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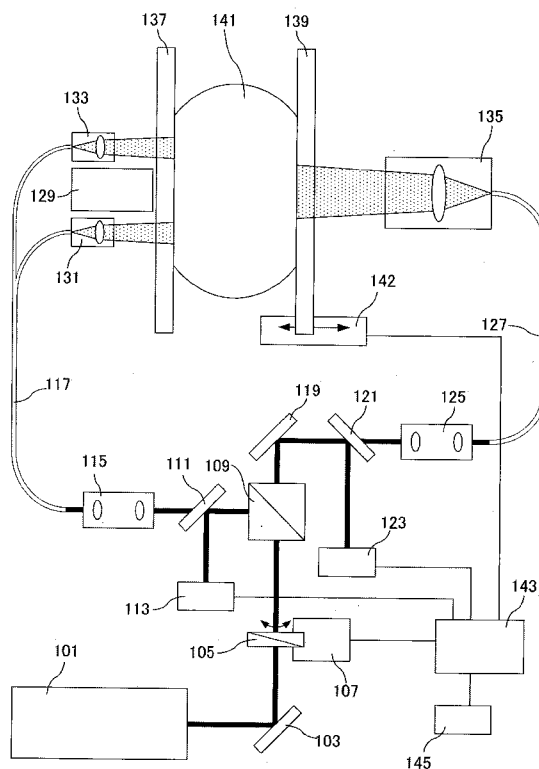
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[Continued on next page]

(54) Title: OBJECT INFORMATION ACQUIRING APPARATUS AND CONTROL METHOD FOR CONTROLLING THE SAME

**Fig. 1**

(57) Abstract: An object information acquiring apparatus is used, wherein the apparatus comprises a first holding plate and a second holding plate; a first illumination unit configured to illuminate an object with a light beam from a side of the first holding plate; a second illumination unit configured to illuminate the object with a light beam from a side of the second holding plate; a detecting unit configured to detect an acoustic wave generated from an observation area disposed inside the object beyond the first holding plate; and a control unit configured to control light amounts for illuminating the object by means of the first illumination unit and the second illumination unit respectively on the basis of a spacing distance between the holding plates and depth information of the observation area.



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DESCRIPTION

Title of Invention

OBJECT INFORMATION ACQUIRING APPARATUS AND CONTROL METHOD FOR
CONTROLLING THE SAME

Technical Field

[0001]

The present invention relates to an object information acquiring apparatus and a control method for controlling the same.

Background Art

[0002]

In recent years, research and development are promoted in order to visualize information about the inside of a living body by using a light wave which is noninvasive with respect to the living body, especially the near infrared light (near infrared ray) which has a high transmittance with respect to the living body. In particular, an apparatus has been suggested (Non Patent Literature 1), wherein the photoacoustic tomography (PAT) is utilized to determine the spatial distribution of the optical characteristic in a living body at a high resolution by utilizing the characteristic of the ultrasonic wave which is less scattered in the living body as compared with the light. When a pulsed light beam, which is generated from a light source, is radiated onto the living body,

the pulsed light beam is propagated or transmitted while being diffused in the living body. A light absorbing material, which is contained in a biological tissue, absorbs the energy of the propagated pulsed light beam to generate an acoustic wave (typically an ultrasonic wave). An ultrasonic wave signal, which is obtained by receiving the ultrasonic wave by means of a probe, is analyzed and processed. Accordingly, the spatial distribution of the absorption coefficient as the optical characteristic in the living body is determined, which can be subjected to the imaging and displayed as an image.

[0003]

According to Non Patent Literature 1, the sound pressure (acoustic pressure) (P) of the ultrasonic wave, which is obtained from the light absorbing material contained in the living body in accordance with the light absorption in the photoacoustic tomography, can be represented by the following expression (1).

$$P = \Gamma \cdot \mu_a \cdot \Phi \quad \dots (1)$$

In this expression, Γ represents the Gruneisen coefficient as the elastic characteristic value, which is obtained by dividing, by the specific heat (C_p), the product of the coefficient of volume expansion (β) and the square of the sound velocity (c). μ_a represents the absorption coefficient of the light absorbing material, and Φ represents the light amount in the local area (light amount radiated onto the light absorbing material).

[0004]

The sound pressure, which is the ultrasonic wave signal in the photoacoustic tomography apparatus, is proportional to the local light amount allowed to arrive at the light absorbing material as indicated in the foregoing expression. The light, which is radiated onto the living body, is suddenly attenuated in the living body on account of the scattering and the absorption. Therefore, the ultrasonic wave, which is generated in the deep tissue in the living body, has the sound pressure which is greatly attenuated depending on the distance from the light irradiation portion. In order to strengthen or intensify the ultrasonic wave signal, it is necessary to increase the irradiation light amount with which the living body is irradiated.

[0005]

It is generally known that the irradiation area size is appropriately decreased as small as possible if the same amount of light is used, in order to propagate the light into the deeper portion in the living body. On the other hand, from a viewpoint of the safety with respect to the living body, it is necessary to pay attention to the irradiation density with which the living body is irradiated (irradiation light amount per unit areal size) when a laser is used as the light source. It is necessary that the maximum value of the irradiation density does not exceed the maximum permissible exposure (MPE) as defined in the laser safety standard (C6802 of JIS (Japanese Industrial Standard) and IEC 60825-1).

[0006]

An inspection apparatus for breasts, which is based on the use of the photoacoustic effect, is known as a photoacoustic tomography apparatus as described in Non Patent Literature 2. In this apparatus, the breast is interposed by two flat plates. An illumination light beam is allowed to come from the side of one flat plate, and an ultrasonic wave signal is acquired by an ultrasonic wave detector which is arranged on the side of the other flat plate.

[0007]

Patent Literature 1 relates to a probe type apparatus for visualizing the sound velocity distribution in a living body. The probe is constructed such that an ultrasonic wave unit and an illumination unit are integrated into one unit. A laser beam is radiated onto the living body, and the sound velocity change, which is obtained in this situation, is visualized. Accordingly, the information, which relates to the biological tissue, is visualized.

On the other hand, Patent Literature 2 discloses an example as a photoacoustic tomography apparatus in which one laser beam is divided to illuminate a living body in two directions.

Citation List

Patent Literature

[0008]

PTL1: JP2008-049063A;

PTL2: United States Patent No. 7774042.

Non Patent Literature

[0009]

NPL1: Xu, L. V. Wang "Photoacoustic imaging in biomedicine", Review of scientific instruments, 77, 041101 (2006);

NPL2: Srirang Manohar et al, "The Twente Photoacoustic Mammoscope : system overview and performance", Phys. Med. Biol. 50 (2005) .

Summary of Invention

Technical Problem

[0010]

In the apparatus described in Non Patent Literature 2, the living body is interposed by the two flat plates. An illumination light beam is allowed to come from the side of one flat plate, and a photoacoustic signal is acquired by an ultrasonic wave detector which is arranged on the side of the other flat plate. In this case, a problem arises such that the photoacoustic signal, which is generated in the vicinity of the ultrasonic wave detector, is weakened, because the light beam is attenuated in the living body.

[0011]

Patent Literature 1 provides an example in which an ultrasonic wave detector and an illumination unit are arranged on the same side with respect to a living body. When this arrangement is applied to a photoacoustic tomography apparatus, a problem arises such that the photoacoustic signal, which is

generated at a portion separated from the ultrasonic wave detector, is weakened.

[0012]

Patent Literature 2 discloses an example in which a living body is illuminated in two directions. However, the illumination is not provided from the side of an ultrasonic wave detector. When the living body is held or retained by interposing the living body by means of two flat plates, it is difficult to apply this arrangement.

[0013]

The technique, in which the living body is held or retained by interposing the living body by means of the two flat plates and the illumination is performed from the both sides of the living body through the two flat plates respectively, is effective to strengthen or intensify the ultrasonic wave signal brought about at the deep portion in the living body. However, apart from such a case that the output energy of the light source has a margin, the following problem arises. That is, when the output energy of the light source is insufficient, if a light beam, which comes from the light source, is simply divided into two so that the illumination is performed with light beams from the both sides, then the contrast is lowered depending on the portion intended to be observed.

[0014]

The present invention has been made taking the foregoing problems into consideration, an object of which is to provide such a technique that a high contrast image of an observation

area is acquired while obeying the maximum permissible exposure in a photoacoustic tomography apparatus in which an object (object to be examined) is retained or held by two holding plates.

Solution to Problem

[0015]

In order to solve the problems described above, the present invention adopts the following construction. That is, the present invention resides in an object information acquiring apparatus comprising a first holding plate and a second holding plate configured to hold an object by interposing the object; a first illumination unit configured to illuminate the object by allowing a light beam to pass through the first holding plate and a second illumination unit which illuminates the object by allowing a light beam to pass through the second holding plate; a detecting unit configured to detect an acoustic wave propagated from an observation area disposed inside the object and allowed to pass through the first holding plate; and a control unit configured to control light amounts for illuminating the object by means of the first illumination unit and the second illumination unit respectively on the basis of a holding distance as a spacing distance between the first holding plate and the second holding plate and depth information as a distance between the first holding plate and the observation area.

[0016]

In another aspect, the present invention adopts the following construction. That is, the present invention resides in a control method for controlling an object information acquiring apparatus comprising a first holding plate and a second holding plate configured to hold an object by interposing the object; a first illumination unit configured to illuminate the object by allowing a light beam to pass through the first holding plate and a second illumination unit which illuminates the object by allowing a light beam to pass through the second holding plate; and a detecting unit configured to detect an acoustic wave propagated from an observation area disposed inside the object and allowed to pass through the first holding plate; the control method comprising a control step of controlling light amounts for illuminating the object by means of the first illumination unit and the second illumination unit respectively on the basis of a holding distance as a spacing distance between the first holding plate and the second holding plate and depth information as a distance between the first holding plate and the observation area; an illumination step of illuminating the object with the light amounts controlled in the control step; and a detecting step of detecting an acoustic wave propagated from the observation area disposed inside the object illuminated in the illumination step.

Advantageous Effects of Invention

[0017]

According to the present invention, it is possible to provide such a technique that a high contrast image of the observation area is acquired while obeying the maximum permissible exposure in the photoacoustic tomography apparatus in which the object (object to be examined) is retained or held by the two holding plates.

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 Drawings

[0018]

Fig. 1 shows a schematic arrangement in relation to a first embodiment according to the present invention.

