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(54) **SUBJECT INFORMATION ACQUISITION APPARATUS AND SUBJECT INFORMATION ACQUISITION METHOD**

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(57) **ABSTRACT**

A subject information acquisition apparatus of the present invention acquires a sound speed in the subject by using a signal outputted from a first probe when a first probe receives an elastic wave, a member-to-member distance information between a first holding member and the second holding member, an amount of deformation of a first holding member measured by a first holding member deformation amount measuring unit, an amount of deformation of a second holding member measured by a second holding member deformation amount measuring unit, position information of the first holding member deformation amount measuring unit, and position information of the second holding member deformation amount measuring unit.

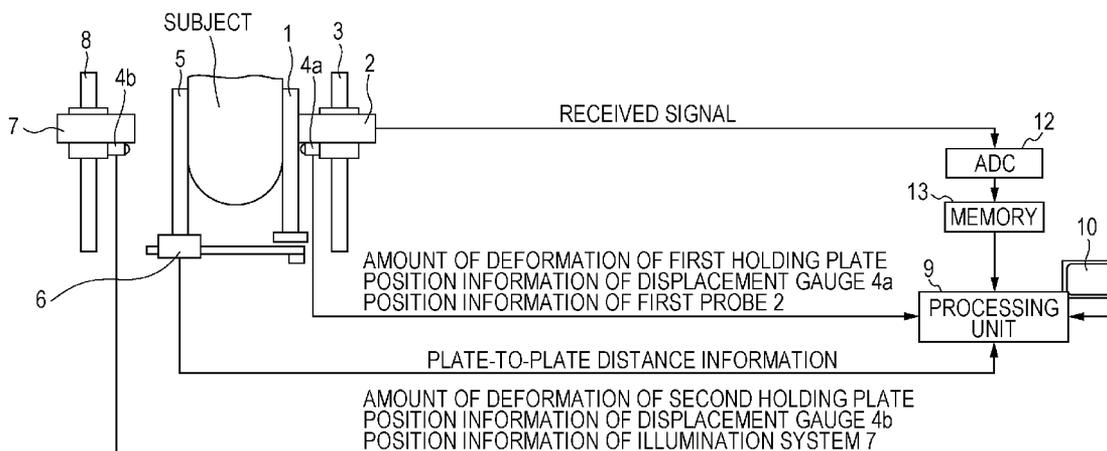


FIG. 1A

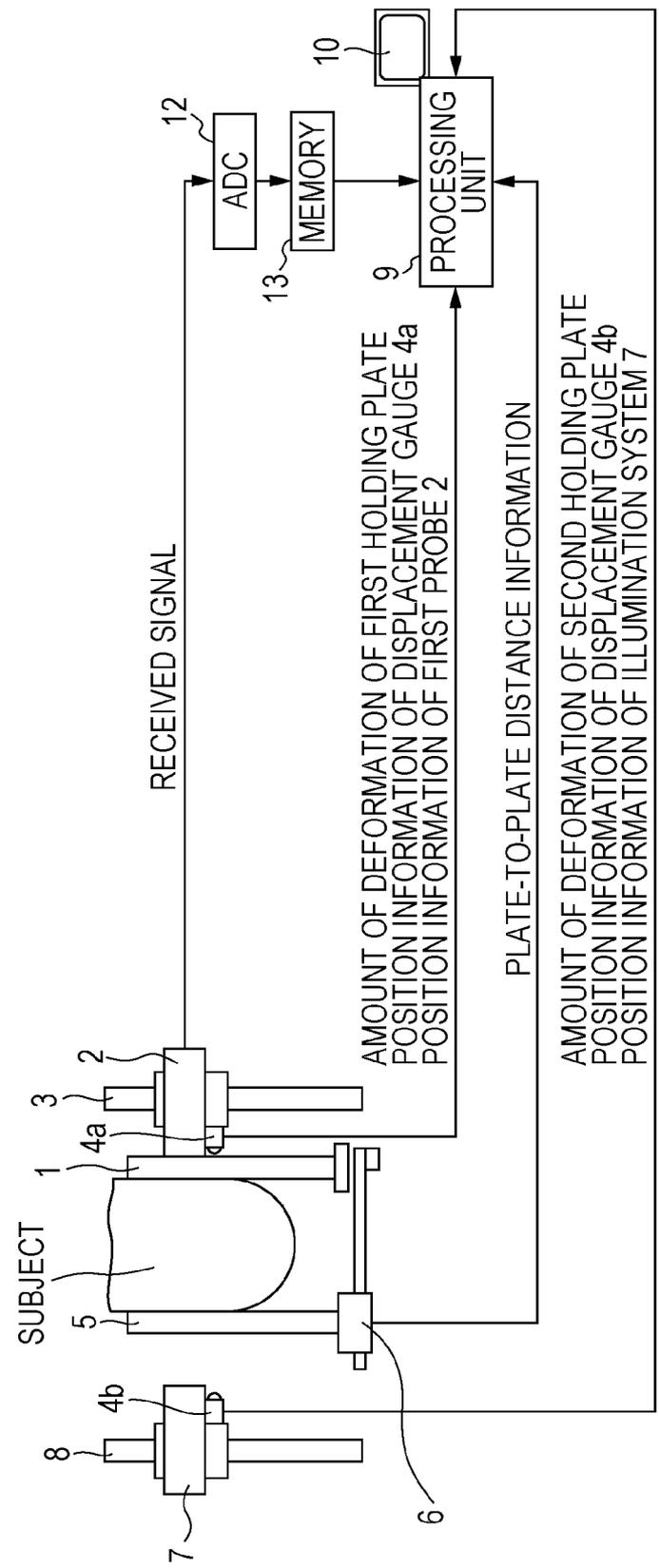


FIG. 1B

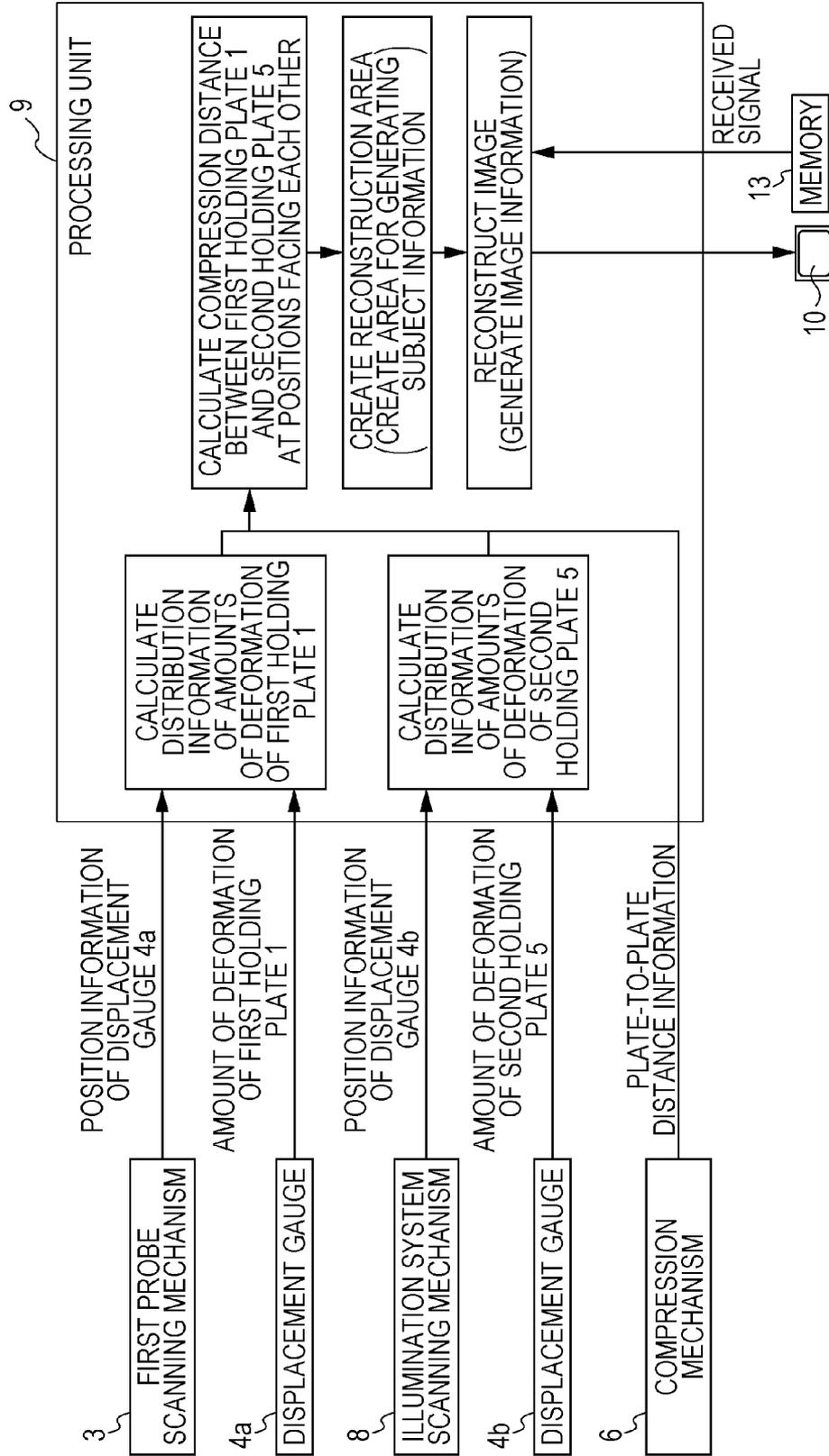


FIG. 1C

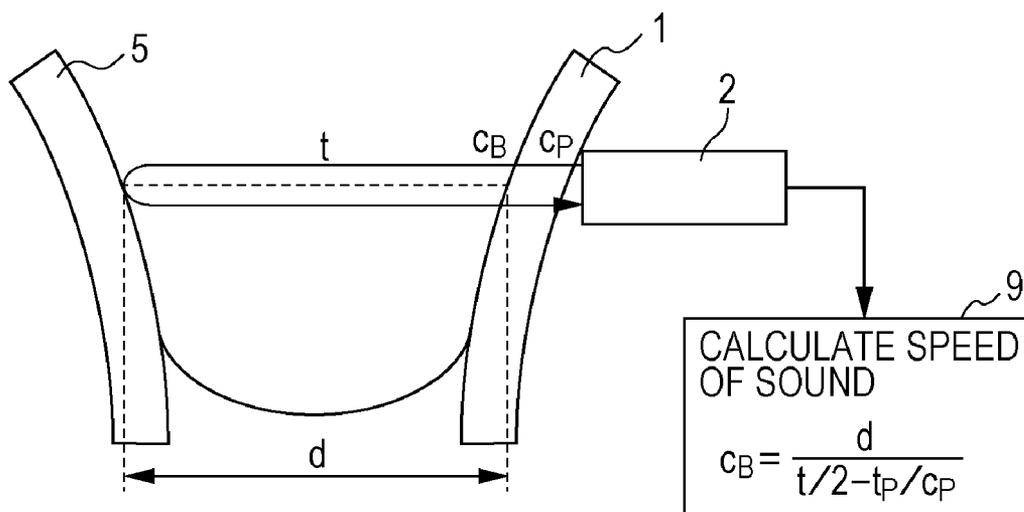


FIG. 2

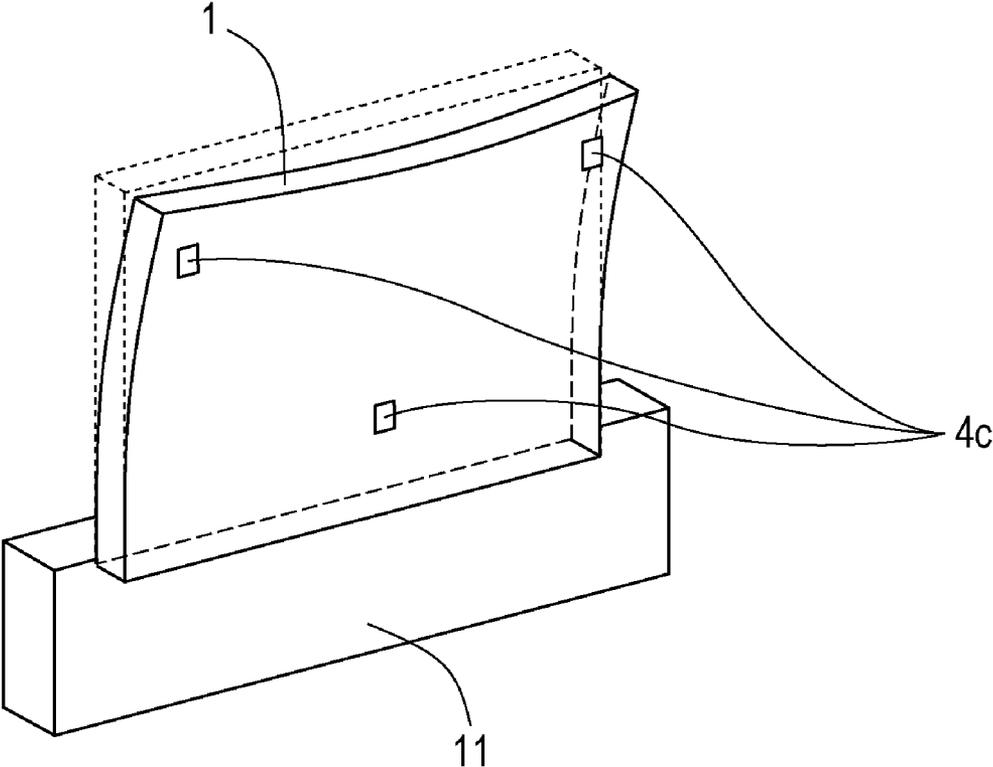


FIG. 3A

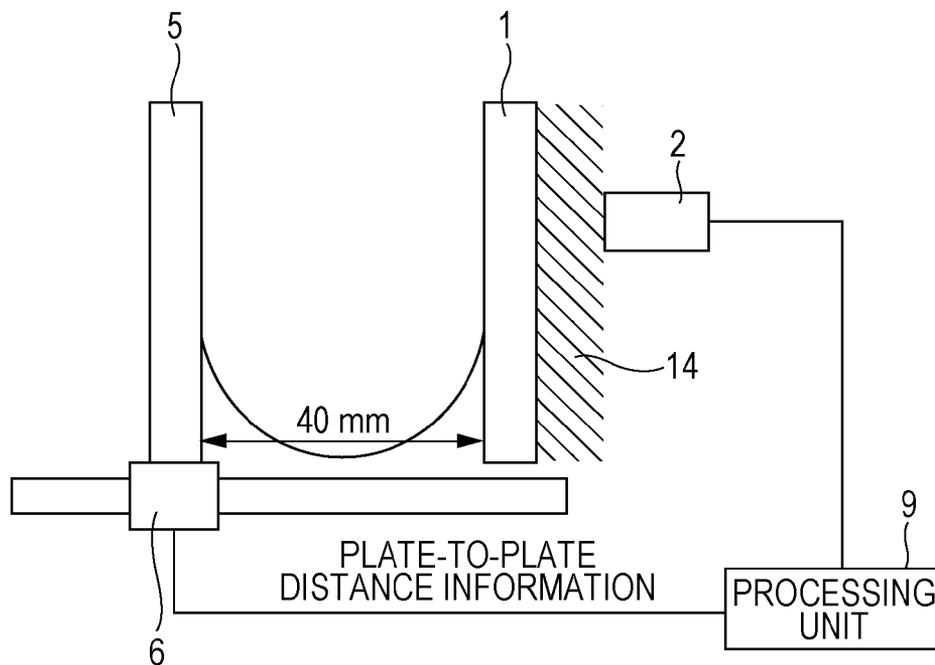


FIG. 3B

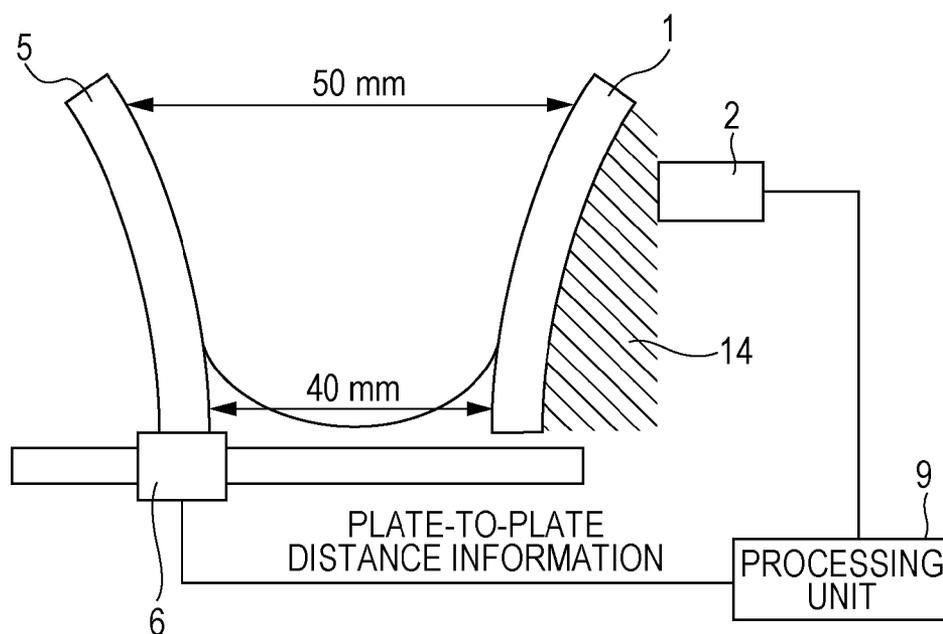


FIG. 4A

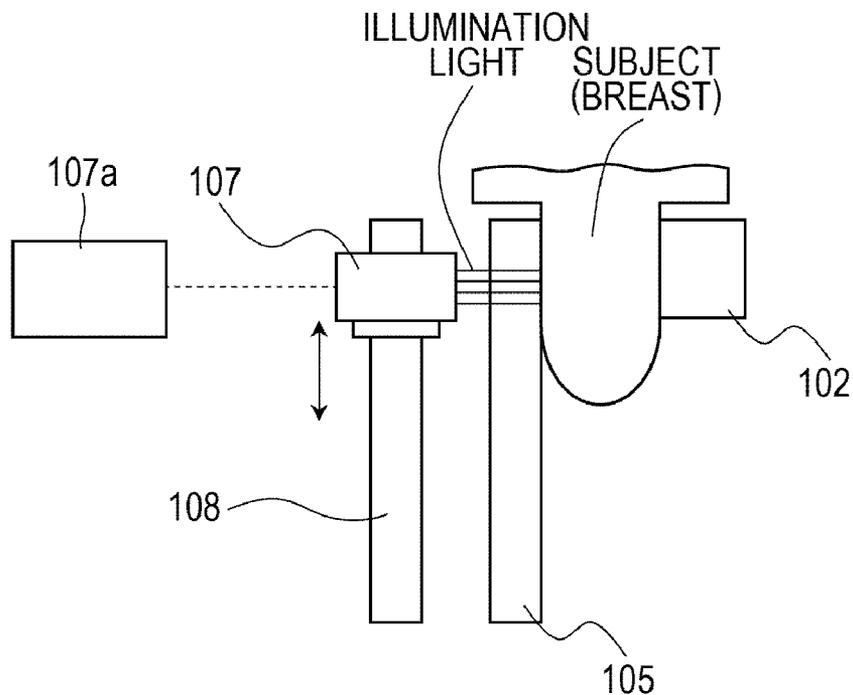
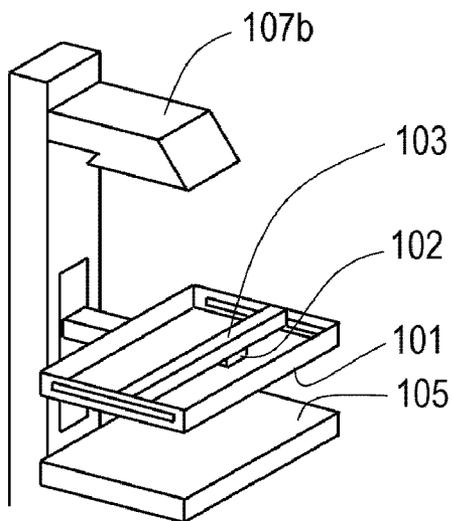


FIG. 4B



**SUBJECT INFORMATION ACQUISITION  
APPARATUS AND SUBJECT INFORMATION  
ACQUISITION METHOD**

BACKGROUND OF THE INVENTION

**[0001]** 1. Field of the Invention

**[0002]** The present invention relates to a subject information acquisition apparatus and a subject information acquisition method for acquiring subject information of a subject by receiving an elastic wave. In this description, the elastic wave is a concept including a sound wave, an ultrasonic wave, an acoustic wave, a photoacoustic wave, and an optical ultrasonic wave.

