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(54) **ULTRASOUND DIAGNOSIS APPARATUS
AND ULTRASOUND PROBE**

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(57) **ABSTRACT**

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An ultrasound diagnosis apparatus according to an embodiment includes an ultrasound probe and transmitter circuitry. The ultrasound probe is connected to a body through a cable and includes an ultrasound transducer element to transmit and receive an ultrasound wave. The transmitter circuitry generates transmission waveform data, generates, from the generated transmission waveform data, transmission signals that the ultrasound probe uses for transmitting ultrasound waves, and outputs the generated transmission signals to the ultrasound probe. When causing the ultrasound probe to transmit a plurality of ultrasound waves with different phases successively depending on a transmission condition, the transmitter circuitry generates transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range, by using the transmission signals detected between the cable and the ultrasound transducer element.

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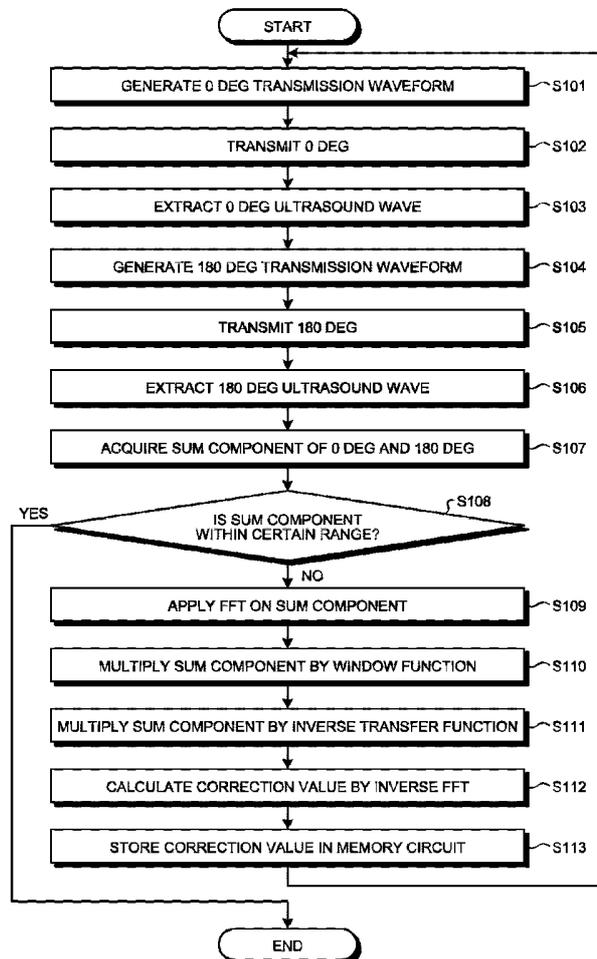


