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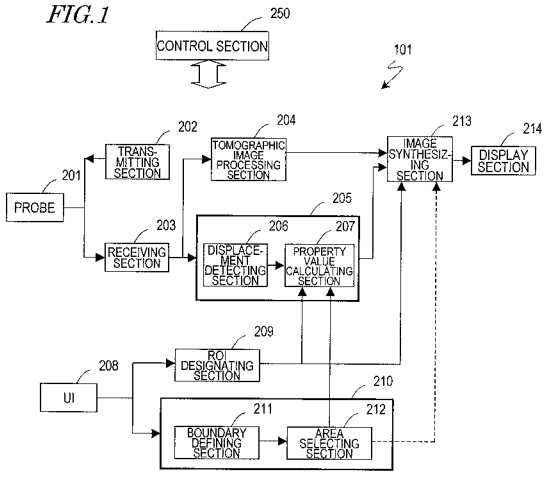
(54) ULTRASONOGRAPH

(57) An ultrasonic diagnostic apparatus according to the present invention includes: a transmitting section for driving an ultrasonic probe to transmit an ultrasonic wave toward a measuring region of a subject, including an arterial vascular wall; a receiving section for receiving a reflected wave, produced by getting the ultrasonic wave reflected from the subject, at the probe, thereby generating a received signal; a displacement detecting section for calculating the magnitude of displacement of each measuring point in the measuring region on the wall by analyzing the received signal; a tissue-to-present determining section, which defines at least one boundary between tissues included in the measuring region on the wall and which selects one of at least two areas divided by the boundary defined; and a property value calculating section for calculating a property value of the subject based on the magnitude of displacement of each measuring point. The distribution of property values of the measuring points in the area selected by the tissue-to-present determining section is presented as a two-dimensional image.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an ultrasonic diagnostic apparatus and more particularly relates to an ultrasonic diagnostic apparatus that can obtain an attribute value of a blood vessel.

BACKGROUND ART

[0002] An ultrasonic diagnostic apparatus is used to make a noninvasive checkup on a subject by irradiating him or her with an ultrasonic wave and analyzing the information contained in its reflected wave (i.e., echo). For example, a conventional ultrasonic diagnostic apparatus that has been used extensively converts the intensity of the reflected wave into its associated pixel luminance, thereby presenting the subject's structure as a tomographic image. In this manner, the internal structure of the subject can be known.

[0003] Meanwhile, some people are attempting recently to track the motion of a subject's tissue more precisely and evaluate the strain and the elasticity, viscosity or any other physical (attribute) property of the tissue (among other things, an arterial vascular wall) mainly by analyzing the phase of the reflected wave (Patent Document No. 1 or 2).

[0004] If the elastic property of each site of the arterial vascular wall under inspection is presented as a two-dimensional distribution by using such a technique, a portion of the arterial vascular wall with a unique elastic modulus can be easily identified. That is why an ultrasonic diagnostic apparatus could be used in diagnosing arterial sclerosis.

Patent Document No. 1: Japanese Patent Application Laid-Open Publication No. 10-5226
Patent Document No. 2: Japanese Patent Application Laid-Open Publication No. 2000-229078
Patent Document No. 3: Pamphlet of PCT International Application Publication No. 2004/112568
Patent Document No. 4: Japanese Patent Application Laid-Open Publication No. 2000-271117

DISCLOSURE OF INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] In presenting an attribute property value representing an elastic property, for example, as a two-dimensional distribution image, only the attribute property values at respective sites of the subject are displayed as pieces of information without reflecting any structural difference of the subject. For example, if the adventitia and its adjacent media of an arterial vascular wall have the same tissue hardness, then their elastic moduli will also be the same, thus making no difference in the information displayed.

[0006] However, in order to make a more accurate pathological diagnosis on the subject, it would be more beneficial to allow the person making the diagnosis to determine what tissue the region of interest belongs to.

[0007] In order to overcome the problems described above, the present invention has an object of providing an ultrasonic diagnostic apparatus that can selectively present the elastic modulus distribution of any arbitrary tissue in the subject.

MEANS FOR SOLVING THE PROBLEMS

[0008] An ultrasonic diagnostic apparatus according to the present invention includes: a transmitting section for driving an ultrasonic probe that sends out an ultrasonic wave toward a measuring region of a subject, the region including an arterial vascular wall; a receiving section for receiving a reflected wave, produced by getting the ultrasonic wave reflected from the subject, at the ultrasonic probe, thereby generating a received signal; a displacement detecting section for calculating the magnitude of displacement of each measuring point in the measuring region on the vascular wall by analyzing the received signal; a tissue-to-present determining section, which defines at least one boundary between multiple tissues included in the measuring region on the vascular wall and which selects one of at least two areas that have been divided by the boundary defined; and a property value calculating section for calculating a property value of the subject based on the magnitude of displacement of each said measuring point. The distribution of property values of the measuring points included in the area that has been selected by the tissue-to-present determining section is presented as a two-dimensional image.

[0009] In one preferred embodiment, the tissue-to-present determining section includes: a boundary defining section for defining at least one boundary between the multiple tissues included in the vascular wall; and an area selecting section for selecting one of at least two areas that have been divided by the boundary defined. The area selecting section generates the location information of the one area in accordance with an operator's command.

[0010] In this particular preferred embodiment, the ultrasonic diagnostic apparatus further includes: an image processing section for generating a tomographic image of the measuring region of the subject based on the received signal; and a display section for presenting the tomographic image.

[0011] In a specific preferred embodiment, the boundary defining section generates the location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image presented on the display section.

[0012] In another preferred embodiment, the boundary defining section automatically generates the location information of the at least one boundary based on the re-

ceived signal.

[0013] In this particular preferred embodiment, the ultrasonic diagnostic apparatus further includes a storage section that stores not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

[0014] In a specific preferred embodiment, the ultrasonic diagnostic apparatus reads the information about the tomographic image from the storage section to present the tomographic image on the display section. The boundary defining section reads the location information of the at least one boundary between the tissues from the storage section. And the boundary defining section updates the location of the at least one boundary based on the location that has been specified by the operator on the tomographic image presented on the display section.

[0015] In another preferred embodiment, the boundary defining section automatically generates the location information of the at least one boundary based on the received signal, and updates the location information of the at least one boundary generated based on the location that has been specified by the operator on the tomographic image presented on the display section.

[0016] In still another preferred embodiment, the property value is an elastic modulus.

[0017] In yet another preferred embodiment, the ultrasonic diagnostic apparatus further includes a region-of-interest designating section for allowing the operator to designate a region of interest within the measuring region based on the tomographic image presented on the display section. The property value calculating section calculates a property value of the subject based on the magnitude of displacement of a measuring point inside the region of interest.

[0018] In this particular preferred embodiment, the property value calculating section further calculates at least one of the average, maximum value, minimum value and variance of elastic moduli within the region of interest.

[0019] In an alternative preferred embodiment, the property value calculating section further figures out the distribution of elastic moduli within the region of interest and presents the distribution of elastic moduli as a histogram on the display section.

[0020] In yet another preferred embodiment, the vascular wall includes an intima, a media and an adventitia and the at least one boundary is at least one of a boundary between the intima and a vascular lumen, a boundary between the intima and the adventitia, and a boundary between the adventitia and an extravascular tissue.

[0021] A control method according to the present invention is a method for controlling an ultrasonic diagnostic apparatus using a control section of the apparatus. The method includes the steps of: (A) driving an ultrasonic probe and sending out an ultrasonic wave; (B) receiving a reflected wave from a subject, including an arterial vascular wall, at the ultrasonic probe, thereby generating a received signal; (C) calculating the magnitude of displacement of each measuring point in a measuring region on the vascular wall by analyzing the received signal; (D) defining at least one boundary between multiple tissues included in the measuring region on the vascular wall and selecting one of at least two areas that have been divided by the boundary defined; (E) calculating a property value of the subject based on the magnitude of displacement of each said measuring point; and (F) presenting the property values of the measuring points included in the at least one area as a two-dimensional image.

[0022] In one preferred embodiment, the step (D) includes the steps of: (D1) defining at least one boundary between the multiple tissues included in the vascular wall; and (D2) selecting one of the at least two areas that have been divided by the boundary defined. The step (D2) includes generating the location information of the one area in accordance with an operator's command.

[0023] In this particular preferred embodiment, the method further includes the steps of: (G) generating a tomographic image of the measuring region of the subject based on the received signal; and (H) presenting the tomographic image.

[0024] In another preferred embodiment, the step (D1) includes generating the location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image.

[0025] In still another preferred embodiment, the step (D1) includes automatically generating the location information of the at least one boundary based on the received signal.

[0026] In this particular preferred embodiment, the method further includes, between the steps (D) and (E), the step (I) of storing, in the storage section, not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

[0027] In a specific preferred embodiment, the method further includes, between the steps (D) and (E), the step (J) of reading the information about the tomographic image from the storage section to present the tomographic image on the display section, and making the boundary defining section retrieve the location information of the at least one boundary between the tissues from the storage section, and the step (K) of updating the location information of the at least one boundary by allowing the operator to modify the location of the at least one boundary on the tomographic image.

EFFECTS OF THE INVENTION

[0028] According to the present invention, the bound-

ary between arbitrary tissues on a subject can be detected and a two-dimensional distribution image of elastic moduli can be presented for the tissues specified by the operator. As a result, the distribution of elastic moduli can be known, and the pathological diagnosis of the subject can be made more accurately, on a tissue-by-tissue basis within the measuring region.

BRIEF DESCRIPTION OF DRAWINGS

[0029]

FIG. **1** is a block diagram illustrating a first preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention.

FIG. **2** is a flowchart showing how the ultrasonic diagnostic apparatus shown in FIG. **1** operates.

FIG. **3** illustrates an example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **1.**

FIG. **4** illustrates another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **1.**

FIG. **5** illustrates still another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **1.**

FIG. **6** is a block diagram illustrating a second preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention.

FIG. **7** illustrates an example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **6.**

FIG. **8** illustrates another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **6.**

FIG. **9** illustrates still another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **6.**

FIG. **10** is a block diagram illustrating a third preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention.

FIG. **11** is a flowchart showing how the ultrasonic diagnostic apparatus shown in FIG. **10** operates.

FIG. **12** illustrates an example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **10.**

FIG. **13** illustrates another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **10.**

FIG. **14** illustrates still another example of an image to be presented on the display section of the ultrasonic diagnostic apparatus shown in FIG. **10.**

DESCRIPTION OF REFERENCE NUMERAL

[0030]

101, 102, 103	ultrasonic diagnostic apparatus
201	probe
202	transmitting section
203	receiving section
204	tomographic image processing section
205	computing section
206	displacement detecting section
207	property value calculating section
208	user interface
209	region-of-interest designating section
210	tissue-to-present determining section
211, 221, 223	boundary defining section
212	area selecting section
213	image synthesizing section
214	display section
250	control section
251	memory

BEST MODE FOR CARRYING OUT THE INVENTION

(EMBODIMENT 1)

[0031] Hereinafter, a first preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention will be described. The ultrasonic diagnostic apparatus of the present invention is used to measure the elastic modulus, magnitude of strain, coefficient of viscosity or any other attribute property value of a vascular wall. In the following description of preferred embodiments, the ultrasonic diagnostic apparatus is supposed to calculate the elastic modulus as an attribute property value. Alternatively, the apparatus may also calculate the magnitudes of strains or the coefficients of viscosity and present an image representing the two-dimensional distribution thereof.

