US 20170086796A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2017/0086796 A1**

WATANABE (43) **Pub. Date: Mar. 30, 2017**

(54) **ULTRASONIC RECEPTION SIGNAL CORRECTION DEVICE, ULTRASONIC MEASUREMENT APPARATUS, AND ULTRASONIC RECEPTION SIGNAL CORRECTION METHOD**

(71) Applicant: **SEIKO EPSON CORPORATION**, Suwa-shi (JP)

(72) Inventor: **Ryoki WATANABE**, Suwa-shi (JP)

(73) Assignee: **SEIKO EPSON CORPORATION**, Tokyo (JP)

(21) Appl. No.: **15/278,710**

(22) Filed: **Sep. 28, 2016**

(30) **Foreign Application Priority Data**

Sep. 29, 2015 (JP) 2015-190937

Publication Classification

(51) **Int. Cl.**

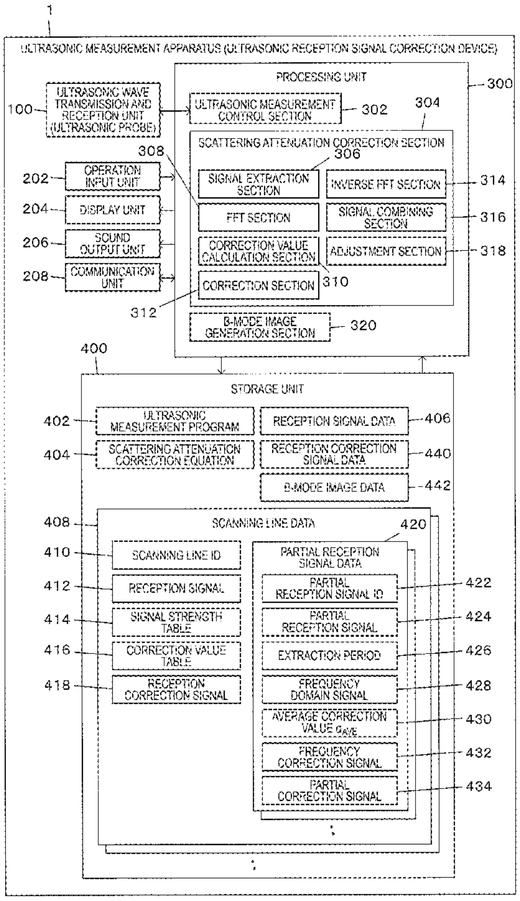
A61B 8/08	(2006.01)
A61B 8/00	(2006.01)
A61B 5/00	(2006.01)
A61B 8/14	(2006.01)
G01S 15/89	(2006.01)
G01S 7/52	(2006.01)

(52) **U.S. Cl.**

CPC ***A61B 8/5269*** (2013.01); ***G01S 15/8988*** (2013.01); ***G01S 7/52026*** (2013.01); ***A61B 5/7257*** (2013.01); ***A61B 8/14*** (2013.01); ***A61B 8/4444*** (2013.01)

(57) **ABSTRACT**

An ultrasonic measurement apparatus extracts, from a reception signal, a plurality of partial reception signals according to overlap periods that are set by shifting the time so as to overlap partially. Then, scattering attenuation correction using a scattering attenuation correction value is performed for a frequency domain signal obtained by performing a Fourier transform of each of the plurality of partial reception signals, and an inverse Fourier transform of a corrected frequency correction signal is performed. Then, partial correction signals corresponding to the respective partial reception signals are obtained by performing an inverse Fourier transform. Then, a signal obtained by combining the partial correction signals is set as a reception correction signal after correcting the reception signal. The scattering attenuation correction value is calculated from the signal strength of incident ultrasonic waves and a sum value of the signal strength of the reception signal at each time.



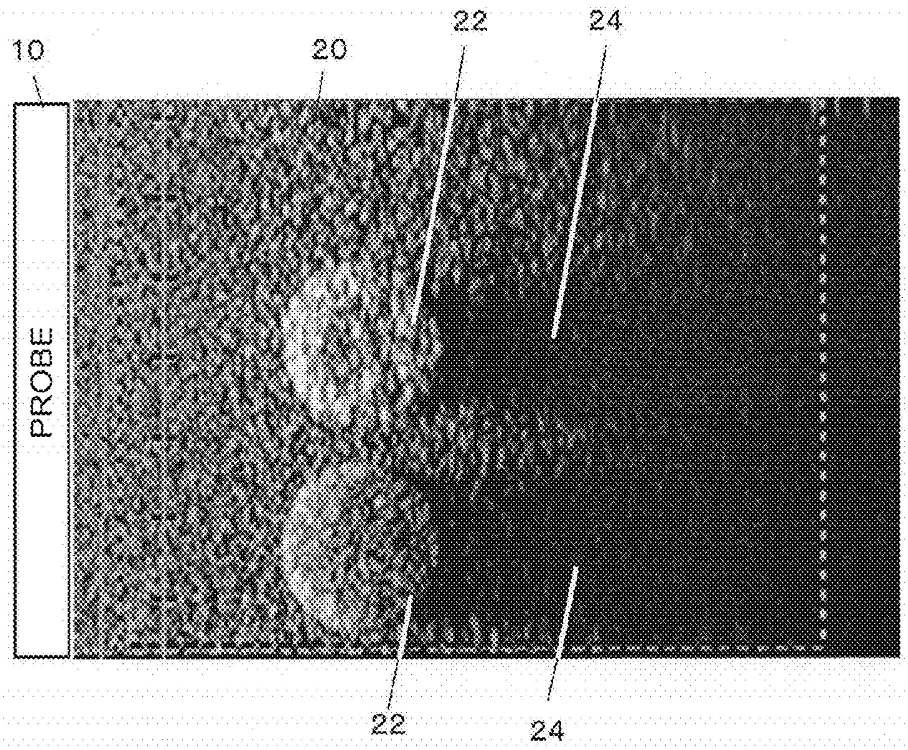

10
20
22
24
PROBE
22
24

FIG. 1

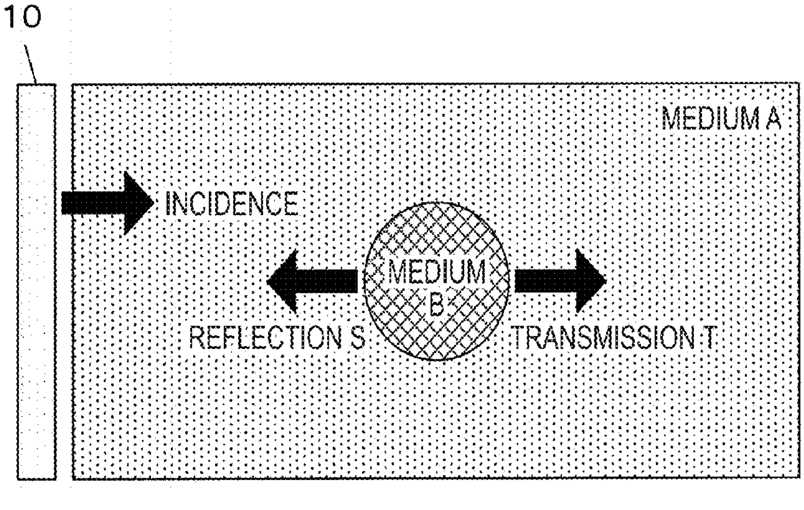

10
MEDIUM A
INCIDENCE
MEDIUM B
REFLECTION S
TRANSMISSION T

FIG. 2

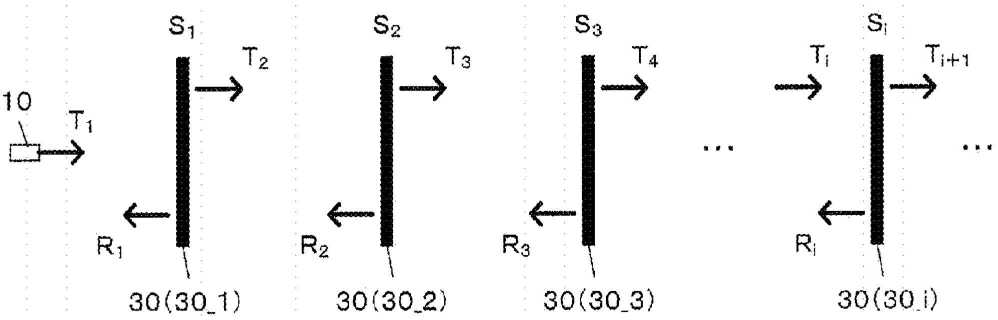

10
T1
S1
T2
R1
30(30_1)
S2
T3
R2
30(30_2)
S3
T4
R3
30(30_3)
...
Ti
Si
Ti+1
Ri
30(30_i)
...

FIG. 3

FIG. 4A

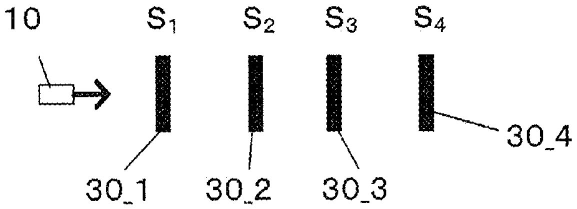


FIG. 4B

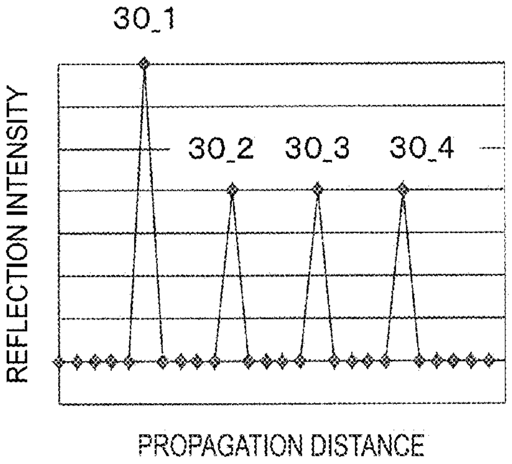


FIG. 4C

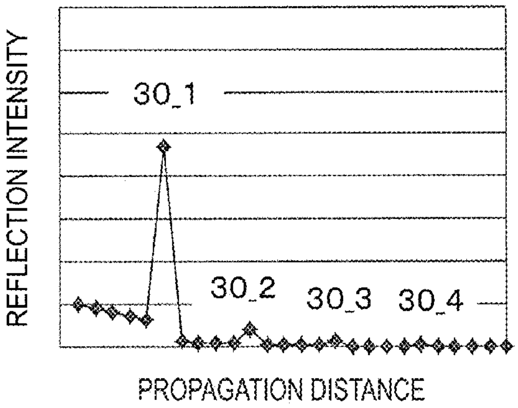
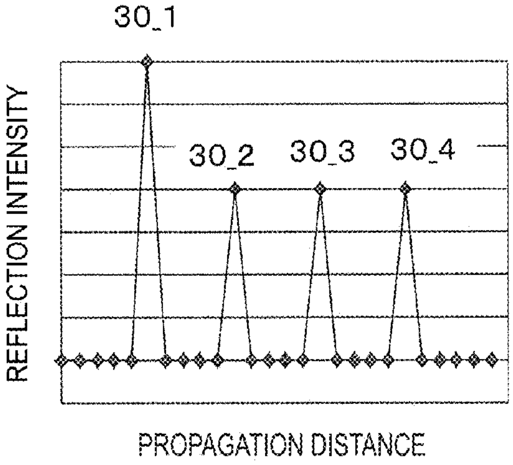