FIG. 1

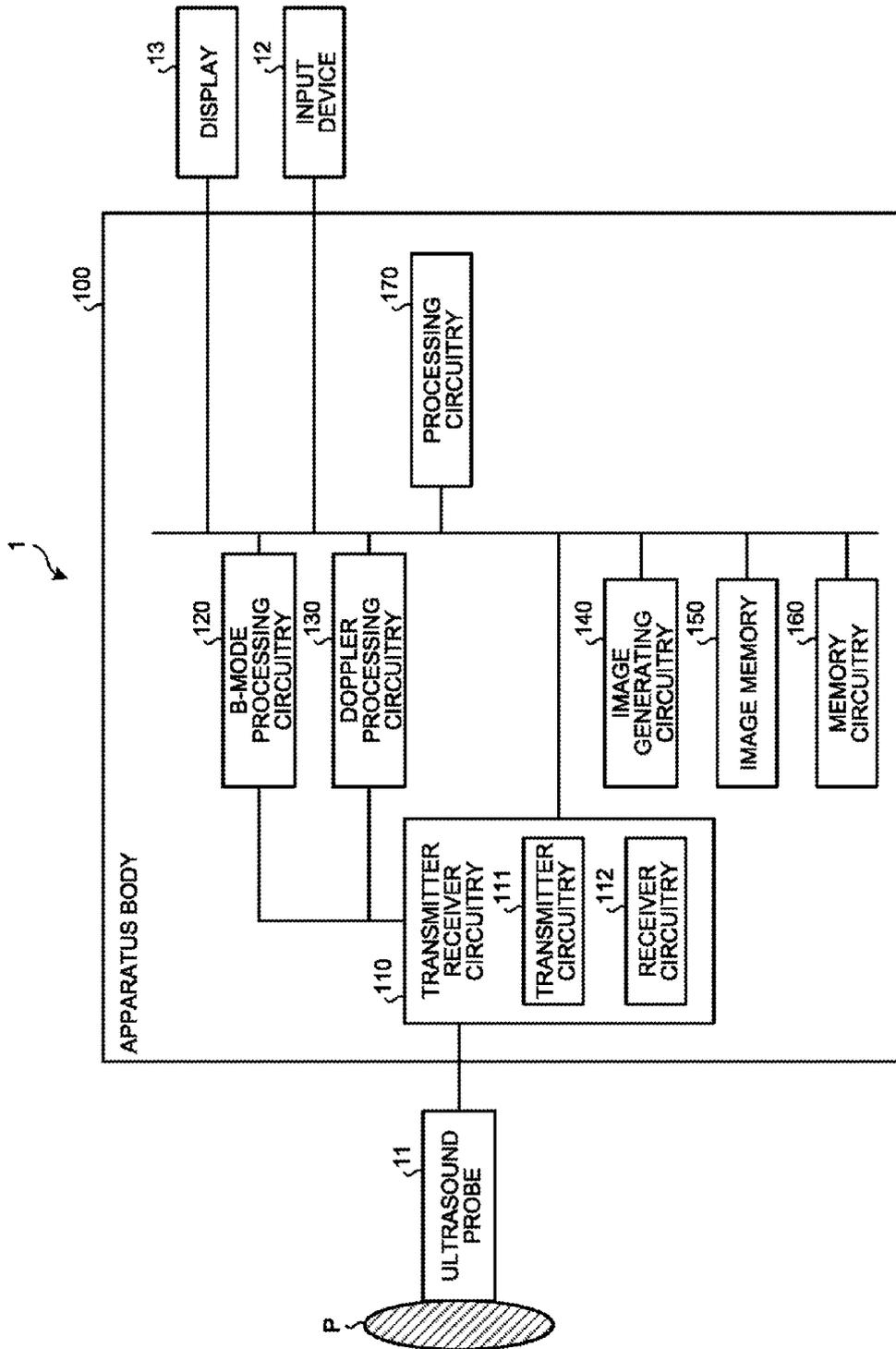


FIG.2

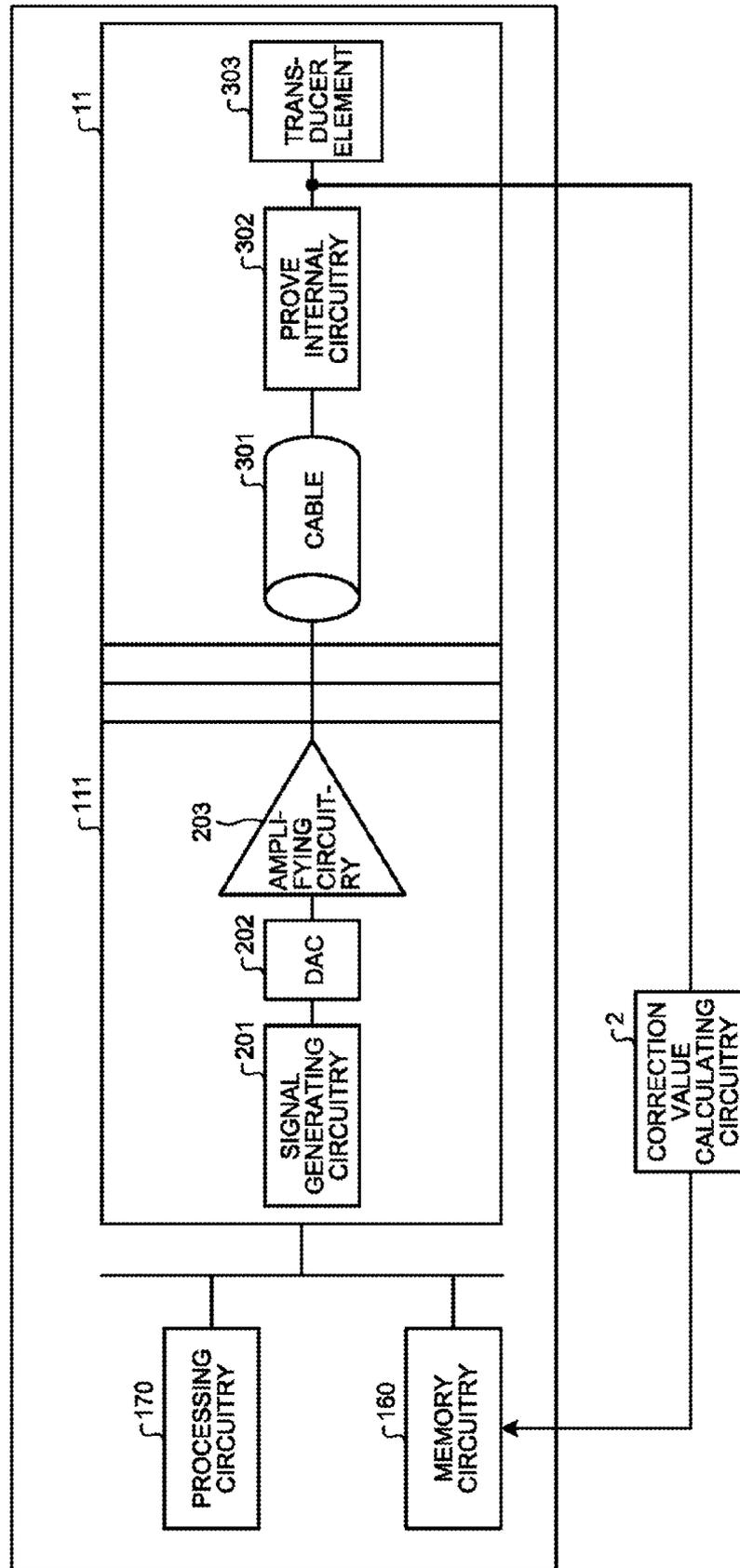


FIG.3

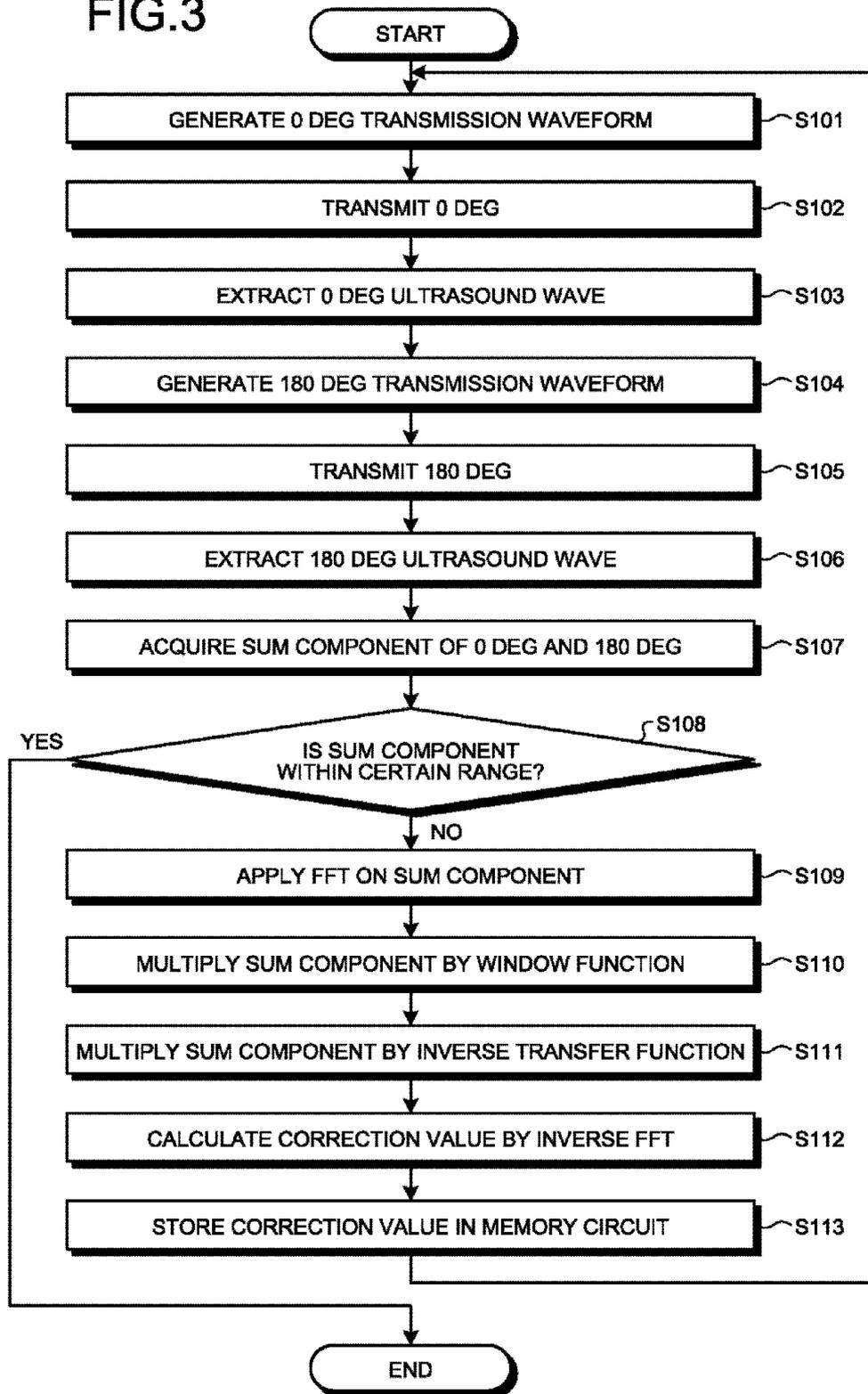


FIG.4

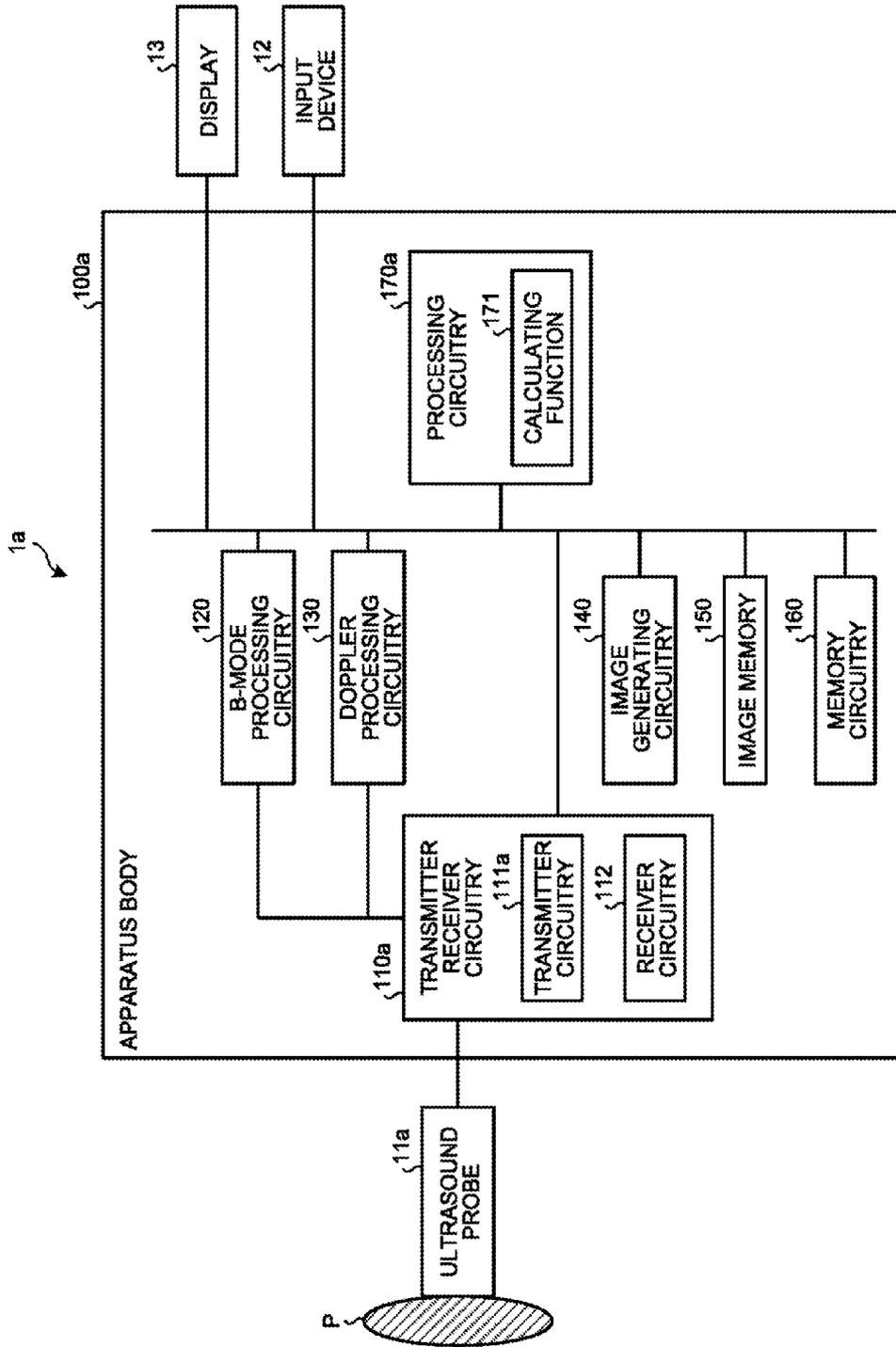


FIG. 5

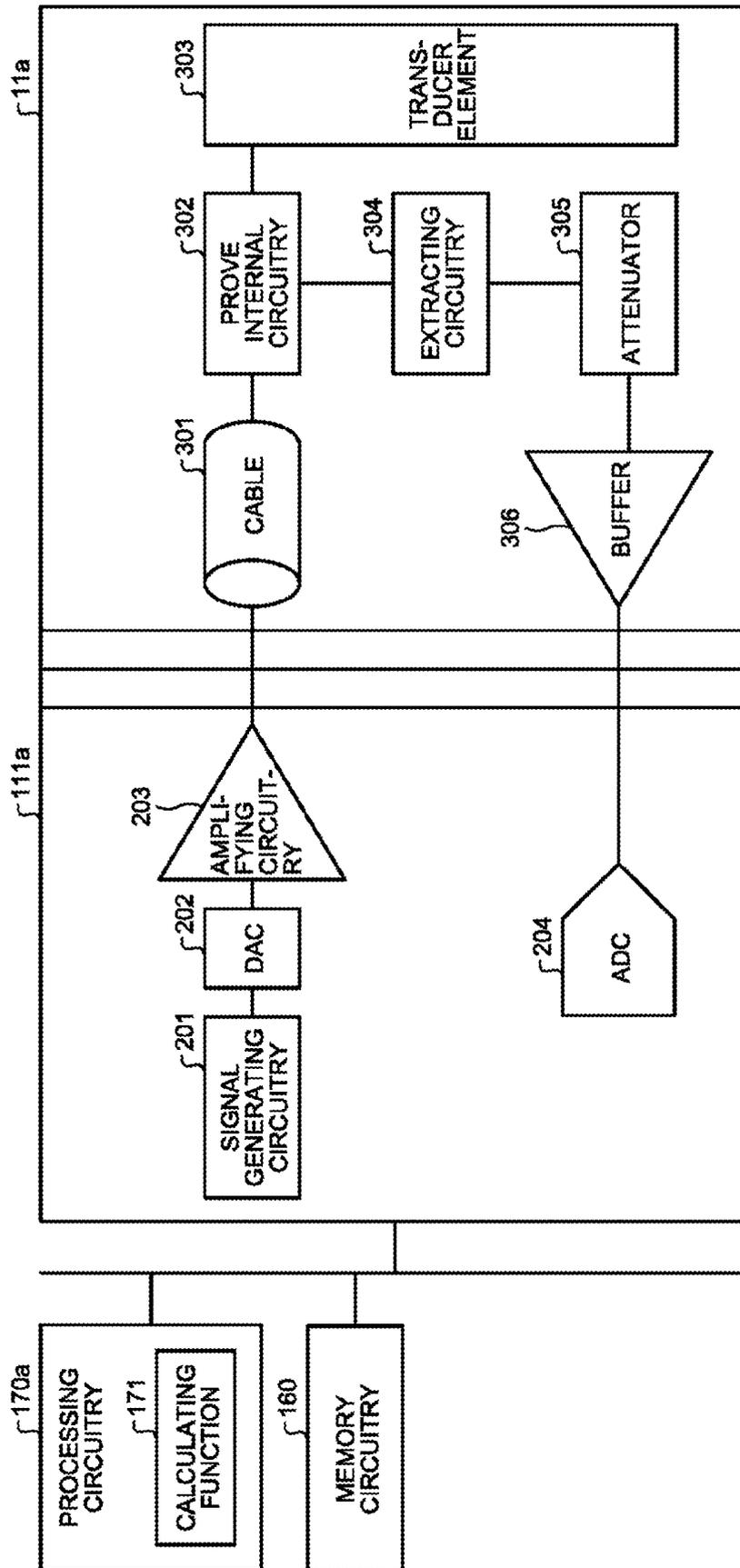
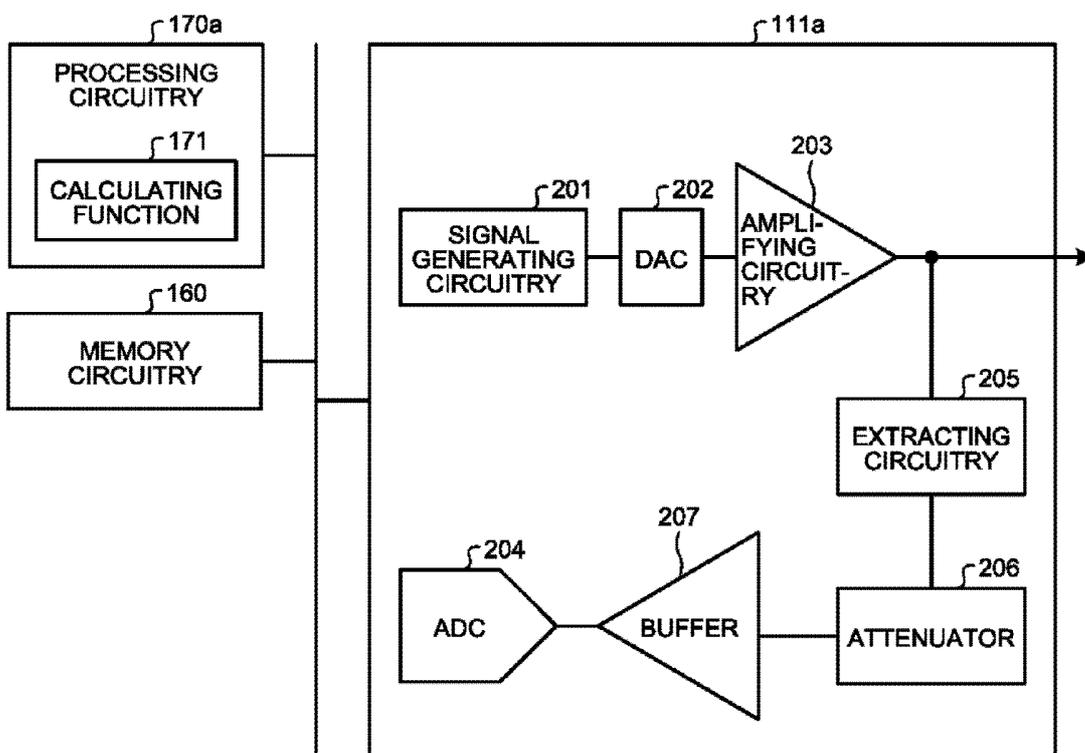


FIG.6



ULTRASOUND DIAGNOSIS APPARATUS AND ULTRASOUND PROBE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2015-188810, filed on Sep. 25, 2015, and Japanese Patent Application No. 2016-177643, filed on Sep. 12, 2016; the entire contents of which are incorporated herein by reference.

FIELD

[0002] Embodiments described herein relate to an ultrasound diagnosis apparatus and an ultrasound probe.

BACKGROUND

[0003] There has been a method for visualization in which a plurality of ultrasound waves with different phases are transmitted successively and nonlinear components (for example, harmonic components such as second harmonic components) contained in reception signals are used. In this method, for example, two ultrasound waves having an identical amplitude and inversed phases are transmitted successively for each scan line, and two reception signals received in this process are added. This addition processing cancels out fundamental components, and provides a signal mainly containing second harmonic components generated in a second nonlinear propagation. This signal is used to visualize the second harmonic components.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1 is a block diagram illustrating an exemplary configuration of an ultrasound diagnosis apparatus according to a first embodiment;

[0005] FIG. 2 is a diagram for explaining the first embodiment;

[0006] FIG. 3 is a flowchart illustrating a procedure of calculating a correction value according to the first embodiment;

[0007] FIG. 4 is a block diagram illustrating an exemplary configuration of an ultrasound diagnosis apparatus according to a second embodiment;

[0008] FIG. 5 is a diagram for explaining the second embodiment; and

[0009] FIG. 6 is a diagram for explaining a modification of the second embodiment.

DETAILED DESCRIPTION

[0010] The following describes an ultrasound diagnosis apparatus and an ultrasound probe according to embodiments with reference to the drawings. The embodiments are not limited to the embodiments described below. The content of one embodiment is basically applied to another embodiment as well.

[0011] An ultrasound diagnosis apparatus according to an embodiment includes an ultrasound probe and transmitter circuitry. The ultrasound probe is connected to a body through a cable and includes an ultrasound transducer element to transmit and receive an ultrasound wave. The transmitter circuitry generates transmission waveform data, generates, from the generated transmission waveform data,

transmission signals that the ultrasound probe uses for transmitting ultrasound waves, and outputs the generated transmission signals to the ultrasound probe. When causing the ultrasound probe to transmit a plurality of ultrasound waves with different phases successively depending on a transmission condition, the transmitter circuitry generates transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range, by using the transmission signals detected between the cable and the ultrasound transducer element.

First Embodiment