Fig. 2 shows a schematic arrangement in relation to a second embodiment according to the present invention.

Fig. 3 shows a schematic arrangement in relation to a third embodiment according to the present invention.

Fig. 4 shows a schematic arrangement in relation to a fourth embodiment according to the present invention.

Fig. 5 illustrates the relationship between the light amount ratio and the light irradiation density at a distance of 50 mm between holding plates.

Fig. 6 illustrates the relationship between the light amount ratio and the light irradiation density at a distance of 70 mm between holding plates.

Fig. 7 shows a flow of the first embodiment according to

the present invention.

Fig. 8 shows a flow of the second embodiment according to the present invention.

Fig. 9 shows a flow of the third embodiment according to the present invention.

Fig. 10 shows a flow of the fourth embodiment according to the present invention.

Description of Embodiments

[0019]

Preferred embodiments of the present invention will be explained below with reference to the drawings. However, the scope of the invention is not limited thereto. The present invention provides an object information acquiring apparatus wherein when the light (electromagnetic wave) is radiated onto an object such as a living body or the like, then the acoustic wave, which is generated in a light absorbing material disposed inside the object in accordance with the photoacoustic effect, is received by a receiving element of a probe, and the acoustic wave is converted into an analog electric signal. The electric signal is subjected to the amplification and the AD conversion, for example, by means of an information processing apparatus to obtain a digital electric signal. Subsequently, an image is reconstructed by means of the information processing apparatus to generate the characteristic information of the interior of the object. The acoustic wave includes the elastic wave referred to, for example, as "sound wave" or "ultrasonic

wave". The acoustic wave, which is generated by the photoacoustic effect, is especially referred to as "photoacoustic wave" or "photo-ultrasonic wave". The following explanation will be made in relation to the ultrasonic wave which is the typical acoustic wave. The electric signal which is generated by receiving the ultrasonic wave by the probe (referred to as "ultrasonic wave detector" as well) and the electric signal which is obtained therefrom by being subjected to the amplification and/or the AD conversion are mentioned as "ultrasonic wave signal".

[0020]

The characteristic information includes the optical characteristic values such as the initial sound pressure, the light absorption coefficient value based on the same, the oxygen saturation value, the light energy absorption density and the like, as well as the concentration of the substance for constructing the tissue. The substrate concentration is, for example, the oxygen saturation, the oxidized/reduced hemoglobin concentration, and the glucose concentration. Further, those obtained also include the image which represents the characteristic distribution such as the initial sound pressure distribution, the light absorption coefficient distribution, the oxygen saturation distribution and the like, and the image data for generating the image. The characteristic information as described above can be also referred to as "object information", because the characteristic information as described above is the

information which relates to the interior of the object. Therefore, the apparatus of the present invention can be referred to as "object information acquiring apparatus".

[0021]

An explanation will be made with reference to Fig. 1 about the basic arrangement of the object information acquiring apparatus of the present invention. An object (object to be examined) 141, which is, for example, a living body, is held by being interposed by two holding plates which are substantially parallel to one another. A probe 129 is arranged for the first holding plate 137. The apparatus of the present invention is provided with first illumination units (131, 133) for illuminating the living body from the side of the first holding plate 137, and a second illumination unit 135 for illuminating the living body from the side of the second holding plate 139, wherein the apparatus is constructed so that the irradiation is effected for the both surfaces. Light beams, which are radiated from the first and second illumination unit, are basically obtained such that a laser beam, which comes from a light source 101, is divided by a light branching unit. However, two light sources are occasionally used for the respective irradiation surfaces in some cases.

The light can be transmitted from the light source or the light branching unit to the illumination unit by using an optical waveguide such as an optical fiber or the like, or a spatial transmission system based on, for example, lenses and mirrors. For example, a YAG laser, a titanium sapphire laser,

or a pigment laser is used as the light source. The light branching unit is preferably the unit which is based on a combination of a half-wave plate and a polarizing beam splitter (105, 109 shown in Fig. 1) or the unit which uses a knife edge reflecting prism (201 shown in Fig. 2), in view of the effective utilization of the light energy of the light source. When the energy of the light source has a margin, it is also allowable to use the unit which provides the attenuation by means of a variable ND filter.

[0022]

The control system (control unit) is an information processing apparatus which adjusts the light amount ratio at which the light is radiated onto the living body on the basis of the holding distance (spacing distance between the holding plates) and the depth information of the observation position.

The depth information of the observation position is the information of the depth (distance) of the position which is provided at the inside of the living body and at which an observer especially intends to acquire the information. For example, the distance of a perpendicular line allowed to extend from the observation position to the holding plate disposed on the side of arrangement of the probe can be defined as the depth. If the probe cannot be moved, the depth can be also defined as the distance from the observation position to the probe. The depth information of the observation position can be set by an operator on the basis of the image information previously measured by an observing apparatus such as MRI or

an ultrasonic wave pulse echo. Alternatively, the observation position may be determined by extracting the characteristic point in accordance with any generally known image processing. Further alternatively, for example, the preliminary measurement is once performed beforehand at a light amount ratio of 1:1 before the formal measurement. The setting may be performed by an operator on the basis of a preliminary image obtained beforehand, or the depth of the observation position in the formal measurement may be determined from the preliminary image obtained beforehand, for example, in accordance with a method of peak position detection.

[0023]

The control of the light amount ratio will be explained with reference to the drawings. Fig. 5 shows the relationship between the living body depth and the irradiation light amount density (optical fluence) as obtained when the laser beams are used to effect the illumination at predetermined light amount ratios on the first illumination unit side and the second illumination unit side on condition that the living body is interposed by the holding plates to provide the holding distance of a thickness of 50 mm. The laser beam has a wavelength of 800 nm, and the total energy is 50 mJ. Five types of light amount ratios are set. The light amount ratios between the first illumination unit side and the second illumination unit side are 10:0, 7.5:2.5, 5:5, 2.5:7.5, and 0:10 respectively. The horizontal axis in the drawing is set so that the depth is increased (value is increased) as the

position advances in the direction directed toward the second holding plate, assuming that the interface between the first holding plate (side of arrangement of the probe) and the living body corresponds to the depth of 0 mm.

[0024]

Fig. 6 shows the relationship between the living body depth and the irradiation light amount density (optical fluence) as obtained when the laser beams are used to effect the illumination at predetermined light amount ratios on the first illumination unit side and the second illumination unit side on condition that the living body is interposed by the holding plates to provide the holding distance of a thickness of 70 mm. The laser beam has a wavelength of 800 nm, and the total energy is 50 mJ. Five types of light amount ratios are set. The light amount ratios between the first illumination unit side and the second illumination unit side are 10:0, 7.5:2.5, 5:5, 2.5:7.5, and 0:10 respectively. Therefore, the wavelength, the total energy, and the light amount ratios of Fig. 6 are the same as those of Fig. 5, but the holding distance differs therebetween.

[0025]

According to Figs. 5 and 6, it is appreciated from the viewpoint of the optical fluence that the first illumination unit side may be intensified when the side (shallow area) disposed near to the probe is predominantly observed, while the second illumination unit side may be intensified when the side (deep area) disposed far from the probe is predominantly

observed. Further, it is appreciated that the depth (position of intersection of five lines), at which the optical fluence does not depend on the light amount ratio, differs depending on the holding distance. Therefore, it is desirable to determine the light amount ratio while considering not only the depth of the observation position but also the holding distance.

[0026]

The following method is available as the simplest method. That is, the object is divided into two parts, i.e., the near side and the far side depending on the holding distance. When the near side (shallow area) is predominantly observed, only the first illumination unit side is used. When the far side (deep area) is predominantly observed, only the second illumination unit side is used. This method is effective in order to intensify or strengthen the photoacoustic signal.

When the both sides are simultaneously illuminated, the photoacoustic signal can be made approximately constant irrelevant to the depth especially in the vicinity of the center depth, as compared with when only the first illumination unit side or only the second illumination unit side is used. Therefore, this procedure is effective when it is intended to observe the deep areas disposed in front of and at the back of the center which corresponds to a certain observation position depth.

The stepwise change of the light amount ratio is effective when a plurality of images, which are obtained by focusing

distinct depths of an identical living body, are compared with each other.

[0027]

The light amount ratio is controlled as follows. That is, when the side (shallow area) disposed near to the probe is predominantly observed, the first illumination unit side is intensified. When the side (deep area) disposed far from the probe is predominantly observed, the second illumination unit side is intensified. When the portion disposed in the vicinity of the center is predominantly observed, the both sides are made equivalent. However, if the irradiation density is excessively raised, a problem arises in view of the safety. Therefore, the irradiation density is within a range not exceeding the maximum permissible exposure (MPE). The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the light amount ratio is previously measured, which is stored beforehand in a storage medium in a form of table or the like. Reference may be made to the table by using, as the key, the determined observation position depth and the holding distance information obtained when the photoacoustic measurement is practically performed, and the light amount ratio may be determined thereby.

[0028]

More conveniently, the following control may be performed. That is, the living body is divided into three parts, i.e., 1/3 disposed on the probe side, 1/3 disposed at the central

portion, and 1/3 disposed on the side opposite to the probe depending on the distance from the probe, and the light amount ratios between the first illumination unit and the second illumination unit are 10:0, 5:5, and 0:10 respectively. Alternatively, for example, the following method is available. That is, the light amount ratio is provided as 9:1, 7:3, 5:5, 3:7, and 1:9 in a stepwise manner corresponding to the observation position ranging from the shallow area to the deep area. The numerals referred to herein are exemplified by way of example, which can be changed depending on the measurement condition. In the case of any measurement condition, the light amount ratio is controlled so that the light having the intense light amount is radiated from the side disposed nearer to the observation area, of the first illumination unit and the second illumination unit.

Further, the illumination unit may be provided with a projection optical system in which the magnification is variable. Accordingly, the light can be radiated while being magnified when the light amount is intense and the irradiation density is excessively intense. The light can be radiated while being reduced when the light amount is weak. The light can be guided into the living body more efficiently.

More detailed construction will be explained in embodiments described below.