**[0003]** 2. Description of the Related Art

**[0004]** Photoacoustic imaging (PAI) attracts attention as a method for specifically imaging angiogenesis caused by cancer. The photoacoustic imaging is a method for irradiating illumination light (near-infrared light or the like) to a living organism or the like and receiving photoacoustic waves generated from the inside of the living organism by a probe to make an image.

**[0005]** As a method for acquiring an image inside a living organism by using a principle of the photoacoustic imaging, photoacoustic mammography (PAM), whose subject is a breast, is disclosed in Srirang Manohar, et al., The Twente photoacoustic mammoscope: system overview and performance, *Physics in Medicine and Biology* 50 (2005) 2543-2557. FIG. 4A is a schematic side view of a measuring method of the above document.

**[0006]** In FIG. 4A, an Nd:YAG laser 107a is a light source that illuminates the subject (breast). An illumination optical system 107 guides laser light emitted from the Nd:YAG laser 107a to the subject and illuminates the subject.

**[0007]** An illumination system scanning mechanism 108 includes the illumination optical system 107 and causes the illumination optical system 107 to scan in a vertical direction (a direction indicated by an arrow in FIG. 4A) and a horizontal direction (a direction perpendicular to the page of FIG. 4A). The probe 102 receives a photoacoustic wave generated from the subject.

**[0008]** A signal processing unit not shown in FIG. 4A selects a receiving device of the probe 102 that acquires a signal to form an image from an illumination position set by the illumination system scanning mechanism 108, amplifies the signal, converting the signal into a digital signal, and reconstruct the image.