[0012] FIG. 1 is a block diagram illustrating an exemplary configuration of an ultrasound diagnosis apparatus 1 according to a first embodiment. As illustrated in FIG. 1, the ultrasound diagnosis apparatus 1 according to the first embodiment includes an ultrasound probe 11, an input device 12, a display 13, and an apparatus body 100. The ultrasound probe 11 is communicably connected to transmitter receiver circuitry 110 described later, which is included in the apparatus body 100. The input device 12 and the display 13 are communicably connected to various circuits included in the apparatus body 100.

[0013] The ultrasound probe 11 is connected to the apparatus body 100 through a cable. In addition, the ultrasound probe 11 is brought into contact with a body surface of a subject P and transmits and receives ultrasound waves. For example, the ultrasound probe 11 includes a plurality of piezoelectric transducer elements (also referred to as transducer elements or ultrasound transducer elements) for transmitting and receiving ultrasound waves. These piezoelectric transducer elements generate ultrasound waves based on transmission signals supplied from the transmitter receiver circuitry 110. The generated ultrasound waves are reflected in body tissue in the subject P and are received by the piezoelectric transducer elements in the form of reflected wave signals. The ultrasound probe 11 transmits the reflected wave signals received by the piezoelectric transducer elements to the transmitter receiver circuitry 110.

[0014] The first embodiment can be applied to the ultrasound probe 11 whether the ultrasound probe 11 is a one-dimensional (1D) array probe that scans (two-dimensionally scans) a two-dimensional region inside the subject P or such a probe as a mechanical four-dimensional (4D) probe or a two-dimensional (2D) array probe that scans (three-dimensionally scans) a three-dimensional region inside the subject P.

[0015] The input device 12 corresponds to, for example, a mouse, a keyboard, a button, a panel switch, a touch command screen, a foot switch, a trackball, a joystick, or other devices. The input device 12 receives various setting requests from an operator of the ultrasound diagnosis apparatus 1 and forwards the received various setting requests to various circuits in the apparatus body 100 as appropriate.

[0016] The display 13 displays a graphical user interface (GUI) used by the operator for inputting various setting requests using the input device 12 and displays, for example, images (ultrasound images) based on ultrasound image data generated by the apparatus body 100.

[0017] The apparatus body 100 is an apparatus that generates ultrasound image data based on the reflected wave signals received by the ultrasound probe 11. As illustrated in FIG. 1, the apparatus body 100 includes, for example, the

transmitter receiver circuitry 110, B-mode processing circuitry 120, Doppler processing circuitry 130, image generating circuitry 140, image memory 150, memory circuitry 160, and processing circuitry 170. The transmitter receiver circuitry 110, the B-mode processing circuitry 120, the Doppler processing circuitry 130, the image generating circuitry 140, the image memory 150, the memory circuitry 160, and the processing circuitry 170 are communicably connected to one another.