FIG. 4D



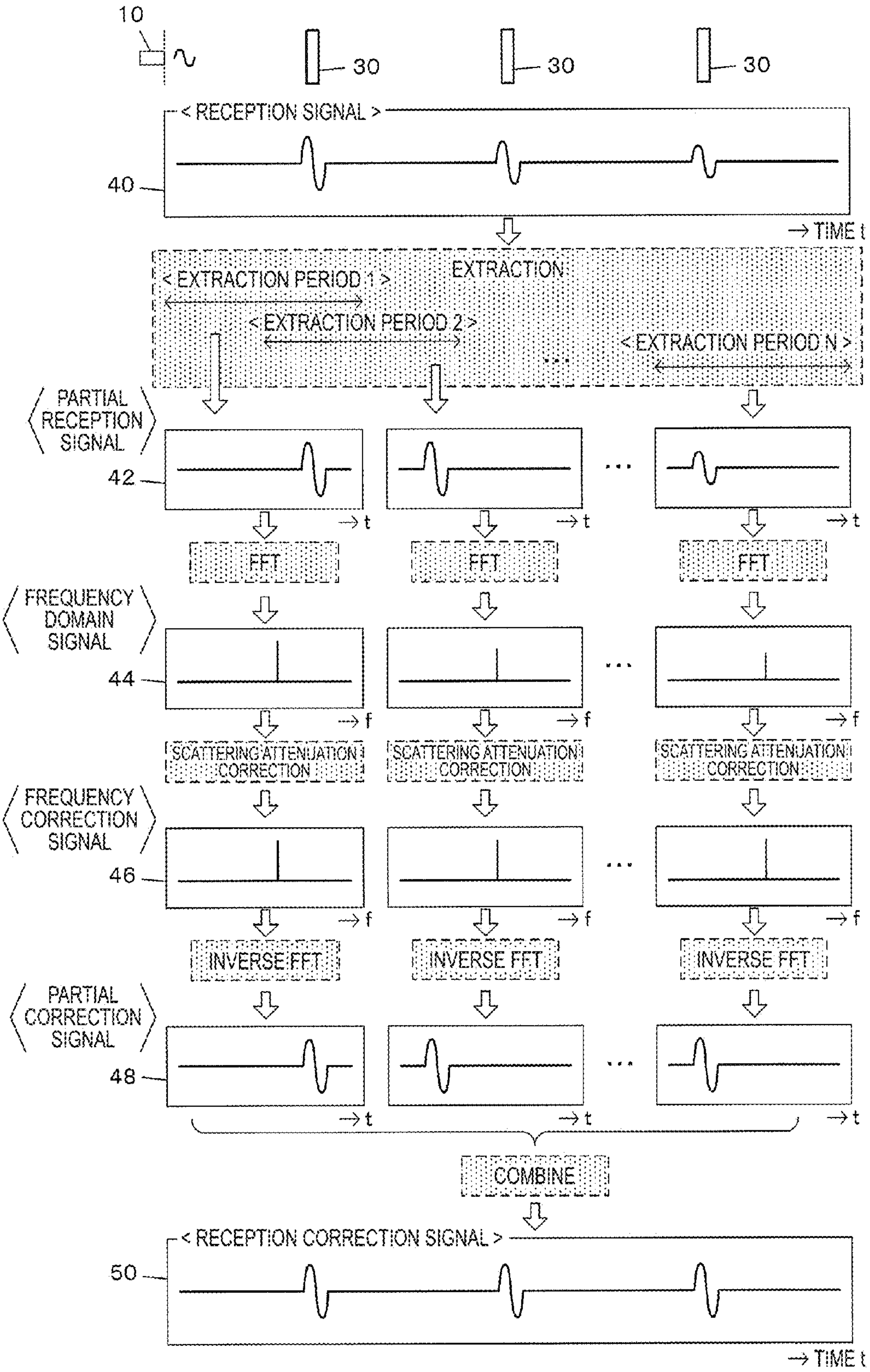

10
30
30
30
< RECEPTION SIGNAL >
40
→ TIME t
EXTRACTION
< EXTRACTION PERIOD 1 >
< EXTRACTION PERIOD 2 >
...
< EXTRACTION PERIOD N >
PARTIAL RECEPTION SIGNAL
42
→ t
FFT
FREQUENCY DOMAIN SIGNAL
44
→ f
SCATTERING ATTENUATION CORRECTION
FREQUENCY CORRECTION SIGNAL
46
→ f
INVERSE FFT
PARTIAL CORRECTION SIGNAL
48
→ t
COMBINE
< RECEPTION CORRECTION SIGNAL >
50
→ TIME t

FIG. 5

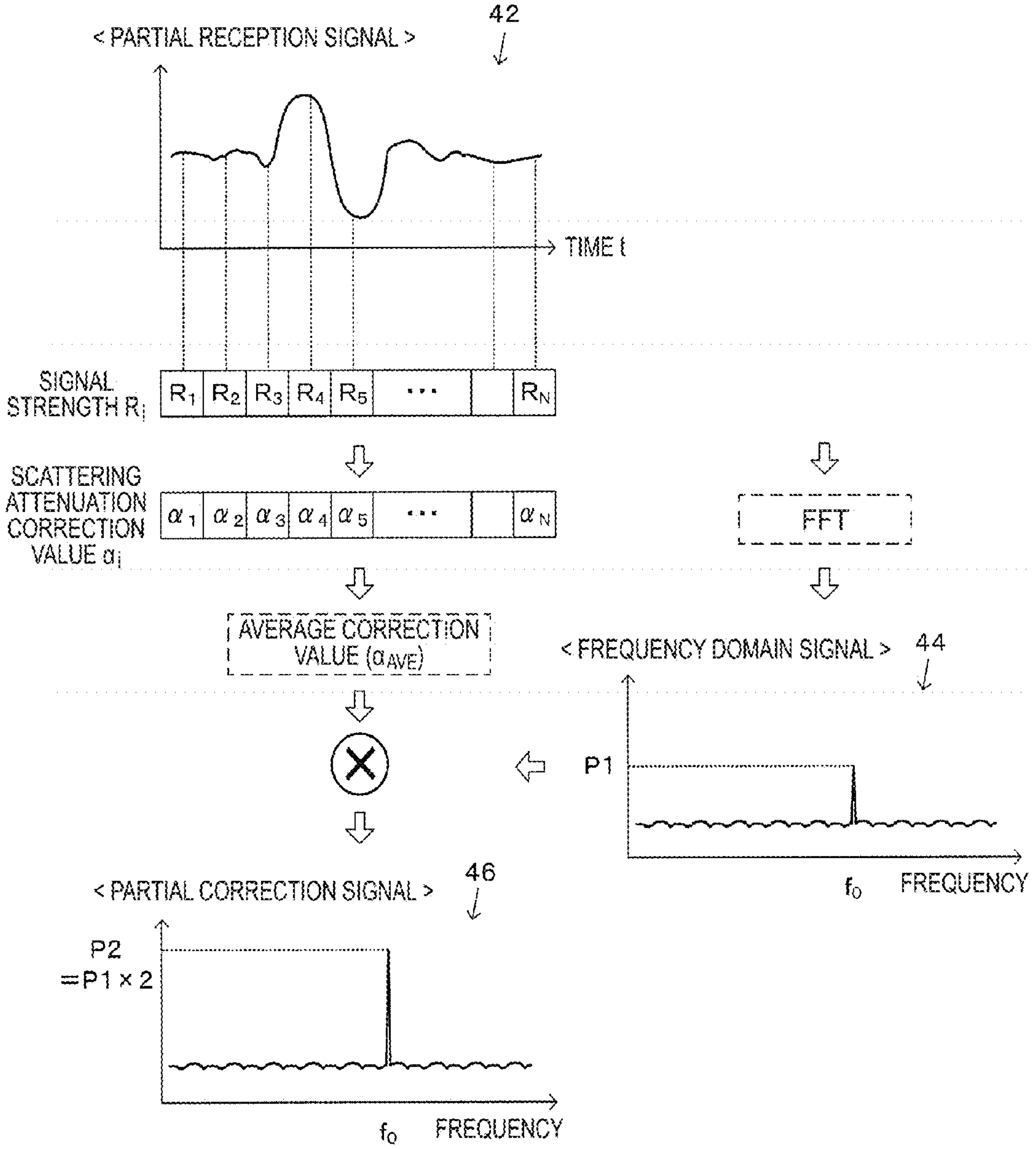

< PARTIAL RECEPTION SIGNAL >
42
TIME t
SIGNAL STRENGTH R_i
R_1
R_2
R_3
R_4
R_5
···
R_N
SCATTERING ATTENUATION CORRECTION VALUE α_i
α_1
α_2
α_3
α_4
α_5
···
α_N
FFT
AVERAGE CORRECTION VALUE (α_{AVE})
< FREQUENCY DOMAIN SIGNAL >
44
P1
f_0
FREQUENCY
< PARTIAL CORRECTION SIGNAL >
46
P2 =P1 × 2
f_0
FREQUENCY