[0029]

(First Embodiment)

Fig. 1 conceptually illustrates an embodiment of the

present invention. In the drawing, reference numeral 101 indicates a titanium sapphire laser light source which has a wavelength of 800 nm, a pulse width of 10 nsec, a repetition frequency of 10 Hz, and an output per pulse of 70 mJ. Reference numeral 103 indicates a total reflection mirror, 105 indicates a half-wave plate, 107 indicates a rotary stage which rotates the half-wave plate 105, and 109 indicates a polarizing beam splitter. The light beam, which is irradiated from the light source 101, is controlled to be in a desired polarization state by the wavelength plate 105, and the light beam is divided into those directed in the two directions by the polarizing beam splitter 109. One of the divided light beams passes through an optical pickup 111 and a combining optical system (coupling optical system) 115, and the light beam is guided to a light transmission system 117 composed of an optical fiber bundle. A part of the light beam is reflected by the optical pickup 111, and the light beam is detected by a light energy meter 113. The other divided light beam passes through a total reflection mirror 119, an optical pickup 121, and a combining optical system (coupling optical system) 125, and the light beam is guided to a light transmission system 127 composed of an optical fiber bundle. A part of the light beam is reflected by the optical pickup 121, and the light beam is detected by a light energy meter 123.

[0030]

Reference numeral 141 indicates an object, which is a living body such as a breast of a woman or the like in this

embodiment. The living body 141 is held and fixed by a first holding plate 137 and a second holding plate 139.

Reference numeral 129 indicates an ultrasonic wave detecting unit which is composed of a plurality of probes aligned two-dimensionally. The ultrasonic wave detecting unit corresponds to the detecting unit of the present invention.

The light transmission system 117 is branched into two at an intermediate position. The irradiated light beam, which is irradiated from one of the two, passes through the first holding plate 137 by means of an illumination unit 131 (corresponding to the first illumination unit) composed of a magnifying projection optical system, and the light beam is radiated onto the living body 141. The irradiated light beam, which is irradiated from the other of the branched light transmission system 117, passes through the first holding plate 137 by means of an illumination unit 133 (corresponding to the first illumination unit as well) composed of a magnifying projection optical system, and the light beam is radiated onto the living body 141.

The irradiated light beam, which is irradiated from the light transmission system 127, passes through the second holding plate 139 by means of an illumination unit 135 (corresponding to the second illumination unit) composed of a magnifying projection optical system, and the light beam is radiated onto the living body 141.

[0031]

The ultrasonic wave, which is generated at the inside of the living body 141, passes through the living body 141 and the first holding plate 137, and the ultrasonic wave is detected by the ultrasonic wave detecting unit 129. Although not shown in the drawing, an acoustic impedance matching layer, which is composed of, for example, water or oil, is provided to suppress the reflection of the ultrasonic wave between the first holding plate 137 and the ultrasonic wave detecting unit 129. The signal, which is detected by the ultrasonic wave detecting unit 129, is used to reconstruct an image in accordance with a generally known technique including, for example, Delay and Sum (phasing addition method) and Filtered Back Projection (FBP method).

The second holding plate 139 can be driven in the direction perpendicular to the surface by means of a driving stage 142. The driving stage 142 is constructed so that the position information thereof can be detected.

[0032]

Reference numeral 145 indicates an observation area determining unit which has such a function that an operator can input the position intended to be observed before acquiring an image. The observation area determining unit corresponds to the determining unit of the present invention.

Reference numeral 143 indicates a control system. The control system 143 determines the light amount ratio from the holding distance which is calculated on the basis of the position information of the second holding plate 139 detected

by the driving stage 142 and the depth information of the observation position which is inputted from the observation area determining unit 145. The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the light amount ratio is previously measured and provided as a table. The control system 143 determines the light amount ratio by making reference to the table. The control system 143 rotates the half-wave plate 105 to provide a desired angle by means of the rotary stage 107 on the basis of the determined light amount ratio. When the half-wave plate 105 is rotated, then the polarization state is controlled for the light beam allowed to pass through the half-wave plate 105, and the branching ratio, which is brought about by the polarizing beam splitter 109, is controlled. Parts of the branched light beams are monitored by light energy meters 113, 123. If necessary, the control system 143 finely adjusts the angle of the half-wave plate 105 so that the desired light amount ratio is obtained, in accordance with the monitored light amounts. The light energy meter corresponds to the monitor unit of the present invention.

For example, if the distance between the holding plates is 50 mm, and it is intended to observe the portion at a depth of 10 mm, then the light amount ratio is set so that 10 is provided for the first illumination unit side and 0 is provided for the second illumination unit side. Further, if the distance between the holding plates is 50 mm, and it is intended to observe the portion at a depth in the vicinity of 25 mm,

then the light amount ratio is set so that 5 is provided for the first illumination unit side and 5 is provided for the second illumination unit side. The depth herein means the distance from the first holding plate disposed on the side of the ultrasonic wave detecting unit.

[0033]

Fig. 7 shows a flow of the measurement.

After the start of the measurement, in Step S701, the first holding plate 137 and the second holding plate 139 interpose and hold the living body.

In Step S702, the driving stage 142 detects the position of the second holding plate. Accordingly, the distance (holding distance) between the first holding plate and the second holding plate is determined.

In Step S703, the operator designates the observation area (depth) by means of the observation area determining unit 145.

In Step S704, the control system 143 makes reference to the table by using, as the key, the position information of the holding plates (holding distance) and the depth information of the observation area.

In Step S705, the control system 143 determines the light amount ratio between the first illumination unit (131, 133) and the second illumination unit 135 on the basis of the information acquired from the table.

In Step S706, the control system 143 rotates the half-wave plate 105 to control the branching ratio of the light beam brought about by the polarizing beam splitter 109.

In Step S707, the light energy meters (113, 123) monitor the light amounts in the respective branches.

In Step S708, the control system 143 judges whether or not the branching ratio is appropriate. If the branching ratio is not appropriate (S708 = No), the angle of the half-wave plate is adjusted again.

In Step S709, the light beams are radiated onto the living body from the first illumination unit and the second illumination unit.

In Step S710, the ultrasonic wave detecting unit 129 acquires the transmitted ultrasonic wave signal generated at the inside of the living body in accordance with the photoacoustic effect.

In Step S711, the ultrasonic wave signal is processed by the information processing apparatus to acquire the living body information image. Accordingly, the series of measurement operations are completed.

[0034]

According to this embodiment, the branching ratio of the light irradiated from one laser light source can be controlled in conformity with the depth of the observation area and the holding distance (spacing distance between the holding plates), and the illumination can be performed from the both sides of the living body. As a result, although the observation objective portion, which is provided when the object such as the breast or the like is observed, is diverse depending on every person, the observation objective portion can be

observed at the high contrast by using the preferred illumination condition in conformity therewith.

Further, the apparatus is constructed by using one laser light source. Therefore, the effect is obtained such that the apparatus can be miniaturized and the cost can be lowered.

The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the angle of the wavelength plate 105 may be previously provided as a table. Accordingly, the branching ratio of the light can be controlled with ease.

[0035]

(Second Embodiment)

Fig. 2 conceptually illustrates another embodiment of the present invention. Parts or portions, which are common to those of the first embodiment, are designated by the same reference numerals, any explanation of which will be omitted.

In the drawing, reference numeral 201 indicates a knife edge reflecting prism which has two reflecting surfaces. The angle formed by the two reflecting surfaces is adjusted to 90 degrees. The knife edge reflecting prism 201 can be driven in the horizontal direction by means of a horizontal driving stage 203. The branching light amount ratio between the light beams is controlled by horizontally moving the knife edge reflecting prism 201.

Reference numeral 245 indicates an observation area determining unit which determines the observation area by extracting the characteristic point of the living body

information image as previously acquired.

Reference numeral 205 indicates a control system. The control system 205 determines the light amount ratio from the holding distance which is calculated on the basis of the position information of the second holding plate 139 detected by the driving stage 142 and the depth information of the observation position which is determined by the observation area determining unit 245. The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the light amount ratio is previously measured and provided as a table. The control system 205 determines the light amount ratio by making reference to the table. The control system 205 controls the branching ratio by moving the knife edge reflecting prism 201 to a desired position by means of the horizontal driving stage 203 on the basis of the determined light amount ratio. Parts of the branched light beams are monitored by light energy meters 113, 123. If necessary, the control system 205 finely adjusts the position of the knife edge reflecting prism 201 so that the desired light amount ratio is obtained, in accordance with the monitored light amounts.

The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the position of the horizontal driving stage 203 may be previously provided as a table.

[0036]

Fig. 8 shows a flow of the measurement.

After the start of the measurement, the holding of the living body in Step S801 and the detection of the position of the second holding plate and the calculation of the holding distance in Step S802 are performed in the same manner as in S701 to S702 shown in Fig. 7.

In Step S803, the control system 205 controls the position of the knife edge reflecting prism 201 by using the horizontal driving stage 203 so that the light amount ratio between the first illumination unit and the second illumination unit is 1:1.

In Step S804, the light beams are radiated onto the living body from the first illumination unit and the second illumination unit.

In Step S805, the ultrasonic wave detecting unit 129 acquires the transmitted ultrasonic wave signal generated at the inside of the living body in accordance with the photoacoustic effect.

In Step S806, the ultrasonic wave signal is processed by means of the information processing apparatus to acquire the living body information image.

In Step S807, the characteristic point is extracted from the living body information image to determine the observation area by means of the observation area determining unit 245. When the characteristic point is extracted, the known image processing is performed by means of the information processing apparatus to determine the area to be especially observed. Alternatively, an area designation designated by an operator

is accepted.

In Step S808, the control system 205 makes reference to the table by using, as the key, the position information of the holding plates (holding distance) and the depth information of the observation area determined in the previous step.

In Step S809, the control system 205 determines the light amount ratio between the first illumination unit and the second illumination unit on the basis of the information acquired from the table. The processes in S808 to S809 are the same as or equivalent to the processes in S704 to S705 shown in Fig. 7.

In Step S810, the knife edge reflecting prism 201 is moved to control the branching ratio of the light by means of the horizontal driving stage 203.

The respective processes in Steps S811 to S813, which include the light irradiation from the illumination unit to the living body, the receiving of the ultrasonic wave signal by the ultrasonic wave detecting unit, and the acquisition of the living body information image from the ultrasonic wave signal by the information processing apparatus, are the same as or equivalent to the processes in S709 to S711 shown in Fig. 7.

[0037]

This embodiment is effective when the position of the observation objective portion in the breast is previously unknown, for example, when the medical examination or the screening is performed. At first, the light amount ratio

between the first illumination unit and the second illumination unit is allowed to be 1:1, and the light beams are radiated onto the living body to acquire the living body information image. Thus, it is possible to acquire the information as a whole.

