300.

**[0094]** The echo data processing unit 407 generates image data 454 from the echo data 453.

**[0095]** The display unit 408 displays the image data 454.

45 **[0096]** The wireless transmission unit 410 wirelessly transmits the control signal 359 for changing the echo ultrasound 353 emitted by the wireless ultrasonic probe 300.

**[0097]** Next, a flow of the operation of the wireless ultrasonic probe 300 is described.

**[0098]** FIG. 10 is a flowchart showing the flow of the operation of the wireless ultrasonic probe 300.

**[0099]** As shown in FIG. 10, when the operating switch 301 is on (Yes in S101), the probe information signal generator

302 generates the probe information signal 331 (S102).

**[0100]** Next, the ultrasound transmission unit 303 transmits, as the pairing ultrasound 351, the probe information signal 331 generated by the probe information signal generator 302 (S103).

5 **[0101]** On the other hand, when the operating switch 301 is off (No in S101), the signal-for-echo generator 304 generates the signal for echo 332 (S104).

**[0102]** Subsequently, the ultrasound transmission unit 303 transmits the signal for echo 332 as the echo ultrasound 353 (S105).

10 **[0103]** Then, the ultrasound transmission unit 303 receives the reflected waves 354 that are the echo ultrasound 353 reflected from the subject, and outputs the reflected waves 354 as the echo signal 333. Next, the echo data processing unit 305 generates the echo data 334 from the echo signal 333 (S106).

**[0104]** Subsequently, the wireless transmission unit 306 wirelessly transmits the echo data 334 as the echo data 352 (S107).

**[0105]** Next, a flow of the operation of the diagnostic device 400 is described.

**[0106]** FIG. 11 is a flowchart showing the flow of the operation of the diagnostic device 400.

15 **[0107]** As shown in FIG. 11, first, the ultrasound reception unit 401 receives the pairing ultrasound 351 and outputs the pairing ultrasound 351 as the probe information signal 451 (S201).

**[0108]** Then, the probe information detection unit 402 determines whether or not an error has occurred with the probe information signal 451 (S202).

20 **[0109]** When an error has occurred with the probe information signal 451 (Yes in S202), the error processing unit 409 notifies the operator of the error occurrence (S209).

**[0110]** On the other hand, when no error has occurred with the probe information signal 451 (No in S202), the probe information detection unit 402 obtains the probe information 452 included in the probe information signal 451 (S203).

**[0111]** Subsequently, according to the probe information 452, the probe information setting unit 405 makes settings of the pairing of the wireless ultrasonic probe 300 with the diagnostic device 400 (S204).

25 **[0112]** Next, the wireless reception unit 406 receives the echo data 352 wirelessly transmitted from the wireless ultrasonic probe 300, and generates the echo data 453 from the received echo data 352 (S205).

**[0113]** Then, the wireless reception unit 406 determines whether or not the received echo data 352 is the echo data 352 transmitted from the paired wireless ultrasonic probe 300 (S206).

30 **[0114]** When the received echo data 352 is not the echo data 352 transmitted from the paired wireless ultrasonic probe 300 (No in S205), the diagnostic device 400 notifies the operator that an error has occurred (S209), and terminates the processing.

**[0115]** On the other hand, when the received echo data 352 is the echo data 352 transmitted from the paired wireless ultrasonic probe 300 (Yes in S206), the echo data processing unit 407 generates the image data 454 from the echo data 453 (S207). Subsequently, the display unit 408 displays the image data 454 (S208).

35 **[0116]** With the above operations, the wireless ultrasonic diagnostic apparatus 30 according to Embodiment 1 of the present invention pairs the wireless ultrasonic probe 300 with the diagnostic device 400 using ultrasound.

**[0117]** Here, in the case where the pairing is performed through the wireless transmission used for transmitting the echo data 352, another diagnostic device might receive the pairing signal transmitted from the wireless ultrasonic probe, resulting in recognition by the other diagnostic device in error.

40 **[0118]** In contrast, the pairing ultrasound 351 output from the wireless ultrasonic probe 300 according to Embodiment 1 of the present invention is low in signal level and thus does not reach the diagnostic device located at distance. This prevents recognition by the other diagnostic device in error.

**[0119]** In such a manner, the wireless ultrasonic diagnostic apparatus 30 according to Embodiment 1 of the present invention can reliably pair the wireless ultrasonic probe 300 with the diagnostic device 400.

45 **[0120]** Another possible approach is to register, in the diagnostic device, information on a plurality of wireless ultrasonic probes in advance, so that the wireless ultrasonic probes can be switched from one to the other through operation on the diagnostic device. When using such a method, it is necessary to make initial settings by, for example, naming each wireless ultrasonic probe, in order to identify a wireless ultrasonic probe for actual use and a wireless ultrasonic probe which is to be selected through the diagnostic device. It is also necessary to put the individual names or the like on the wireless ultrasonic probes, for example, to allow distinction therebetween.

50 **[0121]** In contrast, the wireless ultrasonic diagnostic apparatus 30 according to Embodiment 1 of the present invention can enable the diagnostic device 400 to recognize only a pairing-target wireless ultrasonic probe 300 through a simple operation of pressing the operating switch 301 while allowing the pairing-target wireless ultrasonic probe 300 to contact the diagnostic device 400. In such a manner, the wireless ultrasonic diagnostic apparatus 30 according to Embodiment 1 of the present invention can easily pair the wireless ultrasonic probe 300 with the diagnostic device 400. Furthermore, the wireless ultrasonic diagnostic apparatus 30 according to Embodiment 1 of the present invention is advantageous in that there is no need to perform, in the diagnostic device, the registration and the initial settings that enable the probe identification.

**[0122]** In addition, the wireless ultrasonic diagnostic apparatus 30 according to Embodiment 1 of the present invention uses, for the purpose of pairing, the ultrasound used for generating the echo data. This enables the wireless ultrasonic diagnostic apparatus 30 to perform the above-described functions while suppressing an increase in cost.

**[0123]** Hereinafter, structural examples of the ultrasound transmission unit 303 are described.

**[0124]** FIG. 12 shows a structural example of an ultrasound transmission unit 303A that is an example of the ultrasound transmission unit 303.

**[0125]** The ultrasound transmission unit 303A shown in FIG. 12 includes a transducer 320 and a plurality of transducers 321.

**[0126]** The transducer 320 is used only for the transmission of the pairing ultrasound 351. The transducers 321 are used only for the transmission and reception (emission) of the echo ultrasound 353.

**[0127]** Using the transducer 320 dedicated for the generation of the pairing ultrasound 351 incurs an additional cost for the transducer 320; however, it increases the flexibility of the pairing ultrasound 351. For example, the frequency of the pairing ultrasound 351 can be set lower than that of the echo ultrasound 353. That is to say, the transmission frequency of the transducer 320 may be lower than that of the transducers 321. Here, a lower frequency reduces the amount of attenuation that occurs during propagation through the air. This leads to an increase in the possibility of successful communication between the wireless ultrasonic probe 300 and the diagnostic device 400 using the pairing ultrasound 351 even when they are slightly distant from each other. This means that in the case of using the dedicated transducer 320, the communication between the wireless ultrasonic probe 300 and the diagnostic device 400 is possible by simply bringing them close each other, that is, without making the wireless ultrasonic probe 300 contact the ultrasound reception unit 401.

**[0128]** Note that ultrasound signals are high in frequency and thus have the property of traveling straight without spreading in the lateral direction. For this reason, a wireless ultrasonic probe 300 not in use is placed distantly from the diagnostic device 400, and is usually not positioned along a straight line extending from the reception point of the diagnostic device 400. Therefore, erroneous pressing of the operating switch 301 does not result in recognition of the unused wireless ultrasonic probe 300 by the diagnostic device 400.

**[0129]** FIG. 13 shows a structural example of an ultrasound transmission unit 303B that is another example of the ultrasound transmission unit 303.

**[0130]** The ultrasound transmission unit 303B shown in FIG. 13 includes a transducer 322 and a plurality of transducers 321.

**[0131]** The transducers 321 are used only for the transmission and reception of the echo ultrasound 353. The transducer 322 is used for both the transmission of the pairing ultrasound 351 and the transmission and reception of the echo ultrasound 353.

**[0132]** In the case of using the transducer 322 for the generation of both the pairing ultrasound 351 and the echo ultrasound 353 as described above, no additional cost is necessary for the transducer because the shape thereof remains the same as the conventional one. However, the flexibility in the sound pressure and the frequency of the pairing ultrasound 351 decreases because they are determined based on the echo ultrasound 353.

**[0133]** Note that although the number of the transducers 320 dedicated for the pairing ultrasound 351 is one in FIG. 12, there may be more than one transducer 320.

**[0134]** In addition, although the number of the transducers 322 used for both the pairing ultrasound 351 and the echo ultrasound 353 is one in FIG. 13, there may be more than one transducer 322. Furthermore, all the transducers included in the ultrasound transmission unit 303B may be used for both the pairing ultrasound 351 and the echo ultrasound 353.

**[0135]** The number of transducers 321 that are shown in FIGS. 12 and 13 and used for generating the echo ultrasound 353 is a mere example, and there may be more or less transducers 321. The number of transducers 321 may be one.

**[0136]** Furthermore, the diagnostic device 400 may reset the pairing when the wireless ultrasonic probe 300 is switched off and the echo data 352 is no longer transmitted to the diagnostic device 400.

(Embodiment 2)

**[0137]** Embodiment 2 of the present invention describes a variation of the wireless ultrasonic probe 300 according to Embodiment 1.

**[0138]** FIG. 14 is a block diagram showing a structure of a wireless ultrasonic probe 300A according to Embodiment 2 of the present invention. Note that the same elements as those in FIG. 3 are given the same numerical references, and common descriptions are not repeated. Also note that the wireless reception unit 309 is omitted in FIG. 14.

**[0139]** The wireless ultrasonic probe 300A shown in FIG. 14 is different from the wireless ultrasonic probe 300 shown in FIG. 3 in including an ultrasound transmission unit 303C instead of the ultrasound transmission unit 303. In addition, the wireless ultrasonic probe 300A further includes a delay control unit 308.

**[0140]** The ultrasound transmission unit 303C includes a plurality of transducers 322 and a plurality of delay circuits 325 corresponding to the transducers 322 on a one-by-one basis.

[0141] The transducers 322 are used for both the transmission of the pairing ultrasound 351 and the transmission and reception of the echo ultrasound 353. The transducers 322 synchronously transmit the pairing ultrasound 351 according to the probe information signal 331. The transducers 322 also synchronously transmit the echo ultrasound 353 according to the signal for echo 332.

5 [0142] The delay circuits 325 delay the probe information signal 331 and the signal for echo 332 that are provided to the transducers 322.

[0143] The delay control unit 308 controls the amount of delay caused by the delay circuits 325.

[0144] FIG. 15 shows the pairing ultrasound 351 transmitted by the wireless ultrasonic probe 300A. Here, it is assumed that the wireless ultrasonic probe 300A has a convex shape as shown in FIG. 15.