**[0009]** A holding plate 105 made of glass transmits illumination light from the illumination optical system 107 and presses and holds the subject between the holding plate 105 and the probe 102. A subject person lies on her stomach on a bed not shown in FIG. 4A and inserts her breast, which is the subject, into an insertion hole in the bed. The subject is pressed and held between the probe 102 and the holding plate 105.

**[0010]** The apparatus disclosed in the above document acquires image data in a living organism from a photoacoustic signal by a measuring method shown in FIG. 4A.

**[0011]** A multifunction device including an X-ray mammography machine and an ultrasonic device as shown in FIG. 4B is disclosed in U.S. Pat. No. 6,607,489.

**[0012]** The device shown in FIG. 4B presses and holds a subject not shown in FIG. 4B between a first holding plate 101 and a second holding plate 105 by moving the first holding plate 101. A small probe 102 which can move along a surface

of the first holding plate 101 is provided on the first holding plate 101 on the opposite side of the subject. The probe 102 is held by a gantry 103 which functions as a guide. The probe 102 transmits an ultrasonic wave to the subject through the first holding plate 101.

**[0013]** The device shown in FIG. 4B acquires an ultrasonic image in the subject by using a signal generated from a wave reflected from the subject and received by the probe 102.

SUMMARY OF THE INVENTION