[0032] FIG. **1** is a block diagram showing a configuration for an ultrasonic diagnostic apparatus **101** as a first preferred embodiment of the present invention. The ultrasonic diagnostic apparatus **101** includes a transmitting section **202,** a receiving section **203,** a tomographic image processing section **204,** a computing section **205,** a region-of-interest designating section **209,** a tissue-to-present decision section **210** and an image synthesizing section **213.** The apparatus further includes a control section **250** for controlling all of these elements and a user interface **208.** The control section **250** may be implemented as a microcomputer, for example. The user interface **208** is an input device such as a keyboard, a mouse, a track ball, a switch, or a button that accepts an operator's input.

[0033] The ultrasonic diagnostic apparatus **101** is connected to a probe **201,** which sends out an ultrasonic wave toward a measuring region of a subject and receives a reflected wave, produced by getting the ultrasonic wave reflected from the subject.

[0034] In accordance with the instruction given by the control section **250,** the transmitting section **202** generates a high-voltage transmission signal that drives the probe **201** at a specified timing. The probe **201** converts

the transmission signal that has been generated by the transmitting section **202** into an ultrasonic wave and sends out the ultrasonic wave toward a subject, and also converts a reflected wave that has been reflected by an internal organ of the subject into an electrical signal. A number of piezoelectric transducers are arranged in the probe **201.** By changing the piezoelectric transducers to use or the timing to apply a voltage to the piezoelectric transducers, the probe **201** controls the angle of deflection and focus of the ultrasonic waves to transmit and receive. The receiving section **203** amplifies the electrical signal that has been generated by the probe **201,** and outputs a received signal. In this manner, the receiving section **203** detects either only an ultrasonic wave that has been reflected from a predetermined point (i.e., a focused ultrasonic beam) or only an ultrasonic wave that has come from a predetermined direction (or at a predetermined angle of deflection). The ultrasonic waves are usually transmitted and received a number of times (e.g., ten plus times) a second.

[0035] The tomographic image processing section **204** includes a filter, a detector, and a logarithmic amplifier, and analyzes mainly the amplitude of the received signal, thereby sequentially generating image signals representing tomographic images of the subject. Those signals generated are output to the image synthesizing section **213.**

[0036] The image synthesizing section **213** synthesizes together the tomographic image represented by the image signal and the image representing the two-dimensional distribution of attribute property values that have been calculated by the property value calculating section **207,** and outputs the synthetic image thus obtained to the display section **214.**

[0037] The region-of-interest designating section **209** generates the location information of a target region within the measuring region, which has been designated by the operator on the tomographic image on the display section **214** with the user interface **208.** That region designated by the operator is a target region where the attribute property value needs to be calculated, and is called a "region-of-interest". The location information of the region-of-interest thus generated is output to the image synthesizing section **213** and the property value calculating section **207.**

[0038] The tissue-to-present determining section **210** determines the location information of the target tissue for the operator where the attribute property needs to be calculated. For that purpose, the tissue-to-present determining section **210** includes a boundary defining section **211** and an area selecting section **212.** The boundary defining section **211** automatically defines the location of at least one boundary between multiple tissues included in the arterial vascular wall of the subject, thereby generating location information. The boundary location information thus generated is output to the image synthesizing section **213** so that the boundary is indicated on the tomographic image on the display section **214.**

[0039] The arterial vascular wall of the subject includes an intima, a media and an adventitia. Furthermore, outside of the adventitia, there is an extravascular tissue. And the intima is adjacent to the vascular lumen. The boundaries between these tissues can be detected automatically by a known technique (which may be the one disclosed in Patent Document No. 3 or 4). More specifically, the boundaries may be detected based on the magnitude of displacement of the measuring point that has been obtained from the displacement detecting section **206** and the amplitude intensity of the received signal that has been obtained from the tomographic image processing section **204.** If the best detection method changes according to the type of the boundary, then the boundaries may be detected by multiple different detection methods. For example, since blood is flowing inside the vascular lumen, the boundary between the vascular lumen and the intima may be detected by analyzing the received signal by the Doppler's method.

[0040] The tissue-to-present determining section **210** may detect and select the boundaries either over the entire measuring region or only the region-of-interest that has been defined within the measuring region. However, the amount of computations to be done would be the smaller if the boundaries are detected and selected within the region-of-interest.

[0041] Using the user interface **208,** the operator selects one of at least two areas that have been defined by at least one boundary being superimposed on the tomographic image. The area selecting section **212** generates the location information of the area that has been selected by the operator. The selected area's location information thus generated is output to the property value calculating section **207** to be described later.

[0042] The computing section **205** includes the displacement detecting section **206** and the property value calculating section **207.** The displacement detecting section **206** analyzes the received signal, thereby sequentially calculating the magnitudes of displacement of the respective measuring points that have been set within the measuring region of the subject. The method of calculating the magnitudes of displacement is not particularly limited but may be any known method. To calculate the magnitude of displacement with high precision, the phase difference tracking method as disclosed in Patent Document No. 1 may be used, for example. More particularly, the magnitude of displacement of the subject's tissue in the ultrasonic wave transmitting and receiving directions may be figured out by analyzing the phase difference between the received signals.

[0043] The property value calculating section **207** calculates an attribute property value such as the magnitude of strain or elastic modulus in accordance with the location information of the region-of-interest that has been provided by the region-of-interest designating section **209** and based on the magnitudes of displacement of the measuring points within the region-of-interest. More specifically, first, the property value calculating section **207**

adds the magnitude of displacement that has been calculated by the displacement detecting section **206** to the original location of each measuring point, thereby finding the location of the measuring point displaced and plotting a location change waveform representing the change of locations of each measuring point. By calculating the difference between the location change waveforms of two adjacent measuring points or two arbitrary measuring points within the measuring region, a thickness variation waveform Δ**W** is obtained. And by dividing the thickness variation waveform Δ**W** by an initial value **Ws,** the magnitude of strain ε can be obtained.

[0044] The property value calculating section **207** is further provided externally with information about the blood pressure of the subject. For example, the subject's blood pressure is measured with a blood pressure manometer and the property value calculating section **207** receives the blood pressure value from the blood pressure manometer. Supposing the difference between the highest and lowest blood pressures is identified by ΔP, the radial elastic modulus **Er** is calculated by $Er=\Delta P/\varepsilon=\Delta P \cdot Ws/\Delta W$. This elastic modulus **Er** is obtained between every pair of adjacent measuring points within the measuring region. As a result, a two-dimensional distribution of elastic moduli in the measuring region can be obtained. As the highest and lowest blood pressures are normally measured every cardiac cycle, the elastic modulus **Er** is also measured every cardiac cycle.

[0045] The property value calculating section **207** may calculate the attribute property values either only at measuring points within the selected area, representing the tissue that the operator is interested in, or using every measuring point within the region-of-interest.

[0046] The property value calculating section **207** further obtains the maximum, minimum, average and variance values of the elastic moduli that have been measured within the selected area. Optionally, the property value calculating section **207** may also obtain the frequency distribution of elastic moduli. These values calculated are output to the image synthesizing section **213.**

[0047] The image synthesizing section **213** receives the elastic moduli that have been calculated by the property value calculating section **207,** thereby generating an image representing the two-dimensional distribution of the elastic moduli. In this case, if the elastic moduli have been obtained only within the selected area, the image synthesizing section **213** generates the two-dimensional distribution image using every elastic modulus received from the property value calculating section **207.** On the other hand, if the property value calculating section **207** has obtained elastic moduli within the region-of-interest, then the image synthesizing section **213** receives the location information of the selected area from the tissue-to-present determining section **210** and generates the two-dimensional distribution image only within the selected area.

[0048] The two-dimensional distribution image of elastic moduli thus generated is synthesized with the tomographic image of the subject's measuring region, which has been provided by the tomographic image processing section **204.** The image synthesizing section **213** also receives the location information of the region-of-interest from the region-of-interest designating section **209** and the location information of the boundary from the tissue-to-present determining section **210,** thereby generating line segments representing the region-of-interest and the boundary, respectively, and synthesizing those line segments with the tomographic image.

[0049] Furthermore, the image synthesizing section **213** generates numerical values representing the maximum, minimum, average and variance values of the elastic moduli that have been obtained by the property value calculating section **207.** If a frequency distribution of the elastic moduli has been obtained, a histogram of the elastic moduli is generated.

[0050] On the other hand, if the property value calculating section **207** has not calculated the elastic moduli yet, then line segments representing the region-of-interest and the boundary are generated and synthesized with the tomographic image.

[0051] The display section **214** receives and displays the image information that has been generated by the image synthesizing section **213.**

[0052] It should be noted that the respective elements of the ultrasonic diagnostic apparatus **101** described above could be implemented as hardware components or by a software program. The region designating section **209** and the tissue-to-present determining section **210** may be implemented by a microcomputer including the control section **250.**

[0053] Hereinafter, it will be described with reference to FIG. **1** and FIGS. **2** to **5** how the ultrasonic diagnostic apparatus **101** operates. FIG. **2** is a flowchart showing the procedure of operation of the ultrasonic diagnostic apparatus **101.** FIGS. **3** to **5** illustrate exemplary images to be presented on the display section **214.**

[0054] First, the transmitting section **202** drives the probe **201,** thereby sending out an ultrasonic wave toward a subject including his or her arterial vascular wall. Then, a reflected wave, produced by getting the ultrasonic wave reflected by the subject, is received at the receiving section **203** through the probe **201,** thereby generating a received signal in Step **S101.**

[0055] The tomographic image processing section **204** receives the received signal and transforms the amplitude of the received signal into luminance information, thereby generating an image signal representing a tomographic image (in Step **S102**). Then, the image signal is output to the display section **214** by way of the image synthesizing section **213,** and the tomographic image is presented on the display section (in Step **S103**).

[0056] As shown in FIG. **3,** a tomographic image **301** is presented on the screen of the display section **214.** The tomographic image **301** includes the intima **311,** media **312** and adventitia **313** of a vascular anterior wall, the intima **321,** media **322** and adventitia **323** of a vas-

cular posterior wall, a vascular lumen **310,** and extravascular tissues **314** and **334.** In FIG. **3,** the boundaries between these tissues are represented by line segments. In an actual tomographic image, however, these tissues are presented with luminances representing the intensities of the reflected ultrasonic waves. That is why the boundaries between those tissues may sometimes be not so clearly defined.

[0057] While the tomographic image is being generated, the displacement detecting section **206** of the computing section **205** analyzes the received signal, thereby calculating the magnitudes of displacements of respective measuring points within the measuring region of the subject (in Step **S104**).

[0058] The operator defines a region-of-interest **302** on the tomographic image **301** presented on the display section **214** using a user interface **208** such as a mouse. In the example illustrated in FIG. **3,** the region-of-interest **302** is defined by the operator so as to include an atheroma **335** that is observed on the vascular posterior wall. In accordance with the signal that has been entered through the user interface **208,** the ROI designating section **209** determines the location information of the region-of-interest **302** within the measuring region (in Step **S105**). Optionally, the region-of-interest may also be defined after a target area where an attribute property value needs to be calculated has been selected.