10 [0145] As shown in FIG. 15, with the wireless ultrasonic probe 300A having an emitting surface 307A that is curved like a convex shape, for example, there is a route difference 355 between the transducers 322. Therefore, when a large number of transducers 322 are simultaneously driven, the route difference 355 causes a delay in the output signals transmitted from the transducers 322, which could lead to a situation where data included in the output signals do not match each other at the reception position of the diagnostic device 400. To prevent such a situation, the delay circuits 325 delay the probe information signal 331 provided to the transducers 322 so that the route difference 355 is corrected.

15 [0146] Furthermore, the delay control unit 308 adjusts the amount of delay caused by the delay circuits 325 so that the pairing ultrasound 351 becomes plane waves as shown in FIG. 15. More specifically, the transducer 322 at a position 356A in FIG. 15 is the first transducer to transmit ultrasound. At a time when the transmitted ultrasound has traveled the distance of the route difference 355, the transducer 322 at a position 356B in FIG. 15 transmits ultrasound. This allows the ultrasound output from the transducers 322 to be transmitted as plane waves. Such a structure increases the signal level of the pairing ultrasound 351 transmitted from the wireless ultrasonic probe 300A, thereby increasing the possibility of successful communication between the wireless ultrasonic probe 300A and the diagnostic device 400 using the pairing ultrasound 351 even when the wireless ultrasonic probe 300A and the diagnostic device 400 are distant from each other.

20 [0147] With the wireless ultrasonic probe 300A according to Embodiment 2 of the present invention, it is acceptable to use, as the delay circuits 325, a delay circuit which is normally included in the ultrasonic diagnostic apparatus for use in the beamforming performed for generating transmission data.

25 [0148] Here, in the process of beamforming, the transducers 322 are driven and the amount of delay is adjusted in such a manner that the signal level of the output signals is maximized at a focal position 357 as shown in FIG. 16. In other words, the delay control unit 308 adjusts the amount of delay caused by the delay circuits 325 so that the focal position 357 of the echo ultrasound 353 matches a predetermined position as shown in FIG. 16.

30 [0149] In such a manner, the wireless ultrasonic diagnostic apparatus 30 according to Embodiment 2 of the present invention uses, for adjusting the delay of the pairing ultrasound 351, the delay circuits normally included in the ultrasonic diagnostic apparatus, thereby increasing the possibility of successful communication between the wireless ultrasonic probe 300A and the diagnostic device 400 using the pairing ultrasound 351 while suppressing an increase in cost.

35 [0150] FIG. 17 shows a structure of the ultrasound reception unit 401 included in the diagnostic device 400 according to Embodiment 2 of the present invention.

[0151] Here, the pairing ultrasound 351 preferably comes into a focus in a shorter distance. To bring the focal position closer, the ultrasound reception unit 401 may include a focal position adjusting acoustic lens 360 which adjusts the focal length as shown in FIG. 17.

40 [0152] General wireless ultrasonic probes include an acoustic lens 358 so that the focal position is at several centimeters ahead within the body. Thus, when the ultrasound reception unit 401 does not include the focal position adjusting acoustic lens 360, the focal position of the pairing ultrasound 351 is at a focal position 361 shown in FIG. 17. On the other hand, when the ultrasound reception unit 401 includes the focal position adjusting acoustic lens 360, the focal position of the pairing ultrasound 351 is at a focal position 362 shown in FIG. 17.

45 [0153] By bringing the focal position closer in such a manner, it is possible to reduce attenuation of the pairing ultrasound 351, thereby increasing the possibility of successful communication between the wireless ultrasonic probe 300A and the diagnostic device 400 using the pairing ultrasound 351.

[0154] Next, a flow of the operation of the wireless ultrasonic probe 300A is described.

50 [0155] FIG. 18 is a flowchart showing the flow of the operation of the wireless ultrasonic probe 300A. Note that the same processing as that in FIG. 10 are given the same numerical references. FIG. 18 shows Steps S121 and S122 in addition to the processing shown in FIG. 10.

[0156] As shown in FIG. 18, when the operating switch 301 is on (Yes in S101), the probe information signal generator 302 generates the probe information signal 331 (S102).

55 [0157] Next, the delay control unit 308 sets the amount of delay to be caused by the delay circuits 325 to an amount of delay for pairing so that the pairing ultrasound 351 becomes plane waves (S121).

[0158] Next, the ultrasound transmission unit 303 transmits, as the pairing ultrasound 351, the probe information signal 331 delayed by the delay circuits 325 (S103).

[0159] On the other hand, when the operating switch 301 is off (No in S101), the signal-for-echo generator 304

generates the signal for echo 332 (S104).

**[0160]** Next, the delay control unit 308 sets the amount of delay to be caused by the delay circuits 325 to an amount of delay for echo so that the focal position of the echo ultrasound 353 matches a predetermined position (S122).

**[0161]** Subsequently, the ultrasound transmission unit 303 transmits, as the echo ultrasound 353, the signal for echo 332 delayed by the delay circuits 325 (S105).

**[0162]** Then, the ultrasound transmission unit 303 receives the reflected waves 354 that are the echo ultrasound 353 reflected from the subject, and outputs the reflected waves 354 as the echo signal 333. Next, the echo data processing unit 305 generates the echo data 334 from the echo signal 333 (S106).

**[0163]** Subsequently, the wireless transmission unit 306 wirelessly transmits the echo data 334 as the echo data 352 (S107).

**[0164]** Although it has been described above that the wireless ultrasonic probe 300A has a convex shape, the wireless ultrasonic probe 300A may have a different shape. In that case, it is sufficient as long as the delay circuits 325 delay, according to the shape of the emitting surface 307A of the wireless ultrasonic probe 300A, the probe information signal 331 provided to the transducers 322 so that the pairing ultrasound 351 synchronously transmitted by the transducers 322 becomes plane waves.

**[0165]** Although it has also been described above that all the transducers 322 included in the ultrasound transmission unit 303C are used for the generation of both the pairing ultrasound 351 and the echo ultrasound 353, the ultrasound transmission unit 303C may include a transducer dedicated for the pairing ultrasound 351 or a transducer dedicated for the echo ultrasound 353.

(Embodiment 3)

**[0166]** Embodiment 3 of the present invention describes application of the present invention to a mechanical sector-scanning wireless ultrasonic probe.

**[0167]** FIG. 19 is a block diagram showing a structure of a wireless ultrasonic probe 300B according to Embodiment 3 of the present invention. Note that the same elements as those in FIG. 3 are given the same numerical references, and common descriptions are not repeated. Also note that the wireless reception unit 309 is omitted in FIG. 19.

**[0168]** The wireless ultrasonic probe 300B shown in FIG. 19 includes a scan unit 370 in addition to the constituent elements of the wireless ultrasonic probe 300 shown in FIG. 3.

**[0169]** When the ultrasound transmission unit 303 transmits the echo ultrasound 353, the scan unit 370 performs sector scanning in directions in which the echo ultrasound 353 is transmitted. In addition, when the ultrasound transmission unit 303 transmits the pairing ultrasound 351, the scan unit 370 fixes the direction in which the pairing ultrasound 351 is transmitted.

**[0170]** More specifically, when the operating switch 301 is pressed, the scan unit 370 causes the transducer at the tip of the wireless ultrasonic probe 300B to pause at the position directly in front of the diagnostic device 400. This enables the mechanical sector-scanning wireless ultrasonic probe 300B to reliably perform the pairing.

**[0171]** Next, a flow of the operation of the wireless ultrasonic probe 300B is described.

**[0172]** FIG. 20 is a flowchart showing the flow of the operation of the wireless ultrasonic probe 300B. Note that the same processing as that in FIG. 10 are given the same numerical references. FIG. 20 shows Steps S131 and S132 in addition to the processing shown in FIG. 10.

**[0173]** As shown in FIG. 20, when the operating switch 301 is on (Yes in S101), the probe information signal generator 302 generates the probe information signal 331 (S102).

**[0174]** Next, the scan unit 370 fixes the direction in which the pairing ultrasound 351 is transmitted (S131).

**[0175]** Then, the ultrasound transmission unit 303 transmits the probe information signal 331 as the pairing ultrasound 351 (S103).

**[0176]** On the other hand, when the operating switch 301 is off (No in S101), the signal-for-echo generator 304 generates the signal for echo 332 (S104).

**[0177]** Next, the scan unit 370 performs scanning in directions in which the echo ultrasound 353 is transmitted (S132).

**[0178]** Subsequently, the ultrasound transmission unit 303 transmits the signal for echo 332 as the echo ultrasound 353 (S105).

**[0179]** Then, the ultrasound transmission unit 303 receives the reflected waves 354 that are the echo ultrasound 353 reflected from the subject, and outputs the reflected waves 354 as the echo signal 333. Next, the echo data processing unit 305 generates the echo data 334 from the echo signal 333 (S106).

**[0180]** Subsequently, the wireless transmission unit 306 wirelessly transmits the echo data 334 as the echo data 352 (S107).

**[0181]** Although the above embodiments describe that the signal-for-echo generator 304 included in the wireless ultrasonic probe generates the signal for echo 332 from which the echo ultrasound 353 is generated, the wireless ultrasonic probe may output, as the signal for echo 332, a transmission signal transmitted from the diagnostic device.

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**[0182]** FIG. 21 shows a structure of a wireless ultrasonic probe 300C that outputs, as the signal for echo 332, a transmission signal 363 transmitted from the diagnostic device 400.

**[0183]** The wireless ultrasonic probe 300C shown in FIG. 21 is different from the wireless ultrasonic probe 300 shown in FIG. 3 in including a signal-for-echo processing unit 304A instead of the signal-for-echo generator 304. Furthermore,

the wireless reception unit 309 receives the transmission signal 363 wirelessly transmitted from the diagnostic device 400.

**[0184]** The signal-for-echo processing unit 304A outputs, as the signal for echo 332, the transmission signal 363 wirelessly transmitted from the diagnostic device 400.

**[0185]** At least some of the processing units included in the wireless ultrasonic diagnostic apparatus 30 according to the above embodiments may be implemented in the Form of a Large Scale Integrated (LSI) circuit that is an integrated circuit. These may be implemented in a single chip individually, or in a single chip that includes some or all of them.

**[0186]** Furthermore, the means for circuit integration is not limited to an LSI, and implementation with a dedicated circuit or a general-purpose processor is also available. It is also acceptable to use a field programmable gate array (FPGA) that is programmable after the LSI has been manufactured, and a reconfigurable processor in which connections and settings of circuit cells within the LSI are reconfigurable.

**[0187]** Some or all of the functions of the wireless ultrasonic diagnostic apparatus 30 according to the embodiments of the present invention may be achieved through execution of a program by a processor such as a CPU.

**[0188]** In addition, the present invention may be realized as the program or a recording medium on which the program is recorded. It is apparent that the program may be distributed via a transmission medium such as the Internet.