Further, the preferred illumination condition, which is conformed to the characteristic portion included therein, is used, and thus it is possible to observe the observation objective portion at a high contrast. If the characteristic portions are provided at a plurality of points, it is also possible to obtain the ultrasonic wave signal by performing the illumination a plurality of times under illumination conditions in conformity therewith respectively.

In this embodiment, the characteristic point of the living body information image obtained in S806 is extracted to determine the observation objective portion. During this procedure, for example, when an image processing algorithm is used, the determination of the observation area is automated. Therefore, an effect is obtained such that the load on the operator is mitigated. It is also allowable to use such a method that the image obtained in S806 is observed by the operator to determine the observation area.

In this embodiment, the light amount ratio, which is used when the illumination is firstly performed, is 1:1. However, the light amount ratio is not limited thereto. It is enough to grasp an overview or a whole image.

[0038]

(Third Embodiment)

Fig. 3 conceptually illustrates still another embodiment of the present invention. Parts or portions, which are common to those of the first embodiment, are designated by the same reference numerals, any explanation of which will be omitted.

In the drawing, reference numeral 301 indicates a titanium sapphire laser light source which has a wavelength of 800 nm, a pulse width of 10 nsec, and a repetition frequency of 10 Hz. The light beam, which is irradiated from the light source 301, passes through an optical pickup 303 and a combining optical system (coupling optical system) 307, and the light beam is guided to a light transmission system 117 composed of an optical fiber bundle. A part of the light beam is reflected by the optical pickup 303, and the light beam is detected by a light energy meter 305. The light source 301 corresponds to the first light source of the present invention.

On the other hand, reference numeral 311 indicates a titanium sapphire laser light source which has a wavelength of 800 nm, a pulse width of 10 nsec, and a repetition frequency of 10 Hz. The light beam, which is irradiated from the light source 311, passes through an optical pickup 313 and a combining optical system (coupling optical system) 317, and the light beam is guided to a light transmission system 127 composed of an optical fiber bundle. A part of the light beam is reflected by the optical pickup 313, and the light beam is detected by a light energy meter 315. The light source 311 corresponds to the second light source of the present invention.

[0039]

Reference numeral 321 indicates a control system. The control system 321 determines the light amount ratio from the holding distance which is calculated on the basis of the position information of the second holding plate 139 detected by the driving stage 142 and the depth information of the observation position which is determined by the observation area determining unit 145. The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the light amount ratio is previously measured and provided as a table. The control system 321 determines the light amount ratio by making reference to the table. The control system 321 adjusts the electric powers applied to the light source 301 and the light source 311 on the basis of the determined light amount ratio to control the outputs of the light source 301 and the light source 311 so that the desired light amount ratio is provided. If necessary, the control system 321 finely adjusts the electric powers applied to the light source 301 and the light source 311 so that the desired light amount ratio is obtained, in accordance with the light amounts monitored by the light energy meters 305, 315.

The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the electric powers applied to the light source 301 and the light source 311 may be previously provided as a table.

[0040]

Fig. 9 shows a flow of the measurement.

After the start of the measurement, the holding of the living body in Step S901, the detection of the position of the second holding plate in S902, the designation of the observation area (depth) in S903, the making reference to the table in S904, and the determination of the light amount ratio in S905 are performed in the same manner as in S701 to S705 shown in Fig. 7.

In this embodiment, in Step S906, the control system 321 adjusts the electric powers applied to the light source 301 and the light source 311 so that the determined light amount ratio is provided, and the control system 321 controls the outputs from the respective light sources. It is judged in Step S908 whether or not the light amounts monitored in Step S907 are appropriate. If the light amounts are not appropriate, then the electric powers to be applied are controlled again by the control unit, and the outputs from the light sources are controlled.

The respective processes in Steps S909 to S911, which include the light irradiation from the illumination unit to the living body, the receiving of the ultrasonic wave signal by the ultrasonic wave detecting unit, and the acquisition of the living body information image from the ultrasonic wave signal by the information processing apparatus, are the same as or equivalent to the processes in S709 to S711 shown in Fig. 7.

[0041]

In this embodiment, unlike the first and second embodiments, the two independent laser light sources, which correspond to the first and second illumination unit respectively, are used. Therefore, it is possible to adjust only the light amount of one of them without depending on the other. An effect is obtained such that the degree of freedom of the control is increased.

For example, when it is intended to observe the shallow side of the held breast, then the light, which comes from the first illumination unit, predominantly contributes to the photoacoustic wave signal, and the light, which comes from the second illumination unit, scarcely contributes thereto. In such a situation, the output of the laser connected to the second illumination unit side is controlled and lowered. As a result, it is possible to suppress the living body from being irradiated with any unnecessary light. Further, the output of the laser is controlled depending on the requirement or necessity. Therefore, another effect is also obtained such that the electric power consumption is reduced and the laser is allowed to have a long service life.

[0042]

(Fourth Embodiment)

Fig. 4 conceptually illustrates still another embodiment of the present invention. Parts or portions, which are common to those of the first embodiment, are designated by the same reference numerals, any explanation of which will be omitted.

In the drawing, reference numerals 401, 405 indicate illumination units composed of magnifying projection optical systems (corresponding to the first illumination unit). Each of the illumination unit 401, 405 has a driving stage 403, 407 with which it is possible to adjust the rate of magnification or magnification power. The irradiated light beams allowed to come from the light transmission system 117, which are branched into two at the intermediate position, pass through the first holding plate 137 by means of the illumination unit 401, 405, and the irradiated light beams are radiated onto the living body 141.

In the drawing, reference numeral 411 indicates an illumination unit composed of a magnifying projection optical system (corresponding to the second illumination unit). The illumination unit 411 has a driving stage 413 with which it is possible to adjust the rate of magnification or magnification power. The irradiated light beam, which is allowed to come from the light transmission system 127, passes through the second holding plate 139 by means of the illumination unit 411, and the irradiated light beam is radiated onto the living body 141.

[0043]

Reference numeral 421 indicates a control system. The control system 421 determines the light amount ratio from the holding distance which is calculated on the basis of the position information of the second holding plate 139 detected by the driving stage 142 and the depth information of the

observation position which is determined by the observation area determining unit 145. The relationship between the observation position depth and the holding distance (spacing distance between the holding plates) and the light amount ratio is previously measured and provided as a table. The control system 421 determines the light amount ratio by making reference to the table. The control system 421 rotates the half-wave plate 105 to provide a desired angle by means of the rotary stage 107 on the basis of the determined light amount ratio. When the half-wave plate 105 is rotated, then the polarization state of the light beam allowed to pass through the half-wave plate 105 is controlled, and the branching ratio, which is brought about by the polarizing beam splitter 109, is controlled. Parts of the branched light beams are monitored by light energy meters 113, 123. If necessary, the control system 421 finely adjusts the angle of the half-wave plate 105 so that the desired light amount ratio is obtained, in accordance with the monitored light amounts.

Further, the control system 421 has a function to control the rates of magnification of the light beams by controlling the driving stages 403, 407, 413. The rate of magnification is set so that the rate of magnification is raised if the light irradiation density with respect to the living body is approximate to the maximum permissible exposure or if the light irradiation density exceeds the value thereof. The rate of magnification is set so that the rate of magnification is lowered if the light irradiation density with respect to the

living body is sufficiently smaller than the maximum permissible exposure. The relationship between the light amount ratio or the output of the light source and the light irradiation density with respect to the living body is previously measured. The relationship concerning the preferred rate of magnification with respect to the observation position depth and the holding distance (spacing distance between the holding plates) is stored as a table.

[0044]

Fig. 10 shows a flow of the measurement.

After the start of the measurement, the processes in Steps S1001 to S1008 are the same as or equivalent to the processes in S701 to 708 shown in Fig. 7.

In Step S1009, the control system 421 acquires the information required to control the rates of magnification of the light beams by making reference to the table on the basis of the monitored light amounts and the light irradiation densities determined therefrom.

In Step S1010, the control system 421 moves the driving stages 403, 407, 413 for the respective irradiation portions, and the rates of magnification of the light beams are controlled in the magnifying projection optical systems.

The processes in Steps S1011 to S1013 are the same as or equivalent to the processes in S709 to 711 shown in Fig. 7.

[0045]

According to this embodiment, it is possible to obtain the high contrast image. Further, the light irradiation

density is made to be below the maximum permissible exposure by controlling the rate of magnification of the light beam, and thus it is possible to provide the living body information imaging apparatus in which the safety for the living body is improved.

[0046]

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.

This application claims the benefit of Japanese Patent Application No. 2011-235993, filed on October 27, 2011, which is hereby incorporated by reference herein in its entirety.

CLAIMS

1. An object information acquiring apparatus comprising:
 - a first holding plate and a second holding plate configured to hold an object by interposing the object;
 - a first illumination unit configured to illuminate the object by allowing a light beam to pass through the first holding plate and a second illumination unit configured to illuminate the object by allowing a light beam to pass through the second holding plate;
 - a detecting unit configured to detect an acoustic wave propagated from an observation area disposed inside the object and allowed to pass through the first holding plate; and
 - a control unit configured to control light amounts for illuminating the object by means of the first illumination unit and the second illumination unit respectively on the basis of a holding distance as a spacing distance between the first holding plate and the second holding plate and depth information as a distance between the first holding plate and the observation area.
2. The object information acquiring apparatus according to claim 1, wherein the control unit is configured to perform control so that the light amounts, with which the first illumination unit and the second illumination unit is configured to illuminate the object respectively, have values which do not exceed a maximum permissible exposure.

3. The object information acquiring apparatus according to claim 1 or 2, further comprising:

a light source; and

a branching unit configured to branch a light beam irradiated from the light source to guide the light beam to the first illumination unit and the second illumination unit, wherein:

the control unit is configured to control a light amount ratio when the branching unit branches the light beam.

4. The object information acquiring apparatus according to claim 3, wherein:

the branching unit has a half-wave plate and a polarizing beam splitter; and

the control unit is configured to control the light amount ratio by rotating the half-wave plate to control a polarization state of the light beam.

5. The object information acquiring apparatus according to claim 3, wherein:

the branching unit has a knife edge reflecting prism which has two reflecting surfaces; and

the control unit is configured to control the light amount ratio by moving a position of the knife edge reflecting prism with respect to the light beam irradiated from the light source.

6. The object information acquiring apparatus according to any one of claims 3 to 5, wherein the control unit is configured to control the light amount ratio by making reference to a table which retains a relationship between the holding distance and the depth information and the light amount ratio.