**[0014]** However, as disclosed in U.S. Pat. No. 6,607,489 and Srirang Manohar, et al., The Twente photoacoustic mammoscope: system overview and performance, *Physics in Medicine and Biology* 50 (2005) 2543-2557, in elastic wave imaging in which an elastic wave is received and the subject information is acquired from a received signal while the subject is held by the plates, it is desired that the image quality is further improved.

**[0015]** Therefore, in the elastic wave imaging in which the subject information is acquired while the subject is held by the plates, the present invention provides a subject information acquisition apparatus and a subject information acquisition method for acquiring a higher quality image.

**[0016]** The present invention provides a subject information acquisition apparatus including a first holding member that holds a subject, a second holding member that sandwiches the subject between the second holding member and the first holding member, a member-to-member distance measuring unit that acquires member-to-member distance information between the first holding member and the second holding member, a first probe provided to be able to transmit and receive an elastic wave to and from the subject through the first holding member, a first holding member deformation amount measuring unit that measures an amount of deformation of the first holding member, a second holding member deformation amount measuring unit that measures an amount of deformation of the second holding member, a processing unit that acquires a sound speed in the subject by using a signal outputted from the first probe when the first probe receives an elastic wave, the member-to-member distance information, the amount of deformation of the first holding member, the amount of deformation of the second holding member, position information of the first holding member deformation amount measuring unit, and position information of the second holding member deformation amount measuring unit.

