US 20190365347A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2019/0365347 A1
Abe (43) Pub. Date: Dec. 5, 2019

(54) **ULTRASONIC PROBE AND ULTRASONIC IMAGE OBTAINING APPARATUS**

(71) Applicant: **CANON KABUSHIKI KAISHA**, Tokyo (JP)

(72) Inventor: **Naoto Abe**, Machida-shi (JP)

(21) Appl. No.: **16/363,834**

(22) PCT Filed: **Nov. 30, 2017**

(86) PCT No.: **PCT/JP2017/043007**

§ 371 (c)(1),
(2) Date: **Mar. 25, 2019**

(30) **Foreign Application Priority Data**

Dec. 8, 2016 (JP) 2016-238662

Publication Classification

(51) **Int. Cl.**

A61B 8/14	(2006.01)
A61B 8/00	(2006.01)
G01N 29/06	(2006.01)
G01N 29/24	(2006.01)

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

CPC ***A61B 8/14*** (2013.01); ***G01N 29/2418*** (2013.01); ***G01N 29/0672*** (2013.01); ***A61B 8/4444*** (2013.01)

(57) **ABSTRACT**

A hand-held type ultrasonic probe includes a housing having a reception region portion and a grip portion. The reception region portion includes an ultrasonic element array which receives ultrasonic waves and the grip portion includes a vibration actuator.