FIG. 6

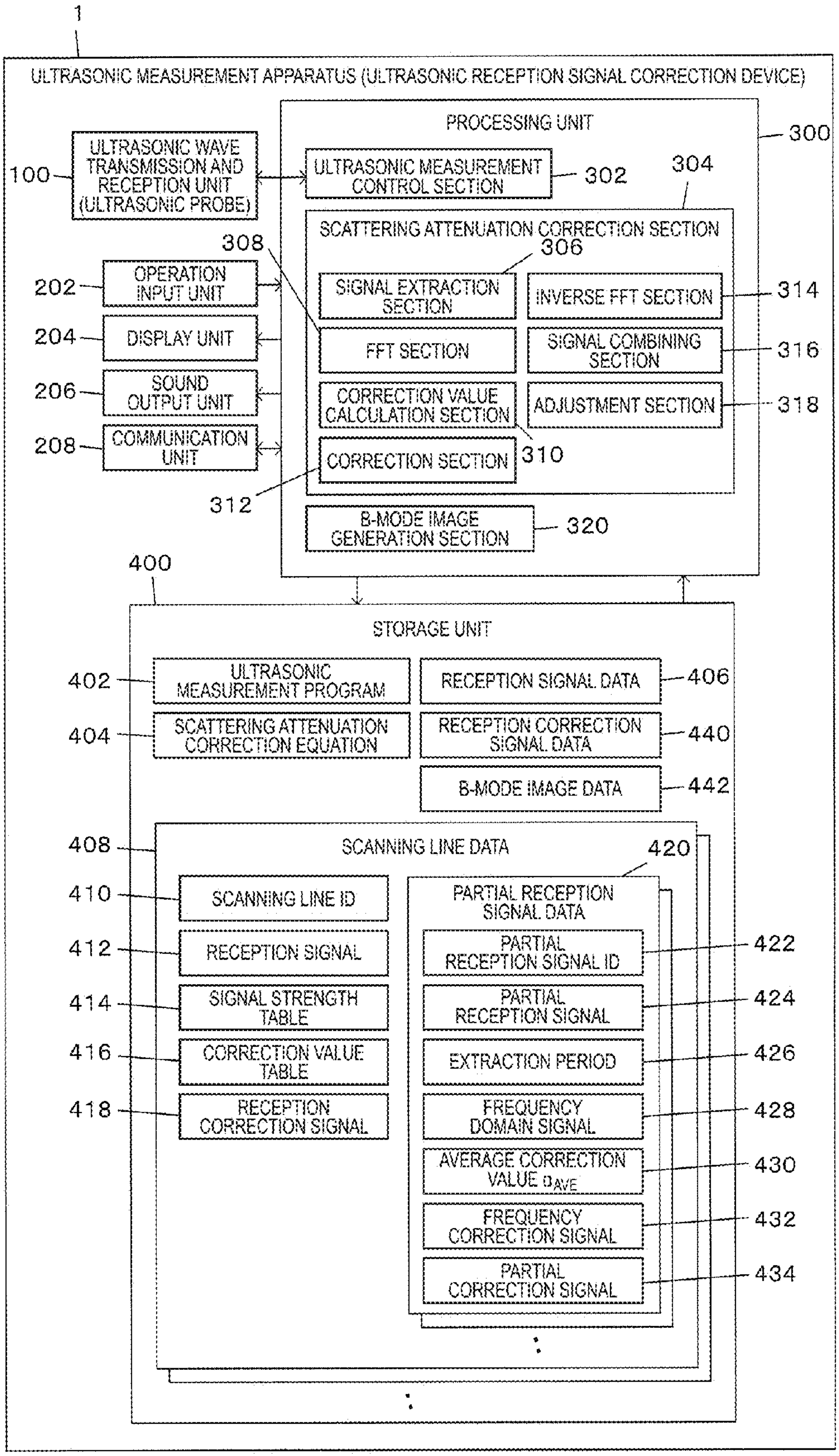

1
ULTRASONIC MEASUREMENT APPARATUS (ULTRASONIC RECEPTION SIGNAL CORRECTION DEVICE)
PROCESSING UNIT
300
100
ULTRASONIC WAVE TRANSMISSION AND RECEPTION UNIT (ULTRASONIC PROBE)
ULTRASONIC MEASUREMENT CONTROL SECTION
302
304
SCATTERING ATTENUATION CORRECTION SECTION
308
306
202
OPERATION INPUT UNIT
SIGNAL EXTRACTION SECTION
INVERSE FFT SECTION
314
204
DISPLAY UNIT
FFT SECTION
SIGNAL COMBINING SECTION
316
206
SOUND OUTPUT UNIT
CORRECTION VALUE CALCULATION SECTION
ADJUSTMENT SECTION
318
208
COMMUNICATION UNIT
CORRECTION SECTION
310
312
B-MODE IMAGE GENERATION SECTION
320
400
STORAGE UNIT
402
ULTRASONIC MEASUREMENT PROGRAM
RECEPTION SIGNAL DATA
406
404
SCATTERING ATTENUATION CORRECTION EQUATION
RECEPTION CORRECTION SIGNAL DATA
440
B-MODE IMAGE DATA
442
408
SCANNING LINE DATA
420
410
SCANNING LINE ID
PARTIAL RECEPTION SIGNAL DATA
412
RECEPTION SIGNAL
PARTIAL RECEPTION SIGNAL ID
422
414
SIGNAL STRENGTH TABLE
PARTIAL RECEPTION SIGNAL
424
416
CORRECTION VALUE TABLE
EXTRACTION PERIOD
426
418
RECEPTION CORRECTION SIGNAL
FREQUENCY DOMAIN SIGNAL
428
AVERAGE CORRECTION VALUE α_AVE
430
FREQUENCY CORRECTION SIGNAL
432
PARTIAL CORRECTION SIGNAL
434

FIG. 7

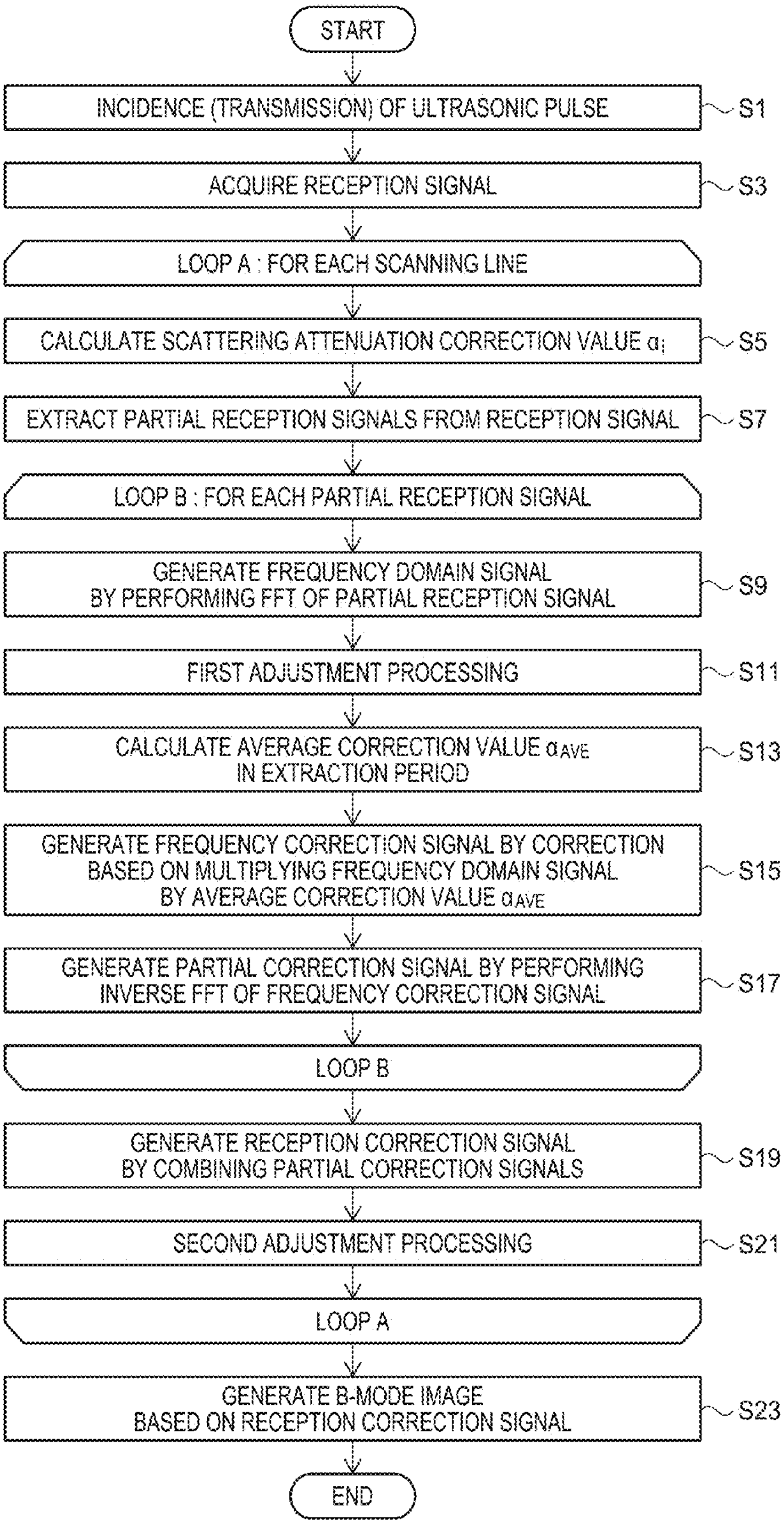

START
INCIDENCE (TRANSMISSION) OF ULTRASONIC PULSE
S1
ACQUIRE RECEPTION SIGNAL
S3
LOOP A : FOR EACH SCANNING LINE
CALCULATE SCATTERING ATTENUATION CORRECTION VALUE α_i
S5
EXTRACT PARTIAL RECEPTION SIGNALS FROM RECEPTION SIGNAL
S7
LOOP B : FOR EACH PARTIAL RECEPTION SIGNAL
GENERATE FREQUENCY DOMAIN SIGNAL BY PERFORMING FFT OF PARTIAL RECEPTION SIGNAL
S9
FIRST ADJUSTMENT PROCESSING
S11
CALCULATE AVERAGE CORRECTION VALUE α_{AVE} IN EXTRACTION PERIOD
S13
GENERATE FREQUENCY CORRECTION SIGNAL BY CORRECTION BASED ON MULTIPLYING FREQUENCY DOMAIN SIGNAL BY AVERAGE CORRECTION VALUE α_{AVE}
S15
GENERATE PARTIAL CORRECTION SIGNAL BY PERFORMING INVERSE FFT OF FREQUENCY CORRECTION SIGNAL
S17
LOOP B
GENERATE RECEPTION CORRECTION SIGNAL BY COMBINING PARTIAL CORRECTION SIGNALS
S19
SECOND ADJUSTMENT PROCESSING
S21
LOOP A
GENERATE B-MODE IMAGE BASED ON RECEPTION CORRECTION SIGNAL
S23
END