**[0017]** According to the present invention, it is possible to provide a subject information acquisition apparatus and a subject information acquisition method for acquiring a higher quality image in the elastic wave imaging in which the subject information is acquired while the subject is held by plates.

**[0018]** Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0019]** FIGS. 1A to 1C are diagrams for explaining an apparatus configuration and a process method according to a first embodiment of the present invention.

**[0020]** FIG. 2 is diagram showing a deformation amount measuring unit according to the present invention.

[0021] FIGS. 3A and 3B are diagrams for explaining a method of measuring a sound speed studied by the inventors of the present invention.

[0022] FIGS. 4A and 4B are diagram for explaining a related art.

DESCRIPTION OF THE EMBODIMENTS

[0023] The sound speed in the subject (breast) is not only different for each subject person, but also may vary depending on a pressed and held state. If accurate sound speed in the subject is not detected, the resolution of generated ultrasonic image or photoacoustic image is degraded. Therefore, it is desired that accurate sound speed in the subject is measured for each measurement.

[0024] Therefore, a method for measuring the sound speed in the subject studied by the inventors of the present invention will be described with reference to a subject information acquisition apparatus shown in FIG. 3A.

[0025] In the subject information acquisition apparatus shown in FIG. 3A, a first probe 2 transmits and receives an elastic wave while the subject is sandwiched between two plates (a first holding plate 1 and a second holding plate 5). Here, the first probe 2 is provided so that the first probe 2 can receive an elastic wave through the first holding member 1. A matching material 14 is filled between the first holding plate 1 and the first probe 2. A compression mechanism 6 drives the second holding plate 5, so that the subject is sandwiched and held.

[0026] The processing unit 9 acquires the sound speed in the subject by using a distance 1 between the two plates measured by a member-to-member distance measuring unit included in the compression mechanism 6 and a propagation time t of an elastic wave in the subject. Here, the first probe 2 transmits and receives an elastic wave to and from the second holding plate 5 and the processing unit 9 acquires a time t from the transmission to the reception from a signal outputted from the first probe 2. When the thickness of the first holding plate 1 is  $T_p$  and the sound speed in the first holding plate 1 is  $c_p$ , the processing unit 9 can calculate the sound speed  $c_B$  in the subject by Formula (1).

$$c_B = \frac{1}{t/2 - T_p/c_p} \quad \text{Formula (1)}$$

[0027] As described above, the subject information acquisition apparatus studied by the inventors acquires the sound speed  $c_B$  in the subject by using the distance 1 between the plates and the propagation time t of an elastic wave in the subject.

[0028] However, when the two plates sandwich the subject, as shown in FIG. 3B, the plates may deform toward the outside.

[0029] For example, even if the distance 1 between the plates is 40 mm when the subject is pressed and held, if the first holding plate 1 and the second holding plate 5 are each deformed by 5 mm, an actual compression distance d is 50 mm.

[0030] Therefore, if an accurate compression distance cannot be measured by the member-to-member distance measuring unit, the measured sound speed in the subject is an inaccurate value.

[0031] For example, let us assume that the distance 1 between the plates measured by the member-to-member distance measuring unit is 40 mm and the compression deforms each holding plate by 5 mm to change the actual compression distance d to 50 mm. In other words, let us assume that the measured plate-to-plate distance 1 is 20% shorter than the actual compression distance d.

[0032] At this time, the sound speed in the subject is obtained by Formula (1), so that the calculated sound speed is 20% smaller than the actual sound speed. For example, the actual sound speed in the subject is 1500 m/s, the sound speed is measured to be 1200 m/s.

[0033] The sound speed error causes degradation of the resolution of an ultrasonic image or a photoacoustic image.

[0034] Therefore, in view of the above problem, the inventors hit upon an idea of acquiring the sound speed in the subject by considering the amount of deformation of the plates.

[0035] The subject information acquisition apparatus of the present invention includes an apparatus that uses an ultrasonic pulse-echo technique in which an ultrasonic wave is transmitted to a subject, the ultrasonic wave reflected in the subject is received, and subject information is acquired. The subject information acquisition apparatus also includes an apparatus that uses a photoacoustic effect in which a subject is irradiated with light (electromagnetic wave), a photoacoustic wave (typically, an ultrasonic wave) generated in the subject is received, and subject information is acquired.

[0036] In the former apparatus which uses the ultrasonic pulse-echo technique, the acquired subject information is information in which differences of acoustic impedances of tissues in the subject and the like are reflected.

[0037] In the latter apparatus which uses the photoacoustic effect, the acquired subject information is a generation source distribution of the photoacoustic waves generated by irradiation of light, an initial acoustic pressure distribution in the subject, a light energy absorption density distribution derived from the initial acoustic pressure distribution, an absorption coefficient distribution, and a density distribution of material included in the tissues and the like. The density distribution of material is, for example, a distribution of degrees of oxygen saturation and an oxyhemoglobin/deoxyhemoglobin density distribution.

[0038] In the present invention, the components described below can be used as components of the embodiments described later.

(First Probe and Second Probe)

[0039] The first and the second probes receive an elastic wave generated or reflected in the subject. A receiver of the probe has one or more conversion devices that receive an elastic wave and convert the elastic wave into an electric signal. The receiver includes a conversion device that uses a piezoelectric phenomenon, a conversion device that uses an optical resonance, and a conversion device that uses capacitance change, and the like.

[0040] As the receiver of the probe, any receiver that can receive an elastic wave and convert the elastic wave into an electrical signal can be used. A plurality of conversion devices that receive an elastic signal are one-dimensionally or two-dimensionally arranged, so that an elastic wave can be received at a plurality of places at the same time. Thus, it is possible to shorten a reception time and reduce effects of vibration and the like of the subject.

**[0041]** The first and the second probes may be included in the first and the second probe scanning mechanisms. When a probe scanning mechanism causes one conversion device to scan, it is possible to acquire the same signals as those acquired by the conversion devices that are two-dimensionally or one-dimensionally arranged. The conversion devices may be provided on the entire surface of the subject.