7. The object information acquiring apparatus according to any one of claims 3 to 6, wherein the control unit is configured to control the light amount ratio so that the illumination unit, which is disposed on a side nearer to the observation area and which is included in the first illumination unit and the second illumination unit, is configured to perform the illumination with the light beam having a more intense light amount.

8. The object information acquiring apparatus according claim 1 or 2, further comprising:

a first light source and a second light source, wherein:

the first illumination unit is configured to illuminate the object with a light beam irradiated from the first light source; and

the second illumination unit is configured to illuminate the object with a light beam irradiated from the second light source.

9. The object information acquiring apparatus according to any one of claims 1 to 8, further comprising determining unit configured to determine a position of the observation area in

the object.

10. The object information acquiring apparatus according to claim 9, wherein the determining unit is configured to determine the position of the observation area by accepting an input from an operator.

11. The object information acquiring apparatus according to claim 9, wherein:

the first illumination unit and the second illumination unit is configured to illuminate the object with predetermined light amounts; the detecting unit is configured to detect the acoustic wave generated from the object by being illuminated with the predetermined light amounts; and

the determining unit is configured to determine the position of the observation area by extracting a characteristic point from an internal image of the object on the basis of the acoustic wave detected by the detecting unit.

12. The object information acquiring apparatus according to any one of claims 1 to 11, further comprising:

a monitor unit configured to detect the light amounts of the first illumination unit and the second illumination unit respectively, wherein:

the control unit is configured to adjust the light amounts for illuminating the object by means of the first illumination unit and the second illumination unit respectively on the basis

of the light amounts detected by the monitor unit.

13. A control method for controlling an object information acquiring apparatus comprising:

a first holding plate and a second holding plate configured to hold an object by interposing the object;

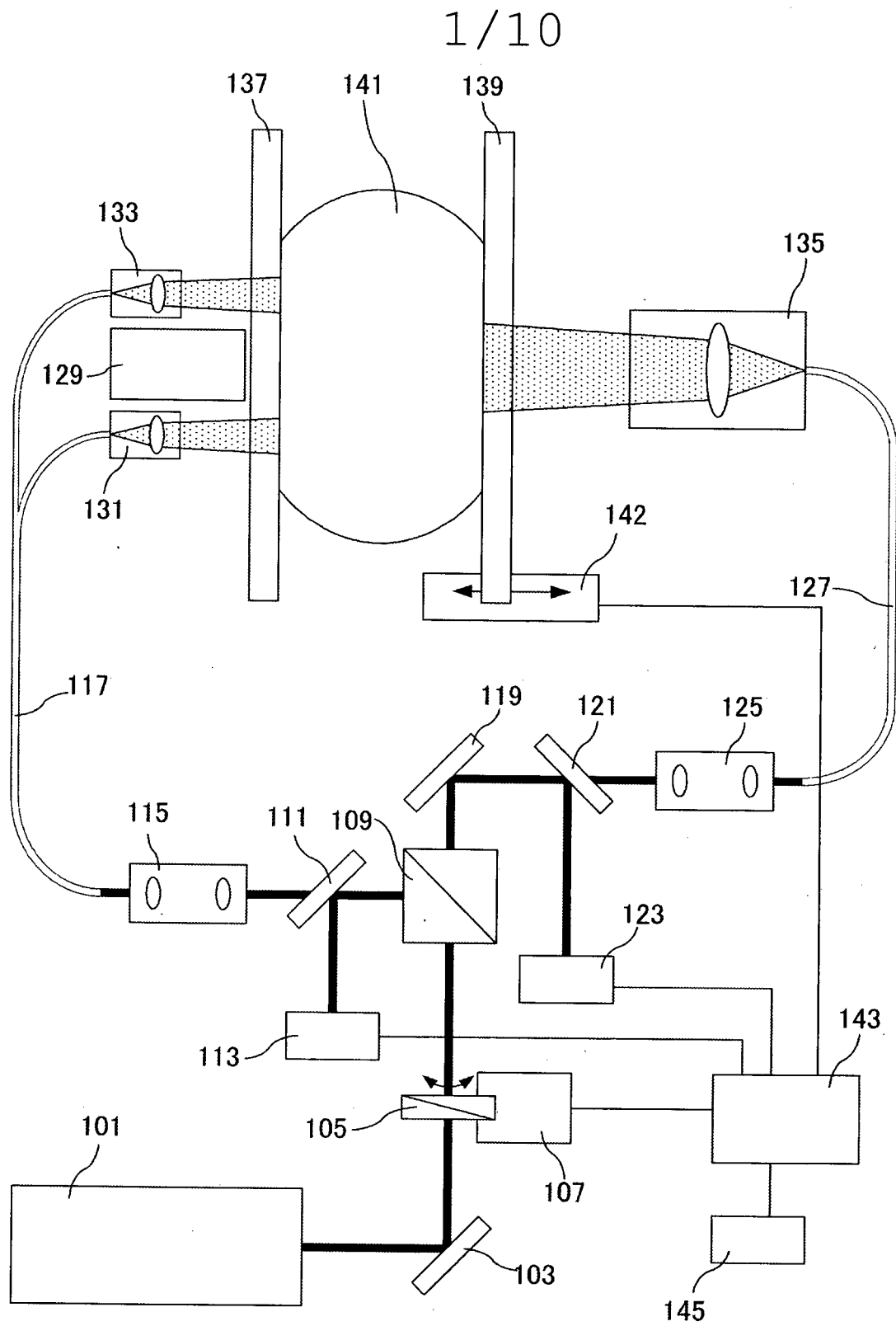
a first illumination unit configured to illuminate the object by allowing a light beam to pass through the first holding plate and a second illumination unit configured to illuminate the object by allowing a light beam to pass through the second holding plate; and

a detecting unit configured to detect an acoustic wave propagated from an observation area disposed inside the object and allowed to pass through the first holding plate, the control method comprising:

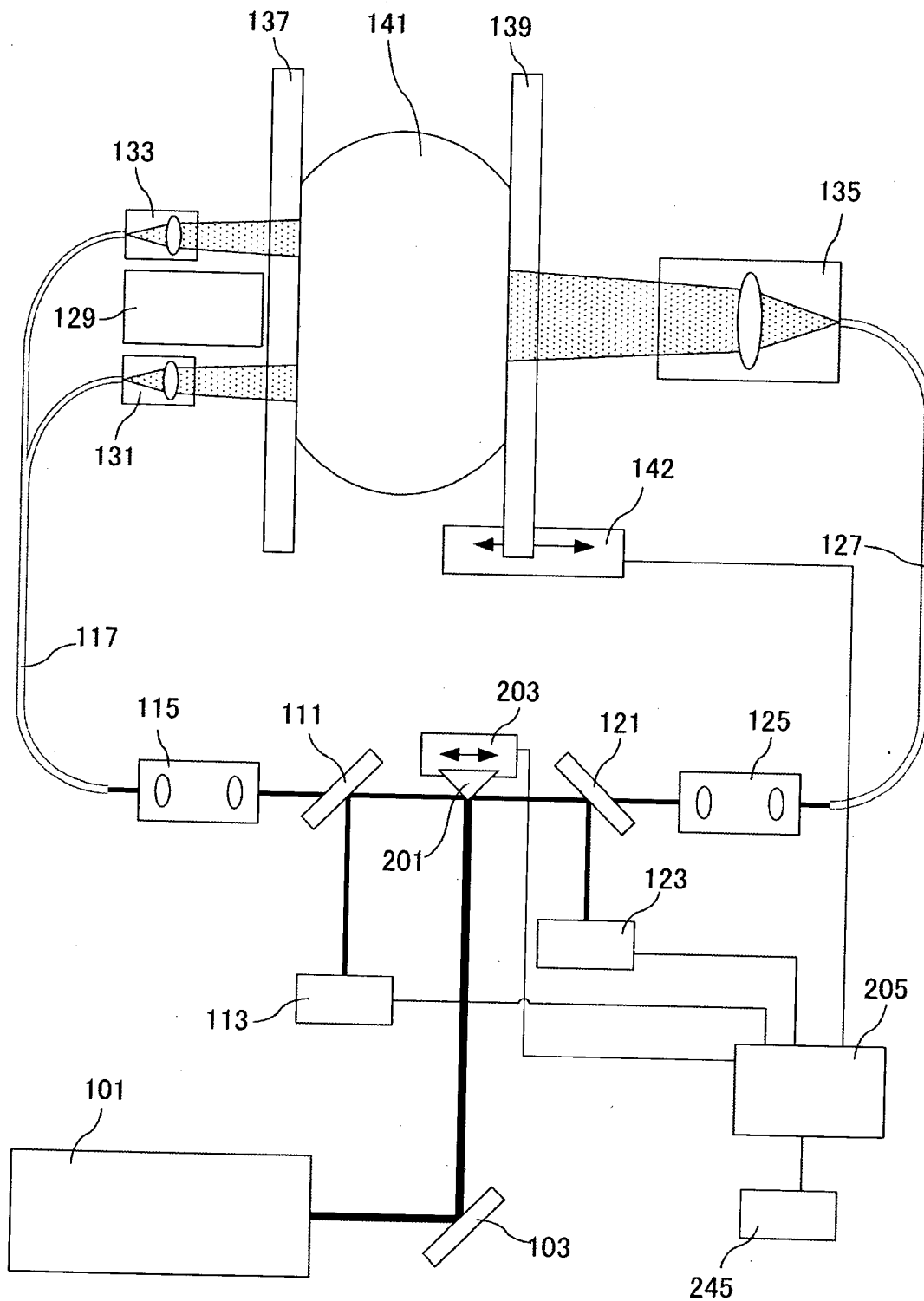
a control step of controlling light amounts for illuminating the object by means of the first illumination unit and the second illumination unit respectively on the basis of a holding distance as a spacing distance between the first holding plate and the second holding plate and depth information as a distance between the first holding plate and the observation area;

an illumination step of illuminating the object with the light amounts controlled in the control step; and

a detecting step of detecting an acoustic wave propagated from the observation area disposed inside the object illuminated in the illumination step.