FIG. 8

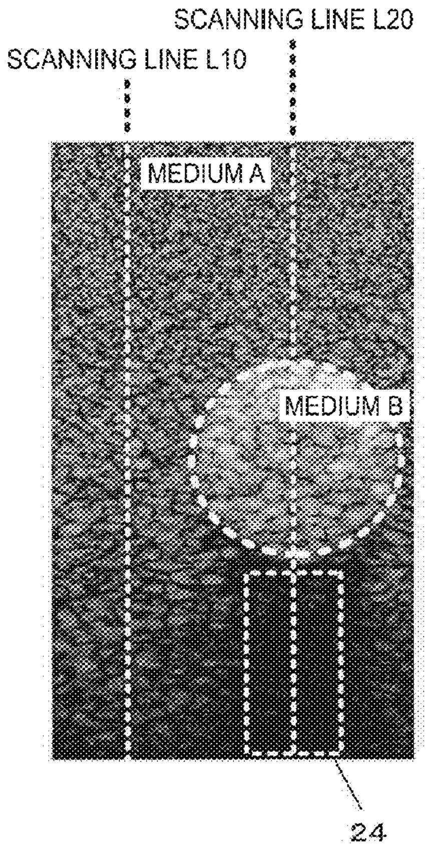


FIG. 9A

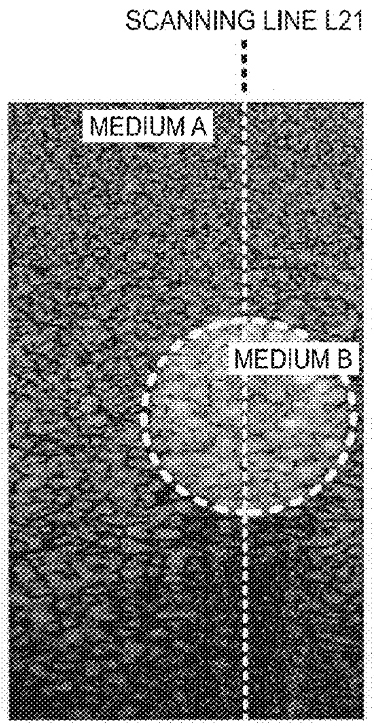


FIG. 9B

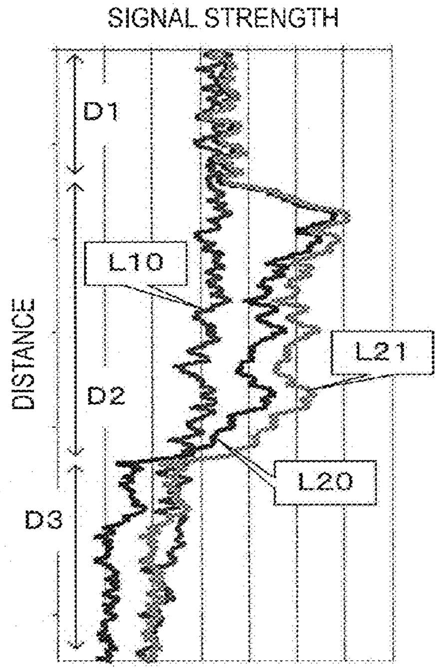


FIG. 9C

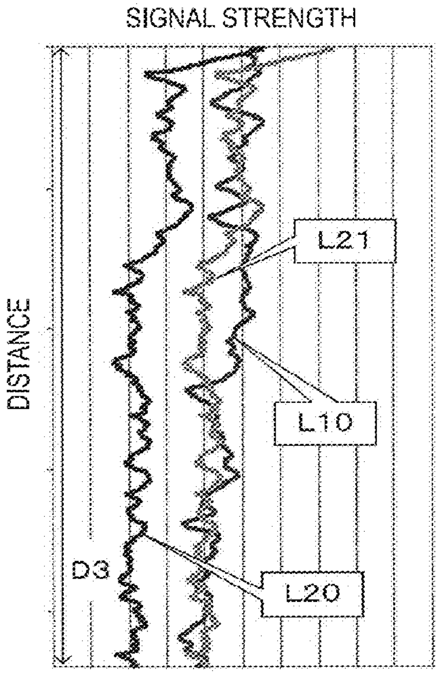


FIG. 9D

ULTRASONIC RECEPTION SIGNAL CORRECTION DEVICE, ULTRASONIC MEASUREMENT APPARATUS, AND ULTRASONIC RECEPTION SIGNAL CORRECTION METHOD

BACKGROUND

[0001] 1. Technical Field

[0002] The present invention relates to an ultrasonic reception signal correction device and the like for correcting a reception signal of reflected waves of ultrasonic waves from a subject.

[0003] 2. Related Art

[0004] In an ultrasonic measurement apparatus that acquires biological information of a subject using ultrasonic waves, there has been a problem of acoustic shadow. Ultrasonic waves incident on the subject propagate through the subject while being reflected on the boundary surface of the body tissue, such as muscles, blood vessels, and bones. Accordingly, it is possible to know the structure of the body tissue from the reception signal of reflected waves (ultrasonic echoes) of the ultrasonic waves. However, since ultrasonic waves cannot pass through the tissue that strongly reflects the ultrasonic waves, such as a bone or a stone, reflected waves from a region behind the tissue that strongly reflects the ultrasonic waves are hardly obtained. A non-echo region or a low echo region where reflected waves are hardly obtained is called an acoustic shadow.

[0005] As a technique for reducing such an acoustic shadow, for example, there is known a method of calculating, from the average brightness of a high-brightness portion and a region behind the high-brightness portion in a tomographic image obtained from reflected waves of ultrasonic waves, an acoustic shadow effect coefficient, which is a value corresponding to the degree of presence of acoustic shadow in the region behind the high-brightness portion, and correcting the brightness of the region behind the high-brightness portion using the coefficient (refer to paragraphs [0066] to [0072] in JP-A-2005-103129).

[0006] However, the above method disclosed in JP-A-2005-103129 is to detect a low brightness region where it is thought that the acoustic shadow occurs and average brightness values including a high brightness region around the low brightness region. Accordingly, it is hard to say that the effect of reducing the acoustic shadow is sufficiently obtained.

SUMMARY

[0007] An advantage of some aspects of the invention is to propose a new method of reducing the acoustic shadow.

[0008] A first aspect of the invention is directed to an ultrasonic reception signal correction device including: a unit that calculates an attenuation correction value using a signal strength of ultrasonic waves incident on a subject and a signal strength sum value of a reception signal obtained by receiving reflected waves from the subject; a unit that performs a Fourier transform of the reception signal; a unit that corrects a signal after the Fourier transform using the attenuation correction value; and a unit that performs an inverse Fourier transform of a signal after the correction.

[0009] As another aspect of the invention, the invention maybe configured as an ultrasonic reception signal correction method of performing arithmetic processing for correcting an ultrasonic reception signal using an arithmetic processing unit. The ultrasonic reception signal correction method includes: calculating an attenuation correction value using a signal strength of ultrasonic waves incident on a subject and a signal strength sum value of a reception signal obtained by receiving reflected waves from the subject; performing a Fourier transform of the reception signal; correcting a signal after the Fourier transform using the attenuation correction value; and performing an inverse Fourier transform of a signal after the correction.

[0010] According to the first aspect and the like of the invention, it is possible to realize a new method capable of reducing the acoustic shadow by appropriately correcting the reception signal obtained by receiving the reflected waves of ultrasonic waves. That is, the reception signal is corrected by calculating the attenuation correction value using the signal strength of the incident ultrasonic waves and the signal strength sum value of the reception signal, performing a signal obtained by performing a Fourier transform of the reception signal using the attenuation correction value, and then performing an inverse Fourier transform. In the signal obtained by performing a Fourier transform of the reception signal, a peak appears at the frequency of the reflected wave. Accordingly, by correcting the signal obtained by performing the Fourier transform, it is possible to correct the reception signal without a need to detect a region where acoustic shadow has occurred.

[0011] As a second aspect of the invention, the ultrasonic reception signal correction device according to the first aspect of the invention may be configured such that the ultrasonic reception signal correction device further includes a unit that extracts a plurality of partial reception signals from the reception signal by shifting a predetermined extraction period in a time direction, the Fourier transform, the correction, and the inverse Fourier trans form are performed for the partial reception signals, and signals after the inverse Fourier transform may be combined as a signal of the corresponding extraction period.

[0012] According to the second aspect of the invention, even in a case where a plurality of reflected waves at different depth positions are included in the reception signal, it is possible to reduce the acoustic shadow by appropriately correcting the reception signal. That is, a plurality of partial reception signals are extracted from the reception signal, and signals obtained by performing the Fourier transform, the correction, and the inverse Fourier transform for the plurality of extracted partial reception signals are combined as a signal of the corresponding extraction period, thereby correcting the reception signal. In a case where a plurality of reflected waves at different depth positions are included in the reception signal, peaks of the plurality of reflected waves appear at the same frequency in a signal obtained by performing a Fourier transform of the reception signal. Therefore, it is possible to perform correction to obtain a more appropriate reception signal by appropriately setting the extraction period so as to reduce the number of reflected waves included in the partial reception signal (ideally, so as to include only one reflected wave).