[0059] The boundary defining section **211** of the tissue-to-present determining section **210** automatically detects the boundaries between the respective tissues, which are included in the arterial vascular wall, within the region-of-interest **302** based on the received signal. The location information of the boundaries detected is passed to the image synthesizing section **213** and then displayed on the display section **214.** As shown in FIG. **3,** within the region-of-interest **302,** the boundary **303a** between the vascular lumen **310** and the intima **321,** the boundary **303b** between the intima **321** and the media **322,** the boundary **303c** between the media **322** and the adventitia **323,** and the boundary **303d** between the adventitia **333** and the extravascular tissue **334** are superimposed on the tomographic image **301.**

[0060] Then, the operator chooses one of the areas **306A, 306B, 306C, 306D** and **306E,** which have been defined by these boundaries **303a** through **303d,** as a target area where the attribute property value needs to be calculated. By moving the cursor **305** with the user interface **208** as shown in FIG. **3,** for example, the operator designates one particular area. In accordance with the signal supplied from the user interface **208,** the area selecting section **212** generates the location information of the selected area that has been designated by the operator and outputs the information to the property value calculating section **207** and the image synthesizing section **213** (in Step **S107**).

[0061] Based on the magnitudes of displacement at the respective measuring points that have been provided by the displacement detecting section **206** and the location information of the selected area that has been provided by the tissue-to-present determining section **210,** the property value calculating section **207** calculates the elastic modulus between the measuring points within the selected area. The property value calculating section **207** also obtains the maximum, minimum and average values and frequency distribution of the elastic moduli within the selected area (in Step **S108**).

[0062] The image synthesizing section **213** generates a two-dimensional distribution image based on the elastic moduli that have been calculated by the property value calculating section **207** and synthesizes the distribution image and the tomographic image together (in Step **S109**). The image synthesizing section **213** also generates numerical values representing the maximum, minimum and average values and further generates a histogram of the elastic moduli. The image thus generated is presented on the display section **214** (in Step **S110**).

[0063] After that, either the region-of-interest or the selected area where the attribute property value needs to be obtained may be modified or changed if necessary. In that case, the same series of processing steps that starts with Step **S105** should be carried out all over again.

[0064] In FIG. **3,** if the operator has selected the area **306C** interposed between the boundaries **303b** and **303c,** then a two-dimensional distribution image **341** of elastic moduli within the area **306C** is superimposed on the tomographic image **301** as shown in FIG. **4.** The area **306C** is portion of the designated region-of-interest **302** that represents the media of the vascular posterior wall. In FIG. **4,** the two-dimensional distribution image **335** is indicated by even shadowing. Actually, however, the two-dimensional distribution image **335** is presented in color tones or grayscale tones associated with the elastic moduli, and a color bar **309** or a grayscale bar **309** representing the correspondence between the elastic moduli and the color tones or grayscale tones is also displayed. The measuring points are set in the entire region-of-interest **302** such that the distribution of elastic moduli can be presented as a two-dimensional matrix consisting of 64 vertical pixels by 32 horizontal pixels, for example.

[0065] On the other hand, if the operator has selected the area **306D** interposed between the boundaries **303c** and **303d** in FIG. **3,** then a two-dimensional distribution image **342** of elastic moduli within the area **306D** is superimposed on the tomographic image **301** as shown in FIG. **5.** The area **306C** is a portion of the designated region-of-interest **302** that represents the adventitia of the vascular posterior wall.

[0066] By displaying the distributions of elastic moduli on a tissue-by-tissue basis as shown in FIGS. **4** and **5,** it becomes clearer what tissue a portion with a specific elastic modulus belongs to. As a result, a person who is carrying out the diagnosis (such as a doctor) can estimate the elastic moduli with the tissue-by-tissue properties into consideration. Thus, according to this preferred embodiment, a boundary between tissues in a subject can be located automatically, and an image representing the

two-dimensional distribution of elastic moduli can be presented for a tissue specified by the operator. Consequently, the distribution of elastic moduli can be known for every tissue within the measuring region, and a more accurate pathological diagnosis can be made on the given subject.

[0067] In the preferred embodiment described above, the boundary defining section **211** locates the boundaries between the respective tissues that form the vascular wall. However, a plurality of tissues may be detected collectively. For example, the intima and the media may be detected as an intima-media thickness (IMT) and the boundary between the IMT and the adventitia and the boundary between the IMT and the vascular lumen may be located.

(EMBODIMENT 2)

[0068] Hereinafter, a second preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention will be described. FIG. **6** is a block diagram showing a configuration for an ultrasonic diagnostic apparatus **102** as a second preferred embodiment of the present invention. Unlike the first preferred embodiment, the ultrasonic diagnostic apparatus **102** includes a tissue-to-present determining section **220** including the boundary defining section **221.**

[0069] The boundary defining section **221** defines the at least one boundary by the location that has been specified by the operator on the tomographic image **301** being presented on the display section **214,** and generates its location information. More specifically, using the user interface **208,** the operator moves the cursor on the tomographic image **301** being presented on the display section **214.** The trace of the cursor on the move is superimposed as a line segment on the tomographic image **301.** If the operator finds the line segment drawn appropriately, then he or she determines his or her selection with the user interface **208,** thereby fixing the boundary that has been specified by him or her. If necessary, one or more line segments may be drawn and fixed as additional boundaries. The boundary defining section **221** generates the location information of the boundaries that have been fixed by the operator in this manner. The line segments may be drawn either in the entire measuring region or only within the region-of-interest. However, it would be less troublesome for the operator to draw a line segment, representing the boundary, only within the region-of-interest.

[0070] Subsequently, using the user interface **208** again, the operator selects one of multiple areas that have been defined by the boundary being superimposed on the tomographic image on the display section **214.** Then, the area selecting section **212** generates the location information of that area selected by the operator. The selected area location information thus generated is then output to the property value calculating section **207.**

[0071] The ultrasonic diagnostic apparatus **102** operates just as the first preferred embodiment described above except that a boundary between tissues is defined manually by the operator within either the measuring region or the region-of-interest.

[0072] FIG. **7** illustrates how the operator have fixed boundaries **303a', 303'b, 303'c** and **303'd2** by drawing line segments between the respective tissues with the cursor **305** moved using the user interface **208.**

[0073] In FIG. **7,** if the operator has selected the area **306C** interposed between the boundaries **303'b** and **303'c,** then a two-dimensional distribution image **341** of elastic moduli within the area **306C** is superimposed on the tomographic image **301** as shown in FIG. **8.** On the other hand, if the operator has selected the area **306D** interposed between the boundaries **303'c** and **303'd** in FIG. **7,** then a two-dimensional distribution image **342** of elastic moduli within the area **306D** is superimposed on the tomographic image **301** as shown in FIG. **9.**

[0074] Thus, according to this preferred embodiment, a boundary between tissues in a subject is drawn manually by the operator and one of the areas divided by the boundary is selected, thereby getting a two-dimensional distribution image of elastic moduli presented for any desired tissue. In particular, since the operator draws the boundary manually in this preferred embodiment, a target area where the elastic modulus needs to be calculated may be determined both arbitrarily and easily by collectively selecting a plurality of tissues as a single area and by getting the two-dimensional distribution image of elastic moduli presented in that selected area, for example. Also, even if the boundary between tissues has become locally indefinite on the tomographic image **301,** the boundary can still be defined according to the operator's own judgment. That is why it is possible to avoid the unwanted situation where such an indefinite boundary prevents the operator from finding his or her target area and obtaining a two-dimensional distribution image of elastic moduli. Consequently, the distribution of elastic moduli can be known for every tissue within the measuring region and a more accurate pathological diagnosis can be made on the subject.

(EMBODIMENT 3)

[0075] Hereinafter, a third preferred embodiment of an ultrasonic diagnostic apparatus according to the present invention will be described. FIG. **6** is a block diagram showing a configuration for an ultrasonic diagnostic apparatus **103** as a third preferred embodiment of the present invention. Unlike the first preferred embodiment described above, the ultrasonic diagnostic apparatus **102** includes a memory **251** functioning as a storage section and a tissue-to-present determining section **220** including a boundary defining section **231.**

[0076] While an ultrasonic wave is being transmitted or received to carry out measurements, the memory **251** stores information about an image signal representing the tomographic image, which has been provided by the

tomographic image processing section **204,** and information about the magnitude of displacement at each measuring point, which has been provided by the displacement detecting section **206,** in association with the time or order of reception of the received signals. The memory **251** also stores the location information of the boundaries that have been defined by the boundary defining section **231.**

[0077] In calculating an elastic modulus by reading the information that is stored in the memory section after the measuring process has ended or suspended (or frozen) (which is also called a "cine-mode"), the image information of the tomographic image and the information about the magnitude of displacement at each measuring point, which are stored in the memory **251,** are read from the memory **251** and supplied to the image synthesizing section **213** and the property value calculating section **207,** respectively, at the same time in accordance with a command given by the operator. In addition, the location information of the boundary is also read from the memory **251** and supplied to the boundary defining section **231.**

[0078] While transmitting or receiving an ultrasonic wave and making a measurement, the boundary defining section **231** automatically detects the boundary between tissues based on the received signal as already described for the first preferred embodiment, thereby outputting its location information. Also, in calculating an elastic modulus by reading out the information stored, the operator can modify the boundary that has been read out from the memory **251** using the user interface **208.** The modification includes deleting the boundary. If the boundary has been modified by the operator, the boundary defining section **231** obtains the location information of the modified boundary and updates the location information.

[0079] Then, based on the location information of the updated boundary, the operator selects a target area where the two-dimensional distribution of elastic moduli needs to be obtained as already described for the first preferred embodiment, thereby producing an image representing the two-dimensional distribution of elastic moduli in the selected area.

[0080] Hereinafter, it will be described with reference to FIG. **10** and FIGS. **11** to **14** how the ultrasonic diagnostic apparatus **103** operates. FIG. **11** is a flowchart showing the procedure of operation of the ultrasonic diagnostic apparatus **101.** FIGS. **12** to **14** illustrate exemplary images to be presented on the display section **214.**

[0081] First, the transmitting section **202** drives the probe **201,** thereby sending out an ultrasonic wave toward a subject including his or her arterial vascular wall. Then, a reflected wave, produced by getting the ultrasonic wave reflected by the subject, is received at the receiving section **203** through the probe **201,** thereby generating a received signal in Step **S111.**

[0082] The tomographic image processing section **204** receives the received signal and transforms the amplitude of the received signal into luminance information, thereby generating an image signal representing a tomographic image (in Step **S112**). Then, the image signal is output to the display section **214** by way of the image synthesizing section **213,** and the tomographic image is presented on the display section (in Step **S113**).

[0083] As shown in FIG. **14,** a tomographic image **301** is presented on the screen of the display section **214.** The tomographic image **301** includes the intima **311,** media **312** and adventitia **313** of a vascular anterior wall, the intima **321,** media **322** and adventitia **323** of a vascular posterior wall, a vascular lumen **310,** and extravascular tissues **314** and **334.**

[0084] While the tomographic image is being generated, the displacement detecting section **206** of the computing section **205** analyzes the received signal, thereby calculating the magnitudes of displacements of respective measuring points within the measuring region of the subject (in Step **S115).**

[0085] The operator defines a region-of-interest **302** using a user interface **208** such as a mouse. In the example illustrated in FIG. **12,** the region-of-interest **302** is defined by the operator so as to include an atheroma **335** that is observed on the vascular posterior wall. In accordance with the signal that has been entered through the user interface **208,** the ROI designating section **209** determines the location information of the region-of-interest **302** within the measuring region (in Step **S116**). Optionally, the region-of-interest may also be defined after a target area where an attribute property value needs to be calculated has been selected.

[0086] The measuring process is carried out in such a state for a predetermined period of time, thereby obtaining measuring data. The image information to be generated sequentially and the magnitudes of displacements of the respective measuring points are stored in the memory **21** in associated with the reception times (in Steps **S114** and **S118**). The location information of the boundary that has been detected automatically is also stored.