**Fig.1**

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**Fig.2**

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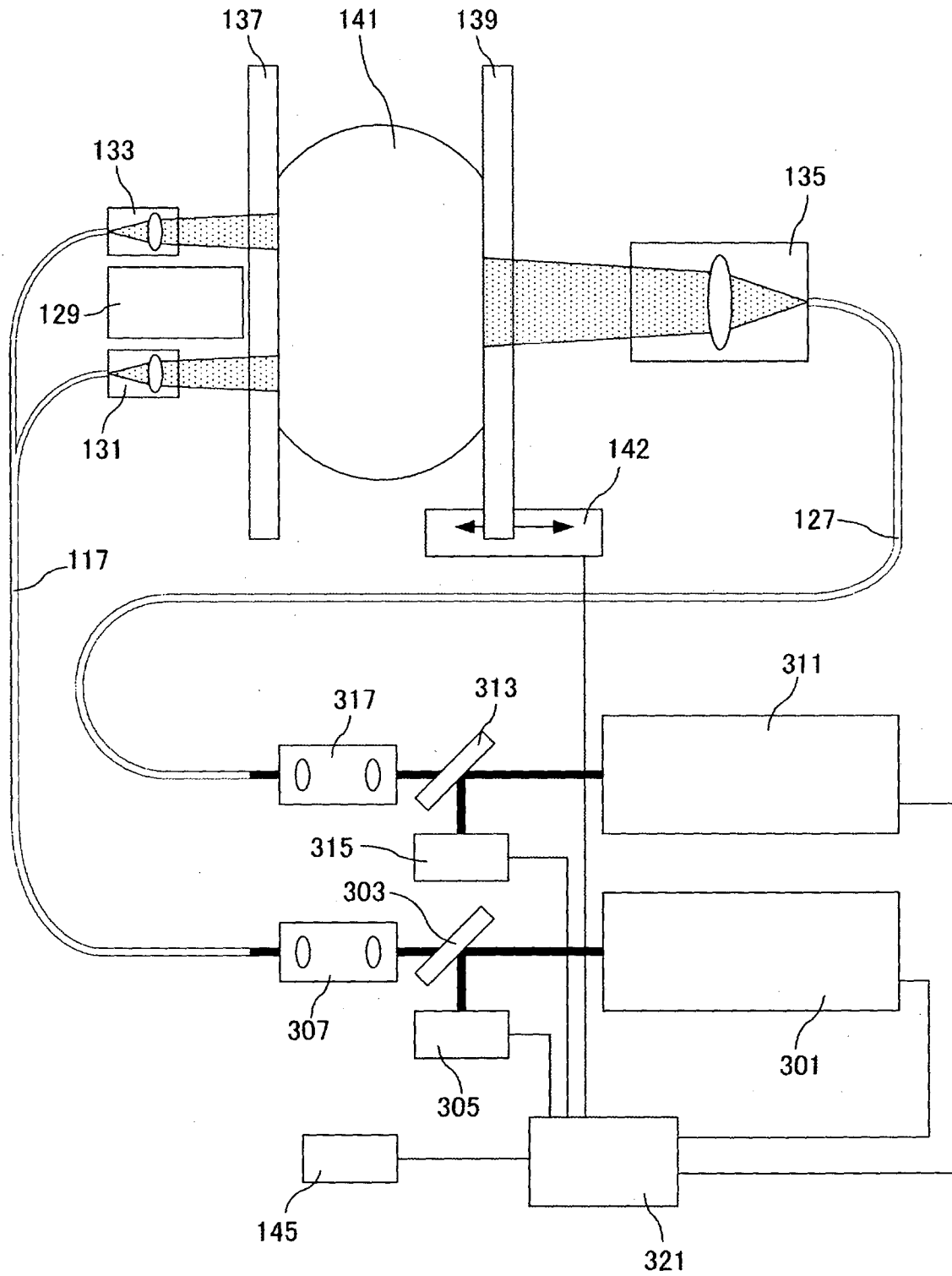
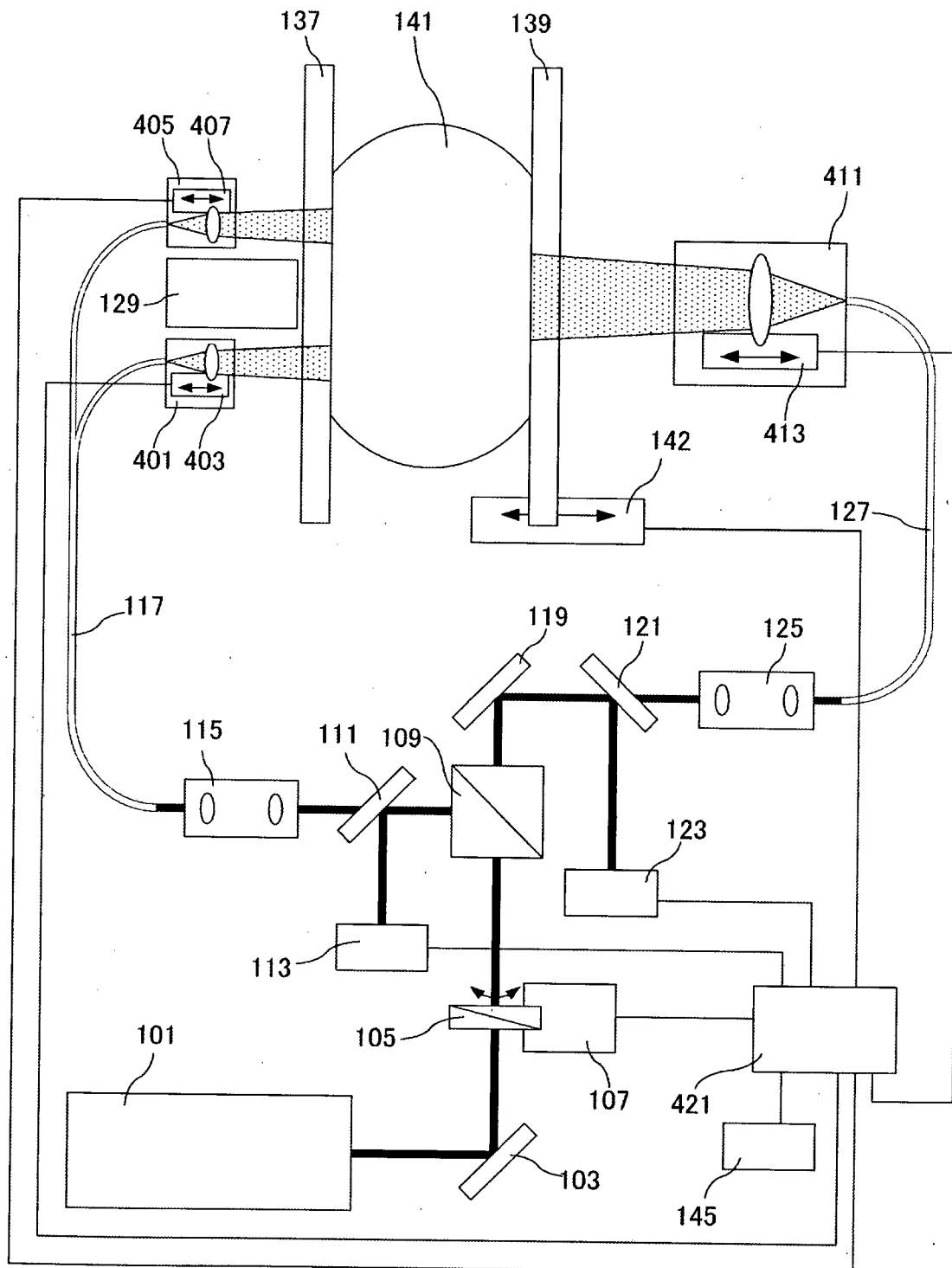
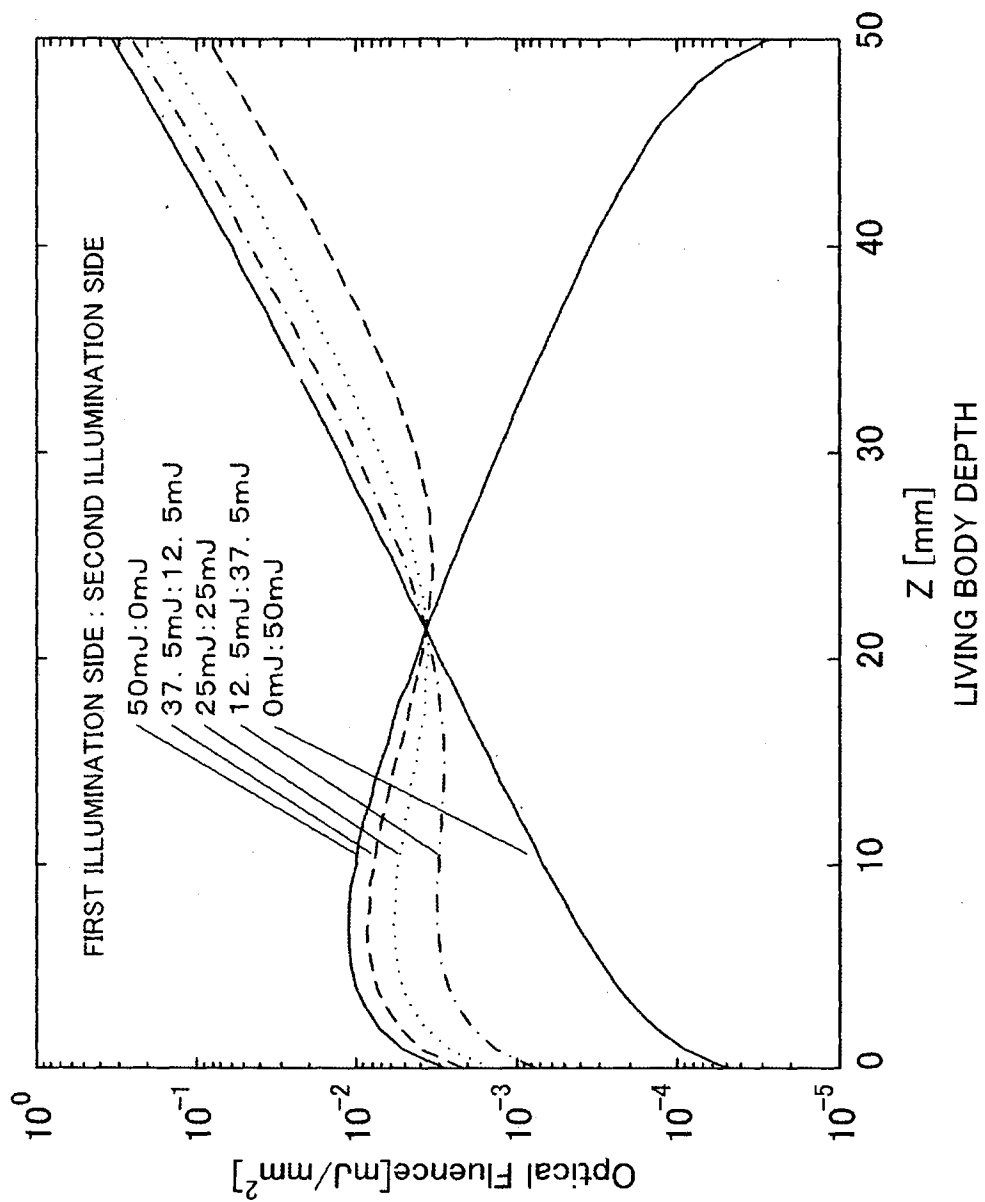