**[0189]** Furthermore, it is possible to combine at least some of the functions of the wireless ultrasonic diagnostic apparatus according to Embodiments 1 to 3 and the wireless ultrasonic diagnostic apparatus according to the variation of Embodiments 1 to 3.

**[0190]** The present invention includes various variations achieved through modifications of the embodiments of the present invention that a person skilled in the art could conceive without departing from the scope of the present invention.

[Industrial Applicability]

**[0191]** The wireless ultrasonic diagnostic apparatus according to the present invention is capable of easily and reliably establishing connection between a wireless ultrasonic probe and a diagnostic device using an ultrasound signal. It is particularly useful as a wireless ultrasonic diagnostic apparatus that uses a plurality of wireless ultrasonic probes.

[Reference Signs List]

### [0192]

10, 30	Wireless ultrasonic diagnostic apparatus
100	Ultrasonic probe
110	PS conversion unit
112	Scrambler
114	Code signal generator
116	Modulator
200	Main device
300, 300A, 300B, 300C	Wireless ultrasonic probe
301	Operating switch
302	Probe information signal generator
303, 303A, 303B, 303C	Ultrasound transmission unit
304	Signal-for-echo generator
304A	Signal-for-echo processing unit
305	Echo data processing unit
306	Wireless transmission unit
307, 307A	Emitting surface
308	Delay control unit
309	Wireless reception unit
320, 321, 322	Transducer
325	Delay circuit
331, 451	Probe information signal
332	Signal for echo
333	Echo signal
334, 352, 453	Echo data

351	Pairing ultrasound
353	Echo ultrasound
354	Reflected waves
355	Route difference
5 356A, 356B	Position
357, 351, 362	Focal position
358	Acoustic lens
359	Control signal
360	Focal position adjusting acoustic lens
10 363	Transmission signal
370	Scan unit
400	Diagnostic device
401	Ultrasound reception unit
402	Probe information detection unit
15 403	Synchronizing signal detection unit
404	Probe information determination unit
405	Probe information setting unit
406	Wireless reception unit
407	Echo data processing unit
20 408	Display unit
409	Error processing unit
410	Wireless transmission unit
452	Probe information
454	Image data
25 501	LED
502	Speaker
601	Data signal
602	Header portion
603	Data portion
30	

**Claims**

1. A wireless ultrasonic diagnostic apparatus comprising:

a wireless ultrasonic probe which generates echo data and wirelessly transmits the echo data; and  
a diagnostic device which receives the echo data wirelessly transmitted by said wireless ultrasonic probe,  
said wireless ultrasonic probe including:  
a first signal generator which generates a first signal including probe information for identifying said wireless  
ultrasonic probe;  
an ultrasound transmission unit configured to transmit the first signal as first ultrasound; and  
a wireless transmission unit configured to wirelessly transmit the echo data associated with the probe information,  
and  
said diagnostic device including:  
an ultrasound reception unit configured to receive the first ultrasound transmitted by said wireless ultrasonic  
probe;  
a probe information detection unit configured to detect the probe information from the first ultrasound received;  
and  
a wireless reception unit configured to receive data that is wirelessly transmitted, and determine, using the  
probe information detected by said probe information detection unit, whether or not the received data is the  
echo data wirelessly transmitted by said wireless ultrasonic probe.

2. The wireless ultrasonic diagnostic apparatus according to Claim 1,  
wherein said wireless ultrasonic probe further includes an operating switch operable by an operator, and  
when said operating switch is pressed,  
said first signal generator generates the first signal, and  
said ultrasound transmission unit is configured to transmit the first signal as the first ultrasound.

3. The wireless ultrasonic diagnostic apparatus according to Claim 1 or Claim 2, wherein said first signal generator generates the first signal including a synchronizing signal, and said probe information detection unit is configured to detect the probe information from the first ultrasound by detecting the synchronizing signal included in the first ultrasound received.
- 5
4. The wireless ultrasonic diagnostic apparatus according to one of Claims 1 to 3, wherein said ultrasound transmission unit is further configured to emit second ultrasound for generating the echo data.
- 10
5. The wireless ultrasonic diagnostic apparatus according to Claim 4, wherein said ultrasound transmission unit includes:
- a first transducer which transmits the first ultrasound according to the first signal; and  
a second transducer which emits the second ultrasound, said second transducer being different from said first transducer.
- 15
6. The wireless ultrasonic diagnostic apparatus according to Claim 5, wherein said first transducer has a transmission frequency lower than a transmission frequency of said second transducer.
- 20
7. The wireless ultrasonic diagnostic apparatus according to Claim 5, wherein said ultrasound transmission unit includes a transducer which transmits the first ultrasound according to the first signal and emits the second ultrasound.
- 25
8. The wireless ultrasonic diagnostic apparatus according to Claim 5, wherein said ultrasound transmission unit includes a plurality of transducers which synchronously transmit the first ultrasound according to the first signal.
- 30
9. The wireless ultrasonic diagnostic apparatus according to Claim 8, wherein said ultrasound transmission unit includes a delay circuit which delays, according to a shape of a surface of said wireless ultrasonic probe from which the first ultrasound is emitted, the first signal provided to said transducers so that the first ultrasound synchronously transmitted by said transducers becomes plane waves.
- 35
10. The wireless ultrasonic diagnostic apparatus according to Claim 9, wherein said wireless ultrasonic probe further includes a second signal generator which generates a second signal, said transducers generate the second ultrasound according to the second signal, and said delay circuit further delays the second signal to adjust a focal position of the second ultrasound, and provides the delayed second signal to said transducers.
- 40
11. The wireless ultrasonic diagnostic apparatus according to one of Claims 4 to 10, wherein said wireless ultrasonic probe includes a scan unit configured to perform, when said ultrasound transmission unit emits the second ultrasound, sector scanning in directions in which the second ultrasound is emitted, and when said ultrasound transmission unit emits the first ultrasound, said scan unit is configured to fix a direction in which the first ultrasound is emitted.
- 45
12. The wireless ultrasonic diagnostic apparatus according to one of Claims 1 to 11, wherein said ultrasound reception unit has an acoustic impedance in a range of 1.5 to 2.0 inclusive.
- 50
13. The wireless ultrasonic diagnostic apparatus according to one of Claims 1 to 12, wherein said ultrasound reception unit includes an acoustic lens which adjusts a focal position of the first ultrasound.
- 55
14. The wireless ultrasonic diagnostic apparatus according to one of Claims 1 to 13, wherein said diagnostic device includes an error processing unit configured to notify an operator of error occurrence when an error occurs with the probe information transmitted by said wireless ultrasonic probe.

15. The wireless ultrasonic diagnostic apparatus according to Claim 14,  
wherein said error processing unit is configured to notify the operator of the error occurrence by causing an LED to  
flash or by changing a color of the LED.

5 16. The wireless ultrasonic diagnostic apparatus according to Claim 14,  
wherein said error processing unit is configured to notify the operator of the error occurrence by beeping.

10 17. A wireless ultrasonic probe which generates echo data and wirelessly transmits the echo data to a diagnostic device,  
said wireless ultrasonic probe comprising:

- a first signal generator which generates a first signal including probe information for identifying said wireless ultrasonic probe;
- an ultrasound transmission unit configured to transmit the first signal to the diagnostic device as first ultrasound;
- and
- 15 a wireless transmission unit configured to wirelessly transmit the echo data associated with the probe information.

18. A probe authentication method performed by a wireless ultrasonic diagnostic apparatus,  
the wireless ultrasonic diagnostic apparatus including:

- 20 a wireless ultrasonic probe which generates echo data and wirelessly transmits the echo data; and
- a diagnostic device which receives the echo data wirelessly transmitted by the wireless ultrasonic probe, and
- said probe authentication method comprising:
  - generating, by the wireless ultrasonic probe, a first signal including probe information for identifying the wireless ultrasonic probe;
  - 25 transmitting, by the wireless ultrasonic probe, the first signal as first ultrasound;
  - wirelessly transmitting, by the wireless ultrasonic probe, the echo data associated with the probe information;
  - receiving, by the diagnostic device, the first ultrasound transmitted by the wireless ultrasonic probe;
  - detecting, by the diagnostic device, the probe information from the first ultrasound received;
  - receiving, by the diagnostic device, data that is wirelessly transmitted; and
  - 30 determining, by the diagnostic device, using the probe information detected, whether or not the received data is the echo data wirelessly transmitted by the wireless ultrasonic probe.

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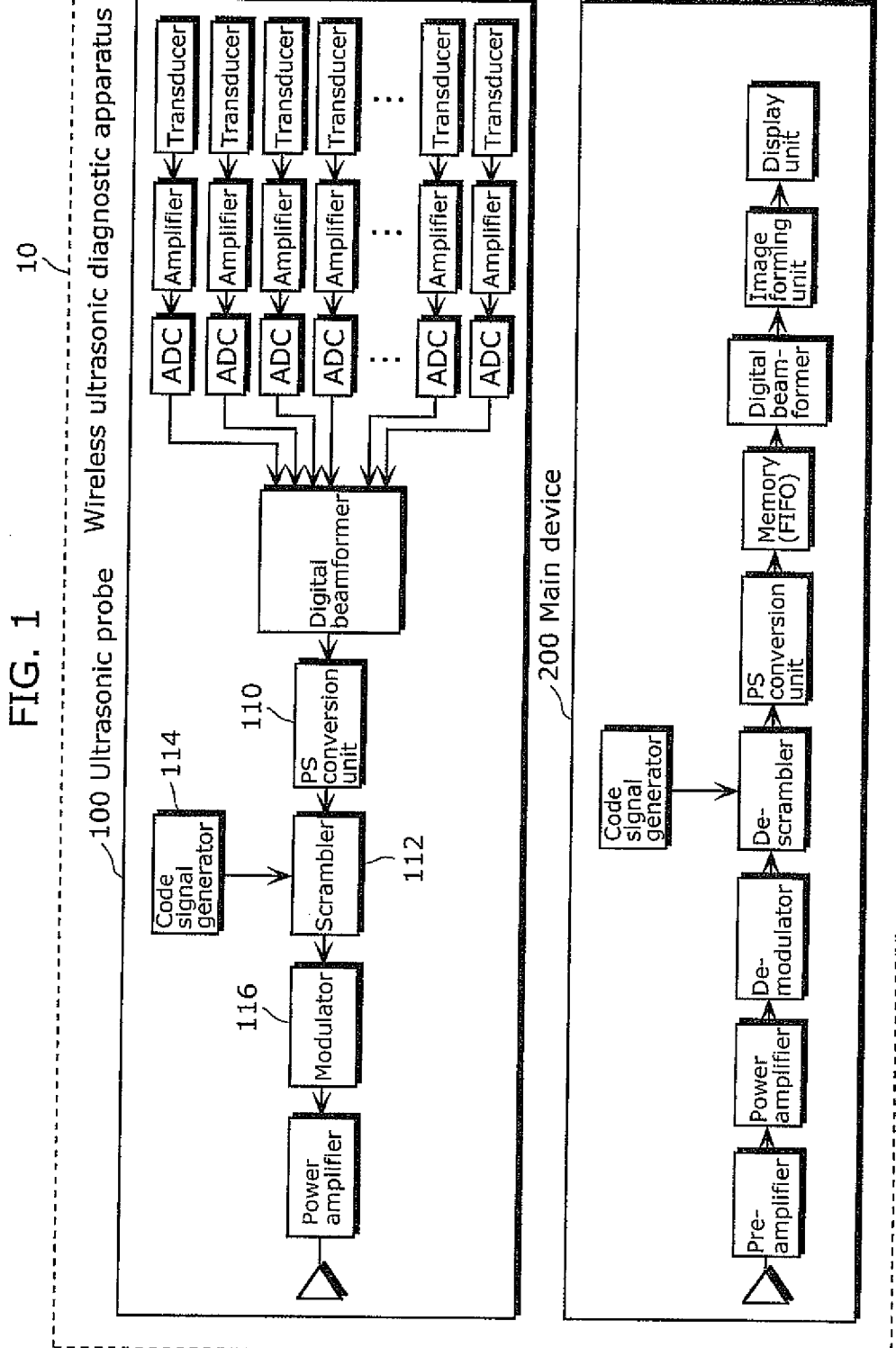