[0087] When the measuring process ends, the image information, the magnitudes of displacements of the respective measuring points, and the location information of the boundary, which have been stored in the memory **251,** are read out. And the image information and the boundary are presented on the display section **214.**

[0088] If necessary, the operator modifies the automatically detected boundary on the tomographic image **301** being presented on the display section **214.** In FIG. **12,** a portion **303e** of the automatically detected boundary **303a** expands toward the vascular lumen **310.** If the operator has determined, based on the tomographic image **301,** that the location of that portion **303e** of the boundary is a detection error, then he or she modifies the location of that portion **303e** of the boundary by moving the cursor **305** as shown in FIG. **13.** Once the boundary has been modified, the boundary defining section **231** updates the location information of that boundary modified (in Step **S120**).

[0089] Then, the operator chooses one of the areas

306A, 306B, 306C, 306D and **306E,** which have been defined by the modified boundary **303a** and the other boundaries **303b** through **303d,** as a target area where the attribute property value needs to be calculated. By moving the cursor **305** with the user interface **208** as shown in FIG. **13,** for example, the operator designates one particular area. In accordance with the signal supplied from the user interface **208,** the area selecting section **212** generates the location information of the selected area that has been designated by the operator and outputs the information to the property value calculating section **207** and the image synthesizing section **213** (in Step **S121**).

[0090] Based on the magnitudes of displacement at the respective measuring points that have been provided by the displacement detecting section **206** and the location information of the selected area that has been provided by the tissue-to-present determining section **210,** the property value calculating section **207** calculates the elastic modulus between the measuring points within the selected area. The property value calculating section **207** also obtains the maximum, minimum and average values and frequency distribution of the elastic moduli within the selected area (in Step **S122**).

[0091] The image synthesizing section **213** generates a two-dimensional distribution image based on the elastic moduli that have been calculated by the property value calculating section **207** and synthesizes the distribution image and the tomographic image together. The image synthesizing section **213** also generates numerical values representing the maximum, minimum and average values and further generates a histogram of the elastic moduli in Step **S123.** The image thus generated is presented on the display section **214** (in Step **S126**).

[0092] After that, the selected area where the attribute property value needs to be obtained may be modified or changed if necessary. In that case, the same series of processing steps that starts with Step **S121** should be carried out all over again.

[0093] In FIG. **13,** if the operator has selected the area **306B** interposed between the boundaries **303a** and **303b,** then a two-dimensional distribution image **343** of elastic moduli within the area **306B** is superimposed on the tomographic image **301** as shown in FIG. **14.** The area **306B** is a portion of the designated region-of-interest **302** that represents the intima of the vascular posterior wall. Since the operator has modified the boundary **303a,** the elastic modulus of only the intima portion is displayed properly. Although not shown in FIG. **14,** the maximum, minimum and average values of elastic moduli in the selected area and histograms of the elastic moduli may also be displayed as in the first and second preferred embodiments described above.

[0094] As described above, according to this preferred embodiment, when the elastic modulus is calculated by reading information from the memory in the cine-mode after the boundary between tissues in the subject has been detected automatically, the operator can modify the automatically detected boundary. Thus, the operator can save the trouble of drawing the boundary by him- or herself and can modify the boundary manually if necessary. As a result, the target tissue, of which the elastic modulus needs to be calculated, can be determined more easily and more accurately, and the distribution of elastic moduli can be known for every tissue within the measuring region. Consequently, a pathological diagnosis can be made on the subject more accurately.

[0095] In the preferred embodiment described above, the boundary defining section **231** is designed so as to automatically detect the boundary between tissues first, read the data from the memory, and then allow the operator to modify the detected boundary if necessary. Likewise, the boundary defining section of the first preferred embodiment described above may also be designed so as to automatically detect the boundary and then allow the operator to modify the boundary if necessary. More specifically, the boundary defining section **211** may automatically generate the location information of at least one boundary based on the received signal. Then, the operator may modify and update the location information of the at least one boundary, which has been generated by the boundary defining section **211,** based on the location specified by the operator on the tomographic image being presented on the display section **214.** As a result, the boundary can be defined more accurately and the burden on the operator can be lightened, too.

INDUSTRIAL APPLICABILITY

[0096] The present invention can be used effectively in an ultrasonic diagnostic apparatus for measuring an attribute property value of a blood vessel.

Claims

1. An ultrasonic diagnostic apparatus comprising:

a transmitting section for driving an ultrasonic probe that sends out an ultrasonic wave toward a measuring region of a subject, the region including an arterial vascular wall;

a receiving section for receiving a reflected wave, produced by getting the ultrasonic wave reflected from the subject, at the ultrasonic probe, thereby generating a received signal;

a displacement detecting section for calculating the magnitude of displacement of each measuring point in the measuring region on the vascular wall by analyzing the received signal;

a tissue-to-present determining section, which defines at least one boundary between multiple tissues included in the measuring region on the vascular wall and which selects one of at least two areas that have been divided by the boundary defined; and

a property value calculating section for calculating a property value of the subject based on the magnitude of displacement of each said measuring point,

wherein the distribution of property values of the measuring points included in the area that has been selected by the tissue-to-present determining section is presented as a two-dimensional image.

2. The ultrasonic diagnostic apparatus of claim 1, wherein the tissue-to-present determining section includes: a boundary defining section for defining at least one boundary between the multiple tissues included in the vascular wall; and an area selecting section for selecting one of at least two areas that have been divided by the boundary defined, and wherein the area selecting section generates the location information of the one area in accordance with an operator's command.

3. The ultrasonic diagnostic apparatus of claim 2, further comprising:

an image processing section for generating a tomographic image of the measuring region of the subject based on the received signal; and a display section for presenting the tomographic image.

4. The ultrasonic diagnostic apparatus of claim 3, wherein the boundary defining section generates the location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image presented on the display section.

5. The ultrasonic diagnostic apparatus of claim 3, wherein the boundary defining section automatically generates the location information of the at least one boundary based on the received signal.

6. The ultrasonic diagnostic apparatus of claim 5, further comprising a storage section that stores not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

7. The ultrasonic diagnostic apparatus of claim 6, wherein the information about the tomographic image is read from the storage section to present the tomographic image on the display section, and the boundary defining section reads the location information of the at least one boundary between the tissues from the storage section, and wherein the boundary defining section updates the location of the at least one boundary based on the location that has been specified by the operator on the tomographic image presented on the display section.

8. The ultrasonic diagnostic apparatus of claim 3, wherein the boundary defining section automatically generates the location information of the at least one boundary based on the received signal, and updates the location information of the at least one boundary generated based on the location that has been specified by the operator on the tomographic image presented on the display section.

9. The ultrasonic diagnostic apparatus of claim 1, wherein the property value is an elastic modulus.

10. The ultrasonic diagnostic apparatus of claim 1, further comprising a region-of-interest designating section for allowing the operator to designate a region of interest within the measuring region based on the tomographic image presented on the display section, and wherein the property value calculating section calculates a property value of the subject based on the magnitude of displacement of a measuring point inside the region of interest.

11. The ultrasonic diagnostic apparatus of claim 10, wherein the property value calculating section further calculates at least one of the average, maximum value, minimum value and variance of elastic moduli within the region of interest.

12. The ultrasonic diagnostic apparatus of claim 10, wherein the property value calculating section further figures out the distribution of elastic moduli within the region of interest and presents the distribution of elastic moduli as a histogram on the display section.

13. The ultrasonic diagnostic apparatus of claim 1, wherein the vascular wall includes an intima, a media and an adventitia and wherein the at least one boundary is at least one of a boundary between the intima and a vascular lumen, a boundary between the intima and the adventitia, and a boundary between the adventitia and an extravascular tissue.

14. A method for controlling an ultrasonic diagnostic apparatus using a control section of the apparatus, the method comprising the steps of:

(A) driving an ultrasonic probe and sending out an ultrasonic wave;
(B) receiving a reflected wave from a subject, including an arterial vascular wall, at the ultra-

sonic probe, thereby generating a received signal;
(C) calculating the magnitude of displacement of each measuring point in a measuring region on the vascular wall by analyzing the received signal;
(D) defining at least one boundary between multiple tissues included in the measuring region on the vascular wall and selecting one of at least two areas that have been divided by the boundary defined;
(E) calculating a property value of the subject based on the magnitude of displacement of each said measuring point; and
(F) presenting the property values of the measuring points included in the at least one area as a two-dimensional image.

15. The method of claim 14, wherein the step (D) includes the steps of:

(D1) defining at least one boundary between the multiple tissues included in the vascular wall; and
(D2) selecting one of the at least two areas that have been divided by the boundary defined, and wherein the step (D2) includes generating the location information of the one area in accordance with an operator's command.

16. The method of claim 15, further comprising the steps of:

(G) generating a tomographic image of the measuring region of the subject based on the received signal; and
(H) presenting the tomographic image.

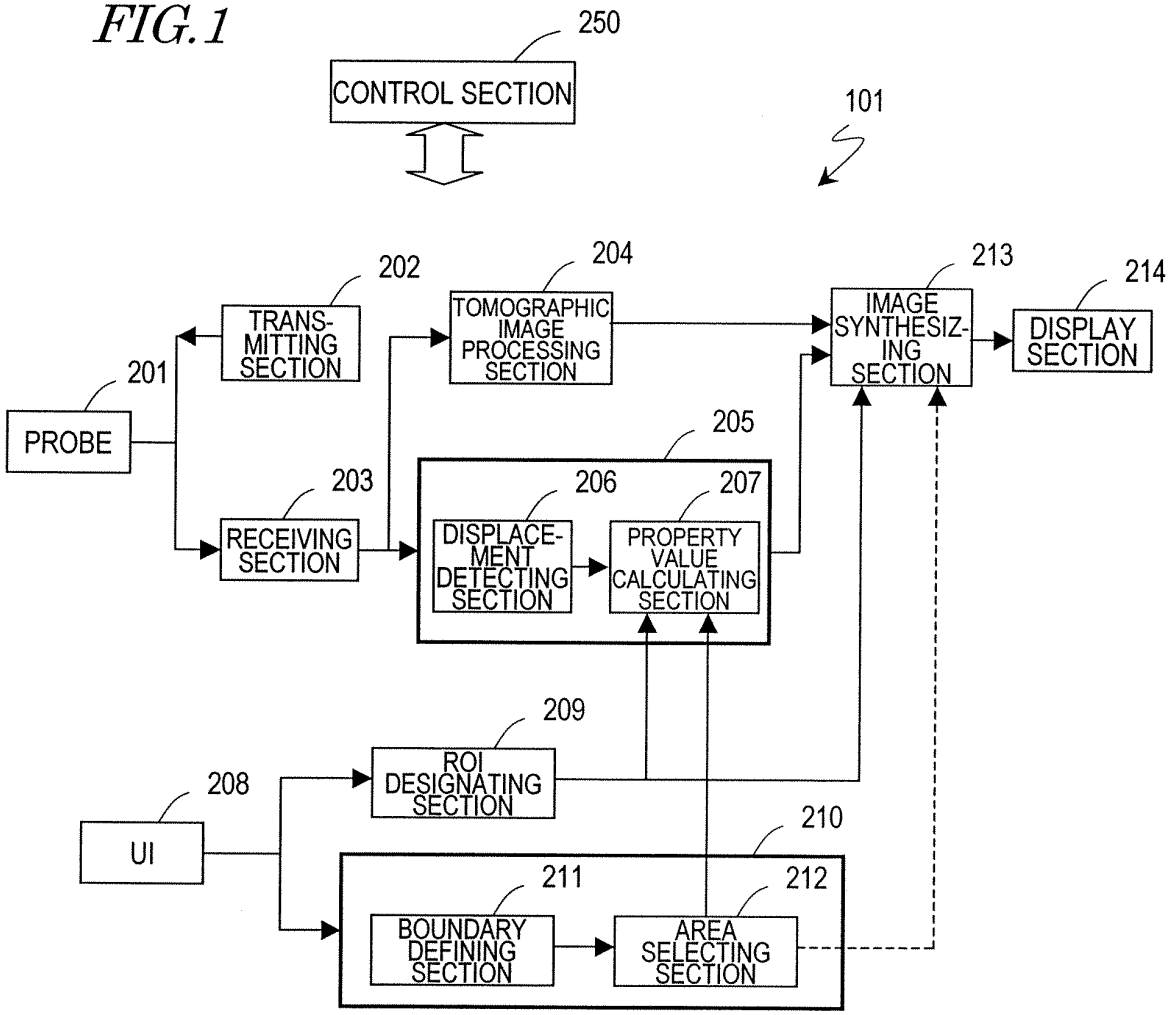
17. The method of claim 14, wherein the step (D1) includes generating the location information of the at least one boundary based on a location that has been specified by the operator on the tomographic image.