Fig.3

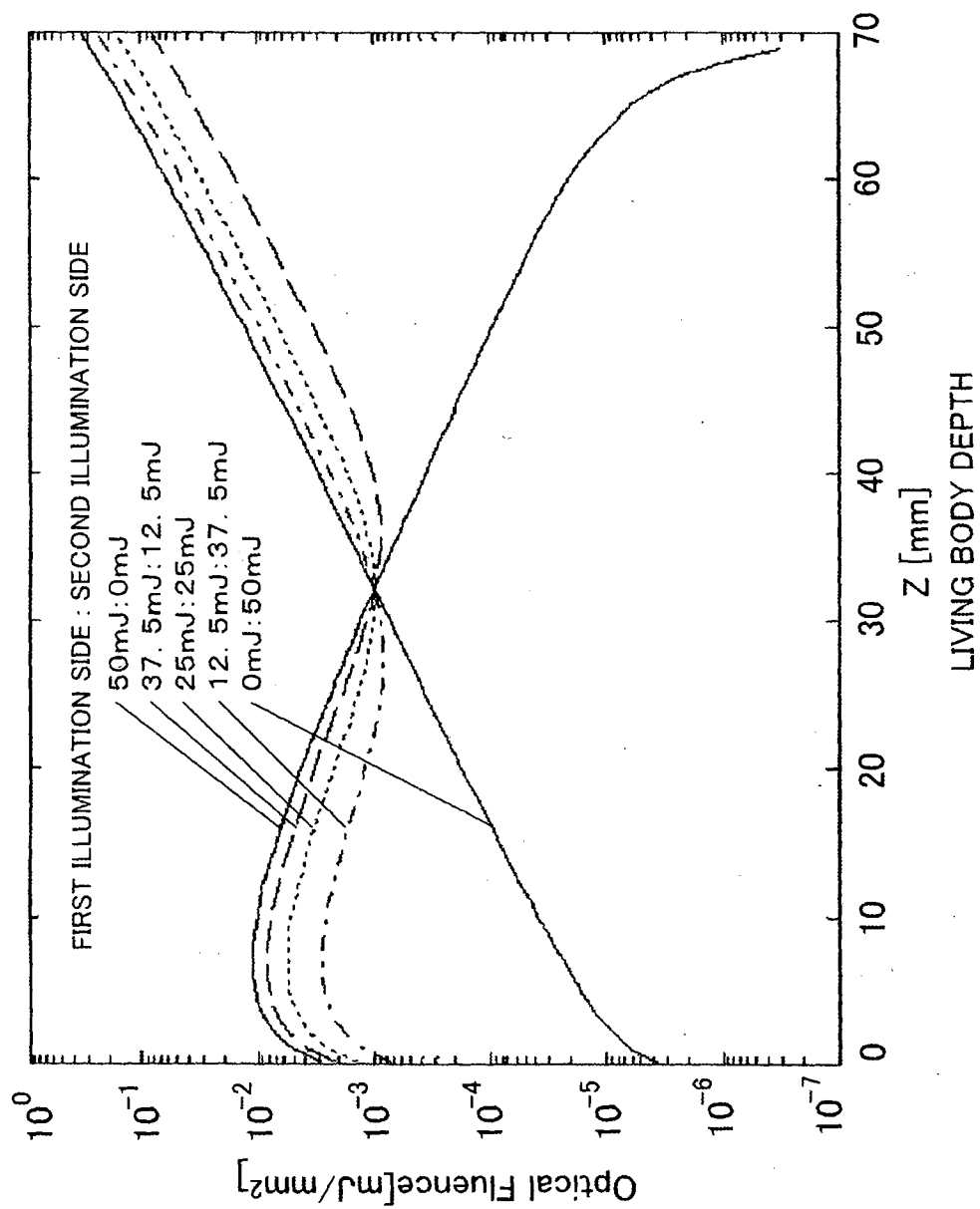
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**Fig.4**

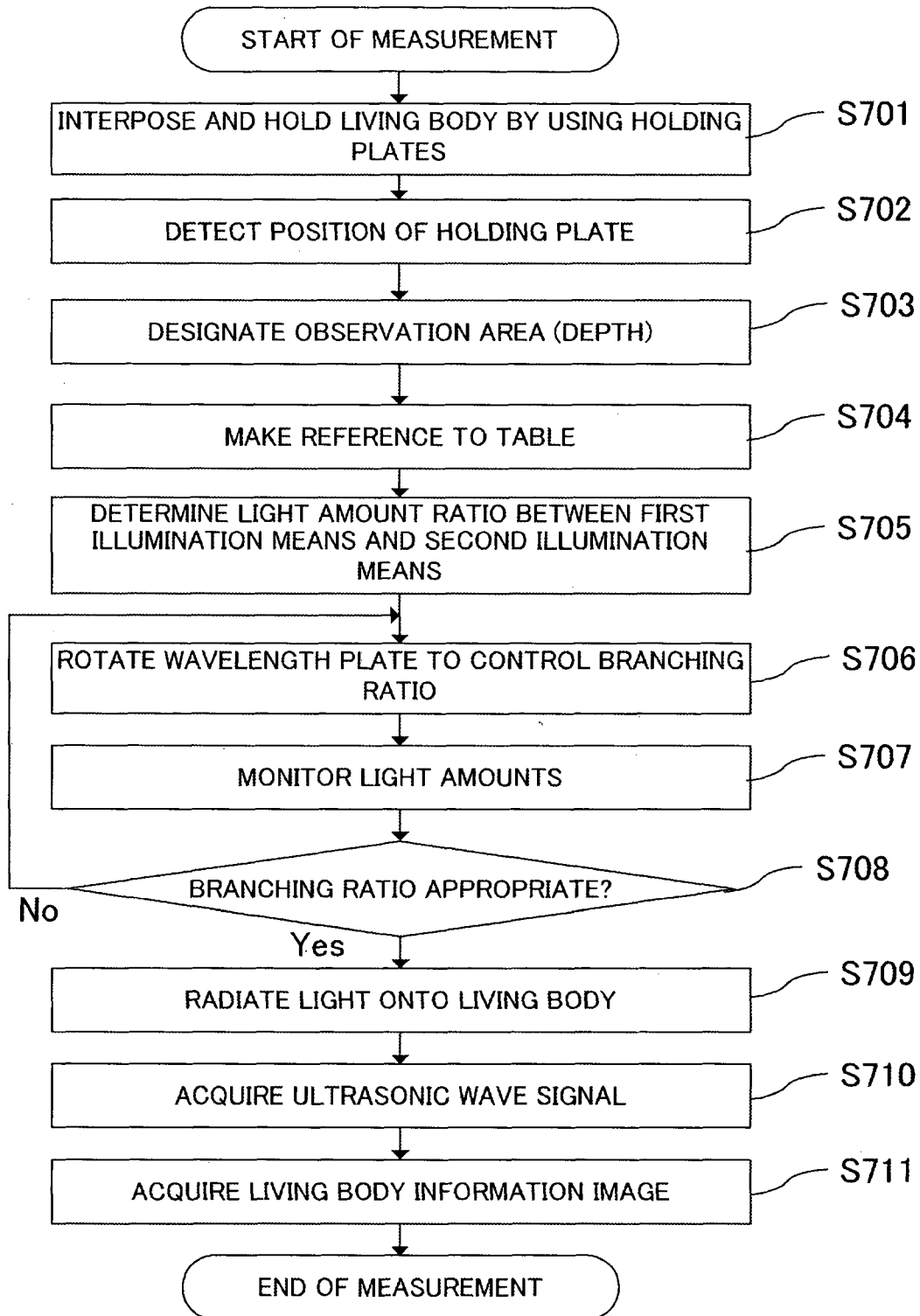
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**Fig.5**