**[0042]** The first probe is a probe provided so that the first probe can transmit and receive an elastic wave through the first holding member described later.

(Light Source)

**[0043]** A light source in the apparatus which uses the photoacoustic effect is a unit for irradiating light having a specific wavelength absorbed by a specific component (for example, hemoglobin) included in the subject (living organism or the like).

**[0044]** For example, the light source includes at least one pulse light source capable of generating pulse light of 5 to 50 nanoseconds. Although the light source is desired to be a laser having a large output power, a light-emitting diode or the like can be used instead of laser. As the laser, various lasers such as a solid-state laser, a gas laser, a dye laser, a semiconductor laser can be used.

**[0045]** The light may be emitted from the side of the probe or may be emitted from the side opposite to the probe. Further, the light may be irradiated to both sides of the subject.

**[0046]** Here, the light means an electromagnetic wave including visual light and infrared light. Specifically, the light means light having a wavelength in a range, for example, from 500 nm to 1300 nm. Light having a specific wavelength within the above range may be selected depending on a component to be measured.

(Illumination System)

**[0047]** Examples of an optical member of the illumination system includes a mirror that reflects light, a lens that collects, enlarges, or deforms light, and a prism that diffuses/refracts/reflects light, an optical fiber that propagates light, and a diffuser panel.

**[0048]** The light emitted from the light source can be guided to the subject by optical members such as a lens and a mirror or propagated by an optical member such as an optical fiber.

**[0049]** As the optical members, any member can be used if the light emitted from the light source is irradiated to the subject in a desired shape. Generally, the light is desired to be enlarged to a certain area rather than to be collected by a lens in a viewpoint of safety of a living organism and enlargement of diagnostic area.

**[0050]** An area irradiated with light in the subject (an irradiation area) is desired to be movable. When the irradiation area is movable, a larger area can be irradiated with light. It is further desired that the irradiation area moves in synchronization with the probe. As a method for moving the irradiation area, there are a method that uses a movable mirror and a method that mechanically moves a light source and an optical member.

(First Holding Member and Second Holding Member)

**[0051]** A first and a second holding members are members for holding at least a part of the shape of the subject. When the first and the second holding members sandwich the subject, a

position of the subject is fixed during the measurement, so that a position error due to movement of the body and the like can be reduced. Further, it is possible to effectively transmit light and an ultrasonic wave to a deep portion in the subject by pressing the subject. As the first and the second holding members, it is possible to use a member having high transmittance of light and ultrasonic wave and high acoustic integrity with the subject and the probe. Polymethylpentene that has acoustic impedance similar to that of the subject is suitable for the material of the first and the second holding plates.

**[0052]** The first holding member is provided between the subject and the first probe and the probe can receive an elastic wave through the first holding member.

**[0053]** An acoustic matching material (matching material) such as gel may be provided between the holding members and the subject and between the holding member and the probe in order to improve acoustic integrity.

(Subject and Light Absorber)

**[0054]** A subject measured by an apparatus that uses a photoacoustic effect will be described. The subject information acquisition apparatus mainly diagnoses malignant tumor, vascular disease, blood sugar level, and the like of a human and an animal and observes processes of chemical treatment. Therefore, a specific subject may be a portion to be diagnosed, such as a breast, a finger, a limb, or the like of a human or an animal.

**[0055]** The light absorber in the subject is a body having a relatively high absorption coefficient in the subject. For example, when a human body is a target to be measured, the light absorbers are oxyhemoglobin, deoxyhemoglobin, a blood vessel containing oxyhemoglobin and/or deoxyhemoglobin, and a malignant tumor including many newborn blood vessels. The light absorber on the surface of the subject is melanin and the like located near the surface of the skin.

**[0056]** Hereinafter, specific embodiments will be described.

#### First Embodiment

**[0057]** A first embodiment will be described with reference to FIGS. 1A to 1C. FIG. 1A schematically shows a diagram of a photoacoustic apparatus in which a subject (a breast or the like) is sandwiched between a first holding plate **1** and a second holding plate **5** and subject information is acquired by using an elastic wave.

**[0058]** The first holding plate **1**, which is the first holding member, is to hold the subject.

**[0059]** A first probe **2** can receive at least an ultrasonic wave emitted from the subject through the first holding plate **1**. The first probe **2** includes an array of transducer elements. A received signal that is received by the first probe **2** is digitally converted by ADC **12** and the digitally converted received signal is stored in a memory **13**.

**[0060]** A first probe scanning mechanism **3** includes the first probe **2** and causes the first probe **2** to scan along a surface of the first holding plate **1**. A matching material **14** for acoustic matching is filled between the first holding plate **1** and a receiving surface of the first probe **2**.

**[0061]** Further, the first probe scanning mechanism **3** includes a displacement gauge **4a**, which is a first holding member deformation amount measuring unit. The displacement gauge **4a** obtains the amount of outward deformation (displacement information) of the first holding plate **1**. The

processing unit 9 acquires position information of the displacement gauge 4a and the first probe 2 on the basis of scanning information of the first probe scanning mechanism 3.

[0062] The displacement gauge 4a may be a contact method that uses an electric micrometer or the like or a non-contact method that uses an optical sensor or the like.

[0063] The first holding member deformation amount measuring unit can be, for example, a unit using a method in which the first probe 2 transmits and receives an elastic wave to and from the first holding plate 1 and the amount of deformation of the first holding plate 1 is measured by multiplying the time period between the transmission and the reception by the sound speed in the acoustic matching material.

[0064] The second holding plate 5, which is the second holding member, sandwiches the subject between the second holding plate 5 and the first holding plate 1 and presses and holds the subject by about 10 N to 300 N. The operations for the second holding plate 5 to press and hold the subject and release the compression are performed by a compression mechanism 6 that drives the second holding plate 5.

[0065] An illumination system 7 is an optical system for irradiating near infrared light whose wavelength is about 600 to 1100 nm to the subject through the second holding plate 5. The illumination system 7 is mounted on an illumination system scanning mechanism 8. FIG. 1A does not show the light source and the optical system from the light source to the illumination system 7.

[0066] Further, the illumination system scanning mechanism 8 includes a displacement gauge 4b, which is a second holding member deformation amount measuring unit. The displacement gauge 4b obtains the amount of outward deformation of the second holding plate 2. The processing unit 9 acquires position information of the displacement gauge 4b and the illumination system 7 on the basis of scanning information of the illumination system scanning mechanism 8.