18. The method of claim 16, wherein the step (D1) includes automatically generating the location information of the at least one boundary based on the received signal.

19. The method of claim 18, further comprising, between the steps (D) and (E), the step (I) of storing, in the storage section, not only the location information of the at least one boundary but also information about the tomographic image and information about the magnitudes of displacement of the respective measuring points in association with points in time when, or the order in which, the received signals arrived.

20. The method of claim 19, further comprising, between the steps (D) and (E), the step (J) of reading the information about the tomographic image from the storage section to present the tomographic image on the display section, and making the boundary defining section retrieve the location information of the at least one boundary between the tissues from the storage section, and
the step (K) of updating the location information of the at least one boundary by allowing the operator to modify the location of the at least one boundary on the tomographic image.

FIG. 1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204
213
214
TRANS-MITTING SECTION
TOMOGRAPHIC IMAGE PROCESSING SECTION
IMAGE SYNTHESIZ-ING SECTION
DISPLAY SECTION
201
PROBE
205
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203
RECEIVING SECTION
DISPLACE-MENT DETECTING SECTION
PROPERTY VALUE CALCULATING SECTION
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ROI DESIGNATING SECTION
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UI
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211
212
BOUNDARY DEFINING SECTION
AREA SELECTING SECTION

FIG.2

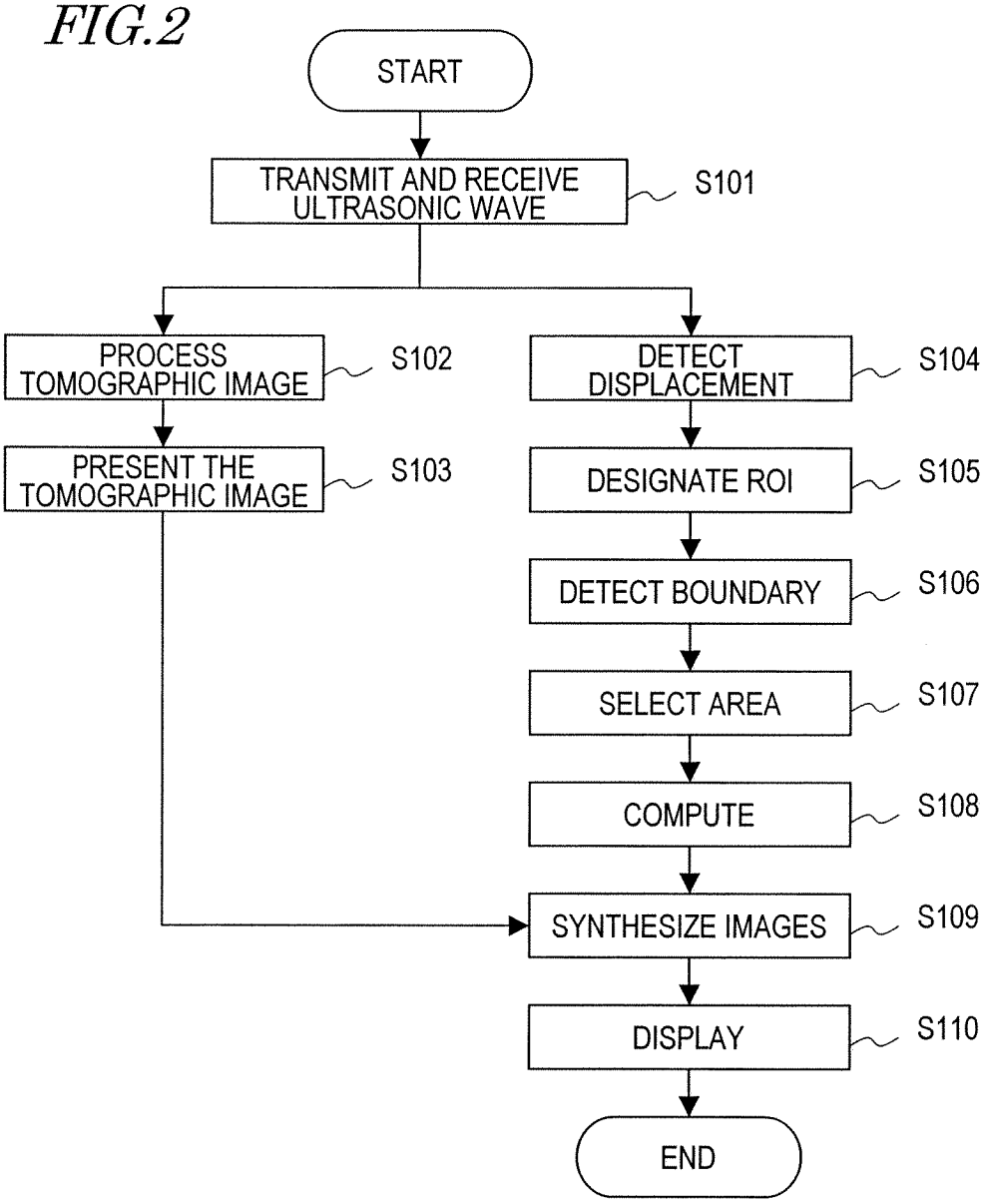
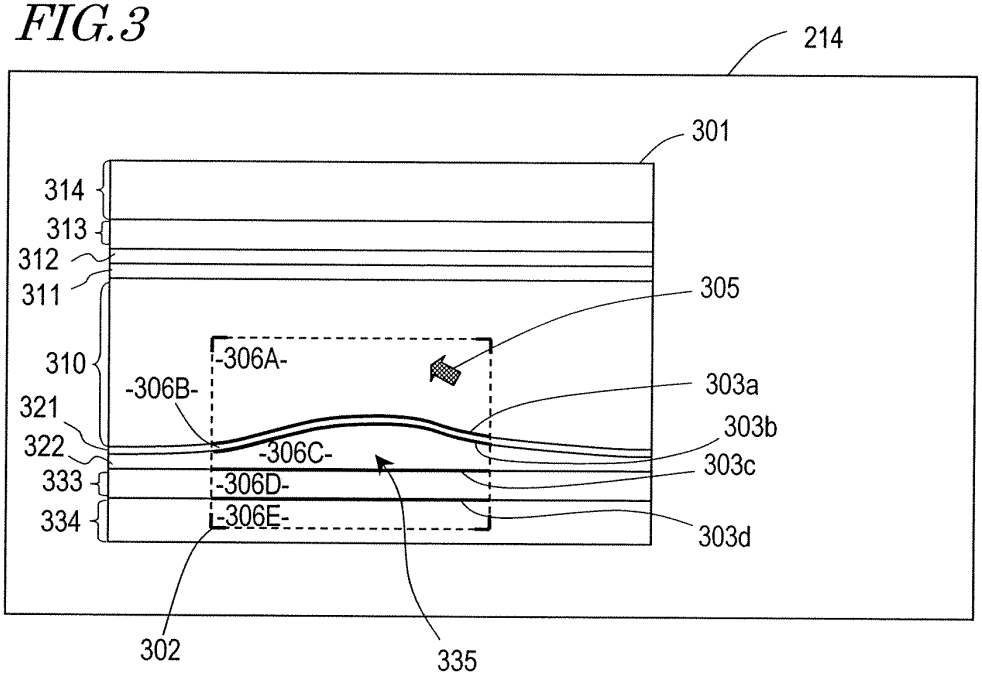

START
TRANSMIT AND RECEIVE ULTRASONIC WAVE
S101
PROCESS TOMOGRAPHIC IMAGE
S102
PRESENT THE TOMOGRAPHIC IMAGE
S103
DETECT DISPLACEMENT
S104
DESIGNATE ROI
S105
DETECT BOUNDARY
S106
SELECT AREA
S107
COMPUTE
S108
SYNTHESIZE IMAGES
S109
DISPLAY
S110
END

FIG.3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312
311
310
321
322
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334
305
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303a
303b
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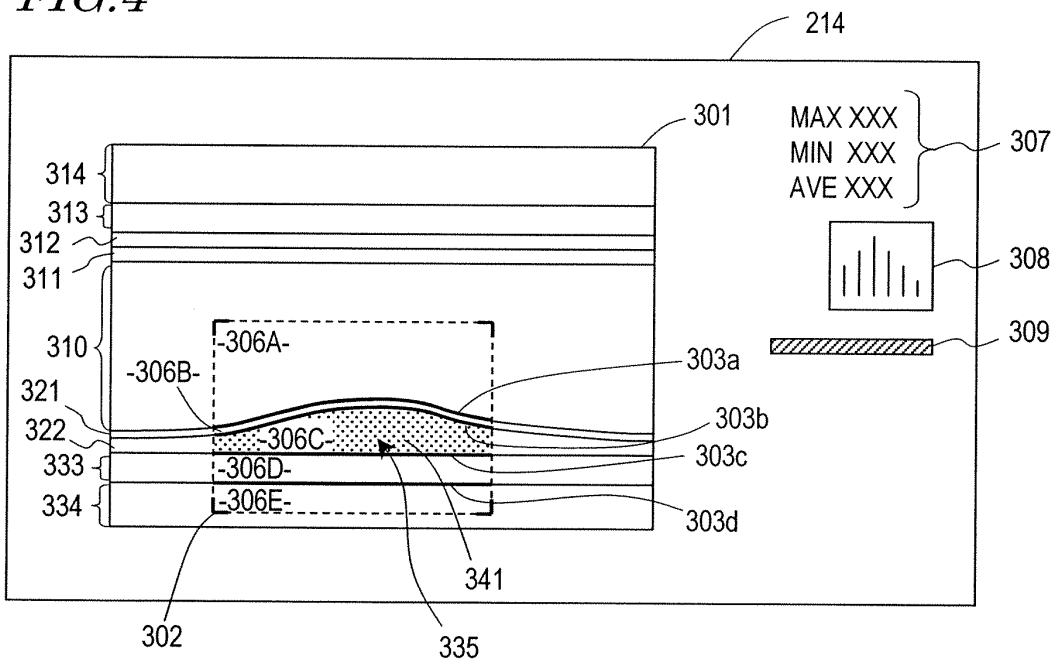
303d
302
335