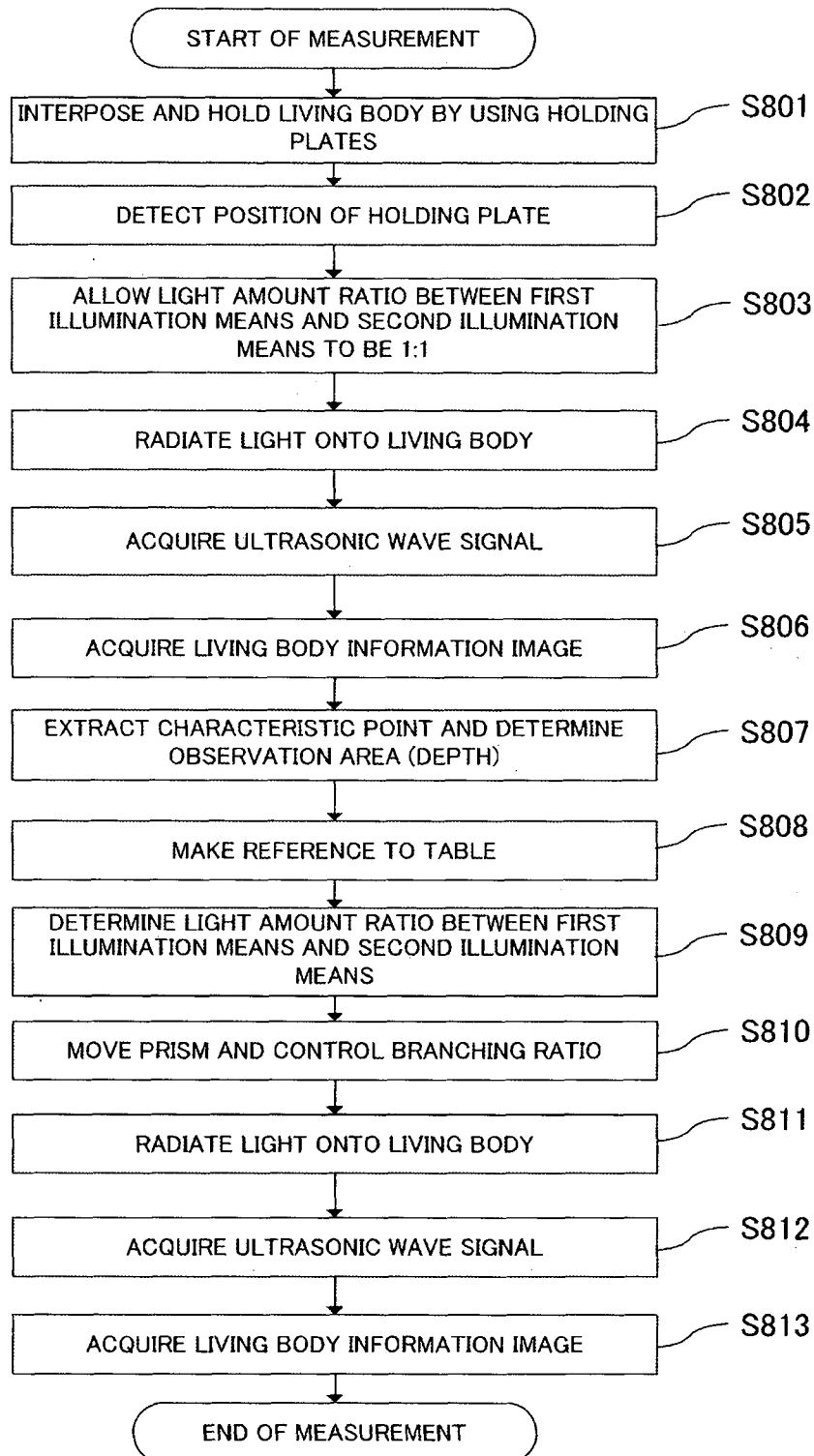
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**Fig.6**

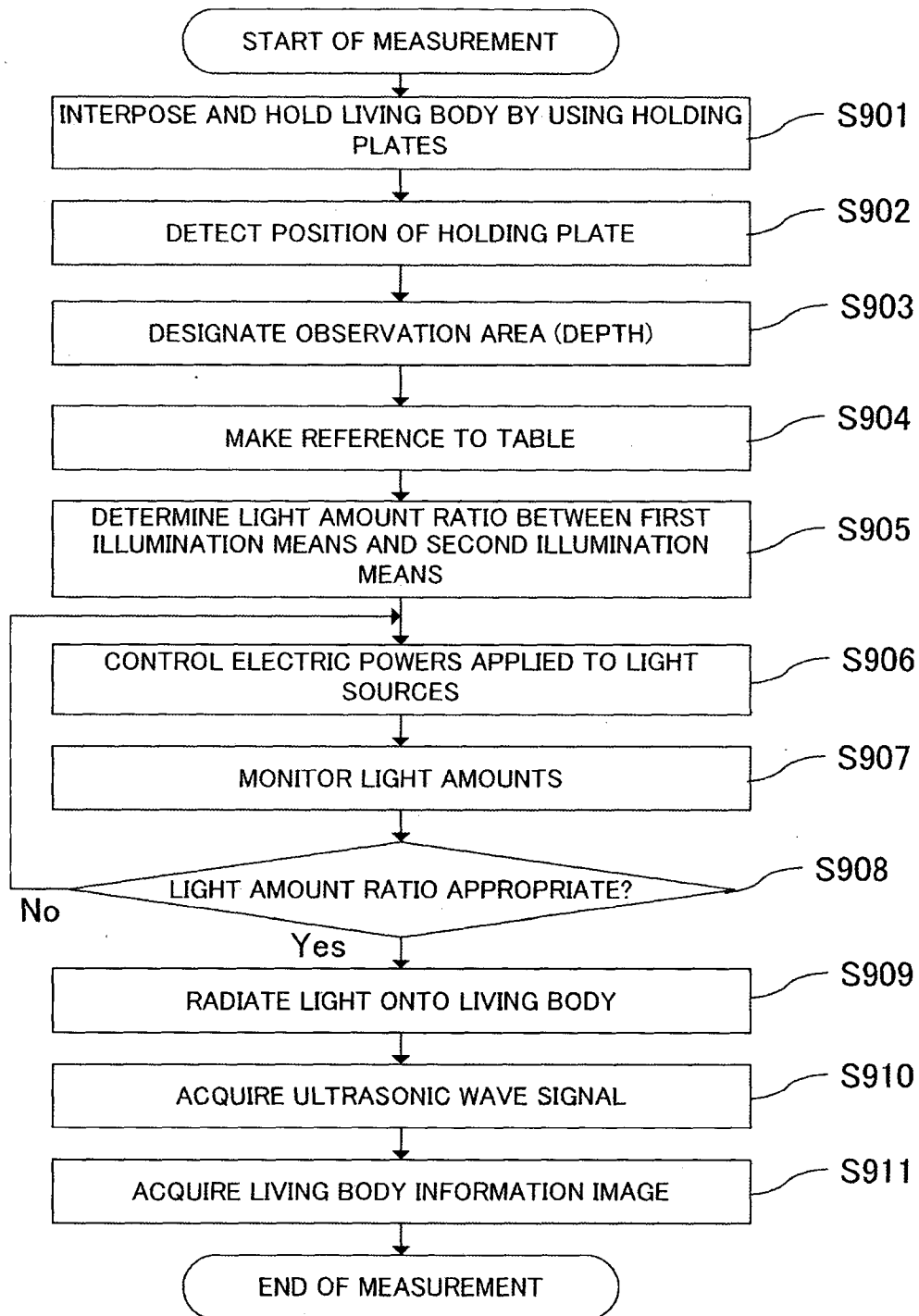
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**Fig.7**

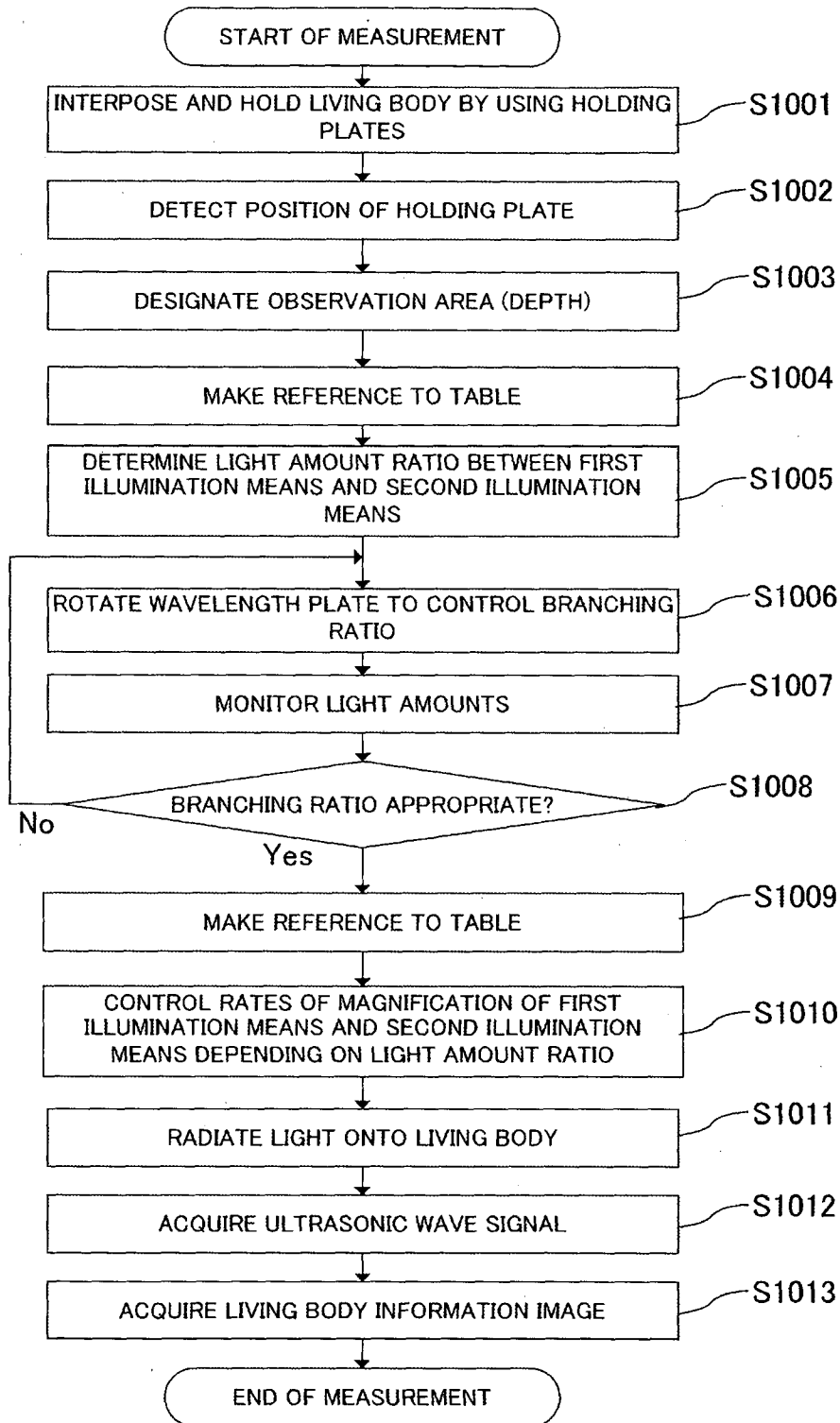
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**Fig.8**

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**Fig.9**

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**Fig.10**

INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2012/077664

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B5/00
ADD.

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)
A61B G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal, WPI Data, BIOSIS, COMPENDEX, EMBASE, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	paragraph [0012] - paragraph [0018] paragraph [0029] figures 1a-b,6	7
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A	WO 2011/039979 A1 (CANON KK [JP]; YUKI OSAMU [JP]) 7 April 2011 (2011-04-07) paragraph [0024] - paragraph [0028] figures 3,5,7	1-13
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

25 January 2013

Date of mailing of the international search report

04/02/2013

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INTERNATIONAL SEARCH REPORT

International application No
PCT/JP2012/077664

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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International application No

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