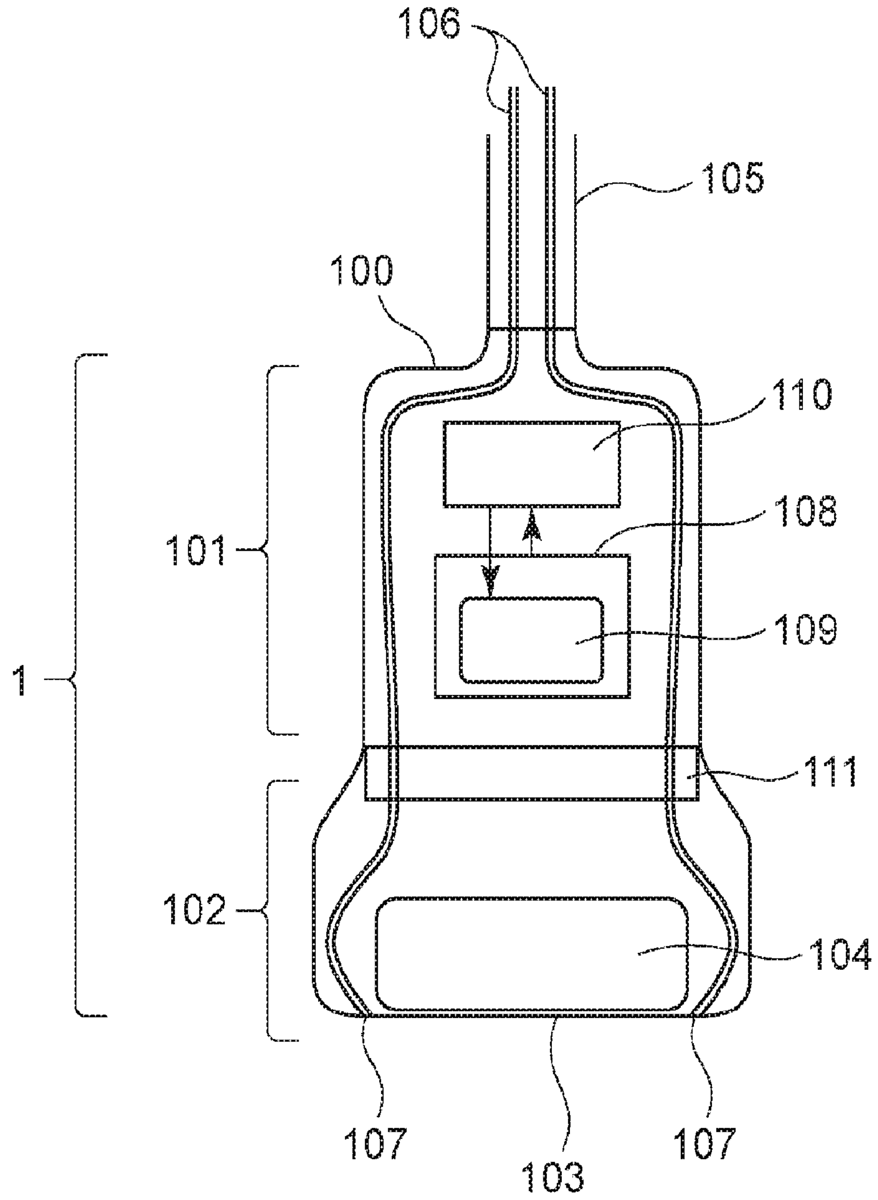


FIG. 1

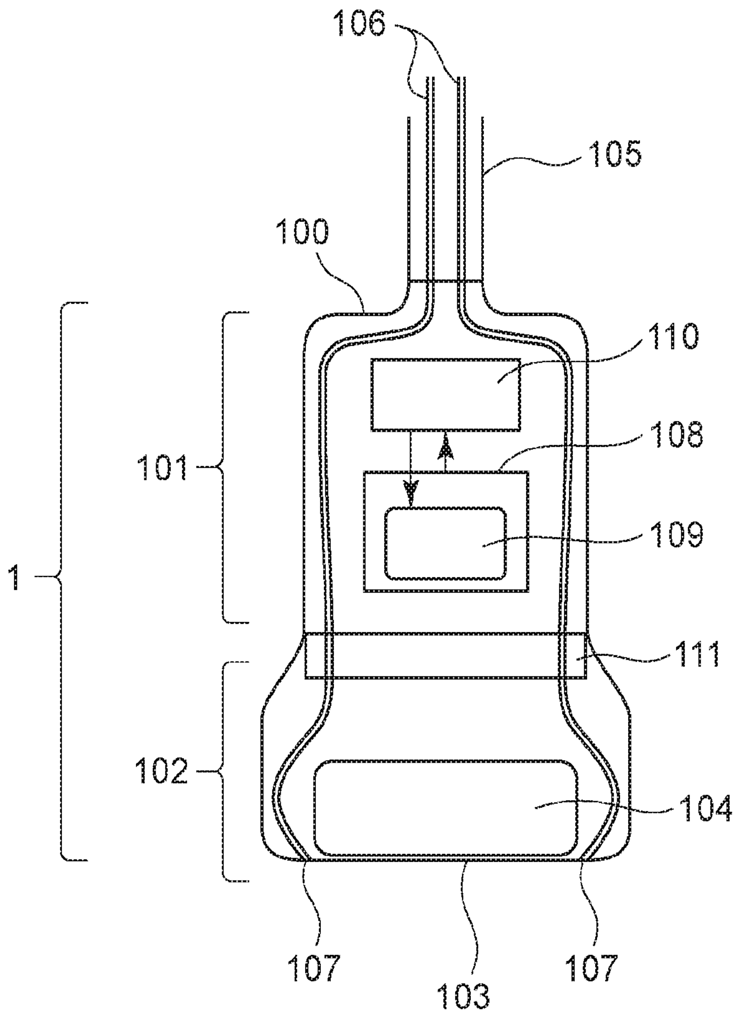


FIG. 2

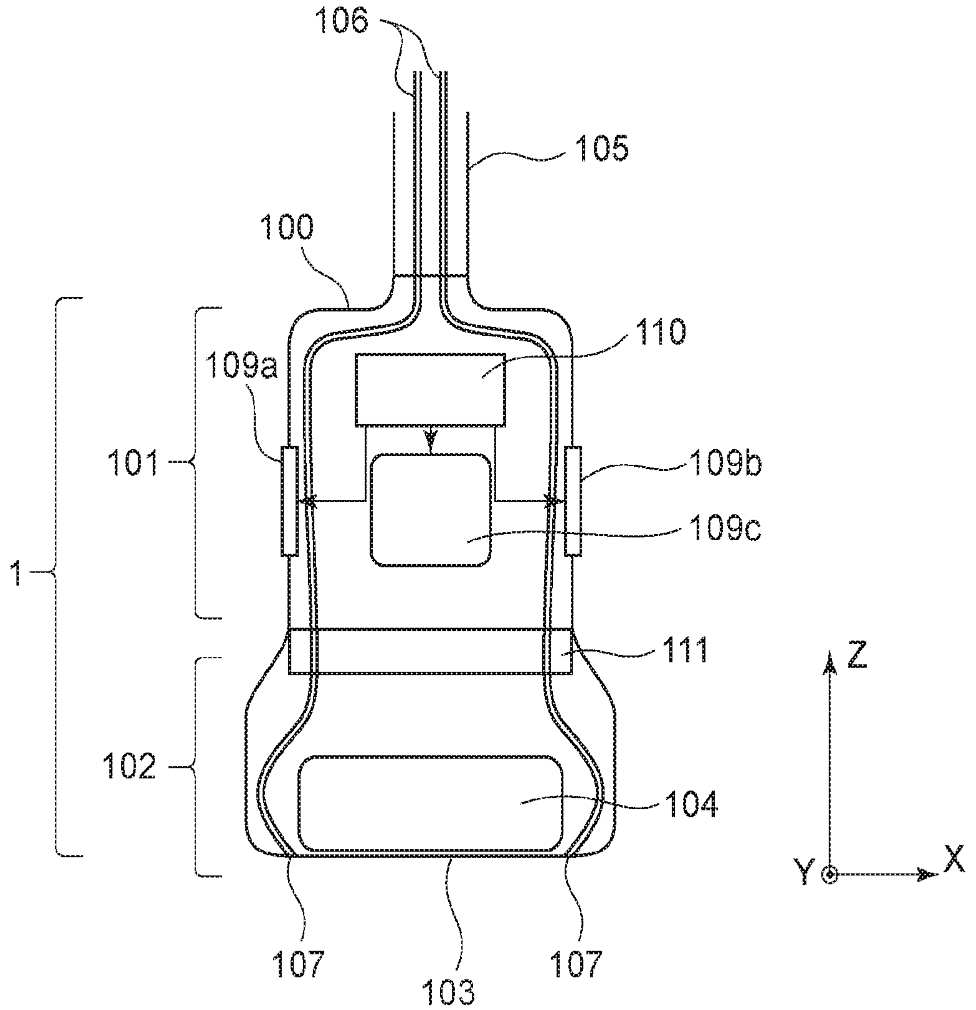