[0013] As a third aspect of the invention, the ultrasonic reception signal correction device according to the second aspect of the invention may be configured such that the calculation of the attenuation correction value is to calculate the attenuation correction value for each cumulative time at which the reception signal is received, and the correction is to correct the relevant partial reception signal using the attenuation correction value at a cumulative time corresponding to the partial reception signal.

[0014] According to the third aspect of the invention, the attenuation correction value is calculated for each cumulative time at which the reception signal is received, and the partial reception signal is corrected using the attenuation correction value at the corresponding cumulative time. Therefore, it is possible to perform appropriate correction for each partial reception signal.

[0015] As a fourth aspect of the invention, the ultrasonic reception signal correction device according to the third aspect of the invention may be configured such that a sampling unit of the cumulative time is set to be shorter than a shifting time of the extraction period, and the correction is to average the attenuation correction value at the cumulative time corresponding to the partial reception signal and correcting the partial reception signal using the average value.

[0016] According to the fourth aspect of the invention, the sampling unit of the cumulative time is shorter than the shifting time of the extraction period, and the partial reception signal is corrected using the average value of the attenuation correction value at the cumulative time corresponding to the partial reception signal.

[0017] As a fifth aspect of the invention, the ultrasonic reception signal correction device according to any one of the second to fourth aspects of the invention may be configured such that the extraction is to extract the partial reception signals by shifting the extraction period so as to overlap partially, and a signal strength of an overlapping portion between the partial reception signals is adjusted.

[0018] According to the fifth aspect of the invention, since the partial reception signals are extracted by shifting the extraction period so as to overlap partially and the signal strength of the overlapping portion between the partial reception signals is adjusted, a signal obtained by combining the signals after the inverse Fourier transform, that is, a signal obtained by correcting the reception signal, can become an appropriate signal.

[0019] A sixth aspect of the invention is directed to an ultrasonic measurement apparatus including: an ultrasonic probe that makes ultrasonic waves incident on a subject and receives reflected waves of the ultrasonic waves; and the ultrasonic reception signal correction device according to any one of the first to fifth aspects of the invention that corrects a reception signal received by the ultrasonic probe.

[0020] According to the sixth aspect of the invention, it is possible to realize the ultrasonic measurement apparatus having the effect according to any one of the first to fifth aspects of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The invention will be described with reference to the accompanying drawings, wherein like numbers reference like elements.

[0022] FIG. **1** is a diagram showing an example of acoustic shadow.

[0023] FIG. **2** is a simple model diagram illustrating scattering attenuation.

[0024] FIG. **3** is a simple model diagram illustrating scattering attenuation correction.

[0025] FIGS. **4**A to **4**D are explanatory views of examples of simulation using a scattering attenuation correction algorithm.

[0026] FIG. **5** is an explanatory view of scattering attenuation correction for a reception signal.

[0027] FIG. **6** is an explanatory view of scattering attenuation correction for a partial reception signal.

[0028] FIG. **7** is a diagram showing the functional configuration of an ultrasonic measurement apparatus.

[0029] FIG. **8** is a flowchart of the ultrasonic measurement process.

[0030] FIGS. **9**A to **9**D are explanatory views of experimental results.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

Principle

[0031] An ultrasonic measurement apparatus of the present embodiment is a device that measures biological information of a subject using ultrasonic waves. By making ultrasonic waves incident on the subject from an ultrasonic probe (by transmitting ultrasonic waves to the subject from the ultrasonic probe) and performing signal processing on a reception signal of reflected waves (ultrasonic echoes), it is possible to obtain the position information of a structure in the subject or reflected wave data, such as temporal changes in the structure. Not only the reception signal itself but also images of respective modes of so-called A mode, B mode, M mode, and color Doppler mode are included in the reflected wave data. In addition, the ultrasonic measurement apparatus is also an ultrasonic reception signal correction device that corrects a reception signal of attenuated ultrasonic waves to reduce the acoustic shadow.

[0032] In an ultrasonic probe, a plurality of ultrasonic elements (ultrasonic transducers) for transmitting and receiving ultrasonic waves are arranged. Each ultrasonic element is an ultrasonic transducer for conversion between an ultrasonic wave and an electrical signal, and transmits an ultrasonic pulse signal having a frequency of several to several tens of megahertz and receives a reflected wave thereof.

(1) Acoustic Shadow

[0033] Acoustic shadow is a "strip-shaped low echo region or non-echo region occurring behind a medium that strongly reflects ultrasonic waves. FIG. **1** is an example of a B-mode image in which acoustic shadow occurs. FIG. **1** shows a B-mode image obtained by making ultrasonic waves incident on a subject **20** containing two strong reflectors **22**, which strongly reflect ultrasonic waves, from an ultrasonic probe **10** in the right direction in the diagram. That is, in FIG. **1**, the right direction is a direction of the depth from the surface of the subject **20**, and the vertical direction is a direction along the surface of the subject **20**. It can be seen that the acoustic shadow **24** having a low brightness, that is, a low reception signal strength has occurred behind the strong reflectors **22** when viewed from the ultrasonic probe **10**.

[0034] (2) Causes of Acoustic Shadow

[0035] Ultrasonic waves incident on the subject propagate through the subject while being attenuated. As attenuation occurring at this time, there are mainly three types of attenuation, that is, diffusion attenuation, absorption attenuation, and scattering attenuation. The diffusion attenuation is attenuation due to sound waves spreading in a spherical shape, and the absorption attenuation is attenuation due to acoustic energy being absorbed into a medium and thermally converted. The scattering attenuation is attenuation due to a non-uniform medium. The scattering attenuation is believed to be the main cause of the acoustic shadow.

[0036] FIG. **2** is a diagram showing a simple ultrasonic wave propagation model illustrating the scattering attenuation. FIG. **2** shows a case where an ultrasonic wave from the ultrasonic probe **10** is incident on a medium A containing a medium B in the right direction in the diagram. Here, it is assumed that there is no scattering attenuation and absorption attenuation of ultrasonic waves.

[0037] The acoustic impedance Z_1 of the medium A is a product of the average density ρ_1 and the average speed of sound c_1 of the medium A, and the acoustic impedance Z_2 of the medium B is a product of the average density ρ_2 and the average speed of sound c_2 of the medium B. The acoustic impedances Z_1 and Z_2 are expressed by the following Equation (1).

$$Z_1=\rho_1\times c_1$$

$$Z_2=\rho_2\times c_2 \tag{1}$$

[0038] A reflectance S when ultrasonic waves, which are incident from the ultrasonic probe **10** and propagate through the medium A, are reflected on the boundary surface of the media A and B is expressed by the following Equation (2) using the acoustic impedances Z_1 and Z_2 of the media A and B.

$$S=\left(\frac{Z_2-Z_1}{Z_2+Z_1}\right)^2 \tag{2}$$

[0039] In addition, a transmittance T of ultrasonic waves passing through the boundary surface of the media A and B is expressed by the following Equation (3).

$$T=1-S=\frac{4Z_1Z_2}{(Z_2+Z_1)^2} \tag{3}$$

[0040] From Equation (3), it can be seen that the reflectance S of ultrasonic waves on the boundary surface of the media A and B increases and the transmittance T of ultrasonic waves on the boundary surface of the media A and B decreases as a difference between the acoustic impedances Z_1 and Z_2 of the media A and B increases.

[0041] That is, since the signal strength of ultrasonic waves transmitted to the back side of the medium B is reduced, acoustic shadow occurs.

(3) Algorithm for Correcting the Reception Signal Strength

[0042] Correction of the reception signal of reflected waves of ultrasonic waves attenuated by scattering attenuation will be described. FIG. **3** is a simple ultrasonic wave propagation model illustrating the correction of the reception signal of reflected waves of ultrasonic waves. FIG. **3** shows a case where an ultrasonic wave from the ultrasonic probe **10** having a signal strength T**1** is incident on a subject having a plurality of medium boundary surfaces **30** in the right direction in FIG. **3**. Here, it is assumed that there is no scattering attenuation and absorption attenuation.

[0043] In the subject, a plurality of medium boundary surfaces **30**_i (i=1, 2, . . .) are present so as to face the incidence direction of ultrasonic waves, and ultrasonic waves incident from the ultrasonic probe **10** propagate while being reflected on the medium boundary surfaces **30** or being transmitted through the medium boundary surfaces **30**. The reflectance Si of the i-th medium boundary surface **30**_i is determined by the acoustic impedance Z of two media at the boundary as expressed by Equation (2). The signal strength (reflection intensity) R_i of the reflected wave of the ultrasonic wave due to the i-th medium boundary surface **30**_i is a product of the signal strength (incidence intensity) T_i of the ultrasonic wave incident on a medium boundary surface i and the reflectance S_i of the medium boundary surface i, and is expressed by the following Equation (4).

$$R_i=T_i\times S_i \tag{4}$$

[0044] The incidence intensity T**1** of the ultrasonic wave incident on the first medium boundary surface **30_1** is an incidence intensity T**1** of the ultrasonic wave from the ultrasonic probe **10**. The incidence intensity T_i of the ultrasonic wave incident on the second medium boundary surface **30**_i (i=2, 3, . . .) is the transmission intensity of the previous (i−1)-th medium boundary surface **30**_(i−1), and is a difference between the incidence intensity T_{i-1} of the ultrasonic wave incident on the medium boundary surface **30**_(i−1) and the reflection intensity of the reflected wave from the medium boundary surface **30**_(i−1). The incidence intensity T_i is expressed by the following Equation (5).

$$T_i=T_{i-1}-R_{i-1} \tag{5}$$

[0045] That is, the incidence intensity T_i of the ultrasonic wave incident on each medium boundary surface **30**_i (i=1, 2, . . .) is expressed by the following Equation (6).

$$\begin{aligned} T_2 &= T_1 - R_1 \\ T_3 &= T_2 - R_2 = (T_1 - R_1) - R_2 \\ T_4 &= T_3 - R_3 = (T_1 - R_1 - R_2) - R_3 \\ &\vdots \\ T_i &= T_1 - \sum_{j=1}^{i-1} T_j \end{aligned} \tag{6}$$

[0046] Then, the reflection intensity R_i of the reflected wave from each medium boundary surface **30**_i is the strength (reception intensity) of the reception signal in the ultrasonic probe **10**. That is, the reception signal of reflected waves of ultrasonic waves for the medium boundary surface **30**_i becomes an attenuated signal since the incidence intensity Ti is reduced by the reflection of some of the ultrasonic waves on the medium boundary surface **30**_j (j=1, 2, . . . , i−1) up to the previous (i−1)-th medium boundary surface.