[0018] The transmitter receiver circuitry 110 controls transmission and reception of ultrasound waves by the ultrasound probe 11. For example, the transmitter receiver circuitry 110 includes transmitter circuitry 111 and receiver circuitry 112 and controls transmission and reception of ultrasound waves by the ultrasound probe 11, based on instructions from the processing circuitry 170 described later. The transmitter circuitry 111 generates transmission waveform data and generates, from the generated transmission waveform data, transmission signals that the ultrasound probe 11 uses for transmitting ultrasound waves. The transmitter circuitry 111 applies transmission signals to the ultrasound probe 11, thereby causing transmission of an ultrasound wave beam obtained by focusing ultrasound waves into a beam shape. The receiver circuitry 112 performs addition processing by assigning certain delay times to reflected wave signals received by the ultrasound probe 11, thereby generating reflected wave data in which reflection components from a direction agreeing with the reception directivity of the reflected wave signals are emphasized, and transmits the generated reflected wave data to the B-mode processing circuitry 120 and the Doppler processing circuitry 130.

[0019] The B-mode processing circuitry 120 applies various kinds of signal processing to the reflected wave data generated by the receiver circuitry 112 from the reflected wave signals. The B-mode processing circuitry 120 applies, for example, logarithmic amplification and envelope detection processing to the reflected wave data received from the receiver circuitry 112, thereby generating data (B-mode data) in which the signal intensity of each sample point (observation point) is expressed in brightness of luminance. The B-mode processing circuitry 120 transmits the generated B-mode data to the image generating circuitry 140.

[0020] In addition, the B-mode processing circuitry 120 performs signal processing for enabling harmonic imaging that visualizes harmonic components. Known examples of harmonic imaging include contrast harmonic imaging (CHI) and tissue harmonic imaging (THI). Known examples of a scanning method for CHI and THI include amplitude modulation and phase modulation.

[0021] The Doppler processing circuitry 130 generates, from the reflected wave data received by the receiver circuitry 112, data (Doppler data) into which pieces of motion information of a moving body based on the Doppler effect are extracted at respective sample points in a scanned region. Specifically, the Doppler processing circuitry 130 generates Doppler data into which average velocities, dispersion values, power values, or other values are extracted as the pieces of motion information of the moving body at the respective sample points. Examples of the moving body include a blood flow, tissue of a cardiac wall, and a contrast agent. The Doppler processing circuitry 130 transmits the generated Doppler data to the image generating circuitry 140.

[0022] The image generating circuitry 140 generates ultrasound image data from the data generated by the B-mode processing circuitry 120 and the Doppler processing circuitry 130. For example, the image generating circuitry 140 generates, from the B-mode data generated by the B-mode processing circuitry 120, B-mode image data in which the intensity of a reflected wave is expressed in luminance. The image generating circuitry 140 also generates Doppler image data representing moving body information from the Doppler data generated by the Doppler processing circuitry 130. The Doppler image data is speed image data, dispersion image data, power image data, or image data obtained by combining any of the foregoing data.

[0023] The image memory 150 is a memory that stores therein data generated by the B-mode processing circuitry 120, the Doppler processing circuitry 130, and the image generating circuitry 140. For example, the image memory 150 stores therein the ultrasound image data generated by the image generating circuitry 140, in association with electrocardiographic waveforms of the subject P. When the amount of data to be stored in the image memory 150 exceeds the memory capacity of the image memory 150, relatively old data is deleted and updated.

[0024] The memory circuitry 160 is a storage device that stores therein various kinds of data. For example, the memory circuitry 160 stores therein: control programs for performing transmission and reception of ultrasound waves, image processing, and display processing; diagnosis information (for example, patient IDs and doctor's opinions); and various kinds of data such as diagnosis protocols and various body marks. Data stored in the memory circuitry 160 can be transferred to an external device via an interface (not illustrated).

[0025] In addition, the memory circuitry 160 stores therein data generated by the B-mode processing circuitry 120, the Doppler processing circuitry 130, and the image generating circuitry 140. For example, the memory circuitry 160 stores therein ultrasound image data corresponding to a certain number of heartbeats as specified by the operator. The memory circuitry 160 is one example of storage circuitry that stores therein a plurality of images acquired by scanning the subject P for a certain time period.

[0026] The processing circuitry 170 controls all processing in the ultrasound diagnosis apparatus 1. Specifically, based on various setting requests input from the operator via the input device 12 and various control programs and various data loaded from the memory circuitry 160, the processing circuitry 170 controls processing in the transmitter receiver circuitry 110, the B-mode processing circuitry 120, the Doppler processing circuitry 130, and the image generating circuitry 140. The processing circuitry 170 causes the display 13 to display ultrasound image data stored in the image memory 150.

[0027] Furthermore, a plurality of components in FIG. 1 may be integrated into one processor to implement the functions thereof. The term "processor" used in the foregoing descriptions means, for example, a central processing unit (CPU), a graphics processing unit (GPU), or a circuit such as an application specific integrated circuit (ASIC) or a programmable logic device (examples of which include a simple programmable logic device (SPLD), a complex programmable logic device (CPLD), and a field programmable gate array (FPGA)). The processor reads out a computer program stored in memory circuitry and executes the com-

puter program to implement a function. Instead of being stored in the memory circuitry 160, the computer program may be configured to be embedded directly in a circuit of the processor. In this case, the processor reads out the computer program embedded in the circuitry and executes the computer program to implement the function. Each processor of this embodiment is not limited to a processor configured as a single circuit, and may be configured as a single processor having a plurality of independent circuits combined therein to implement an intended function.

[0028] The ultrasound diagnosis apparatus 1 configured as above may perform, for example, harmonic imaging by a method in which a plurality of ultrasound waves with different phases are transmitted successively to visualize harmonic components. With reference to FIG. 2, the following describes transfer of transmission signals between the transmitter circuitry 111 and the ultrasound probe 11 in the case of performing harmonic imaging by the method in which a plurality of ultrasound waves with different phases are transmitted successively to visualize harmonic components. FIG. 2 is a diagram for explaining the first embodiment. For the convenience of description, FIG. 2 illustrates the ultrasound probe 11, the transmitter circuitry 111, the memory circuitry 160, and the processing circuitry 170 among the components included in the ultrasound diagnosis apparatus 1. As illustrated in FIG. 2, correction value calculating circuitry 2 is connected to the ultrasound diagnosis apparatus 1.

[0029] As illustrated in FIG. 2, the transmitter circuitry 111 includes signal generating circuitry 201, a digital-analog converter (DAC) 202, and amplifying circuitry 203. The transmitter circuitry 111 generates transmission waveform data, generates, from the generated transmission waveform data, transmission signals that the ultrasound probe 11 uses for transmitting ultrasound waves, and outputs the generated transmission signals to the ultrasound probe 11.

[0030] The signal generating circuitry 201 generates the transmission waveform data, and outputs the generated transmission waveform data to the DAC 202. The following exemplifies a case in which the ultrasound probe 11 transmits an ultrasound wave with a phase of 0 degrees and an ultrasound wave with a phase of 180 degrees. In this case, the signal generating circuitry 201 generates transmission waveform data of the ultrasound wave with a phase of 0 degrees (0 deg transmission waveform data) and transmission waveform data of the ultrasound wave with a phase of 180 degrees (180 deg transmission waveform data). That is, the signal generating circuitry 201 generates a plurality of pieces of transmission waveform data that causes a sum component to be zero. The signal generating circuitry 201 outputs the generated 0 deg transmission waveform data and 180 deg transmission waveform data to the DAC 202.

[0031] The DAC 202 converts the transmission waveform data to analog signals, and outputs the converted analog signals of the transmission waveform data to the amplifying circuitry 203. The amplifying circuitry 203 amplifies the analog signals of the transmission waveform data to generate transmission signals, and outputs the generated transmission signals to the ultrasound probe 11.

[0032] As illustrated in FIG. 2, the ultrasound probe 11 includes a cable 301, probe internal circuitry 302, and a transducer element 303. The cable 301 outputs the transmission signals generated by the transmitter circuitry 111 to the probe internal circuitry 302. The probe internal circuitry

302 includes a semiconductor switch for switching the cable 301, a semiconductor switch for switching the transducer element 303, and serial or parallel tuning circuitry including an inductor or other elements. The transducer element 303 transmits and receives ultrasound waves based on the transmission signals generated from the transmission waveform data by the apparatus body 100 of the ultrasound diagnosis apparatus 1.

[0033] In some cases, although the transmitter circuitry 111 has generated a plurality of pieces of transmission waveform data that causes a sum component to be zero, the sum component of transmission signals applied to the ultrasound probe 11 or the sum component of ultrasound waves transmitted from the ultrasound probe 11 may not completely be canceled out and may leave a residual component.

[0034] Specifically, the amplifying circuitry 203 of the transmitter circuitry 111 generates a transmission signal with positive phase polarity and a transmission signal with negative phase polarity by a p-type semiconductor using holes as carriers and a n-type semiconductor using electrons as carriers. In this configuration, ensuring the symmetry of the phase polarities of transmission signals may be difficult. In addition, the impedance of the transducer element 303 changes between positive amplitude and negative amplitude of transmission signals. This change causes asymmetry of phase polarities. The degree of asymmetry of the phase polarities in the transducer element 303 increases at larger amplitude.

[0035] A residual component of the transmission signals left in the frequency band of a harmonic component generates a problem of degraded signal to noise (S/N) ratio. Specifically, reflected wave signals obtained by transmitting ultrasound waves based on two transmission signals include a harmonic component generated from nonlinearity of a living body intended to be imaged, and a reflected wave signal for the residual component of the transmission signals. The reflected wave signal for the residual component of the transmission signals is not canceled out and imaged as noise.