[0067] Next, FIG. 1B is a diagram showing a process performed by the processing unit 9.

[0068] The processing unit 9 acquires distribution information of amounts of deformation of the first holding plate 1 from position information of the displacement gauge 4a acquired from scanning information of the first probe scanning mechanism 3 and the amounts of deformation of the first holding plate 1 measured by the displacement gauge 4a.

[0069] Here, the distribution information of amounts of deformation is a degree of deformation from the original shape and indicates information related to one-dimensional or two-dimensional deformation. For example, when the original shape of the first holding plate 1 is a flat plate shape, the distribution information is flatness information.

[0070] Similarly, the processing unit 9 acquires distribution information of amounts of deformation of the second holding plate 5 from position information of the displacement gauge 4b acquired from scanning information of the illumination system scanning mechanism 8 and the amounts of deformation of the second holding plate 5 acquired by the displacement gauge 4b.

[0071] Then, the processing unit 9 performs a process for calculating a compression distance between the first holding plate 1 and the second holding plate 5 at positions facing each other from the distribution information of amounts of deformation of the first holding plate 1, the distribution information of amounts of deformation of the second holding plate 5, and plate-to-plate distance information (member-to-member

distance information) acquired by a member-to-member distance measuring unit (for example, a linear scale) included in the compression mechanism 6.

[0072] Next, as shown in FIG. 1C, to measure the sound speed in the subject, the first probe 2 emits an elastic wave to the subject and the first probe 2 receives the elastic wave which passes through the first holding plate 1 and the subject and which is reflected by the second holding plate 5. The processing unit 9 calculates a time t from the transmission to the reception of the elastic wave. At this time, the processing unit 9 refers to the received signal stored in the memory 13 to calculate the propagation time of the elastic wave.

[0073] The processing unit 9 acquires the sound speed  $c_B$  in the subject from Formula (2) by using the time t from the transmission to the reception of the elastic wave and the compression distance d between the first holding plate 1 and the second holding plate 5 at positions facing each other.

$$c_B = \frac{d}{t/2 - T_p/C_p} \quad \text{Formula (2)}$$

[0074] Next, the processing unit 9 acquires photoacoustic image data by using the sound speed in the subject and a signal which is outputted from the first probe 2 when the first probe 2 receives the elastic wave.

[0075] As described above, the subject information acquisition apparatus of the present embodiment acquires the sound speed in the subject by using the compression distance taking into account the deformation of the plates, so that the subject information acquisition apparatus can measure the sound speed in the subject at a high level of accuracy while holding the subject. Therefore, according to the subject information acquisition apparatus of the present embodiment, it is possible to reduce degradation of the resolution in a photoacoustic image, which is caused by an error of the calculation of the sound speed.

[0076] Although, the subject information acquisition apparatus of the present embodiment measures the propagation time of an elastic wave when the first probe 2 receives an elastic wave reflected by the second holding plate 5, it is possible to provide a second probe that can receive an elastic wave from the subject through the second holding plate 5 and measure the propagation time of the elastic wave. In this case, the first probe 2 may receive an elastic wave transmitted from the second probe, or the second probe may receive an elastic wave transmitted from the first probe 2. In this way, it is possible to reduce effects of attenuation of the elastic wave in the subject by providing the second probe to measure the propagation time.

[0077] Although measuring methods of contact type and non-contact type are described as methods of the displacement gauge, the measuring method is not limited to these. As shown in FIG. 2, a strain gauge 4c is attached to a plurality of positions on the first holding plate 1 or a first fixing member 11 that fixes the first holding plate 1 and the processing unit 9 may obtain the distribution information of amounts of deformation of the first holding plate 1 from outputs of the strain gauges 4c when a load is applied. In this case, the distribution information of amounts of deformation of the first holding plate 1 can be obtained without mounting the strain gauge 4c, which is the first holding member deformation amount measuring unit, on the first probe scanning mechanism 3. Besides the strain gauge, it is possible to directly attach a sensor such

as a piezoelectric element, in particular, a piezoelectric film to a plurality of positions on the first holding plate 1 and/or the fixing member 11. As the second holding member deformation amount measuring unit, the same strain gauge or the like can be applied to the second holding plate 5 and/or a second fixing member that fixes the second holding plate 5.

[0078] Although it is described that the first holding plate 1 and the second holding plate 5 are a flat plate (have a flat plate shape) when the subject is not held, it is not limited to a flat plate. For example, the holding plates may have a bowl-shape. In this case, if the flatness and the curvature when the subject is not held are known, the distribution information of amounts of deformation of the holding plates when the subject is held can be obtained from the amounts of deformation measured by the displacement gauge and the position information of the displacement gauge.

[0079] Although the present embodiment is described using a photoacoustic apparatus, the present invention can be applied to an ultrasonic apparatus to obtain an ultrasonic image.

#### Second Embodiment

[0080] In the first embodiment, the sound speed in the subject is obtained by transmitting and receiving an elastic wave by the probe. On the other hand, in the present embodiment, a probe receives a photoacoustic wave generated by irradiating the subject with light, so that the sound speed in the subject is measured, instead of measuring the sound speed in the subject by receiving a transmitted elastic wave by the probe.

[0081] Hereinafter, the present embodiment will be described with reference to the subject information acquisition apparatus shown in FIG. 1A.

[0082] Also in the present embodiment, in the same manner as in the first embodiment, the processing unit 9 obtains the compression distance between the first holding plate 1 and the second holding plate 5 at positions facing each other by using the plate-to-plate distance information measured by the member-to-member distance measuring unit provided in the compression mechanism 6 and the distribution information of amounts of deformation acquired by the displacement gauges 4a and 4b of each plate.

[0083] An initial acoustic pressure P of the photoacoustic wave is represented by  $P = \Gamma \cdot \mu_a \cdot \phi$  ( $\Gamma$ : Gruneisen coefficient,  $\mu_a$ : absorption coefficient,  $\phi$ : light quantity). In other words, the initial acoustic pressure P of the photoacoustic wave is proportional to the light quantity  $\phi$ .

[0084] In the subject information acquisition apparatus shown in FIG. 1, the light quantity of illumination light in the interface between the subject and the second holding plate 5 is strongest among the light quantities in the subject of illumination light irradiated from the outside of the second holding plate 5. Therefore, a specific strong photoacoustic wave is generated in the interface between the subject and the second holding plate 5.