[0047] For the i-th medium boundary surface **30**_i, in a case where there is no previous medium boundary surface **30**_j (j=1, 2, . . . , i−1), that is, considering an ideal state in which ultrasonic waves having the incidence intensity T_1 are incident from the ultrasonic probe **10**, the reflection intensity R_i on the medium boundary surface **30**_i is expressed by the following Equation (7).

$$R_i = T_1 \times S_i \tag{7}$$

[0048] However, the actual reflection intensity R_i of the reflected wave from the i-th medium boundary surface **30**_i is smaller than the reflection intensity R_i in the ideal state due to scattering attenuation, as expressed by Equation (4). Therefore, the actual reflection intensity R_i is made to match the reflection intensity R_i in the ideal state by multiplying the actual reflection intensity R_i by a predetermined scattering attenuation correction coefficient α_i, as shown in the following Equation (8).

$$T_1 \times R_i = \alpha_i \times (T_i \times R_i) \tag{8}$$

[0049] From Equation (8), the scattering attenuation correction coefficient α_i for the i-th medium boundary surface **30**_i is expressed by the following Equation (9).

$$\alpha_i = \frac{T_1}{T - \sum_{j=1}^{i-1} R_j} \tag{9}$$

[0050] That is, a reception signal obtained by receiving the reflected wave from the i-th medium boundary surface **30**_i can be corrected to become a reception signal in a case where no scattering attenuation occurs by multiplying the reception signal by the correction coefficient α_i.

[0051] FIGS. **4**A to **4**D show examples of the simulation result using such a scattering attenuation correction algorithm. As a prerequisite for simulation, it is assumed that medium boundary surfaces **30_1** to **30_4** having higher reflectances S_1 to S_4 than the reflectance of a medium (virtual body of a subject), which has uniform reflectance and attenuation effect, are present in the medium. The reflectances S_1 to S_4 are set to satisfy the relationship of $S_1 > S_2 = S_3 = S_4$. Then, ultrasonic waves are incident from the ultrasonic probe **10** placed on the medium boundary surface **30_1** side of the medium, reflected waves of the ultrasonic waves are received at the incidence position, and a reflection intensity corresponding to the distance from the incidence position is calculated based on the reception signal.

[0052] In FIG. **4**B, a reflection intensity at a relevant position is calculated in consideration of the reflectance at only each position in the medium (in other words, by setting the reflectance or the attenuation effect at positions other than the relevant position to zero). Since the reflectance in the medium is uniform, reflection intensities at positions other than the positions of the medium boundary surfaces **30_1** to **30_4** are the same. In addition, the relationship among the positions of the medium boundary surfaces **30_1** to **30_4** is the same as $S_1 > S_2 = S_3 = S_4$, which is the relationship among the reflectances S_1 to S_4. This is a reflection intensity in consideration of the reflectance at only each relevant position. Accordingly, needless to say, the reflection intensity in FIG. **4**B can be said to be a "reflection intensity to be received originally" and a reflection intensity in the ideal state.

[0053] FIG. **4**C shows a simulation result obtained by calculating the reflection intensity in consideration of the reflectance or the attenuation effect at all positions in the medium. This reflection intensity can be said to be a "reflection intensity of reflected waves actually received" obtained by making ultrasonic waves incident on the actual subject.

[0054] When FIG. **4**C is compared with FIG. **4**B, first, at a position before the position of the first medium boundary surface **30_1**, it can be seen that the reflection intensity decreases with an increase in the distance since ultrasonic waves propagate through the medium having uniform reflectance and attenuation effect. Then, the reflection intensity at the position of the first medium boundary surface **30_1** is reduced (attenuated) to about half of the reflection intensity in the case shown in FIG. **4**B due to the attenuation effect until the ultrasonic waves reach the position of the first medium boundary surface **30_1**. In addition, as a result of the reflection of many ultrasonic wave on the medium boundary surface **30_1**, the reflection intensity at a position immediately after passing through the medium boundary surface **30_1** is greatly reduced. Even after the medium boundary surface **30_1**, the reflection intensity decreases with an increase in the distance since the ultrasonic waves propagate through the medium having uniform reflectance and attenuation effect. For this reason, the reflection intensity at the position of the second medium boundary surface **30_2** appears slightly, the magnitude is greatly reduced (attenuated) compared with that in the case shown in FIG. **4**B. Compared with the medium, ultrasonic waves are greatly reflected on the medium boundary surface **30_2**. Accordingly, the reflection intensity at subsequent positions are further reduced.

[0055] FIG. **4**D is a signal strength (reflection intensity) when performing scattering attenuation correction of the present embodiment for the reflection intensity of the simulation result shown in FIG. **4**C. That is, for each of the positions of the four medium boundary surfaces **30_1** to **30_4**, the scattering attenuation correction value α_i is calculated from Equation (9) using the reflection intensity R_i, the reflection intensity R_{i-1} on each medium boundary surface **30** on the front side (ultrasonic probe **10** side), and the incidence intensity T_1 of the ultrasonic wave. Then, a signal strength after correction is calculated by multiplying the reflection intensity R_i by the scattering attenuation correction value α_i.

[0056] When FIG. **4**D is compared with FIG. **4**C, the reflection intensity is corrected so as to increase all of the positions of the four medium boundary surfaces **30_1** to **30_4**. When FIG. **4**D is compared with FIG. **4**B, the reflection intensities at all of the positions of the four medium boundary surfaces **30_1** to **30_4** in FIG. **4**D are almost the same as those in FIG. **4**B. That is, correction approaching the "ideal reflection intensity" is realized.

[0057] From the simulation result, it can be said that the scattering attenuation correction of the present embodiment can be applied to the correction of scattering attenuation or absorption attenuation. This is because the incidence intensity of the ultrasonic wave incident on the certain medium boundary surface **30**_i is the transmission intensity of the medium boundary surface **30**_(i−1) before the medium boundary surface **30**_i (on the ultrasonic probe **10** side) in Equation (9) of the scattering attenuation correction value α_i. That is, this is because the transmission intensity T_i and the reflection intensity R_i on the medium boundary surface **30**_i appear as values including attenuation due to a medium between the medium boundary surface **30**_i and the medium boundary surface **30**_(i−1) before the medium boundary surface **30**_i (ultrasonic probe **10** side) (refer to FIG. **3**).

(4) Application to an Ultrasonic Measurement Apparatus

[0058] An ultrasonic measurement apparatus makes ultrasonic pulses incident on a subject. However, since a variety tissues are included in the body as a subject, the reflection position of ultrasonic waves in the subject, that is, the position of a medium boundary surface, is not known. Accordingly, the above-described scattering attenuation correction is performed for a signal in the frequency domain obtained by performing a Fourier transform of a reception signal that is a signal in the time domain, and a signal after the correction is returned to the signal in the time domain by performing an inverse Fourier transform. Within the body that is a subject, a number of medium boundary surfaces due to body tissues are present, and the positions thereof are not known. Accordingly, since a reception signal becomes a composite signal of reflected waves from the plurality of medium boundary surfaces, it is very difficult to determine from which medium boundary surface (that is, depth position) an ultrasonic wave has been reflected. For this reason, the reception signal is extracted so as to be divided into a plurality of partial reception signals, scattering attenuation correction is performed for each of the partial reception signals, and then signals after correction are combined.

[0059] FIG. **5** is a schematic diagram of the procedure of scattering attenuation correction for a reception signal in the ultrasonic measurement apparatus. The procedure is in the order from top to bottom. First, ultrasonic pulses are incident on the subject **20** from the ultrasonic probe **10**. A number of medium boundary surfaces **30** are present in the subject **20**. In FIG. **5**, only the three medium boundary surfaces **30** are shown. In practice, however, four or more medium boundary surfaces **30** may be present or two or less medium boundary surfaces **30** may be present, and the positions thereof are not known.

[0060] In response to the incidence of the ultrasonic pulses, a reception signal **40** is obtained in the ultrasonic probe **10**. In the reception signal **40**, a reflected wave from the relevant medium boundary surface **30** is generated at a time t corresponding to the depth position of the medium boundary surface **30**. In general, the signal strength of the reflected wave included in the reception signal **40** decreases due to attenuation as the depth position deepens.

[0061] From the reception signal **40**, partial reception signals **42** are extracted during a plurality of set extraction periods. It is assumed that the extraction periods are the same length and the length is larger than the period of the ultrasonic pulse. The extraction periods are set so as to be shifted from each other in the time direction so that parts of the extraction periods overlap each other. Accordingly, needless to say, parts of the partial reception signals **42** in the extraction periods partially overlapping each other also overlap each other.

[0062] Then, a frequency domain signal **44** that is a signal in the frequency domain is generated by performing a Fourier transform ("FFT" in the diagram) for the extracted partial reception signals **42**. In a case where a reflected wave of the ultrasonic pulse is included in each partial reception signal **42**, a large peak appears at a frequency f_0 of the ultrasonic pulse in the frequency domain signal **44** obtained by performing a Fourier transform of the reflected wave.

[0063] Then, a frequency correction signal **46** is generated by performing scattering attenuation correction for the frequency domain signal **44**. FIG. **6** is an explanatory view of detailed scattering attenuation correction for the partial reception signal. Discrete value data of the signal strength R_i ($i=1, 2, \ldots$) is generated by performing sampling at predetermined sampling intervals (sampling unit) Ts for the partial reception signal **42**. As the signal strength R_i, signal strengths $R_1, R_2, \ldots, R_N$ are set in order of shallow depth position (early reception time). By regarding the signal strength R_i, which is the discrete value, as the reflection intensity R_i on the medium boundary surface, the scattering attenuation correction value α_i corresponding to each signal strength R_i is calculated using Equation (9). Then, the average correction value α_{AVE} that is an average value of the scattering attenuation correction value α_i is calculated. Then, the frequency correction signal **46** is generated by multiplying the frequency domain signal **44** by the average correction value α_{AVE}. The frequency correction signal **46** is a signal obtained by multiplying the peak magnitude in the frequency domain signal **44** by the average correction value α_{AVE}.