[0036] Thus, when causing the ultrasound probe 11 to transmit a plurality of ultrasound waves with different phases successively depending on a transmission condition, the transmitter circuitry 111 of the ultrasound diagnosis apparatus 1 according to the first embodiment generates transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range, by using transmission signals detected between the cable and the ultrasound transducer element. For example, the transmitter circuitry 111 generates transmission waveform data based on a plurality of pieces of uncorrected transmission waveform data corresponding to a plurality of respective ultrasound waves transmitted successively depending on a transmission condition and causing a sum component to be zero, and a correction value dependent on the transmission condition.

[0037] The memory circuitry 160, for example, stores therein the correction value dependent on the transmission condition. For example, the correction value is set depending on a mode such as THI, CHI, or phase modulation. When receiving a mode selected by the operator via the GUI displayed on the display 13, for example, the transmitter circuitry 111 reads out the correction value of the selected mode and generates transmission waveform data. The correction value may be set in association with transmission

voltage and transmission frequency. In this case, for example, when receiving a transmission voltage and a transmission frequency selected by the operator via the GUI displayed on the display 13, the transmitter circuitry 111 reads out the associated correction value and generates transmission waveform data.

[0038] The following describes calculation processing of the correction value. The first embodiment describes a case in which the correction value is calculated, for example, by an apparatus other than the ultrasound diagnosis apparatus 1 before shipment of the ultrasound diagnosis apparatus 1. In this case, it is assumed that the correction value calculating circuitry 2 calculates the correction value. Calculation processing of the correction value is preferably performed by bringing the ultrasound probe 11 into contact with a subject having acoustic impedance similar to that of a living body, such as water or a phantom. The correction value calculating circuitry 2 is an example calculation circuitry.

[0039] The transmitter circuitry 111 generates a plurality of pieces of uncorrected transmission waveform data corresponding to a plurality of respective ultrasound waves transmitted successively depending on a transmission condition and causing a sum component to be zero, and then generates a plurality of uncorrected transmission signals corresponding to the respective generated pieces of uncorrected transmission waveform data. For example, the transmission signals generated from the uncorrected transmission waveform data generated by the signal generating circuitry 201 deform due to noise or other factors mixed in before the transmission signals are applied to the transducer element 303. That is, a transmission signal obtained by logical conversion of the uncorrected transmission waveform data generated by the signal generating circuitry 201 from which mixed noise or other factors are removed differs from an actual transmission signal applied to the transducer element 303.

[0040] Specifically, noise or other factors are mixed in the logically converted transmission signal while the transmission signal is processed by the DAC 202, the amplifying circuitry 203, or other circuits, and passing through the probe internal circuitry 302 of the ultrasound probe 11. A logical transmission signal with a phase of 0 degrees is denoted as $\text{Sin } p$ and a logical transmission signal with a phase of 180 degrees is denoted as $\text{Sin } n$ when the uncorrected transmission waveform data generated by the signal generating circuitry 201 is assumed to be converted to logical transmission signals from which noise or other factors are removed.

[0041] The correction value calculating circuitry 2 acquires, as an uncorrected sum component, a sum component of the uncorrected transmission signals acquired at a point in time from immediately after generation of the signals to immediately before application of the signals to the transducer element 303 in the ultrasound probe 11, or a sum component of the uncorrected ultrasound waves each acquired at the point when the ultrasound probe 11 transmits the ultrasound waves based on the respective uncorrected transmission signals. For example, the correction value calculating circuitry 2 acquires the plurality of the uncorrected transmission signals from the probe internal circuitry 302 and acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals. The sum component of the uncorrected transmission signals is represented as a time-

base waveform $\Delta\text{So}(t)$ by “ $\text{Sop}(t)+\text{Son}(t)$ ”, where Sop is the acquired uncorrected transmission signal with a phase of 0 degrees and Son is the acquired uncorrected transmission signal with a phase of 180 degrees. The correction value calculating circuitry 2 calculates a correction value based on the acquired uncorrected sum component. That is, $\Delta\text{So}(t)$ is a residual component of the transmission waveforms that has not been canceled. The correction value of the transmission waveform data is calculated such that $\Delta\text{So}(t)$ is within a certain range. The following describes a case of calculating a correction value that provides a minimum $\Delta\text{So}(t)$.

[0042] For example, the correction value calculating circuitry 2 applies fast Fourier transform (FFT) to $\Delta\text{So}(t)$ to convert $\Delta\text{So}(t)$ to a frequency spectrum $\Delta\text{So}(\omega)$. On the frequency axis, the correction value calculating circuitry 2 multiplies $\Delta\text{So}(\omega)$ by a frequency window function that weights a frequency band that needs to be canceled. For example, the correction value calculating circuitry 2 multiplies a frequency band of a nonlinear component of a living body, the frequency band being around second harmonic components, by the frequency window function. That is, the correction value calculating circuitry 2 derives a frequency spectrum by weighting a certain frequency band corresponding to the transmission condition in the frequency spectrum of the uncorrected sum component.

[0043] Subsequently, the correction value calculating circuitry 2 calculates a conversion component from a conversion spectrum calculated from a conversion function and the frequency spectrum obtained by weighting a certain frequency band corresponding to the transmission condition in the frequency spectrum of the uncorrected sum component. The conversion function is a function that corrects a waveform by considering noise so as to convert the waveform back to that of the transmission waveform data that has been used to generate the waveform, the waveform acquired at a point in time from immediately after generation of signals to immediately before application of the signals to the transducer element 303 in the ultrasound probe 11, or at the point when the ultrasound probe 11 transmits the waveform based on corresponding one of the uncorrected transmission signals. In other words, the conversion function converts a frequency spectrum of a waveform acquired at a point in time from immediately after generation of signals to immediately before application of the signals to the transducer element 303 in the ultrasound probe 11, or a frequency spectrum of a waveform acquired at the point when the ultrasound probe 11 transmits the waveform based on corresponding one of the uncorrected transmission signals, back to the frequency spectrum of a waveform of the transmission waveform data that has been used to generate the waveform at the point in time.

[0044] The conversion function for the uncorrected transmission signal with a phase of 0 degrees, Sop , is denoted as $\text{Hinvp}(\omega)$, and the conversion function for the uncorrected transmission signal with a phase of 180 degrees, Son , is denoted as $\text{Hinvn}(\omega)$. A conversion function is set for each transmission condition. For example, the conversion function is determined depending on a transmission voltage and a transmission frequency in a transmission condition. The conversion function may be set for each mode. For example, the conversion function for CHI or the conversion function for THI may be set.

[0045] For example, the correction value calculating circuitry 2 calculates a correction value based on the conversion component obtained by converting the uncorrected sum component by a conversion function. Specifically, the correction value calculating circuitry 2 derives $\Delta \text{Sin}(\omega)$ by multiplying $\Delta \text{So}(\omega)$, which has been multiplied by the frequency window function, by the conversion function $\text{Hinvp}(\omega)$ or $\text{Hinvn}(\omega)$. The correction value calculating circuitry 2 may determine that halves of $\Delta \text{So}(t)$ are a nonlinear component of $\text{Sop}(t)$ and a nonlinear component of $\text{Son}(t)$, respectively, and multiply $\text{Sop}(t)$ by the conversion function $\text{Hinvp}(\omega)$ and $\text{Son}(t)$ by the conversion function $\text{Hinvn}(\omega)$. Alternatively, the correction value calculating circuitry 2 may determine $\Delta \text{So}(t)$ to be the nonlinear component of $\text{Sop}(t)$ and multiply $\text{Sop}(t)$ by the conversion function $\text{Hinvp}(\omega)$, or determine $\Delta \text{So}(t)$ to be the nonlinear component of $\text{Son}(t)$ and multiply $\text{Son}(t)$ by the conversion function $\text{Hinvn}(\omega)$.

[0046] The correction value calculating circuitry 2 applies inverse FFT to the conversion component $\Delta \text{Sin}(\omega)$ to convert $\Delta \text{Sin}(\omega)$ back to time-based representation, thereby deriving the correction value. The correction value calculating circuitry 2 stores the derived correction value in the memory circuitry 160. The transmitter circuitry 111 generates transmission waveform data by, for example, subtracting the correction value from the uncorrected transmission waveform data. The correction value calculating circuitry 2 may repeat the same correction processing on the results of ultrasound waves transmitted based on the corrected transmission waveform data. For example, the correction value calculating circuitry 2 may repeat the correction processing a certain number of times or until ΔSo reaches a certain value or smaller.

[0047] FIG. 3 is a flowchart illustrating a procedure of calculating a correction value according to the first embodiment. The transmitter circuitry 111 generates 0 deg transmission waveform data (Step S101), and causes the ultrasound probe 11 to transmit the generated 0 deg transmission waveform data (Step S102). Subsequently, the correction value calculating circuitry 2 extracts a 0 deg ultrasound wave (Step S103).

[0048] The transmitter circuitry 111 generates 180 deg transmission waveform data (Step S104), and causes the ultrasound probe 11 to transmit the generated 180 deg transmission waveform data (Step S105). Subsequently, the correction value calculating circuitry 2 extracts a 180 deg ultrasound wave (Step S106). The correction value calculating circuitry 2 acquires a sum component of the 0 deg ultrasound wave and the 180 deg ultrasound wave (Step S107).

[0049] The correction value calculating circuitry 2 determines whether the sum component is within a certain range (Step S108). If the correction value calculating circuitry 2 determines that the sum component is within the certain range (Yes at Step S108), the process ends. If the correction value calculating circuitry 2 does not determine that the sum component is within the certain range (No at Step S108), FFT is applied to the sum component (Step S109).