FIG.4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-306C-
-306D-
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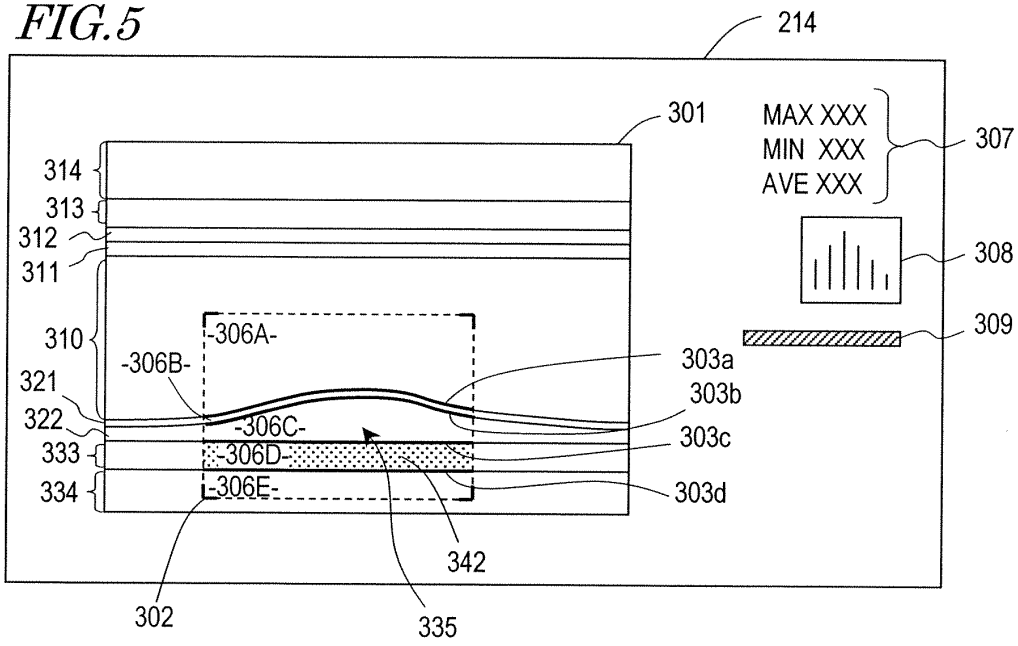
303d
MAX XXX
MIN XXX
AVE XXX
307
308
309
341
302
335

FIG.5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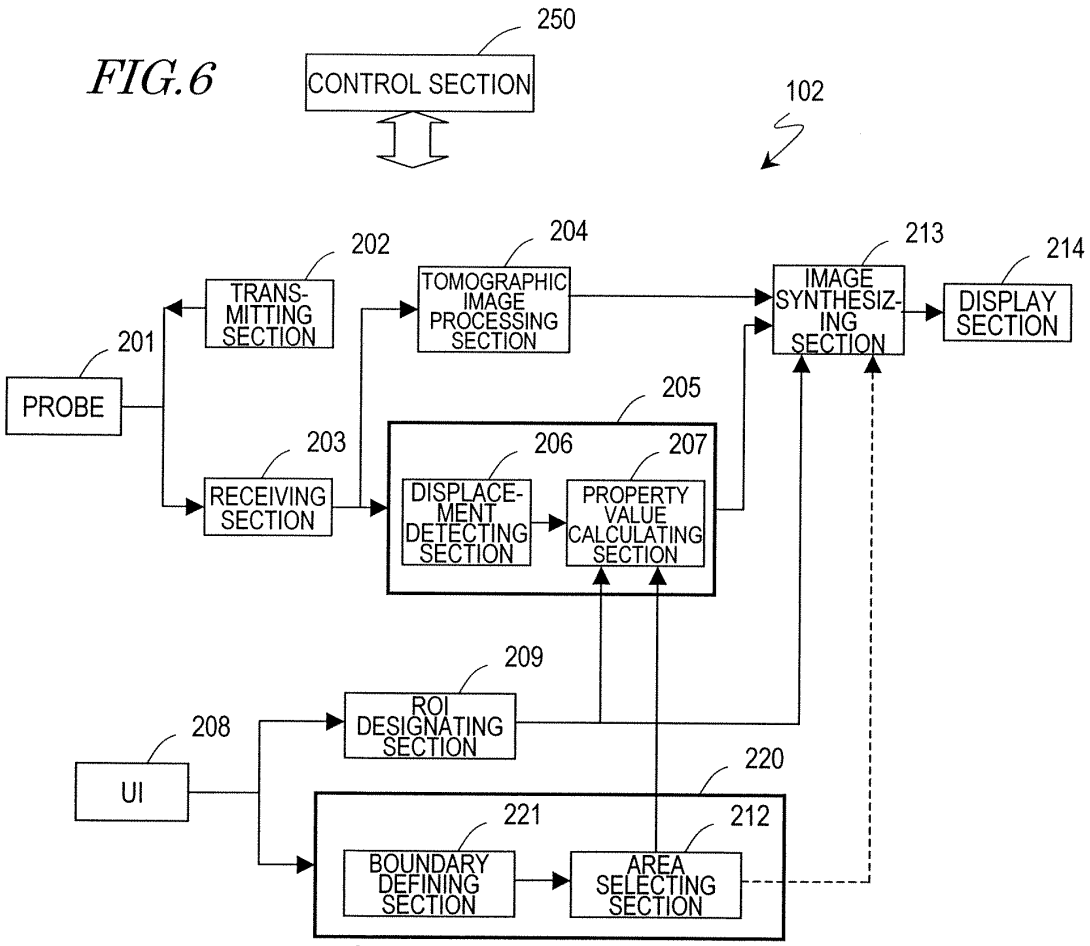
303a
303b
303c
303d
342
302
335

FIG.6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TRANS-MITTING SECTION
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TOMOGRAPHIC IMAGE PROCESSING SECTION
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IMAGE SYNTHESIZ-ING SECTION
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DISPLAY SECTION
201
PROBE
205
203
206
207
RECEIVING SECTION
DISPLACE-MENT DETECTING SECTION
PROPERTY VALUE CALCULATING SECTION
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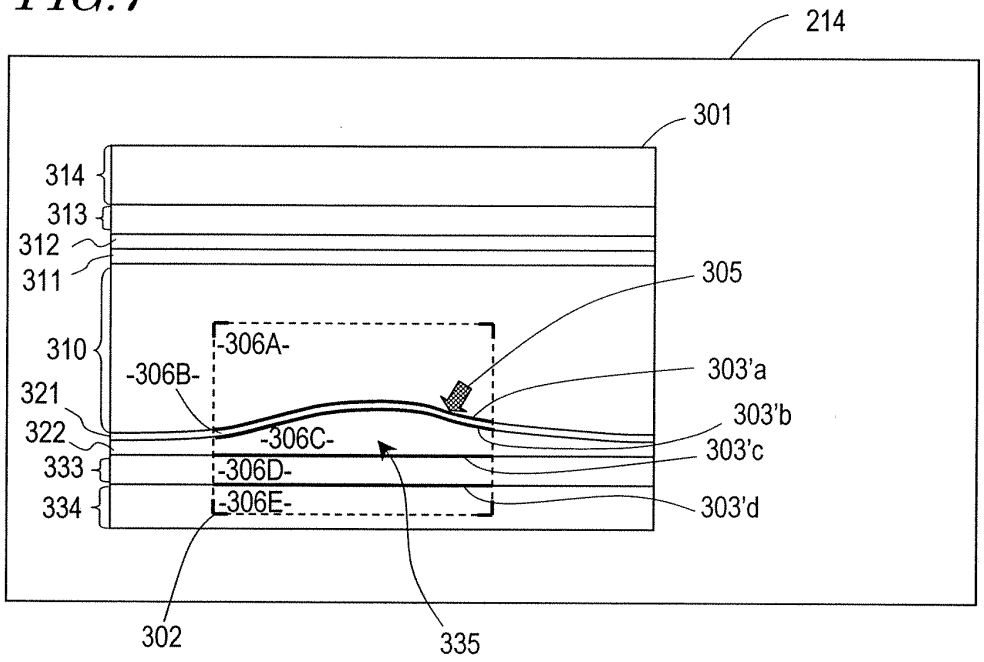
ROI DESIGNATING SECTION
208
UI
220
221
212
BOUNDARY DEFINING SECTION
AREA SELECTING SECTION

FIG. 7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311
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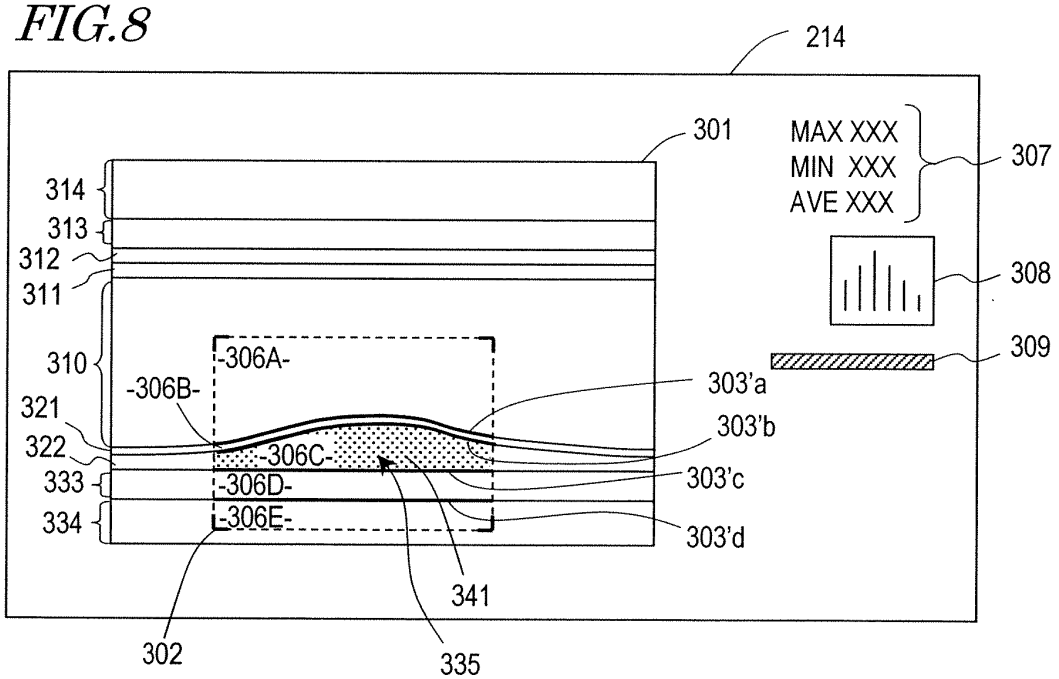
322
333
334
-306A-
-306B-
-306C-
-306D-
-306E-
305
303'a
303'b
303'c
303'd
302
335