[0064] Then, referring back to FIG. **5**, a partial correction signal **48** that is a signal in the time domain is generated by performing an inverse Fourier transform ("inverse FFT" in the diagram) of the frequency correction signal **46**. Then, by combining the respective partial correction signals **48**, a reception correction signal **50** that is a signal obtained by performing scattering attenuation correction for the reception signal **40** is finally generated.

Functional Configuration

[0065] FIG. **7** is a diagram showing the functional configuration of an ultrasonic measurement apparatus **1**. As shown in FIG. **7**, the ultrasonic measurement apparatus **1** includes an ultrasonic wave transmission and reception unit **100**, an operation input unit **202**, a display unit **204**, a sound output unit **206**, a communication unit **208**, a processing unit **300**, and a storage unit **400**. Since the ultrasonic measurement apparatus **1** has a function of an ultrasonic reception signal correction device, the ultrasonic measurement apparatus **1** is also an ultrasonic reception signal correction device.

[0066] The ultrasonic wave transmission and reception unit **100** is an ultrasonic probe, and has a plurality of ultrasonic elements for transmitting and receiving ultrasonic waves. Each ultrasonic element transmits an ultrasonic pulse according to a pulse voltage input from the processing unit **300**, receives reflected waves of ultrasonic waves, converts the reflected waves into a reflected wave signal that is an electrical signal, and outputs the reflected wave signal to the processing unit **300**.

[0067] The operation input unit **202** is implemented by input devices, such as button switches, a touch panel, and various sensors, and outputs an operation signal corresponding to an operation to the processing unit **300**. The display unit **204** is implemented by a display device, such as a liquid crystal display (LCD), and performs various kinds of display based on the display signal from the processing unit **300**. The sound output unit **206** is implemented by a sound output device, such as a speaker, and outputs various sounds based on the sound signal from the processing unit **300**. The communication unit **208** is implemented by a wireless communication device, such as a wireless local area network (LAN) or Bluetooth (registered trademark), or a wired communication device, such as a modem, a wired communication cable jack, or a control circuit, and performs communication with an external device by being connected to a predetermined communication circuit.

[0068] The processing unit **300** is implemented by a microprocessor, such as a central processing unit (CPU) or a graphics processing unit (GPU) , or an electronic component, such as an application specific integrated circuit (ASIC), a field programmable gate array (FPGA), or an integrated circuit (IC) memory. The processing unit **300** controls the operation of the ultrasonic measurement apparatus **1** by executing various kinds of arithmetic processing based on a program or data stored in the storage unit **400**, an operation signal from the operation input unit **202**, or the like. The processing unit **300** includes an ultrasonic measurement control section **302**, a scattering attenuation correction section **304**, and a B-mode image generation section **320**.

[0069] The ultrasonic measurement control section **302** controls the transmission and reception of ultrasonic waves by the ultrasonic wave transmission and reception unit **100**. That is, a pulse voltage for giving an instruction on a transmission timing for each ultrasonic element is generated, and is output to the ultrasonic wave transmission and reception unit **100**. By performing amplification processing or filtering processing, A/D conversion processing, and reception focusing processing on the reflected wave signal of ultrasonic waves input from the ultrasonic wave transmission and reception unit **100**, reception signal data **406** is generated. The reception signal data **406** is data of a reception signal for each scanning line.

[0070] The scattering attenuation correction section **304** includes a signal extraction section **306**, an FFT section **308**, a correction value calculation section **310**, a correction section **312**, an inverse FFT section **314**, a signal combining section **316**, and an adjustment section **318**, and generates a reception correction signal by performing scattering attenuation correction for the reception signal for each scanning line (refer to FIGS. **5** and **6**). The generated reception correction signal for each scanning line is stored as reception correction signal data **440**.

[0071] For the reception signal, the signal extraction section **306** extracts a plurality of partial reception signals partially overlapping each other while shifting the extraction period in a time direction.

[0072] The FFT section **308** generates a frequency domain signal by performing a Fourier transform of the partial reception signal.

[0073] The correction value calculation section **310** calculates the scattering attenuation correction value α_i for the frequency domain signal. That is, data of a discrete value of the signal strength R_i ($i=1, 2, \ldots$) is generated by performing sampling at predetermined sampling intervals for the reception signal. Then, by regarding the signal strength R_i as the reflection intensity R_i on the medium boundary surface, the scattering attenuation correction value α_i corresponding to each signal strength R_i is calculated using Equation (9). Equation (9) is stored as a scattering attenuation correction equation **404**. Then, for each partial reception signal, an average correction value α_{AVE} that is an average value of the scattering attenuation correction value α_i corresponding to an extraction period is calculated.

[0074] For each partial reception signal, the correction section **312** generates a frequency correction signal by correcting the frequency domain signal by multiplying the frequency domain signal by the average correction value α_{AVE}.

[0075] The inverse FFT section **314** generates a partial correction signal by performing an inverse Fourier transform of the frequency correction signal.

[0076] The signal combining section **316** generates a reception correction signal by combining partial correction signals corresponding to the respective reception signals.

[0077] The adjustment section **318** adjusts the signal strength of the overlapping portion between the partial reception signals so as to weaken, for example. Specifically, the adjustment section **318** performs adjustment for the frequency domain signal, and the FFT section **308** performs a Fourier transform of the adjusted frequency domain signal. In addition, the adjustment section **318** performs adjustment for the reception correction signal, and the signal combining section **316** combines the respective adjusted reception correction signals.

[0078] The B-mode image generation section **320** generates a B-mode image based on the reception signal (reception correction signal) corrected by the scattering attenuation correction section **304**. The generated B-mode image is stored as B-mode image data **442**.

[0079] The storage unit **400** is implemented by a storage device, such as a read only memory (ROM), a random access memory (RAM), or a hard disk. The storage unit **400** stores a system program required for the processing unit **300** to perform overall control of the ultrasonic measurement apparatus **1**, other programs, data, and the like, and is used as a working area of the processing unit **300**. In addition, results of calculation performed by the processing unit **300**, operation data from the operation input unit **202**, and the like are temporarily stored in the storage unit **400**. An ultrasonic measurement program **402**, the scattering attenuation correction equation **404**, the reception signal data **406**, scanning line data **408**, the reception correction signal data **440**, the B-mode image data **442** are stored in the storage unit **400**.

[0080] The scanning line data **408** is data for each scanning line that is generated in the process of scattering attenuation correction performed by the scattering attenuation correction section **304**. A reception signal **412**, a signal strength table **414** that is discrete value data of the signal strength R_i obtained by sampling the reception signal **412** at predetermined sampling intervals, a correction value table **416** that is data of the scattering attenuation correction value α_i corresponding to each signal strength R_i of the signal strength table **414**, partial reception signal data **420**, and a reception correction signal **418** obtained by performing scattering attenuation correction for the reception signal **412** are stored so as to match a scanning line ID **410** that is an identification number of the relevant scanning line.

[0081] The partial reception signal data **420** is data for each partial reception signal extracted from the reception signal. A partial reception signal **424**, an extraction period **426**, a frequency domain signal **428** obtained by performing a Fourier transform of the partial reception signal **424**, an average correction value **430** that is an average value of the scattering attenuation correction value α_i of each signal strength R_i in the extraction period **426**, a frequency correction signal **432** obtained by correcting the frequency domain signal **428** using the average correction value **430**, and a partial correction signal **434** obtained by performing an inverse Fourier transform of the frequency correction signal

432 are stored so as to match a partial reception signal ID **422** that is an identification number of the relevant partial reception signal.

Process Flow

[0082] FIG. **8** is a flowchart illustrating the ultrasonic measurement process. This process is a process realized when the processing unit **300** executes the ultrasonic measurement program **402**.

[0083] First, the ultrasonic measurement control section **302** controls the ultrasonic wave transmission and reception unit **100** to transmit an ultrasonic pulse to a subject (step S1). Then, reflected waves thereof are received, thereby acquiring a reception signal (reception signal data **406**) (step S3). At this time, the reception signal **412** for each scanning line can be acquired by scanning the surface position of the subject.

[0084] Then, processing of a loop A for each scanning line is performed. In the loop A, the correction value calculation section **310** generates discrete value data of the signal strength R_i by performing sampling at predetermined sampling intervals for the reception signal **412** of the target scanning line. Then, the scattering attenuation correction value α_i corresponding to each signal strength R_i is calculated (step S5). Then, the signal extraction section **306** sets the extraction periods **426** such that parts of the extraction periods **426** overlap each other while shifting a predetermined time in the time direction, and extracts the partial reception signal **424** corresponding to each extraction period **426** from the reception signal **412** (step S7).

[0085] Then, processing of a loop B for each partial reception signal **424** is performed. In the loop B, the FFT section **308** generates the frequency domain signal **428** by performing a Fourier transform of the target partial reception signal **424** (step S9). Then, the adjustment section **318** performs first adjustment processing, which is for adjusting the signal strength, for the frequency domain signal **428** (step S11). The first adjustment processing is for preventing a signal value from being saturated in subsequent arithmetic processing (preventing the signal value from reaching the upper limit or the lower limit of calculation), for example, by multiplying the signal value by a predetermined value uniformly. Then, the correction value calculation section **310** calculates the average correction value α_{AVE} **430** that is an average value of the scattering attenuation correction value α_i corresponding to the extraction period **426** of the target partial reception signal **424** (step S13). Then, the correction section **312** performs correction by multiplying the frequency domain signal **428** by the average correction value α_{AVE} **430**, thereby generating the frequency correction signal **432** (step S15). Then, the inverse FFT section **314** generates the partial correction signal **434** by performing an inverse Fourier transform of the frequency correction signal **432** (step S17). In this manner, the loop B is performed.

[0086] After performing the processing of the loop B for all partial reception signals **424**, the signal combining section **316** generates a reception correction signal (reception correction signal data **440**) by combining the partial correction signals **434** (step S19). Then, the adjustment section **318** performs second adjustment processing, which is for adjusting the signal strength, for the reception correction signal (step S21). The second adjustment processing is for preventing a signal value from being saturated in subsequent arithmetic processing (preventing the signal value from reaching the upper limit or the lower limit of calculation), for example, by multiplying the signal value by a predetermined value uniformly. In this manner, the loop A is performed.