[0050] Subsequently, the correction value calculating circuitry 2 multiplies the sum component by a window function (Step S110), and then by an inverse transfer function (Step S111). The correction value calculating circuitry 2 applies inverse FFT to calculate a correction value (Step S112). The correction value calculating circuitry 2 stores the correction

value in the memory circuitry 160 (Step S113). After Step S113 is completed, the process proceeds to Step S101.

[0051] As described above, when causing the ultrasound probe 11 to transmit a plurality of ultrasound waves with different phases successively depending on a transmission condition, the ultrasound diagnosis apparatus 1 according to the first embodiment generates transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range. Thus, the ultrasound diagnosis apparatus 1 according to the first embodiment can reduce noise in an image of a harmonic component generated by transmitting a plurality of ultrasound waves with different phases. Specifically, a nonlinear component from a living body is imaged with reduced degradation of S/N ratio, the degradation being caused by an uncanceled residual component generated by the nonlinearity of the uncorrected transmission signals. The sum component of the uncorrected transmission signals tends to be strongly affected by the amplifying circuitry 203 when transmission voltage is small, and more strongly affected by the transducer element 303 when the transmission voltage becomes larger. Thus, the ultrasound diagnosis apparatus 1 according to the first embodiment can also perform correction with the properties of the transducer element 303 being considered.

[0052] The ultrasound diagnosis apparatus 1 according to the first embodiment generates transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range, by using transmission signals detected between the cable 301 and the transducer element 303. This configuration enables generation of transmission waveform data that is not affected by the impedance of the cable 301.

[0053] Specifically, when transmission waveform data is generated by using transmission signals detected between the amplifying circuitry 203 and the cable 301, the phase polarities of transmission signals immediately before input to the cable 301 are symmetry. However, the transmission signals after passing through the cable 301 have been affected by the impedance of the cable 301, and thus the phase polarities of the transmission signals are asymmetry. Thus, using the transmission signals detected between the amplifying circuitry 203 and the cable 301 to generate transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range does not provide transmission signals with symmetric phase polarities at the transducer element 303. In contrast, the ultrasound diagnosis apparatus 1 according to the first embodiment generates transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range, by using transmission signals detected between the cable 301 and the transducer element 303. That is, the ultrasound diagnosis apparatus 1 according to the first embodiment generates transmission waveform data by considering the effect of the impedance of the cable 301. Consequently, the ultrasound diagnosis apparatus 1 according to the first embodiment provides transmission signals having symmetric phase polarities at the transducer element 303.

[0054] Examples of harmonic imaging include CHI and THI. CHI transmits ultrasound waves at small amplitude to capture nonlinear behavior of contrast agent bubbles without breaking the bubbles. THI transmits ultrasound waves at

large amplitude to generate the actual nonlinearity of a living body. Thus, the transmitter circuitry **111** needs to maintain the symmetry of positive and negative polarities when the phases are inverted under both conditions of CHI and THI. In the first embodiment described above, when causing the ultrasound probe **11** to transmit a plurality of ultrasound waves with different phases successively depending on a transmission condition, the ultrasound diagnosis apparatus **1** generates transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range. As a result, the ultrasound diagnosis apparatus **1** according to the first embodiment can maintain the symmetry of positive and negative polarities when the phases are inverted in both CHI transmitting ultrasound waves at small amplitude and THI transmitting ultrasound waves at large amplitude. Thus, the ultrasound diagnosis apparatus **1** according to the first embodiment can perform correction to improve S/N ratio of both the transmission at small amplitude to image the nonlinearity of a contrast agent and the transmission at large amplitude to image the actual nonlinearity of a living body.

[0055] In the above embodiment, the case is described where the correction value calculating circuitry **2** acquires, as an uncorrected sum component, a sum component of a plurality of uncorrected transmission signals acquired at a point in time from immediately after generation of the signals to immediately before application of the signals to the transducer element **303** in the ultrasound probe **11**. However, the embodiment is not limited to this case. For example, the correction value calculating circuitry **2** may acquire, as an uncorrected sum component, a sum component of a plurality of uncorrected ultrasound waves each acquired at the point in time when the ultrasound probe **11** transmits the ultrasound waves based on the respective uncorrected transmission signals. In this case, the correction value calculating circuitry **2** acquires a plurality of uncorrected ultrasound waves measured by a hydrophone and acquires a sum component of the uncorrected ultrasound waves by adding the plurality of the uncorrected ultrasound waves, for example.

Second Embodiment

[0056] In the first embodiment, a case has been described in which the correction value is calculated by an external apparatus other than the ultrasound diagnosis apparatus **1**, for example, before shipment, and stored in the memory circuitry **160**. The second embodiment describes a case in which the correction value is calculated by an ultrasound diagnosis apparatus.

[0057] FIG. **4** is a block diagram illustrating an exemplary configuration of an ultrasound diagnosis apparatus **1a** according to the second embodiment. As illustrated in FIG. **4**, the ultrasound diagnosis apparatus **1a** according to the second embodiment includes an ultrasound probe **11a**, the input device **12**, the display **13**, and an apparatus body **100a**. Among the components included in the ultrasound diagnosis apparatus **1a** illustrated in FIG. **4**, the components having the same functions as those of the components illustrated in FIG. **1** are assigned with the same reference signs and detailed descriptions thereof are omitted. Furthermore, similarly to the case of FIG. **1**, a plurality of components in FIG. **4** may be integrated into one processor to implement the functions thereof.

[0058] The apparatus body **100a** is an apparatus that generates ultrasound image data based on the reflected wave signals received by the ultrasound probe **11a**. The configuration of the apparatus body **100a** is the same as the configuration of the apparatus body **100** according to the first embodiment except that the configuration of transmitter receiver circuitry **110a** and processing circuitry **170a** is different. As illustrated in FIG. **4**, the apparatus body **100a** includes, for example, the transmitter receiver circuitry **110a**, the B-mode processing circuitry **120**, the Doppler processing circuitry **130**, the image generating circuitry **140**, the image memory **150**, the memory circuitry **160**, and the processing circuitry **170a**. Among the components included in the apparatus body **100a** illustrated in FIG. **4**, the components having the same functions as those of the components illustrated in FIG. **1** are assigned with the same reference signs and detailed descriptions thereof are omitted.

[0059] The transmitter receiver circuitry **110a** controls transmission and reception of ultrasound waves by the ultrasound probe **11a**. For example, the transmitter receiver circuitry **110a** includes transmitter circuitry **111a** and the receiver circuitry **112** and controls transmission and reception of ultrasound waves by the ultrasound probe **11a**, based on instructions from the processing circuitry **170a** described later. The configuration of the transmitter receiver circuitry **110a** according to the second embodiment is the same as the configuration of the transmitter receiver circuitry **110** according to the first embodiment except that the configuration of a part of the transmitter circuitry **111a** is different. In the same manner as the transmitter circuitry **111** according to the first embodiment performs, the transmitter circuitry **111a** according to the second embodiment generates transmission waveform data, generates, from the generated transmission waveform data, transmission signals that the ultrasound probe **11a** uses for transmitting ultrasound waves, and outputs the generated transmission signals to the ultrasound probe **11a**. For example, the transmitter circuitry **111a** generates transmission waveform data based on a plurality of pieces of uncorrected transmission waveform data corresponding to a plurality of respective ultrasound waves transmitted successively depending on a transmission condition and causing a sum component to be zero, and a correction value dependent on the transmission condition.

[0060] The processing circuitry **170a** controls all processing in the ultrasound diagnosis apparatus **1a**. The configuration of the processing circuitry **170a** according to the second embodiment is the same as the configuration of the processing circuitry **170** according to the first embodiment except that the processing circuitry **170a** includes a calculating function **171**. The calculating function **171** is a function that is implemented by the processing circuitry **170a** reading out and executing a computer program corresponding to the calculating function **171** from the memory circuitry **160**. The calculating function **171** is an example calculation circuitry. In FIG. **4**, it is described that the single processing circuitry **170a** implements the processing function performed by the calculating function **171**. However, a plurality of independent processors may be combined to be processing circuitry and each of the processors may execute a computer program, thereby implementing the function.

[0061] The following describes the ultrasound probe **11a**, the transmitter circuitry **11a**, and the processing circuitry **170a** with reference to FIG. **5**. FIG. **5** is a diagram for explaining the second embodiment. For the convenience of

description, FIG. 5 illustrates the ultrasound probe 11a, the transmitter circuitry 111a, the memory circuitry 160, and the processing circuitry 170a among the components included in the ultrasound diagnosis apparatus 1a.

[0062] The ultrasound probe 11a is communicably connected to the transmitter receiver circuitry 110a described later, which is included in the apparatus body 100a. The ultrasound probe 11a further includes extracting circuitry 304 that outputs the plurality of the uncorrected transmission signals to the calculating function. For example, as illustrated in FIG. 5, the ultrasound probe 11a includes the cable 301, the probe internal circuitry 302, the transducer element 303, the extracting circuitry 304, an attenuator 305, and a buffer 306. Among the components included in the ultrasound probe 11a, the components having the same functions as those of the components of the ultrasound probe 11 according to the first embodiment are assigned with the same reference signs and detailed descriptions thereof are omitted.

[0063] The extracting circuitry 304 acquires the plurality of the uncorrected transmission signals from the probe internal circuitry 302 and outputs the plurality of the uncorrected transmission signals to the calculating function 171 via the attenuator 305. The attenuator 305 attenuates the uncorrected transmission signals extracted by the extracting circuitry 304 when the plurality of the uncorrected transmission signals cannot directly be stored in the buffer 306 due to large amplitude. The buffer 306 outputs the uncorrected transmission signals output by the attenuator 305 to an analog-digital converter (ADC) 204.