[0085] The light speed is extremely faster than the sound speed in the subject, so that it can be considered that photoacoustic waves are generated in the entire subject at substantially the same time as when the light is emitted.

[0086] Thereby, it is possible to differentiate the specific strong photoacoustic wave generated in the interface between the subject and the second holding plate 5 from other photoacoustic waves that reach the first probe 2.

[0087] Therefore, the processing unit 9 can calculate the sound speed  $c_B$  in the subject from Formula (3) by using the propagation time t from when the illumination light is emitted to when the first probe 2 receives the specific strong photoacoustic wave and the obtained compression distance d taking into account the deformation of the plates.

$$c_B = \frac{d}{t - T_p / C_p} \quad \text{Formula (3)}$$

[0088] At this time, the processing unit 9 obtains the propagation time t from illumination information and a received signal stored in a memory in the processing unit 9. The illumination information may be acquired by providing a photodiode not shown in FIG. 1A to a part of the illumination system 7 and acquiring an output of the photodiode.

[0089] The illumination system 7 may be provided on the side of the first holding plate 1 and the subject may be irradiated with the illumination light through the first holding plate. The second probe may be provided so that the second probe can receive an elastic wave through the second holding plate 5. In this case, a specific strong photoacoustic wave is generated in the interface between the subject and the first holding plate 1 by the illumination light irradiated from the outside of the first holding plate 1. It is possible to obtain the sound speed  $c_B$  in the subject from the propagation time t from when light is emitted to when a photoacoustic wave generated at substantially the same time as when the light is emitted is received by the second probe, the obtained compression distance d taking into account the deformation of the plates, the thickness  $T_{p5}$  of the second holding plate 5, and the sound speed  $c_{p5}$  in the second holding plate 5.

[0090] The processing unit 9 may obtain the sound speed in the subject when the first probe 2 receives a photoacoustic wave which is generated in the interface between the subject and the first holding plate 1 and reflected by the second holding plate 5.

[0091] As described above, the subject information acquisition apparatus according to the present invention can obtain an accurate sound speed in the subject by using the propagation time of the photoacoustic wave generated between the subject and the first holding plate 1 or the second holding plate 5 and the compression distance obtained by using the amounts of deformation of each plate obtained by the displacement gauges 4a and 4b.

[0092] The sound speed in the subject is obtained as described above, so that it is not necessary to transmit an elastic wave to measure the sound speed in the subject. Therefore, when the subject information acquisition apparatus is a photoacoustic apparatus, the sound speed in the subject can be measured when receiving a photoacoustic wave, so that it is possible to reduce processes to obtain an image by the photoacoustic apparatus.

[0093] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

[0094] This application claims the benefit of Japanese Patent Application No. 2011-058661 filed Mar. 17, 2011, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

- 1. A subject information acquisition apparatus comprising: a first holding member configured to hold a subject; a second holding member configured to enclose the subject between the second holding member and the first holding member; a member-to-member distance measuring unit configured to acquire member-to-member distance information between the first holding member and the second holding member; a first probe provided to be able to transmit and receive an elastic wave to and from the subject through the first holding member; a first holding member deformation amount measuring unit configured to measure an amount of deformation of the first holding member; a second holding member deformation amount measuring unit configured to measure an amount of deformation of the second holding member; and a processing unit configured to acquire a sound speed in the subject by using a signal outputted from the first probe when the first probe receives an elastic wave, the member-to-member distance information, the amount of deformation of the first holding member, the amount of deformation of the second holding member, position information of the first holding member deformation amount measuring unit, and position information of the second holding member deformation amount measuring unit.
- 2. The subject information acquisition apparatus according to claim 1, further comprising: a compression mechanism configured to drive the first holding member or the second holding member, wherein the compression mechanism includes the member-to-member distance measuring unit.
- 3. The subject information acquisition apparatus according to claim 1, further comprising: a second probe provided to be able to transmit and receive an elastic wave through the second holding member, wherein the first probe receives the elastic wave transmitted by the second probe.
- 4. The subject information acquisition apparatus according to claim 1, wherein the first probe transmits the elastic wave to the subject and receives the elastic wave reflected by the second holding member.
- 5. The subject information acquisition apparatus according to claim 1, wherein the first probe receives the elastic wave generated in an interface between the subject and the first holding member or the second holding member by irradiating light.
- 6. The subject information acquisition apparatus according to claim 1, further comprising: a first probe scanning mechanism configured to cause the first probe to scan along a surface of the first holding member.

- 7. The subject information acquisition apparatus according to claim 6, wherein: the first probe scanning mechanism includes the first holding member deformation amount measuring unit, and the processing unit acquires position information of the first holding member deformation amount measuring unit on the basis of scanning information of the first probe scanning mechanism.
- 8. The subject information acquisition apparatus according to claim 3, further comprising: a second probe scanning mechanism configured to cause the second probe to scan along a surface of the second holding member.
- 9. The subject information acquisition apparatus according to claim 8, wherein: the second probe scanning mechanism includes the second holding member deformation amount measuring unit, and the processing unit acquires position information of the second holding member deformation amount measuring unit on the basis of scanning information of the second probe scanning mechanism.
- 10. The subject information acquisition apparatus according to claim 1, wherein the first holding member deformation amount measuring unit is directly attached to a plurality of positions on the first holding member or a first fixing member that fixes the first holding member.
- 11. The subject information acquisition apparatus according to claim 1, wherein the second holding member deformation amount measuring unit is directly attached to a plurality of positions on the second holding member or a second fixing member that fixes the second holding member.
- 12. The subject information acquisition apparatus according to claim 1, wherein the processing unit acquires subject information by using the signal outputted from the first probe and the sound speed in the subject.
- 13. A subject information acquisition method comprising: a step of receiving an elastic wave from a subject while the subject is sandwiched between a first holding member and a second holding member; a step of acquiring a member-to-member distance between the first holding member and the second holding member; a step of acquiring distribution information of amounts of deformation of the first holding member; a step of acquiring distribution information of amounts of deformation of the second holding member; and a step of acquiring a sound speed in the subject by using a received signal acquired in the step of receiving an elastic wave, the member-to-member distance, the distribution information of amounts of deformation of the first holding member, and the distribution information of amounts of deformation of the second holding member.

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