FIG. 3

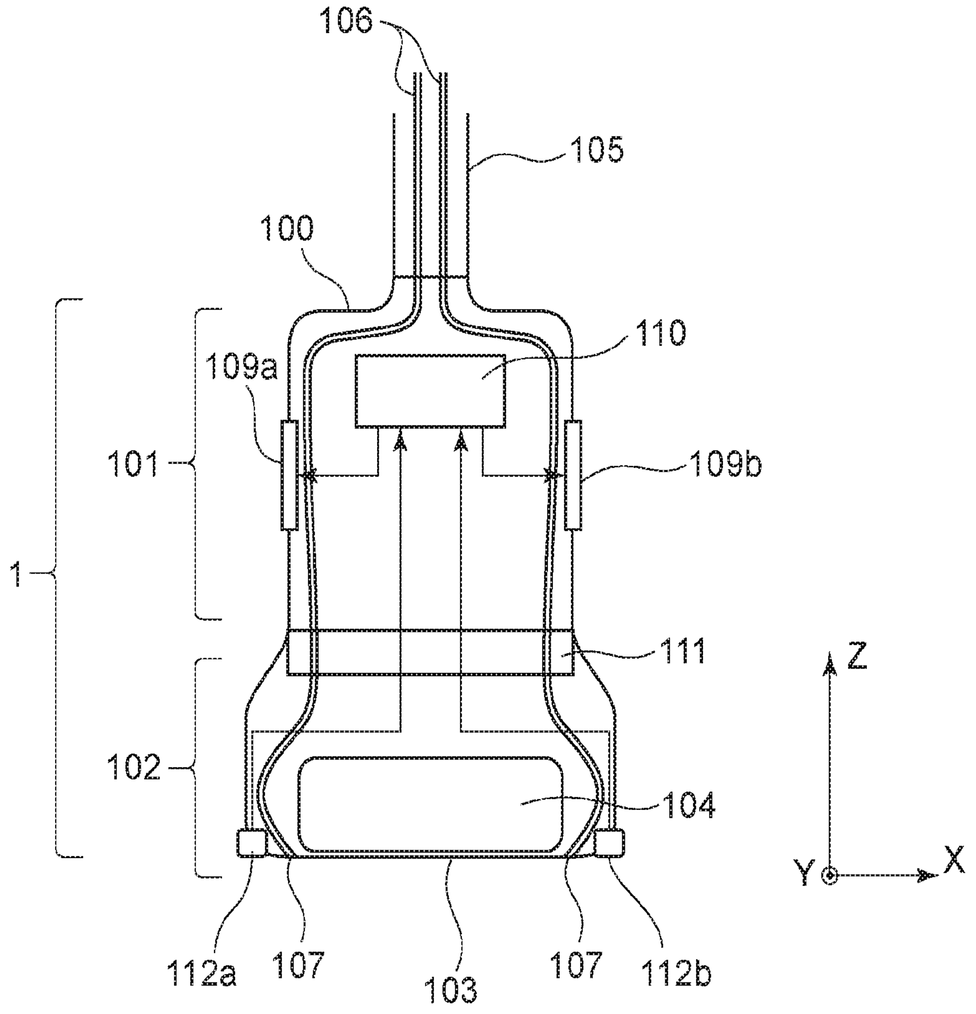

106
105
100
110
109a
101
109b
1
111
Z
102
104
Y
X
112a
107
103
107
112b