FIG. 2

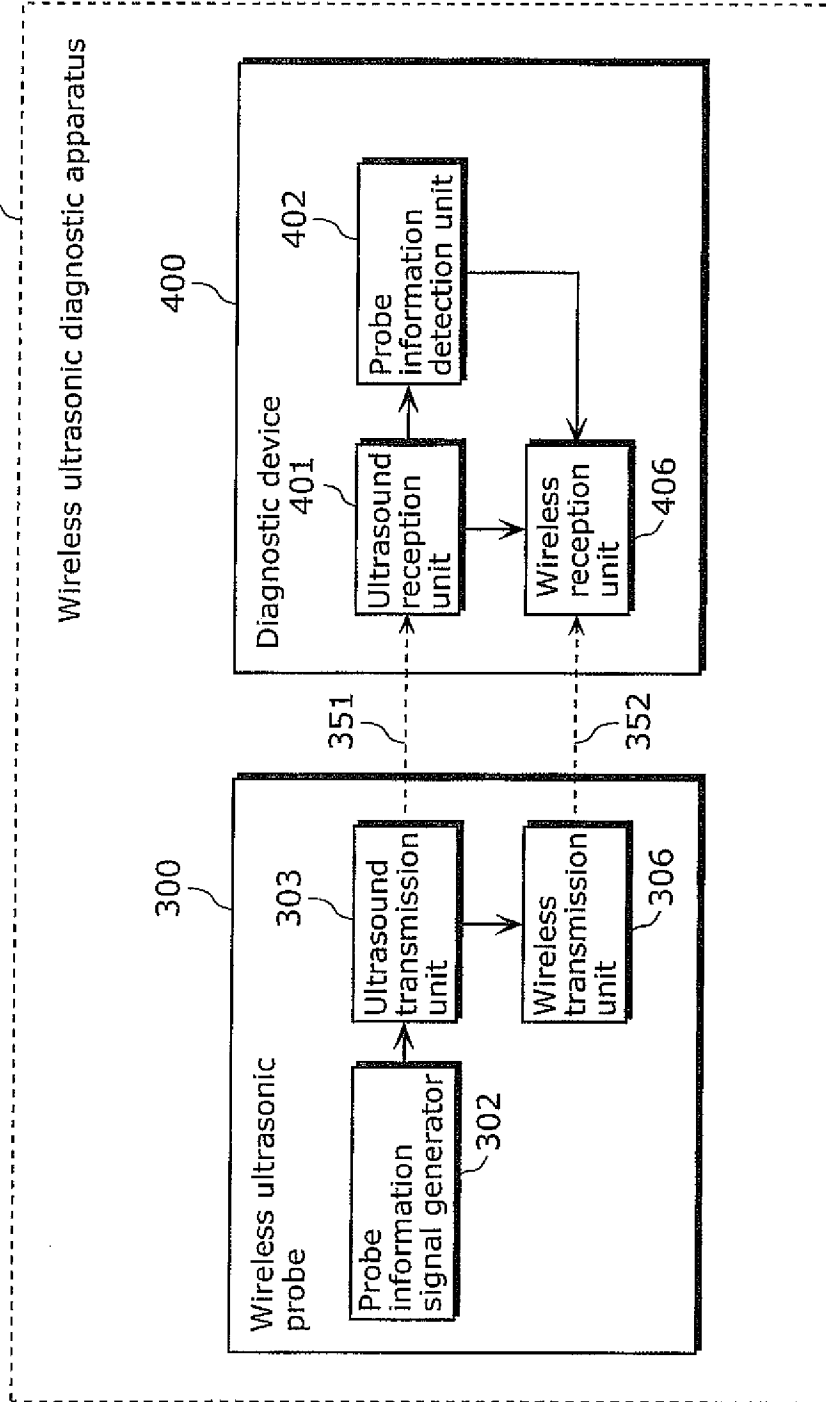


FIG. 3

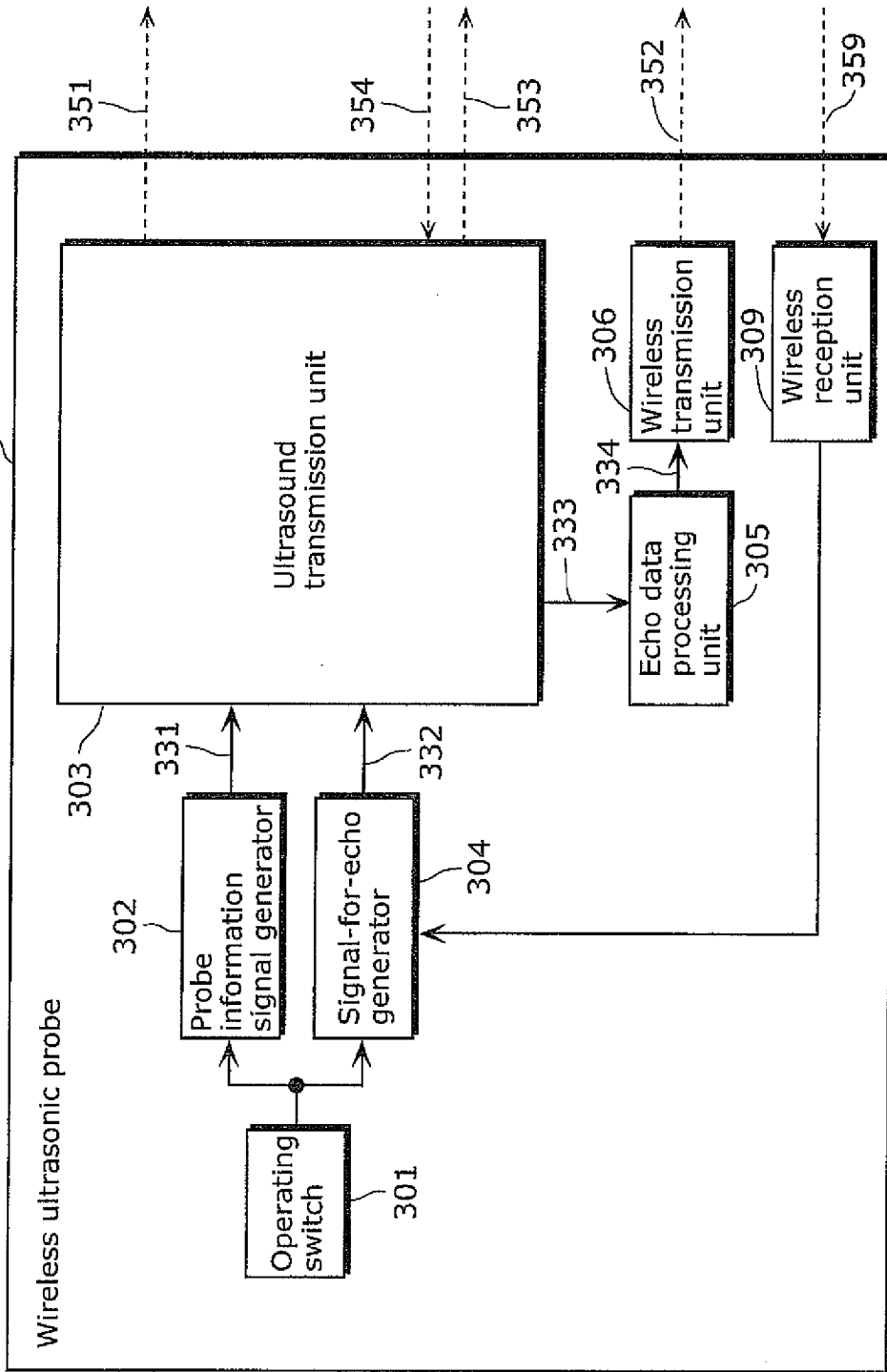


FIG. 4

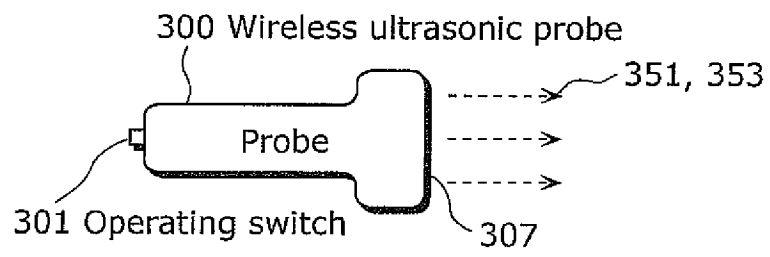


FIG. 5

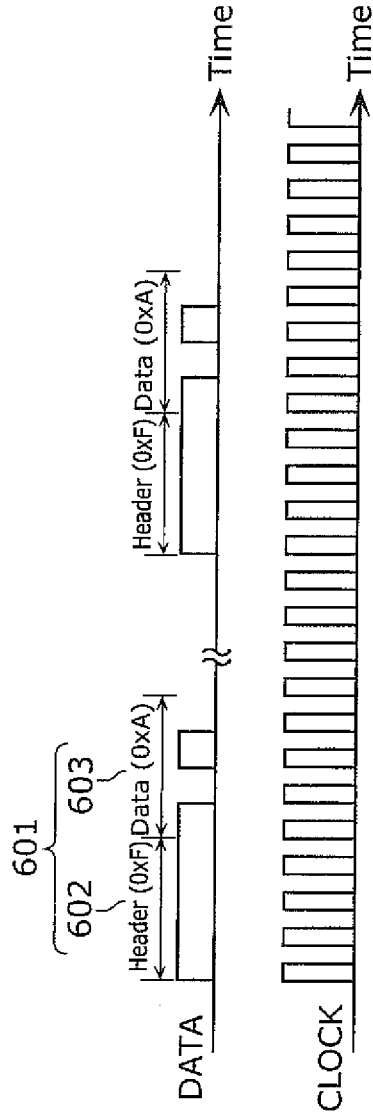


FIG. 6

data	Shape of probe
0x1	Convex
0x2	Linear
:	
0xA	Sector

FIG. 7

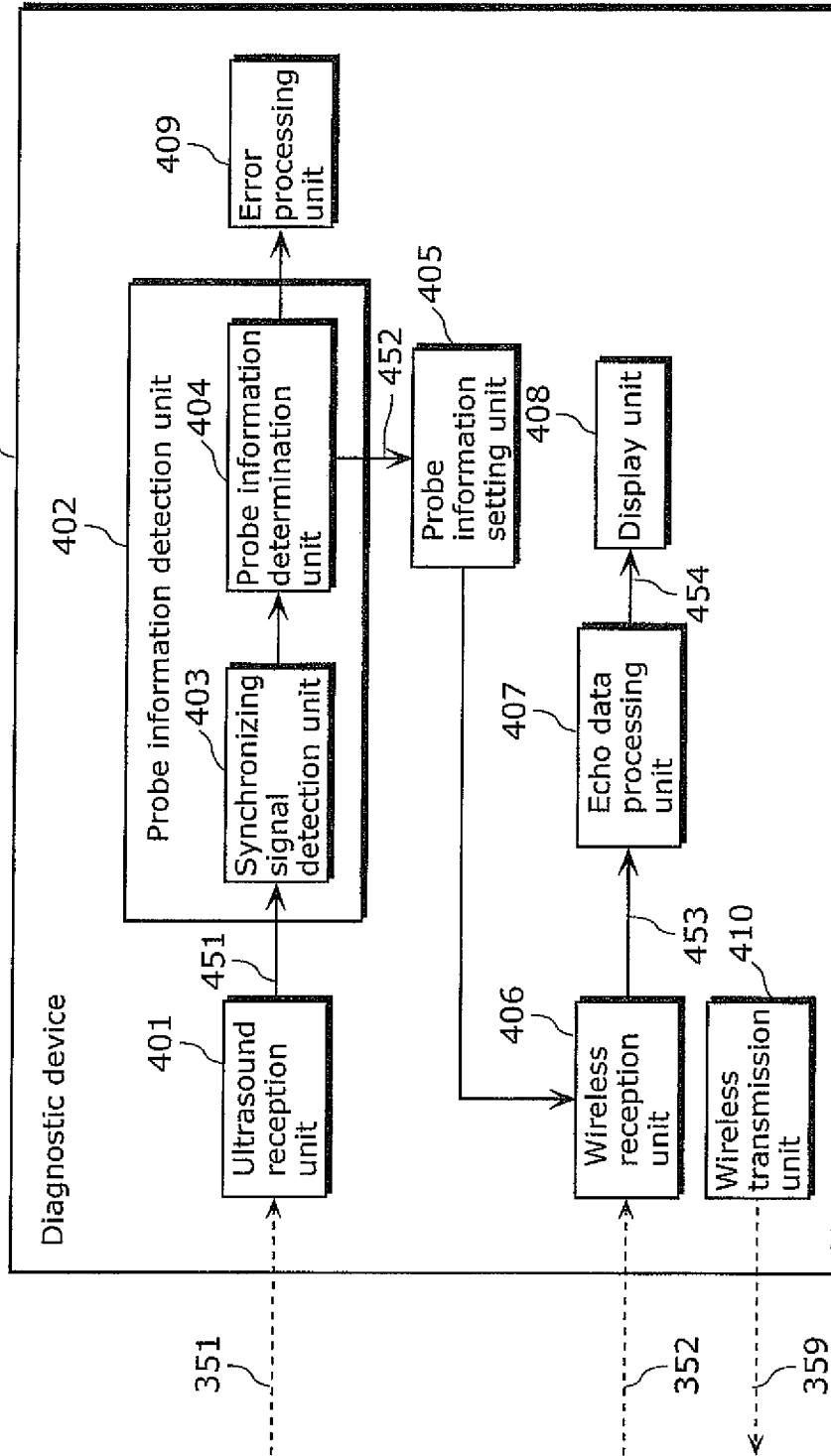


FIG. 8

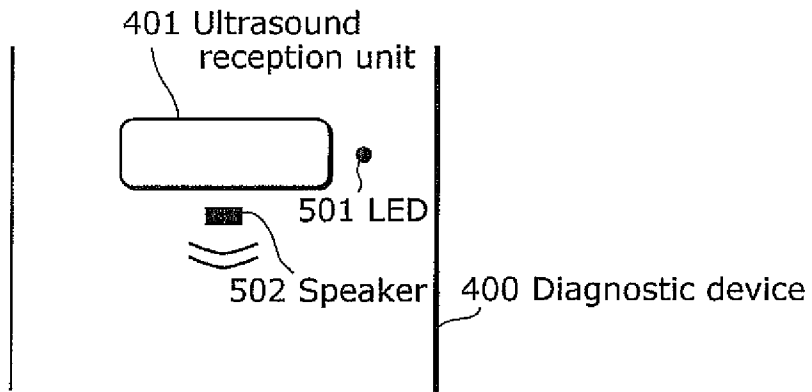


FIG. 9

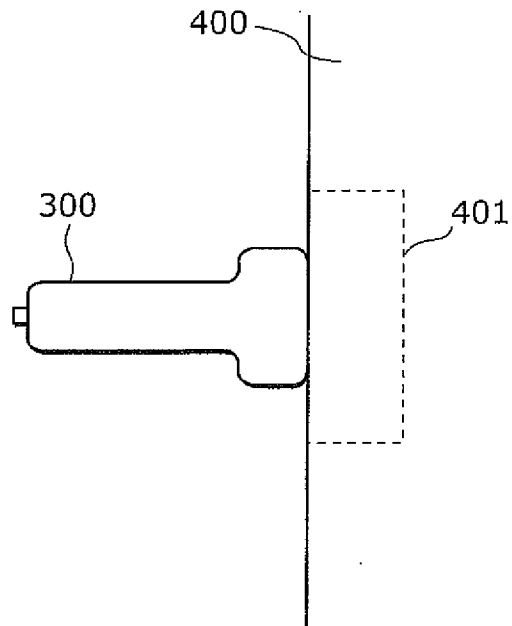


FIG. 10

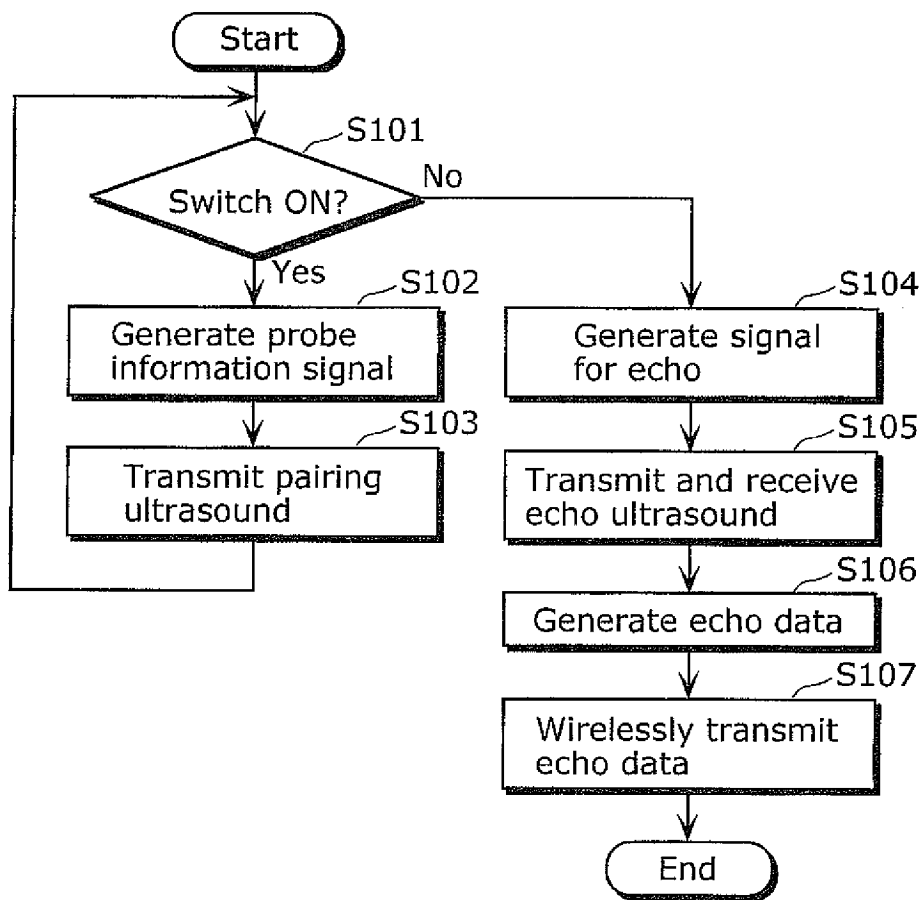


FIG. 11

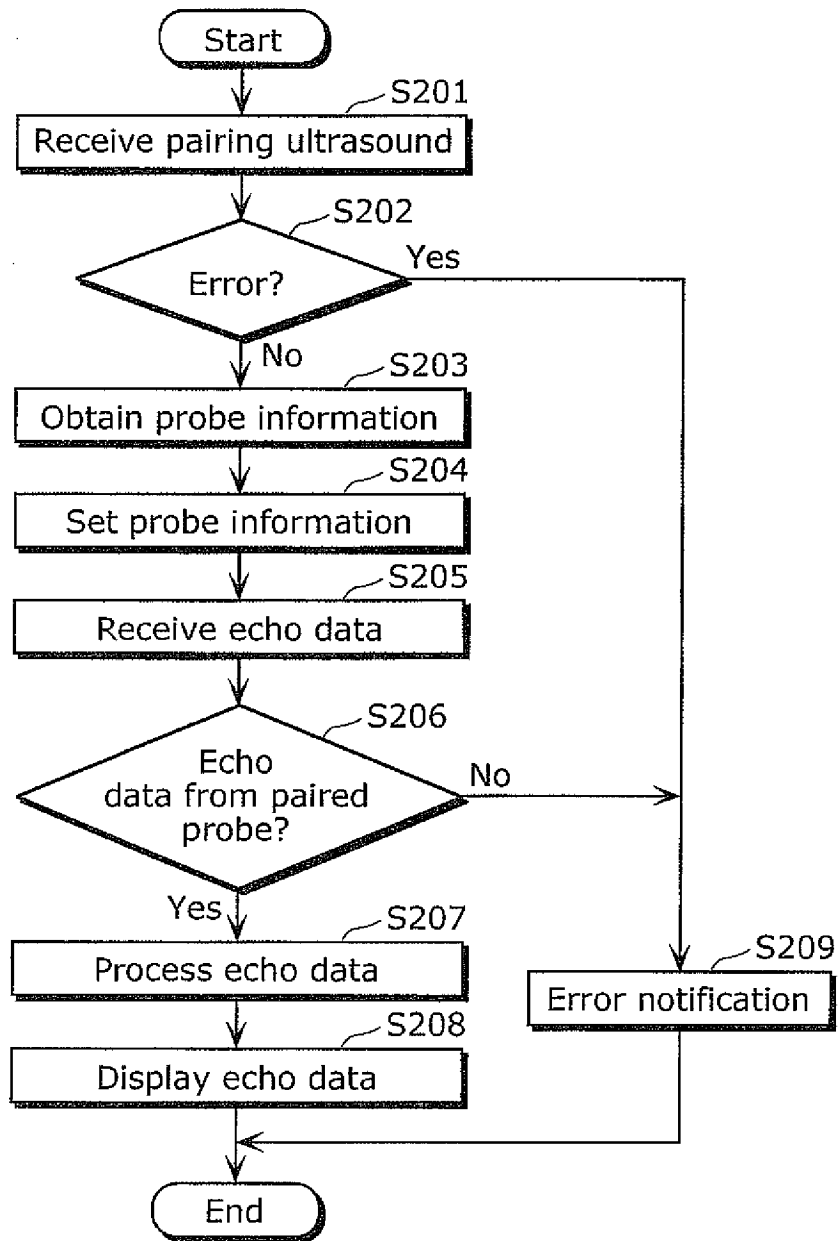