[0087] After performing the processing of the loop A for all scanning lines, the B-mode image generation section **320** generate a B-mode image (B-mode image data **442**) based on the reception correction signal for each scanning line (reception correction signal data **440**) (step S23).

Experimental Results

[0088] FIGS. **9**A to **9**D are diagrams showing examples of the processing result of the ultrasonic measurement apparatus **1**. FIG. **9**A is a B-mode image obtained from a reception signal of reflected waves of ultrasonic waves incident on the medium A configured to include the medium B that is a strong reflector. Here, scattering attenuation correction is not performed. FIG. **9**B is a B-mode image obtained from a signal that is obtained by performing scattering attenuation correction for the reception signal obtained in FIG. **9**A using the ultrasonic measurement apparatus **1**. When FIGS. **9**A and **9**B are compared, an acoustic shadow **24** occurs on the back side of the medium B in FIG. **9**A. However, as shown in FIG. **9**B, it can be seen that the acoustic shadow is reduced by performing the scattering attenuation correction of the present embodiment.

[0089] FIG. **9**C is a "graph of the signal strength with respect to a depth position" along scanning lines L**10**, L**20**, and L**21** in FIGS. **9**A and **9**B. Specifically, three graphs of a graph of the average signal strength of **20** scanning lines including the scanning line L**10**, which does not pass through the medium B, at the center and a graph of the average signal strength of **20** scanning lines including the scanning line L**20**, which passes through the medium B, at the center (these graphs are shown in FIG. **9**A) and a graph of the signal strength of the scanning line L**21**, that is, a graph of the signal strength obtained by performing scattering attenuation correction for the signal strength of the scanning line L**20** (this graph is shown in FIG. **9**B) are shown so as to overlap each other. FIG. **9**D is graphs obtained by enlarging a range, which corresponds to the "acoustic shadow **24**" in FIG. **9**A, in the graphs shown in FIG. **9**C.

[0090] According to FIGS. **9**C and **9**D, the signal strength of the scanning line L**10** decreases (attenuates) gradually as the depth position becomes deep, and the degree of attenuation is uniform. This is believed to be due to diffusion attenuation and absorption attenuation.

[0091] When the signal strengths of the scanning lines L**10** and L**20** are compared, it can be seen that the signal strengths of the scanning lines L**10** and L**20** are approximately the same in a depth range D**1** before reaching the medium B but the signal strength of the scanning line L**20** increases abruptly at the boundary position between the media A and B and ultrasonic waves are strongly reflected. Then, the signal strength of the scanning line L**20** decreases (attenuates) gradually in a depth range D**2** corresponding to the inside of the medium B, and becomes lower (smaller) than the signal strength of the scanning line L**10** on the whole in a depth range D**3** corresponding to the back side of the medium B. That is, the acoustic shadow **24** occurs on the back side of the medium B.

[0092] In addition, the signal strengths of the scanning lines L**20** and L**21** are approximately the same in the depth range D**1** before reaching the medium B and the depth range D**2** corresponding to the inside of the medium B. However, in the depth range D**3** corresponding to the back side of the medium B, the signal strength of the scanning line L**21** is higher (larger) than the signal strength of the scanning line L**20**, and is approximately the same as the signal strength of the scanning line L**10**.

[0093] That is, as can be seen through the comparison between FIGS. **9**A and **9**B, it can be seen that the acoustic shadow **24** is reduced by the scattering attenuation correction of the present embodiment.

Effects

[0094] Thus, according to the ultrasonic measurement apparatus **1** of the present embodiment, it is possible to reduce the acoustic shadow by appropriately correcting a reception signal obtained by receiving the reflected waves of ultrasonic waves.

[0095] That is, a plurality of partial reception signals according to overlapping periods, which are set by shifting the time so as to overlap partially, are extracted from the reception signal obtained by receiving reflected waves of ultrasonic waves incident on the subject. Then, scattering attenuation correction using the scattering attenuation correction value α is performed for a frequency domain signal obtained by performing a Fourier transform of each of the plurality of partial reception signals, and an inverse Fourier transform of the corrected frequency correction signal is performed. Then, a signal obtained by combining the partial correction signals after the inverse Fourier transform corresponding to the respective partial reception signals is set as a reception correction signal obtained by correcting each reception signal. The scattering attenuation correction value α is calculated from the signal strength of incident ultrasonic waves and a sum value of the signal strength of the reception signal at each time.

[0096] A subject includes a number of medium boundary surfaces **30**. For this reason, reflected waves at a plurality of different depth positions are included in a reception signal, and the depth position is unknown. In a signal obtained by performing a Fourier transform of the reception signal, a peak appears at the frequency of the reflected wave. Accordingly, by correcting the signal obtained by performing the Fourier transform, it is possible to correct the reception signal without detecting a region where acoustic shadow has occurred. In addition, by correcting partial reception signals with a small number of reflected waves and combining the partial reception signals, it is possible to correct the reception signal more appropriately.

[0097] In addition, it should be understood that embodiments to which the invention can be applied are not limited to the embodiment described above and various modifications can be made without departing from the spirit and scope of the invention.

[0098] The entire disclosure of Japanese Patent Application No. 2015-190937 filed on Sep. 29, 2015 is expressly incorporated by reference herein.

What is claimed is:

1. An ultrasonic reception signal correction device, comprising:
a processing unit configured to calculate an attenuation correction value using a signal strength of ultrasonic waves incident on a subject and a signal strength sum value of a reception signal obtained by receiving reflected waves from the subject,
perform a Fourier transform of the reception signal, correct a signal after the Fourier transform using the attenuation correction value, and
perform an inverse Fourier transform of a signal after the correction.

2. The ultrasonic reception signal correction device according to claim **1**, further comprising:
the processor configured to extract a plurality of partial reception signals from the reception signal by shifting a predetermined extraction period in a time direction,
wherein the Fourier transform, the correction, and the inverse Fourier transform are performed for the partial reception signals, and
signals after the inverse Fourier transform are combined as a signal of the corresponding extraction period.

3. The ultrasonic reception signal correction device according to claim **2**,
wherein the calculation of the attenuation correction value is to calculate the attenuation correction value for each cumulative time at which the reception signal is received, and
the correction is to correct the relevant partial reception signal using the attenuation correction value at a cumulative time corresponding to the partial reception signal.

4. The ultrasonic reception signal correction device according to claim **3**,
wherein a sampling unit of the cumulative time is set to be shorter than a shifting time of the extraction period, and
the correction is to average the attenuation correction value at the cumulative time corresponding to the partial reception signal and correct the partial reception signal using the average value.

5. The ultrasonic reception signal correction device according to claim **2**,
wherein the extraction is to extract the partial reception signals by shifting the extraction period so as to overlap partially, and
a signal strength of an overlapping portion between the partial reception signals is adjusted.

6. An ultrasonic measurement apparatus, comprising:
an ultrasonic probe that makes ultrasonic waves incident on a subject and receives reflected waves of the ultrasonic waves; and
the ultrasonic reception signal correction device according to claim **1** that corrects a reception signal received by the ultrasonic probe.

7. An ultrasonic measurement apparatus, comprising:
an ultrasonic probe that makes ultrasonic waves incident on a subject and receives reflected waves of the ultrasonic waves; and
the ultrasonic reception signal correction device according to claim **2** that corrects a reception signal received by the ultrasonic probe.

8. An ultrasonic measurement apparatus, comprising:
an ultrasonic probe that makes ultrasonic waves incident on a subject and receives reflected waves of the ultrasonic waves; and
the ultrasonic reception signal correction device according to claim **3** that corrects a reception signal received by the ultrasonic probe.

9. An ultrasonic measurement apparatus, comprising:

an ultrasonic probe that makes ultrasonic waves incident on a subject and receives reflected waves of the ultrasonic waves; and

the ultrasonic reception signal correction device according to claim **4** that corrects a reception signal received by the ultrasonic probe.

10. An ultrasonic measurement apparatus, comprising:

an ultrasonic probe that makes ultrasonic waves incident on a subject and receives reflected waves of the ultrasonic waves; and

the ultrasonic reception signal correction device according to claim **5** that corrects a reception signal received by the ultrasonic probe.

11. An ultrasonic reception signal correction method of performing arithmetic processing for correcting an ultrasonic reception signal using an arithmetic processing unit, the method comprising:

calculating an attenuation correction value using a signal strength of ultrasonic waves incident on a subject and a signal strength sum value of a reception signal obtained by receiving reflected waves from the subject;

performing a Fourier transform of the reception signal;

correcting a signal after the Fourier transform using the attenuation correction value; and

performing an inverse Fourier transform of a signal after the correction.

* * * * *

专利名称(译)	超声波接收信号校正装置，超声波测量装置和超声波接收信号校正方法		
公开(公告)号	US20170086796A1	公开(公告)日	2017-03-30
申请号	US15/278710	申请日	2016-09-28
[标]申请(专利权)人(译)	精工爱普生株式会社		
申请(专利权)人(译)	SEIKO EPSON CORPORATION		
当前申请(专利权)人(译)	SEIKO EPSON CORPORATION		
[标]发明人	WATANABE RYOKI		
发明人	WATANABE, RYOKI		
IPC分类号	A61B8/08 A61B8/00 A61B5/00 A61B8/14 G01S15/89 G01S7/52		
CPC分类号	A61B8/5269 G01S15/8988 A61B8/4444 A61B5/7257 A61B8/14 G01S7/52026 A61B8/5207 G01S15/8977 G06T2207/10132		
优先权	2015190937 2015-09-29 JP		
外部链接	Espacenet USPTO		

摘要(译)

超声波测量装置根据通过移位时间而设置的重叠时段从接收信号中提取多个部分接收信号，以便部分地重叠。然后，对通过对多个部分接收信号中的每一个执行傅里叶变换而获得的频域信号执行使用散射衰减校正值的散射衰减校正，并且执行校正的频率校正信号的逆傅立叶变换。然后，通过执行逆傅里叶变换获得与各个部分接收信号对应的部分校正信号。然后，在校正接收信号之后，将通过组合部分校正信号获得的信号设置为接收校正信号。根据入射超声波的信号强度和每次接收信号的信号强度的和值计算散射衰减校正值。