FIG. 4

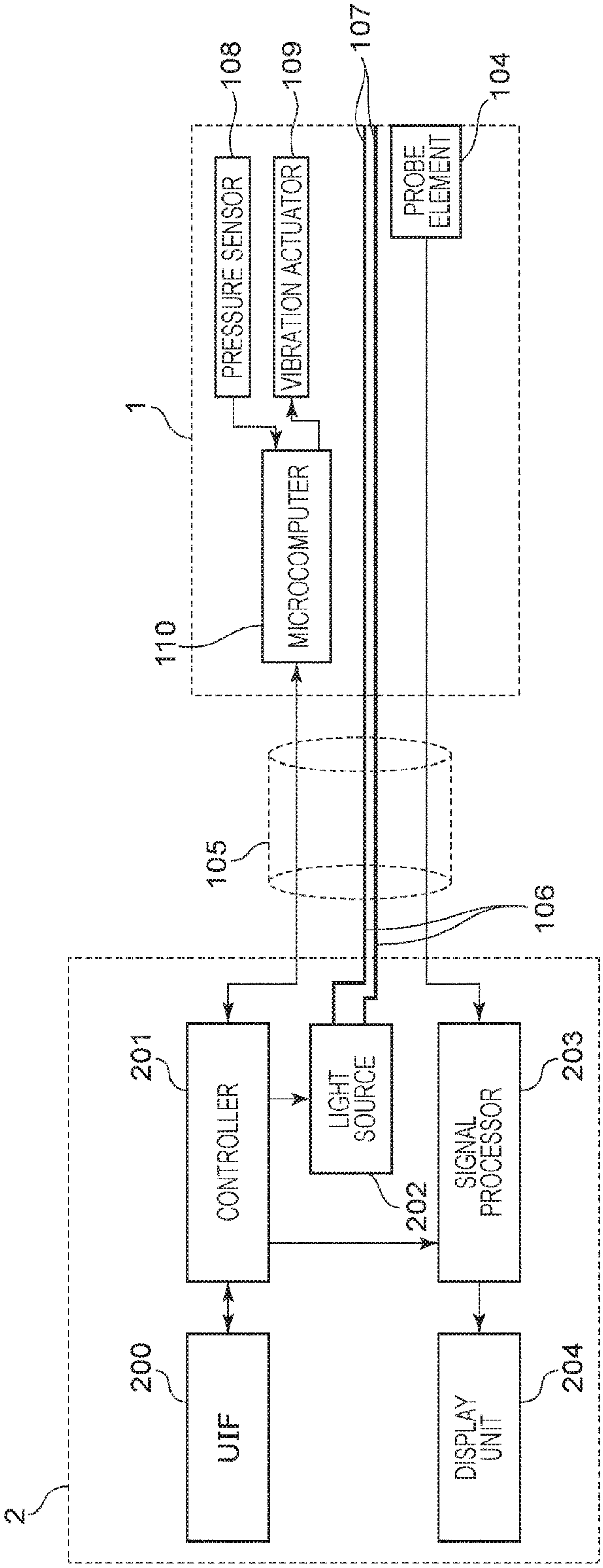

108
PRESSURE SENSOR
109
VIBRATION ACTUATOR
107
104
PROBE ELEMENT
1
110
MICROCOMPUTER
105