[0064] As illustrated in FIG. 5, the transmitter circuitry 111a includes the signal generating circuitry 201, the DAC 202, the amplifying circuitry 203, and the ADC 204. Among the components included in the transmitter circuitry 111a, the components having the same functions as those of the components of the transmitter circuitry 111 according to the first embodiment are assigned with the same reference signs and detailed descriptions thereof are omitted.

[0065] The ADC 204 digitally converts the uncorrected transmission signals output from the buffer 306 and outputs the converted component to the calculating function 171.

[0066] The calculating function 171 has the same function as the correction value calculating circuitry 2 according to the first embodiment. That is, the calculating function 171 acquires, as an uncorrected sum component, a sum component of a plurality of uncorrected transmission signals acquired at a point in time from immediately after generation of the signals to immediately before application of the signals to the transducer element 303 in the ultrasound probe 11a, or a sum component of a plurality of uncorrected ultrasound waves each acquired at the point when the ultrasound probe 11a transmits the ultrasound waves based on the respective uncorrected transmission signals. For example, the calculating function 171 acquires the plurality of the uncorrected transmission signals output by the extracting circuitry 304 and acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals. Alternatively, for example, the calculating function 171 acquires a plurality of uncorrected ultrasound waves measured by a hydrophone and acquires a sum component of the uncorrected ultrasound waves by adding the plurality of the uncorrected ultrasound waves. The calculating function 171 calculates a correction value based on the acquired uncorrected sum component.

[0067] When the calculating function 171 acquires the plurality of the uncorrected transmission signals, the plurality of the uncorrected transmission signals passes through the extracting circuitry 304, the attenuator 305, the buffer 306, and the ADC 204. The extracting circuitry 304, the attenuator 305, the buffer 306, and the ADC 204 are also collectively referred to as correcting circuitry. The plurality of the uncorrected transmission signals acquired by the calculating function 171 may contain noise mixed in the course of passing through the correcting circuitry. Thus, the calculating function 171 multiplies the acquired sum component of the uncorrected transmission signals by a conversion function for the correcting circuitry to derive a sum component $\Delta S_o(t)$ of the uncorrected transmission signals from which the effect of noise mixed in the course of passing through the correcting circuitry is removed. The conversion function for the correcting circuitry is a function that corrects the sum component by considering noise so as to convert the sum component back to the sum component of the uncorrected transmission signals at the point in time when being output from the probe internal circuitry 302, the sum component of the uncorrected transmission signals acquired by the calculating function 171.

[0068] After deriving $\Delta S_o(t)$, the calculating function 171 calculates a correction value in the same manner as the correction value calculating circuitry 2 according to the first embodiment performs.

[0069] Deriving in advance a transfer function for the correcting circuitry, the conversion function $H_{invp}(\omega)$, and the conversion function $H_{invn}(\omega)$ described in the first embodiment enables acquisition of the plurality of the uncorrected transmission signals, calculation of a correction value, and correction by subtraction in the ultrasound diagnosis apparatus 1a. This configuration facilitates acquisition of a correction value depending on a transmission condition, such as the number of waves, frequency, and voltage, or for each ultrasound probe 11a. Thus, the ultrasound diagnosis apparatus 1a according to the second embodiment can calculate a correction value in real time when the correction value has not been calculated, so as to generate transmission waveform data based on which a sum component of a plurality of ultrasound waves transmitted successively is within a certain range. This configuration also enables calculation of an appropriate correction value every time modes are switched. Consequently, transmission waveform data based on which a sum component of a plurality of ultrasound waves transmitted successively is within a certain range can be generated every time modes are switched.

[0070] When the ultrasound probe 11a alone is newly purchased, an appropriate correction value can be calculated by simply deriving the transfer function for the correcting circuitry, the conversion function $H_{invp}(\omega)$, and the conversion function $H_{invn}(\omega)$ between the ultrasound probe 11a and the existing apparatus body 100a. Consequently, transmission waveform data based on which a sum component of a plurality of ultrasound waves transmitted successively is within a certain range can be generated.

[0071] The correcting circuitry does not need to be provided to every transducer element. That is, the correcting circuitry may be provided for at least one representative channel of uncorrected transmission signals. In other words, the extracting circuitry 304 may extract a plurality of uncorrected transmission signals output to a certain transducer element among a plurality of transducer elements 303

in the ultrasound probe **11a**. When the extracting circuitry **304**, the attenuator **305**, and the buffer **306** are implemented in the ultrasound probe **11a**, the number of circuits is preferably limited to the smallest necessary number in order to prevent the temperature the probe from being increased by power consumption.

[0072] The calculating function **171** may report an abnormality when the calculated correction value is outside the certain range. For example, a settable range for a correction value is specified in advance to prevent an acoustic power limit from being exceeded by an abnormal value. If a correction value is outside this range, the calculating function **171** determines the value as abnormal, reports an error, and stops transmitting ultrasound waves. Because a correction value is typically equal to or smaller than 3% of amplitude, which is a small value, the acoustic power limit will not be exceeded if a default value of the acoustic power is set to a lower value in advance with the correction value being considered. Thus, the effect on sensitivity is significantly small, which causes no problem.

[0073] Similarly to the ultrasound diagnosis apparatus **1** according to the first embodiment, the ultrasound diagnosis apparatus **1a** according to the second embodiment generates transmission waveform data based on which a sum component of a plurality of ultrasound waves transmitted successively is within a certain range, by using transmission signals detected between the cable **301** and the transducer element **303**. This configuration enables generation of transmission waveform data that is not affected by the impedance of the cable **301**. Consequently, the ultrasound diagnosis apparatus **1a** according to the second embodiment provides transmission signals having symmetric phase polarities at the transducer element **303**.

Modification of Second Embodiment

[0074] In the second embodiment, the case is described where a plurality of uncorrected transmission signals is extracted from the ultrasound probe **11a**. However, the embodiment is not limited to this case. For example, if a dominant factor causing a residue is the amplifying circuitry **203** and thus the effect of noise mixed due to the ultrasound probe **11a** does not need to be considered, the plurality of the uncorrected transmission signals may be extracted from, for example, an output from the amplifying circuitry **203** in the transmitter circuitry **11a**.

[0075] FIG. 6 is a diagram for explaining a modification of the second embodiment. The transmitter circuitry **111a** according to the modification of the second embodiment includes the signal generating circuitry **201**, the DAC **202**, the amplifying circuitry **203**, the ADC **204**, extracting circuitry **205**, an attenuator **206**, and a buffer **207**. Among the components included in the transmitter circuitry **111a** according to the modification of the second embodiment, the components having the same functions as those of the components of the transmitter circuitry **111a** according to the second embodiment are assigned with the same reference signs and detailed descriptions thereof are omitted.

[0076] The extracting circuitry **205** outputs a plurality of uncorrected transmission signals output from the amplifying circuitry **203** to the calculating function **171** via the attenuator **206**. The attenuator **206** attenuates the uncorrected transmission signals extracted by the extracting circuitry **205** when the plurality of the uncorrected transmission signals cannot directly be stored in the buffer **207** due to large

amplitude. The buffer **207** outputs the uncorrected transmission signals output by the attenuator **206** to the ADC **204**.

[0077] When the calculating function **171** according to the modification of the second embodiment acquires the plurality of the uncorrected transmission signals, the plurality of the uncorrected transmission signals passes through the extracting circuitry **205**, the attenuator **206**, the buffer **207**, and the ADC **204**. The extracting circuitry **205**, the attenuator **206**, the buffer **207**, and the ADC **204** are also collectively referred to as correcting circuitry. The plurality of the uncorrected transmission signals acquired by the calculating function **171** may contain noise mixed in the course of passing through the correcting circuitry. Thus, the calculating function **171** multiplies the acquired sum component of the uncorrected transmission signals by a conversion function for the correcting circuitry to derive a sum component $\Delta S_o(t)$ of the uncorrected transmission signals from which the effect of noise mixed in the course of passing through the correcting circuitry is removed. The conversion function for the correcting circuitry is a function that corrects the sum component of the uncorrected transmission signals by considering noise so as to convert the sum component back to the sum component of the uncorrected transmission signals at the point in time when being output from the amplifying circuitry **203**, the sum component of the uncorrected transmission signals acquired by the calculating function **171**.

[0078] After deriving $\Delta S_o(t)$, the calculating function **171** calculates a correction value in the same manner as the correction value calculating circuitry **2** according to the first embodiment performs.

[0079] In the above embodiment, the case is described where the calculating function **171** acquires, as an uncorrected sum component, a sum component of a plurality of uncorrected transmission signals by adding the plurality of the uncorrected transmission signals acquired at a point in time from immediately after generation of the signals to immediately before application of the signals to the transducer element **303** in the ultrasound probe **11a**. However, the embodiment is not limited to this case. For example, the calculating function **171** may acquire, as an uncorrected sum component, a sum component of a plurality of uncorrected ultrasound waves by adding the plurality of the uncorrected ultrasound waves acquired at the point in time when the ultrasound probe transmits the ultrasound waves based on the respective uncorrected transmission signals. In this case, the calculating function **171** acquires a sum component of uncorrected ultrasound waves measured by a hydrophone, for example.

[0080] In the second embodiment, the case is described where the calculating function **171** is provided in the processing circuitry **170a**. However, the embodiment is not limited to this case. For example, calculating circuitry having the same function as the calculating function may be provided in the transmitter circuitry **111a** illustrated in FIG. 5 and FIG. 6.

Other Embodiments

[0081] The first embodiment and the second embodiment have been described. Embodiments according to the present disclosure, however, can be implemented in various different forms other than the foregoing first and second embodiments.

[0082] In the above embodiments, the case is described where two ultrasound waves with a phase of 0 degrees and

a phase of 180 degrees, respectively, are transmitted successively. However, the embodiments are not limited to this case. For example, the embodiments are applicable to a case where three ultrasound waves with a phase of 0 degrees, a phase of 120 degrees, and a phase of 240 degrees, respectively, are transmitted successively to remove fundamental components and second harmonic components, thereby extracting only third harmonic components.