FIG. 8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-306A-
-306B-
-306C-
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303'b
303'c
303'd
302
335
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MAX XXX
MIN XXX
AVE XXX
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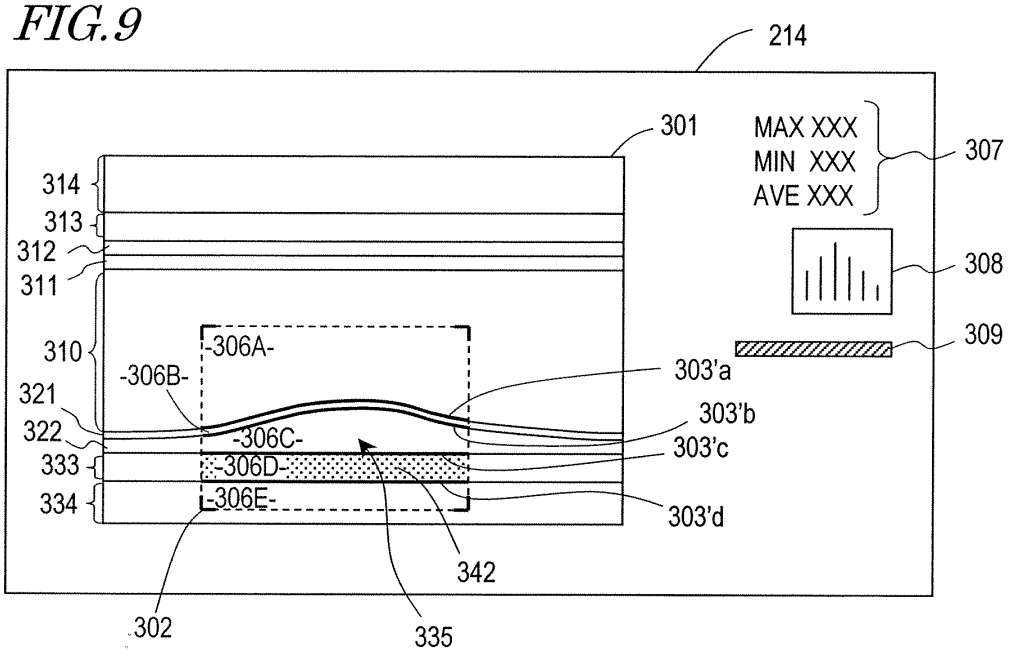
308
309

FIG.9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MAX XXX
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322
333
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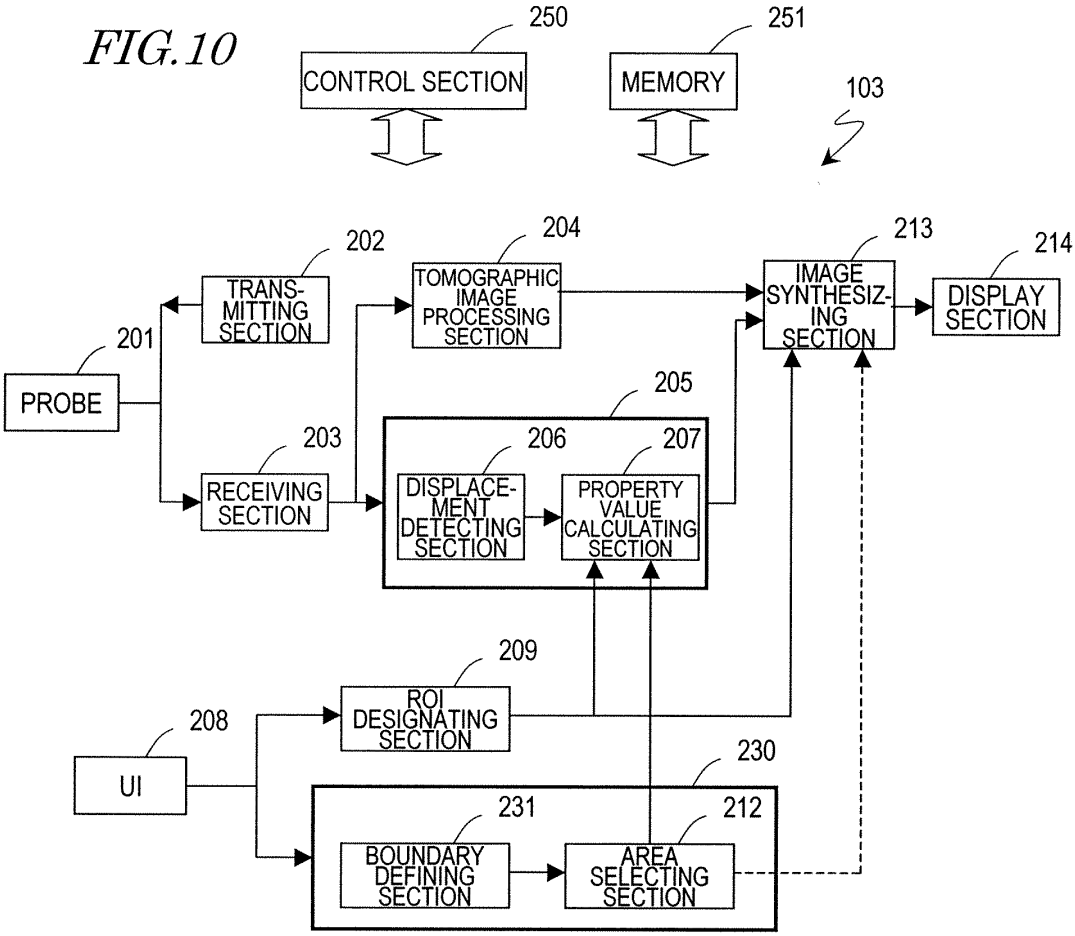
303'c
303'd
342
302
335

FIG.10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CONTROL SECTION
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MEMORY
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202
TRANS-MITTING SECTION
204
TOMOGRAPHIC IMAGE PROCESSING SECTION
213
IMAGE SYNTHESIZ-ING SECTION
214
DISPLAY SECTION
201
PROBE
205
203
206
207
RECEIVING SECTION
DISPLACE-MENT DETECTING SECTION
PROPERTY VALUE CALCULATING SECTION
209
ROI DESIGNATING SECTION
208
UI
230
231
212
BOUNDARY DEFINING SECTION
AREA SELECTING SECTION

FIG.11

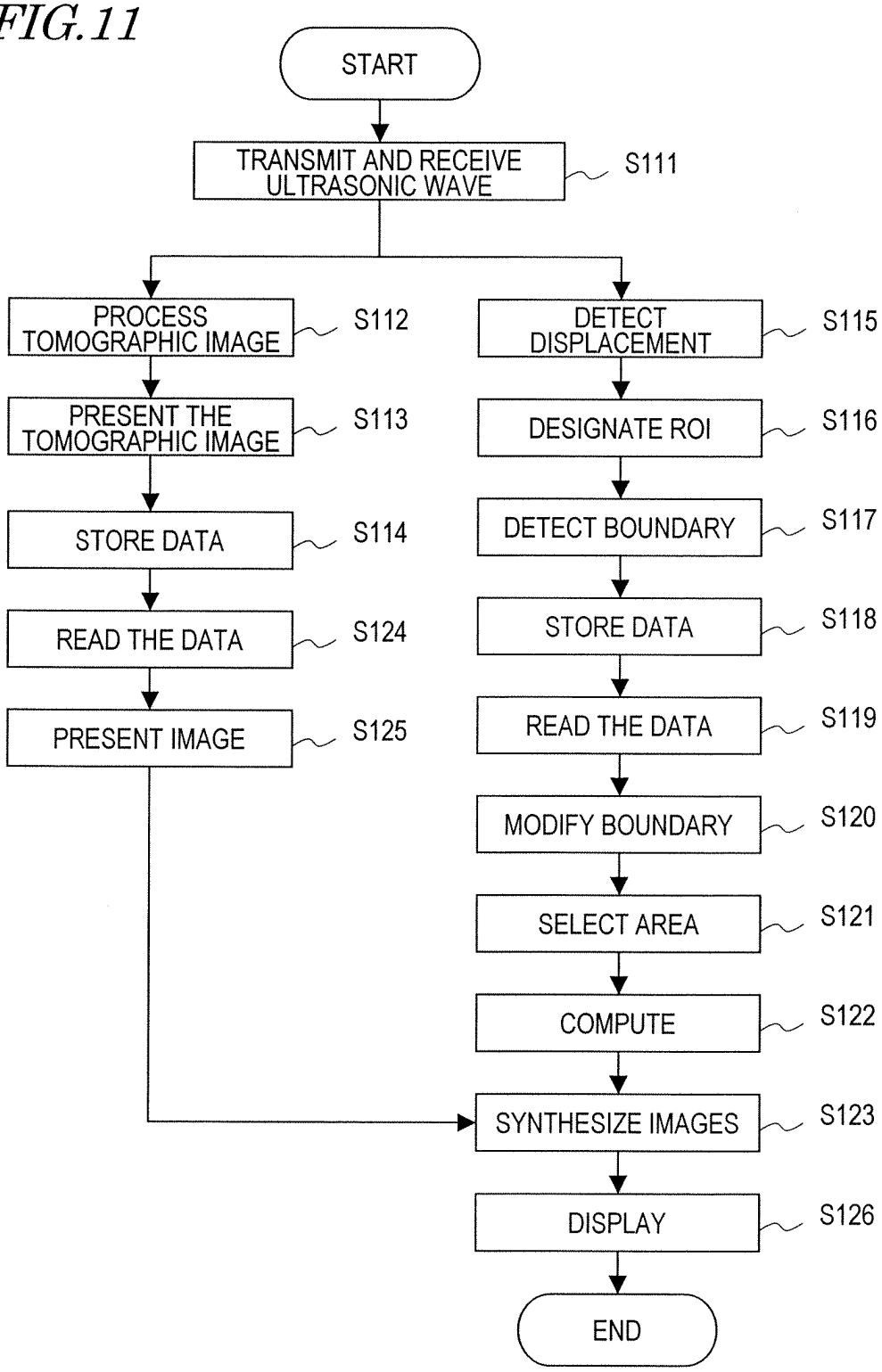
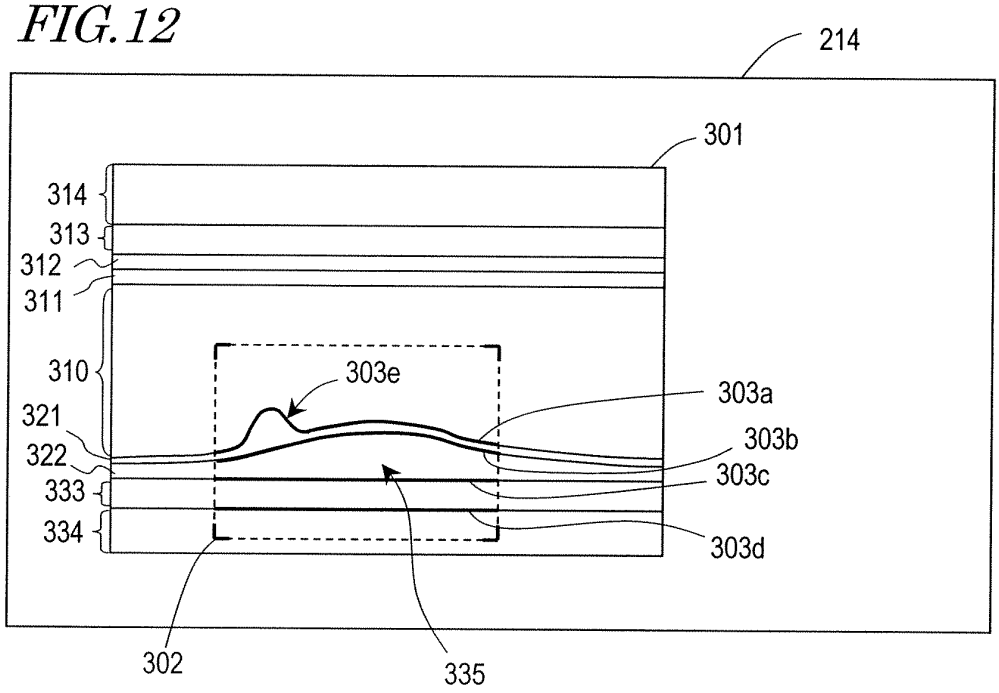