FIG. 12

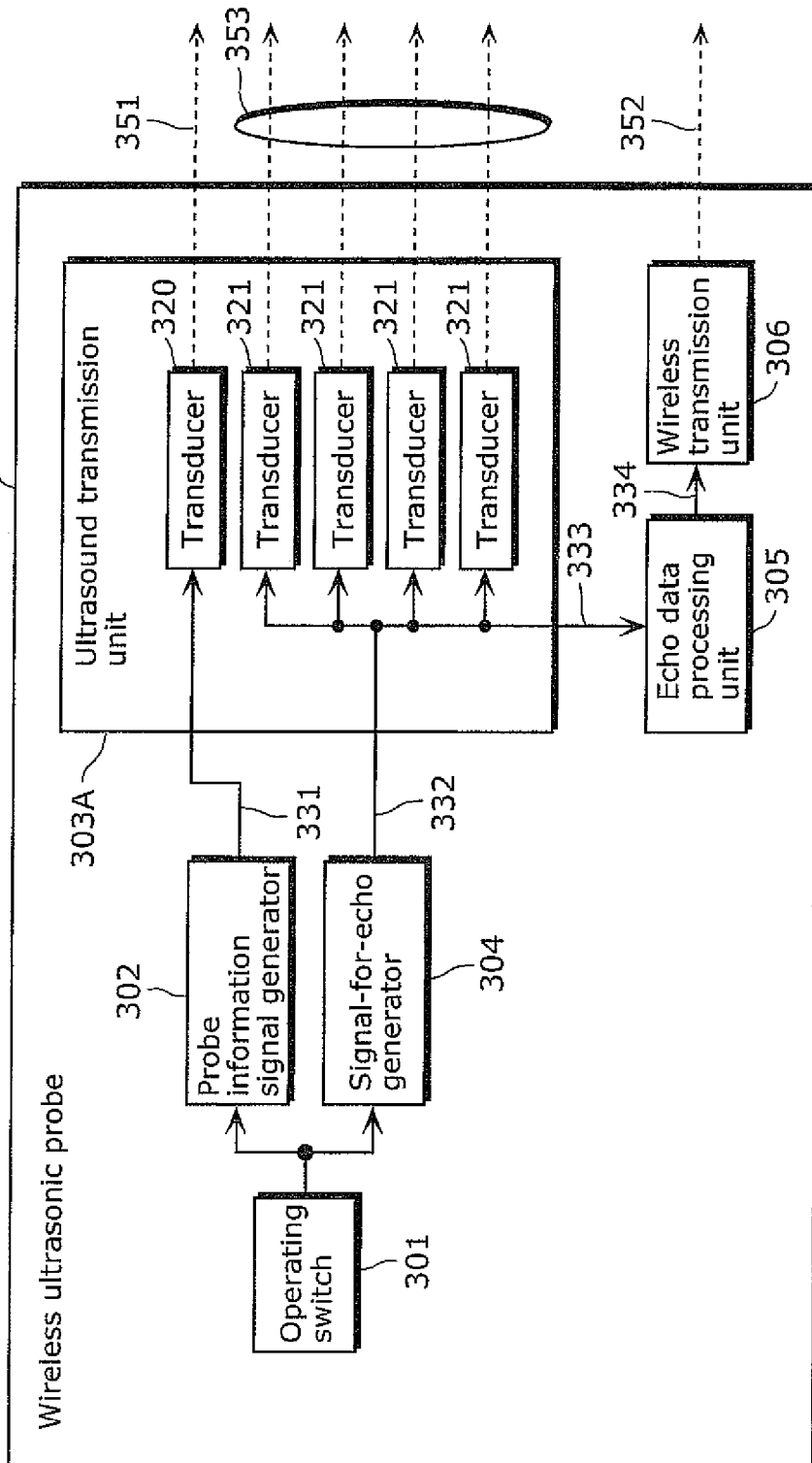


FIG. 13

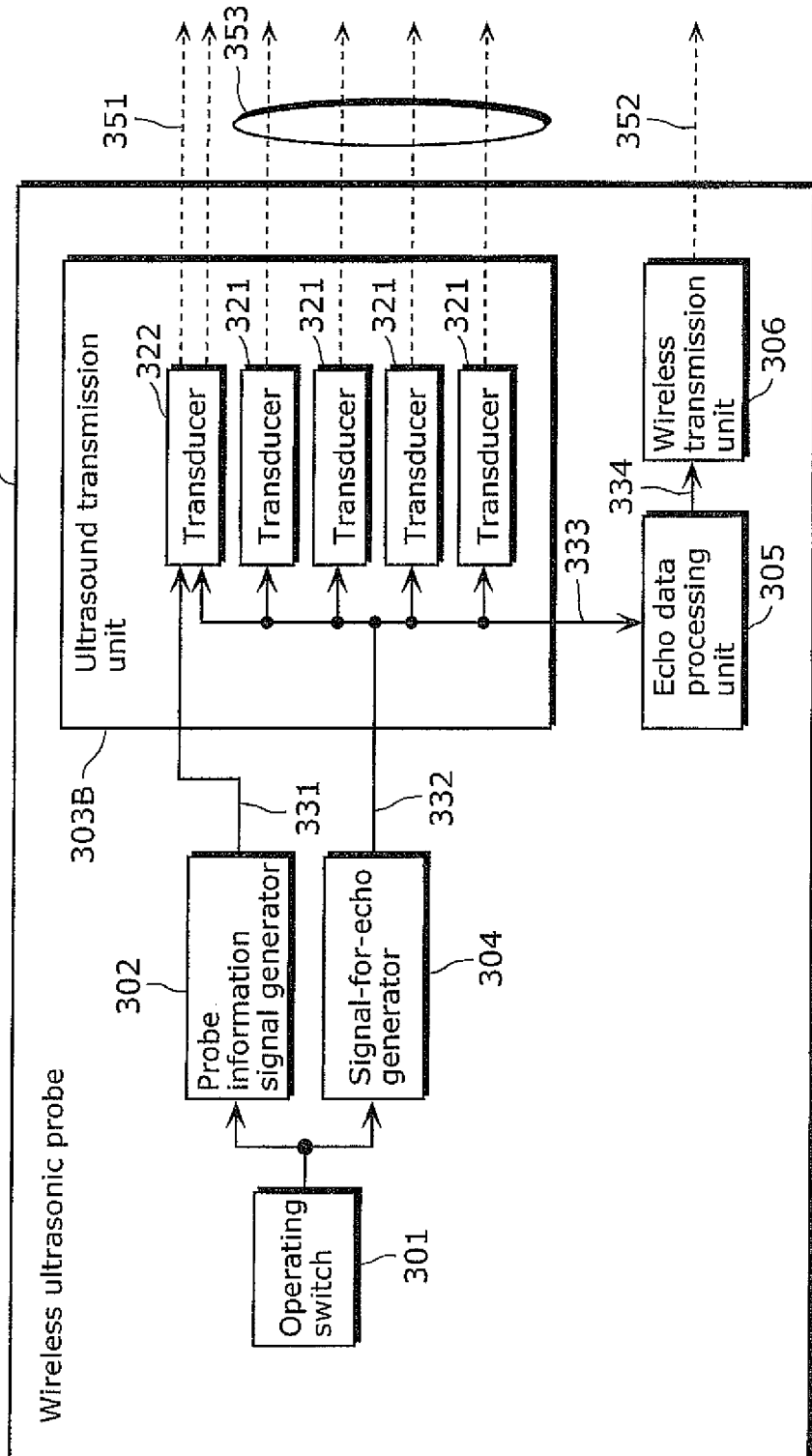


FIG. 14

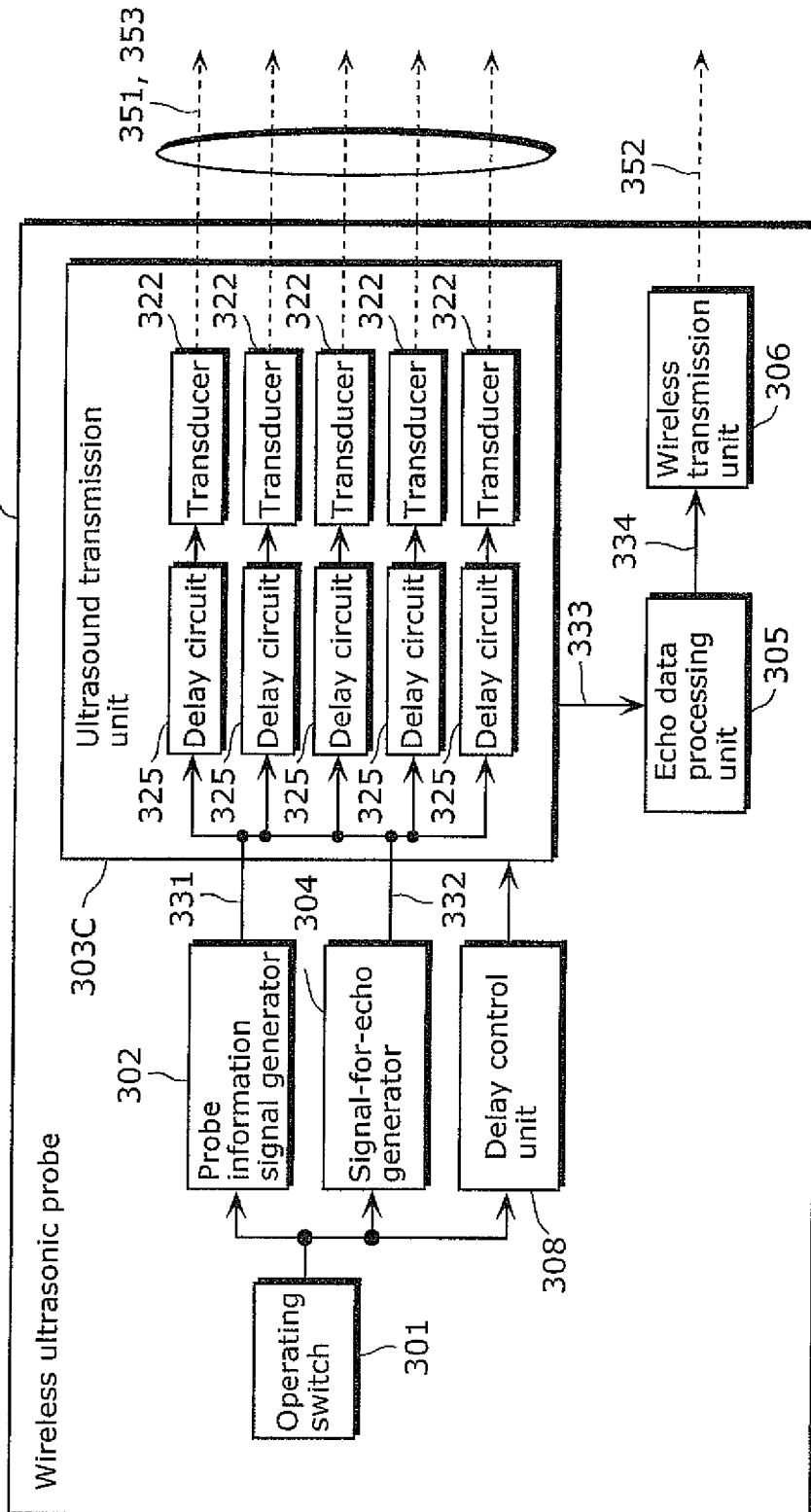


FIG. 15

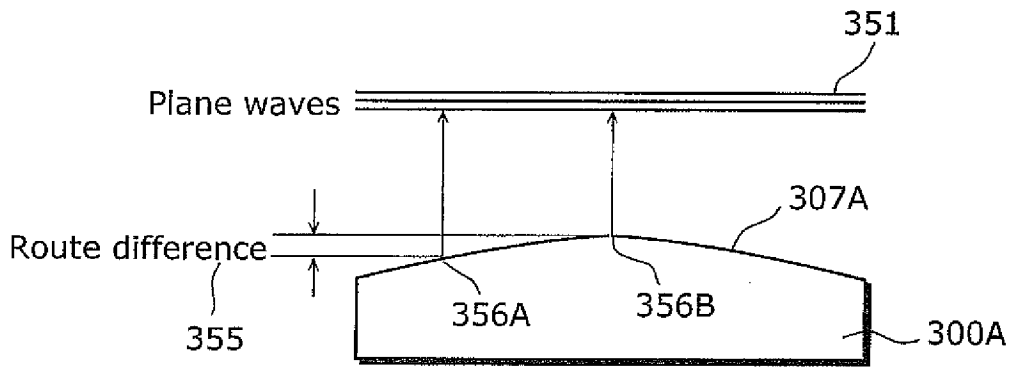


FIG. 16

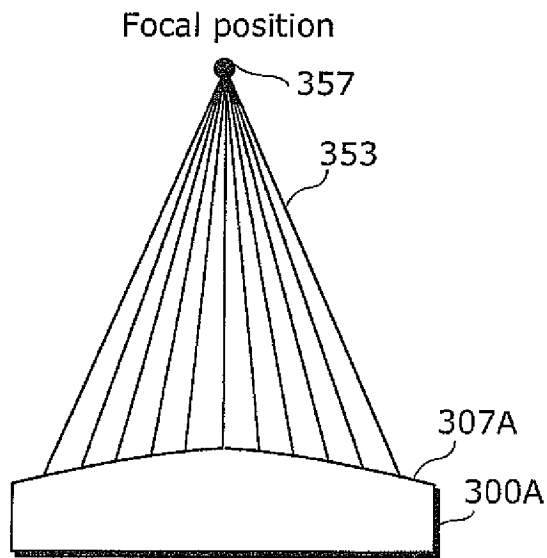


FIG. 17

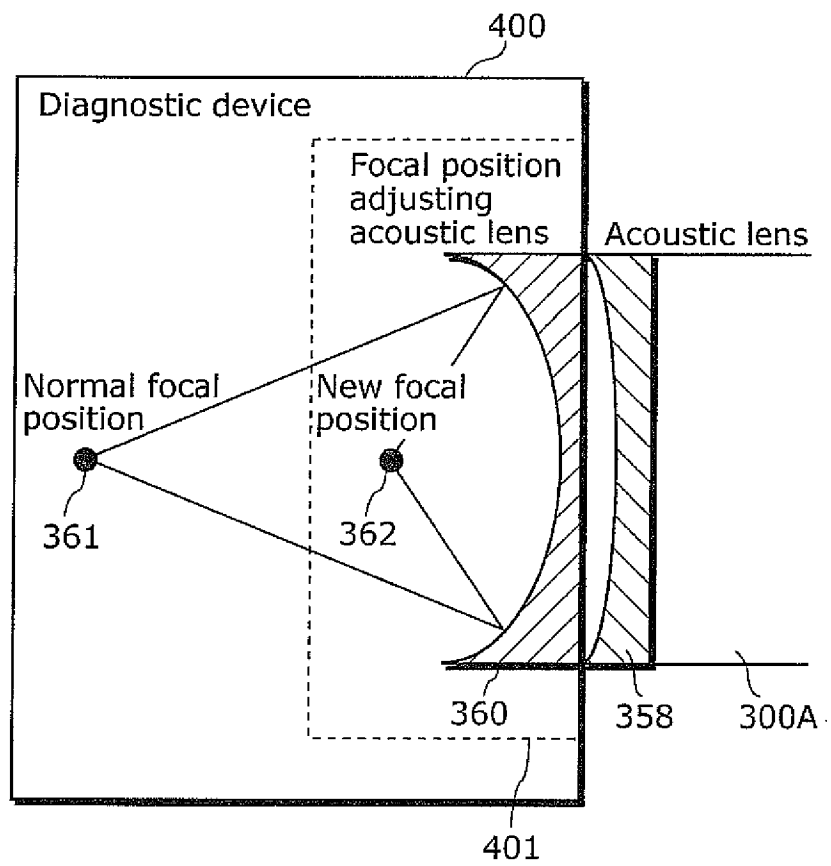


FIG. 18

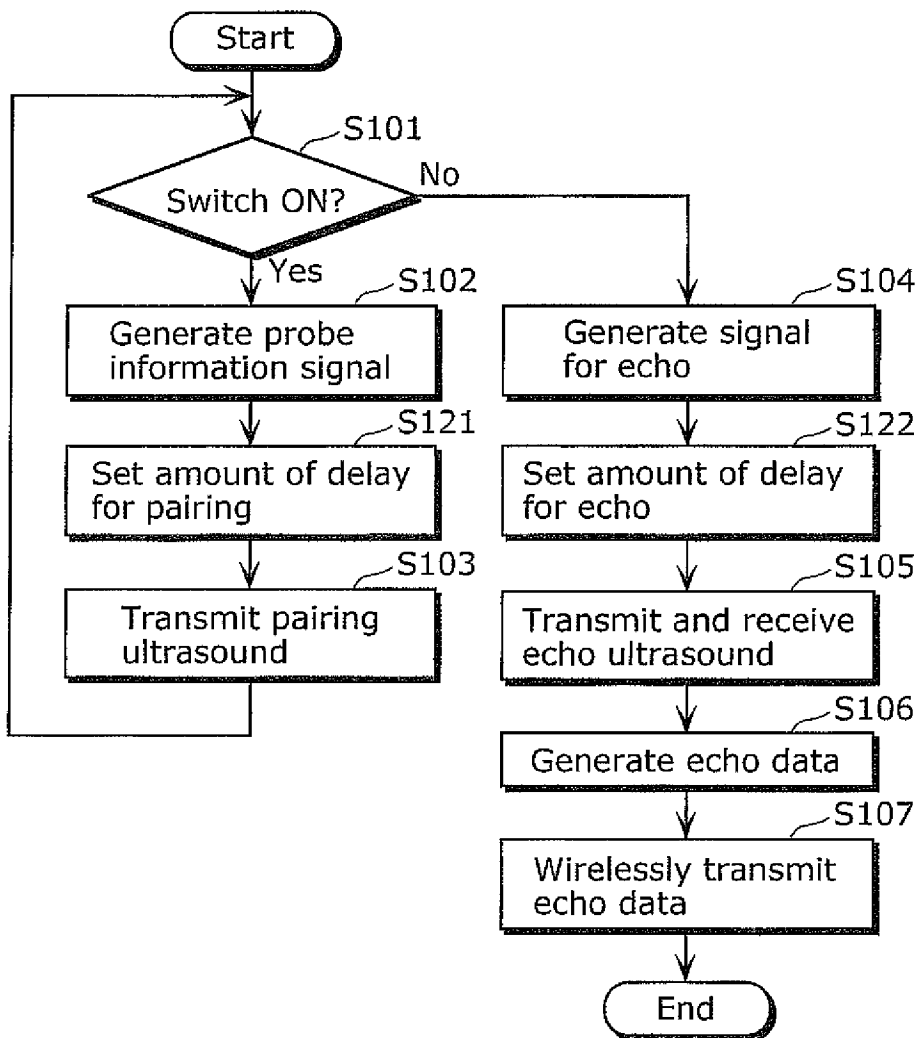


FIG. 19

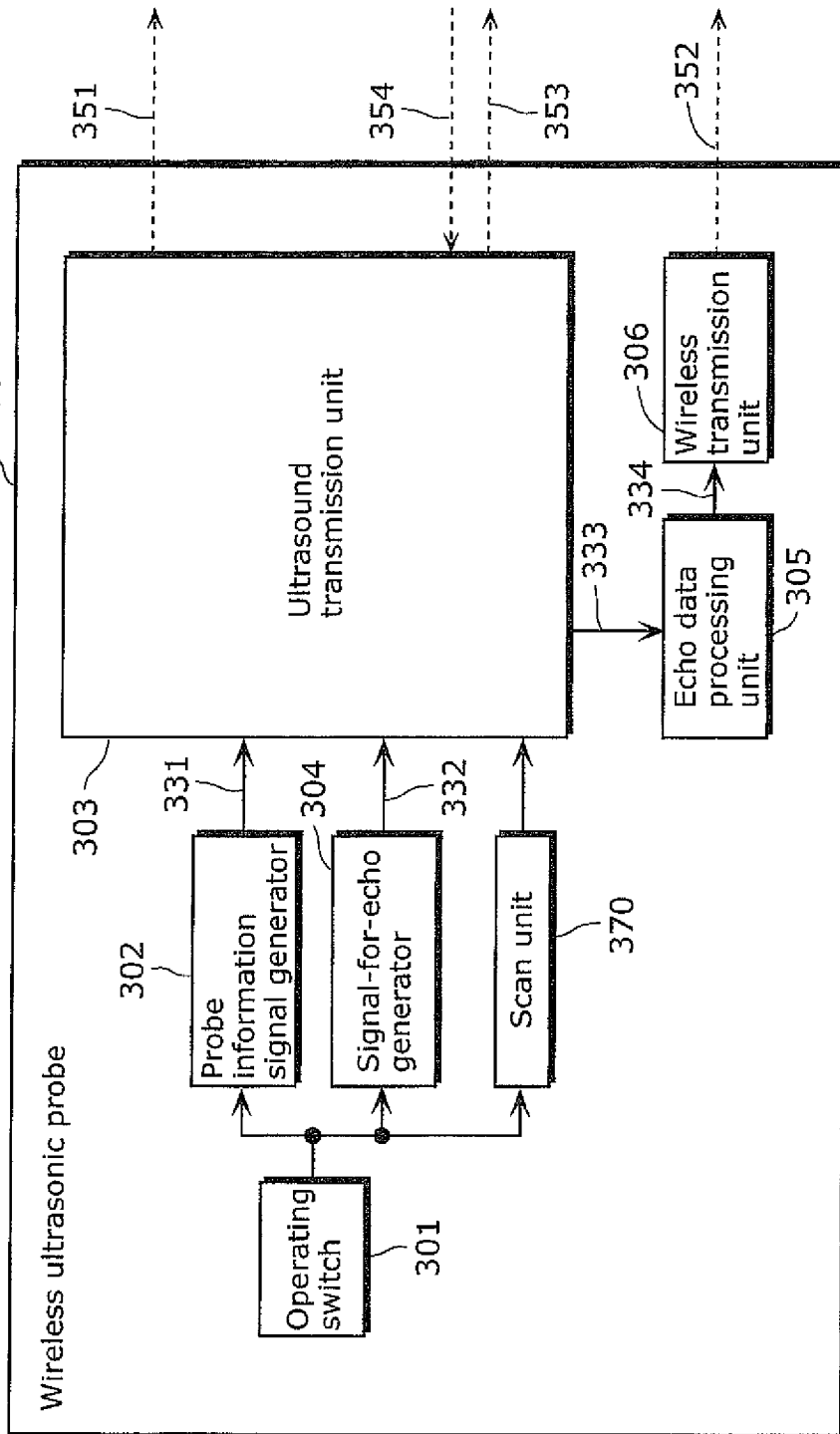
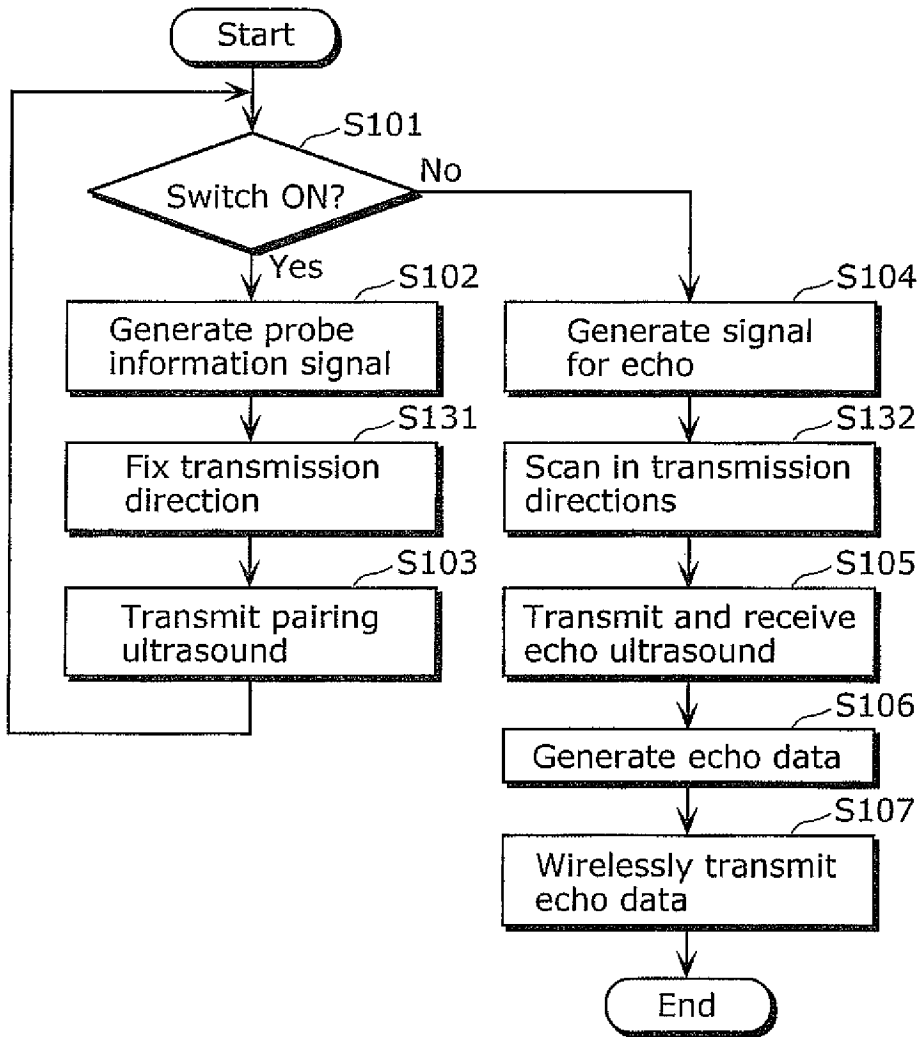
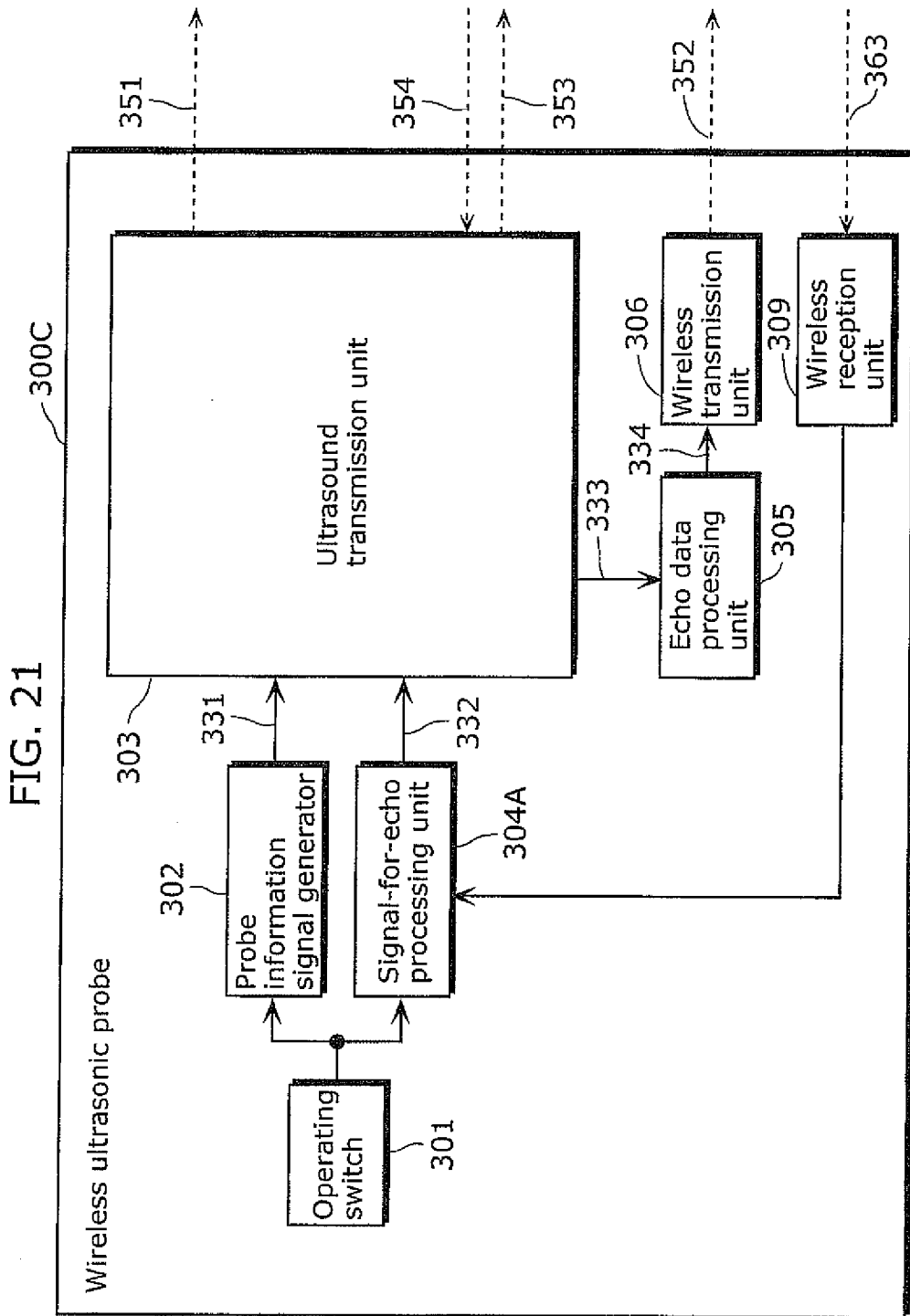


FIG. 20





## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2010/002892

A. CLASSIFICATION OF SUBJECT MATTER A61B8/00(2006.01) i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) A61B8/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2010 Kokai Jitsuyo Shinan Koho 1971-2010 Toroku Jitsuyo Shinan Koho 1994-2010		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2008-253500 A (Toshiba Corp., Toshiba Medical Systems Corp.), 23 October 2008 (23.10.2008), paragraphs [0021] to [0023]; fig. 1 (Family: none)	1-18
A	JP 2006-95071 A (Hitachi Medical Corp.), 13 April 2006 (13.04.2006), paragraphs [0017], [0018]; fig. 2 (Family: none)	1-18
A	JP 2007-244579 A (Aloka Co., Ltd.), 27 September 2007 (27.09.2007), paragraph [0026] (Family: none)	1-18
<input type="checkbox"/> Further documents are listed in the continuation of Box C.		<input type="checkbox"/> See patent family annex.
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Date of the actual completion of the international search 24 June, 2010 (24.06.10)		Date of mailing of the international search report 06 July, 2010 (06.07.10)
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**Patent documents cited in the description**

- JP 2007244579 A [0004]

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其他公开文献	EP2422703A1		
外部链接	<a href="#">Espacenet</a>		

#### 摘要(译)

一种无线超声诊断设备(30)，包括无线超声探头(300)和诊断设备(400)。无线超声探头(300)包括：无线传输单元(306)，其无线传输回波数据(352)；超声波发送单元(303)发送包括用于识别无线超声探头(300)的探测信息的配对超声波(351)。诊断装置(400)包括：超声接收单元(401)，其接收配对超声(351)；探测信息检测单元(402)，其从配对超声波(351)检测探测信息(452)；无线接收单元(406)使用探测信息(452)确定接收数据是否是由无线超声探测器(300)无线发送的回声数据(352)。