[0083] Furthermore, for example, a method for THI has been in actual use in which imaging is performed by using second harmonic components and difference sound components contained in reception signals (also referred to as differential THI). The above embodiments are applicable to the imaging method that uses difference sound components. The imaging method that uses difference sound components, for example, causes the ultrasound probe **11** (**11a**) to transmit transmission ultrasound waves having a composite waveform obtained by combining a first fundamental wave having the center frequency of “f1” and a second fundamental wave having the center frequency of “f2” larger than “f1”. The composite waveform is obtained by combining the waveforms of the first and the second fundamental waves having respective phases adjusted to each other so that a difference sound component having the same polarity as that of a second harmonic component is generated. The transmitter circuitry **111** (**111a**) transmits, for example, two transmission ultrasound waves having the composite waveform successively while inverting the phase of the second wave. In this case, for example, the B-mode processing circuitry **120** adds two reception signals to extract a harmonic component with fundamental components removed and thus mainly containing difference sound components and second harmonic components, and then performs envelope detection processing or other processing.

[0084] In the above embodiments, the conversion function is described as a frequency component; however the conversion function may be a time-based function. In this case, a correction value is calculated by multiplying $\Delta S_o(t)$ by a conversion function that is a time-based function.

[0085] The components of the devices and apparatuses illustrated in the drawings described in the above embodiments are functionally conceptual, and do not necessarily need to be configured physically as illustrated in the drawings. That is, the specific forms of distribution or integration of the devices and apparatuses are not limited to those illustrated, and the whole or a part thereof can be configured by being functionally or physically distributed or integrated in any form of units, depending on various types of loads, usage conditions, and the like. Furthermore, the whole of or a part of the various processing functions performed in the respective devices and apparatuses can be implemented by a CPU, and a computer program parsed and executed by the CPU, or implemented as hardware by wired logic.

[0086] The control method described in the foregoing embodiments can be implemented by executing a previously prepared control program on a computer such as a personal computer or a workstation (medical image diagnosis apparatus). This control program can be distributed through a network such as the Internet. This control program can also be recorded on a computer-readable recording medium such as a hard disk, a flexible disk (FD), a compact disc read only memory (CD-ROM), a magnetic optical disc (MO), or a digital versatile disc (DVD), and executed by being read out from the recording medium by the computer.

[0087] At least one of the embodiments described above can reduce noise in an image of harmonic components generated by transmitting a plurality of ultrasound waves with different phases.

[0088] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An ultrasound diagnosis apparatus comprising:
 - an ultrasound probe that is connected to a body through a cable and includes an ultrasound transducer element to transmit and receive an ultrasound wave; and
 - transmitter circuitry configured to generate transmission waveform data, generate, from the generated transmission waveform data, transmission signals that the ultrasound probe uses for transmitting ultrasound waves, and output the generated transmission signals to the ultrasound probe,
 the transmitter circuitry, when causing the ultrasound probe to transmit a plurality of ultrasound waves with different phases successively depending on a transmission condition, generating transmission waveform data based on which a sum component of the ultrasound waves transmitted successively is within a certain range, by using the transmission signals detected between the cable and the ultrasound transducer element.
2. The ultrasound diagnosis apparatus according to claim 1, wherein the transmitter circuitry generates the transmission waveform data based on a plurality of pieces of uncorrected transmission waveform data corresponding to a plurality of respective ultrasound waves transmitted successively depending on the transmission condition and causing a sum component to be zero, and a correction value dependent on the transmission condition.
3. The ultrasound diagnosis apparatus according to claim 2 further comprising:
 - calculating circuitry configured to calculate the correction value, wherein
 - the transmitter circuitry generates a plurality of pieces of uncorrected transmission waveform data causing the sum component to be zero, and generates a plurality of uncorrected transmission signals corresponding to the respective generated pieces of uncorrected transmission waveform data, and
 - the calculating circuitry acquires, as an uncorrected sum component, a sum component of the uncorrected transmission signals acquired at a point in time from immediately after generation of the signals to immediately before application of the signals to a transducer element in the ultrasound probe, or a sum component of uncorrected ultrasound waves each acquired at a point in time when the ultrasound probe transmits the ultrasound waves based on the respective uncorrected transmission signals, and calculates the correction value based on the acquired uncorrected sum component.

4. The ultrasound diagnosis apparatus according to claim 3, wherein the calculating circuitry calculates the correction value based on a conversion component obtained by converting the uncorrected sum component with a conversion function that corrects a waveform at the point in time by considering noise and converts the waveform back to a waveform of the transmission waveform data that has been used to generate the waveform at the point in time.

5. The ultrasound diagnosis apparatus according to claim 4, wherein

the conversion function is a conversion function that converts a frequency spectrum of the waveform acquired at the point in time, back to a frequency spectrum of a waveform of transmission waveform data that has been used to generate the waveform at the point in time, and

the calculating circuitry calculates the conversion component from a conversion spectrum calculated from the conversion function and a frequency spectrum obtained by weighting a certain frequency band corresponding to the transmission condition in the frequency spectrum of the uncorrected sum component.

6. The ultrasound diagnosis apparatus according to claim 3, wherein the ultrasound probe further includes extracting circuitry configured to output the plurality of the uncorrected transmission signals to the calculating circuitry, wherein

the calculating circuitry acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals output by the extracting circuitry.

7. The ultrasound diagnosis apparatus according to claim 4, wherein the ultrasound probe further includes extracting circuitry configured to output the plurality of the uncorrected transmission signals to the calculating circuitry, wherein

the calculating circuitry acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals output by the extracting circuitry.

8. The ultrasound diagnosis apparatus according to claim 5, wherein the ultrasound probe further includes extracting circuitry configured to output the plurality of the uncorrected transmission signals to the calculating circuitry, wherein

the calculating circuitry acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals output by the extracting circuitry.

9. The ultrasound diagnosis apparatus according to claim 3, further comprising:

converting circuitry configured to convert uncorrected transmission waveform data generated by the transmitter circuitry to uncorrected transmission signals and output the converted signals to the ultrasound probe; and

extracting circuitry configured to output the plurality of the uncorrected transmission signals output by the converting circuitry to the calculating circuitry, wherein

the calculating circuitry acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals output by the extracting circuitry.

10. The ultrasound diagnosis apparatus according to claim 4, further comprising:

converting circuitry configured to convert uncorrected transmission waveform data generated by the transmitter circuitry to uncorrected transmission signals and output the converted signals to the ultrasound probe; and

extracting circuitry configured to output the plurality of the uncorrected transmission signals output by the converting circuitry to the calculating circuitry, wherein

the calculating circuitry acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals output by the extracting circuitry.

11. The ultrasound diagnosis apparatus according to claim 5, further comprising:

converting circuitry configured to convert uncorrected transmission waveform data generated by the transmitter circuitry to uncorrected transmission signals and output the converted signals to the ultrasound probe; and

extracting circuitry configured to output the plurality of the uncorrected transmission signals output by the converting circuitry to the calculating circuitry, wherein

the calculating circuitry acquires the sum component of the uncorrected transmission signals by adding the plurality of the uncorrected transmission signals output by the extracting circuitry.

12. The ultrasound diagnosis apparatus according to claim 6, wherein the extracting circuitry extracts the plurality of the uncorrected transmission signals output to a certain transducer element among a plurality of transducer elements in the ultrasound probe.

13. The ultrasound diagnosis apparatus according to claim 9, wherein the extracting circuitry extracts the plurality of the uncorrected transmission signals output to a certain transducer element among a plurality of transducer elements in the ultrasound probe.

14. The ultrasound diagnosis apparatus according to claim 3, wherein the calculating circuitry acquires the sum component of the uncorrected ultrasound waves by adding the plurality of the uncorrected ultrasound waves measured by a hydrophone.

15. The ultrasound diagnosis apparatus according to claim 4, wherein the calculating circuitry acquires the sum component of the uncorrected ultrasound waves by adding the plurality of the uncorrected ultrasound waves measured by a hydrophone.

16. The ultrasound diagnosis apparatus according to claim 5, wherein the calculating circuitry acquires the sum component of the uncorrected ultrasound waves by adding the plurality of the uncorrected ultrasound waves measured by a hydrophone.

17. The ultrasound diagnosis apparatus according to claim 3, wherein the calculating circuitry reports an abnormality when a calculated correction value is outside a certain range.

18. An ultrasound probe comprising:

a transducer element configured to transmit and receive an ultrasound wave based on a transmission signal generated from transmission waveform data by an ultrasound diagnosis apparatus body; and

extracting circuitry configured to output, to the ultrasound diagnosis apparatus body, a plurality of transmission signals immediately before being output to the trans-

ducer element when causing the transducer element to transmit a plurality of ultrasound waves with different phases successively depending on a transmission condition, wherein
the ultrasound diagnosis apparatus body acquires a sum component of the transmission signals by adding the plurality of the transmission signals output by the extracting circuitry and generates transmission waveform data based on which the sum component of the transmission signals is within a certain range, based on a correction value dependent on the transmission condition.

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摘要(译)

根据实施例的超声诊断装置包括超声波证明和发射机电路。超声波探头通过电缆连接到身体，并且包括用于发送和接收超声波的超声换能器元件。发射机电路产生发送波形数据，从生成的发送波形数据生成超声波探头用于发送超声波的发送信号，并将生成的发送信号输出到超声波探头。当使超声波探头根据发送条件连续地发送具有不同相位的多个超声波时，发送器电路产生发送波形数据，基于该发送波形数据，连续发送的超声波的和分数在一定范围内，通过使用在电缆和超声换能器元件之间检测到传输信号。