START
TRANSMIT AND RECEIVE ULTRASONIC WAVE
S111
PROCESS TOMOGRAPHIC IMAGE
S112
PRESENT THE TOMOGRAPHIC IMAGE
S113
STORE DATA
S114
READ THE DATA
S124
PRESENT IMAGE
S125
DETECT DISPLACEMENT
S115
DESIGNATE ROI
S116
DETECT BOUNDARY
S117
STORE DATA
S118
READ THE DATA
S119
MODIFY BOUNDARY
S120
SELECT AREA
S121
COMPUTE
S122
SYNTHESIZE IMAGES
S123
DISPLAY
S126
END

FIG. 12


214
301
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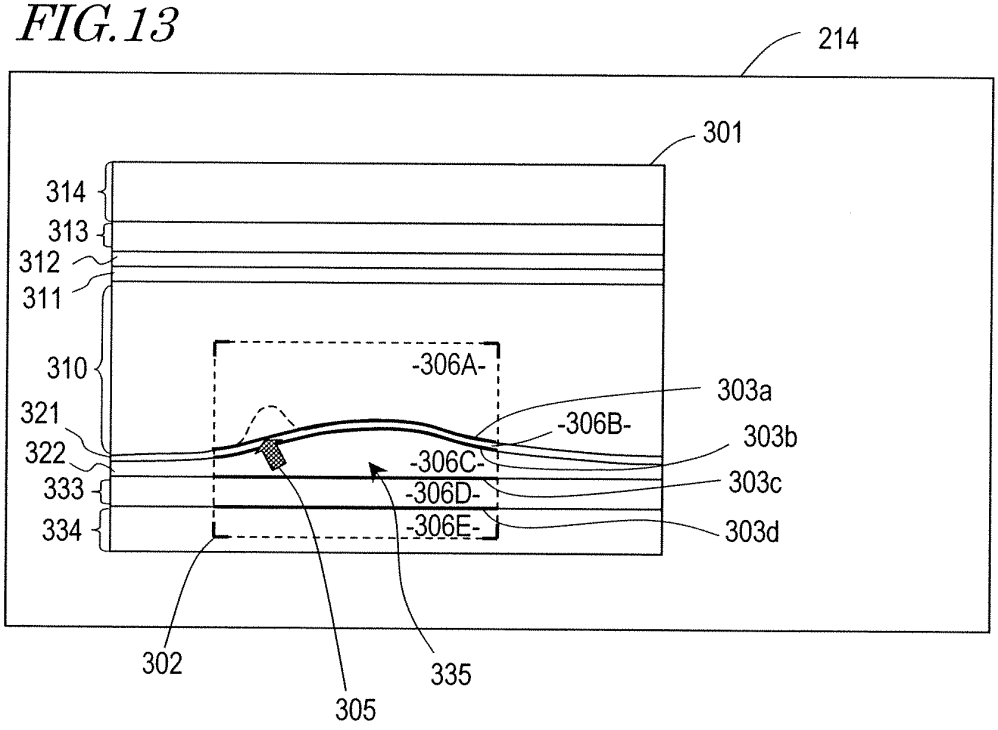
313
312
311
310
303e
303a
321
303b
322
303c
333
334
303d
302
335

FIG. 13


214
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312
311
310
-306A-
303a
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-306B-
303b
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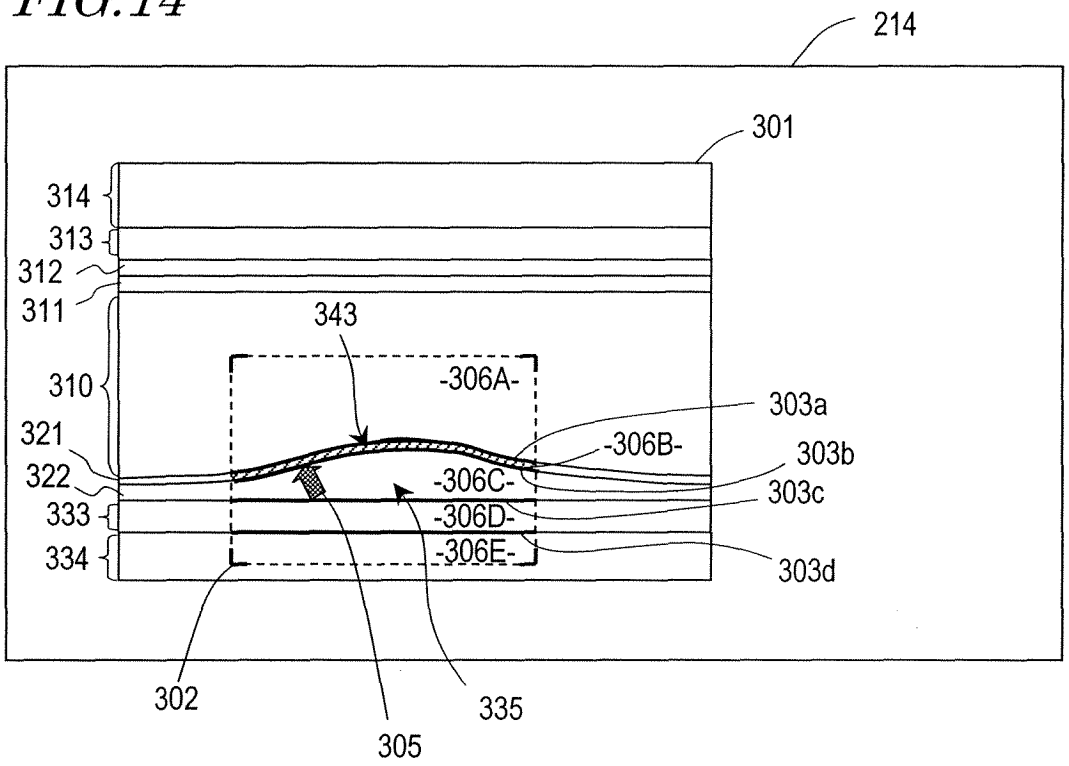
-306C-
303c
333
-306D-
334
-306E-
303d
302
335
305

FIG.14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-306B-
-306C-
-306D-
-306E-
303a
303b
303c
303d
302
305
335

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/308138

A. CLASSIFICATION OF SUBJECT MATTER
A61B8/08(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B8/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2006
Kokai Jitsuyo Shinan Koho 1971-2006 Toroku Jitsuyo Shinan Koho 1994-2006

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Ichushi WEB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Hiroshi KANAI et al., "Kekkanheki Katasa Bunpu no Keihiteki Hyokaho to Denshi Senshoku", The Japanese Journal of Clinical Pathology, 2003, Vol.51, No.8, pages 805 to 812	1-4,9-13
A	B. H. Ong etal., Clinical Demonstration of Functional Wave Front of the Intramyocardial Ischemic Region in Patients with Coronary Stenosis, 2003 IEEE Ultrasonics Symposium Proceedings, 2003, p.1843-1846	1-4,9-13
A	JP 2000-271117 A (Aloka Co., Ltd.), 03 October, 2000 (03.10.00), Full text; all drawings (Family: none) (cited in the present application)	1-4,9-13

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
03 October, 2006 (03.10.06)	10 October, 2006 (10.10.06)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/308138

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-318896 A (Masao ITO, Yoshimitsu YAMASAKI), 24 November, 1999 (24.11.99), Full text; all drawings & US 6132373 A & EP 958784 A1	1-4,9-13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/308138

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
See the extract sheet.

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.: 1-4, 9-13

Remark on Protest

the

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, payment of a protest fee..

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/308138

Continuation of Box No.III of continuation of first sheet(2)

The matter common to the inventions of claims 1-20 is that stated in claim 1 or 14. However, the search has revealed that the matter is not novel since it was publicly known at the date of the filing (see, as an example, document Hiroshi KANAI et al., "Kekkanheki Katasa Bunpu no Keihiteki Hyokaho to Denshi Senshoku", The Japanese Journal of Clinical Pathology, 2003, Vol.51, No.8, pages 805 to 812).

Therefore, the constitution cannot be a special technical feature within the meaning of PCT Rule 13.2, second sentence.

Consequently, the inventions of claims 1-4, the inventions of claims 5-7, the invention of claim 8, the invention of claim 9, the inventions of claims 10-12, the invention of claim 13, the inventions of claims 14-16, 18-20, and invention of claim 17 obviously do not satisfy the requirement of unity of invention.

However, concerning the invention of claim 9, the inventions of claims 10-12, and the invention of claim 13, this authority did not invite payment of any additional fee.

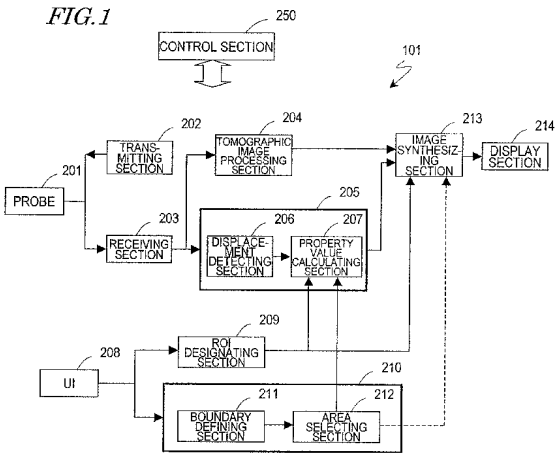
REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 10005226 A **[0004]**
- JP 2000229078 A **[0004]**
- JP 2004112568 W **[0004]**
- JP 2000271117 A **[0004]**

专利名称(译)	超声波诊断装置		
公开(公告)号	EP2014237A1	公开(公告)日	2009-01-14
申请号	EP2006745420	申请日	2006-04-18
申请(专利权)人(译)	松下电器产业株式会社		
当前申请(专利权)人(译)	松下电器产业株式会社		
[标]发明人	WATANABE YOSHINOBU C O PANASONIC CORPORATION IPROC TANNAKA YOSHINAO C O PANASONIC CORPORATION IPROC SUZUKI TAKAO C O PANASONIC CORPORATION IPROC		
发明人	WATANABE, YOSHINOBU C/O PANASONIC CORPORATION IPROC TANNAKA, YOSHINAO C/O PANASONIC CORPORATION IPROC SUZUKI, TAKAO C/O PANASONIC CORPORATION IPROC		
IPC分类号	A61B8/08		
CPC分类号	A61B8/0858 A61B5/02007 A61B5/021 A61B8/463 A61B8/469 A61B8/485		
其他公开文献	EP2014237B1 EP2014237A4		
外部链接	Espacenet		

摘要(译)

根据本发明的超声波诊断装置包括：发送部分，用于驱动超声波探头以向对象的测量区域发送超声波，包括动脉血管壁;接收部分，用于接收在探头处获得从对象反射的超声波产生的反射波，从而产生接收信号;位移检测部分，用于通过分析接收信号计算墙壁上测量区域中每个测量点的位移大小;组织到存在确定部分，其限定包括在壁上的测量区域中的组织之间的至少一个边界，并且选择由限定的边界划分的至少两个区域中的一个;以及特性值计算部分，用于根据每个测量点的位移大小计算对象的特性值。由组织存在确定部分选择的区域中的测量点的特性值的分布被呈现为二维图像。