106
201
CONTROLLER
LIGHT SOURCE
202
203
SIGNAL PROCESSOR
200
UIF
204
DISPLAY UNIT
2

FIG. 5

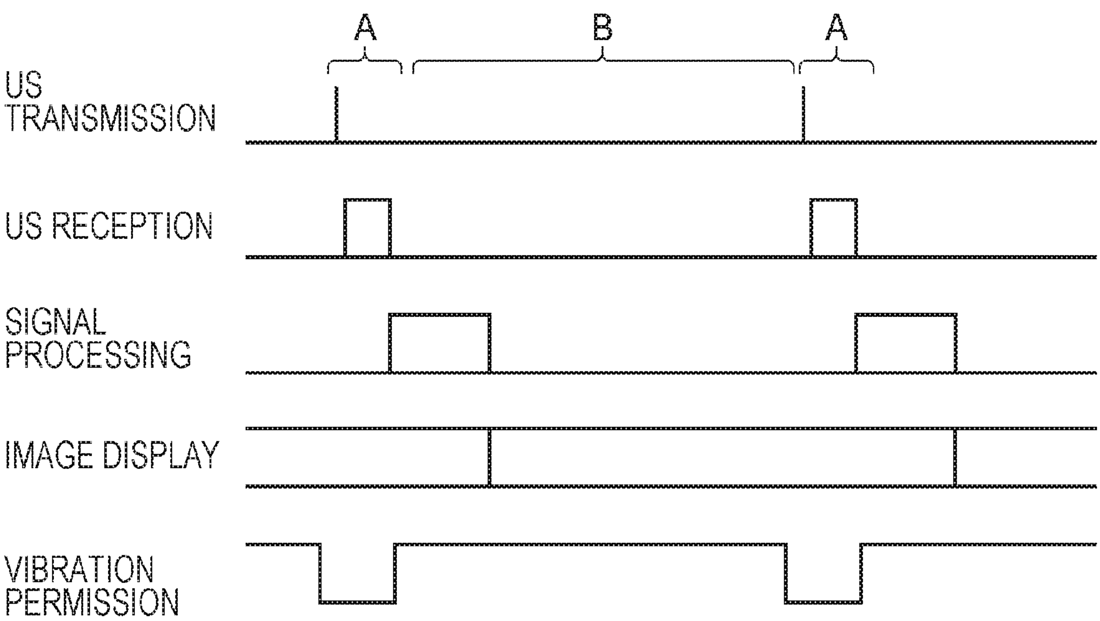
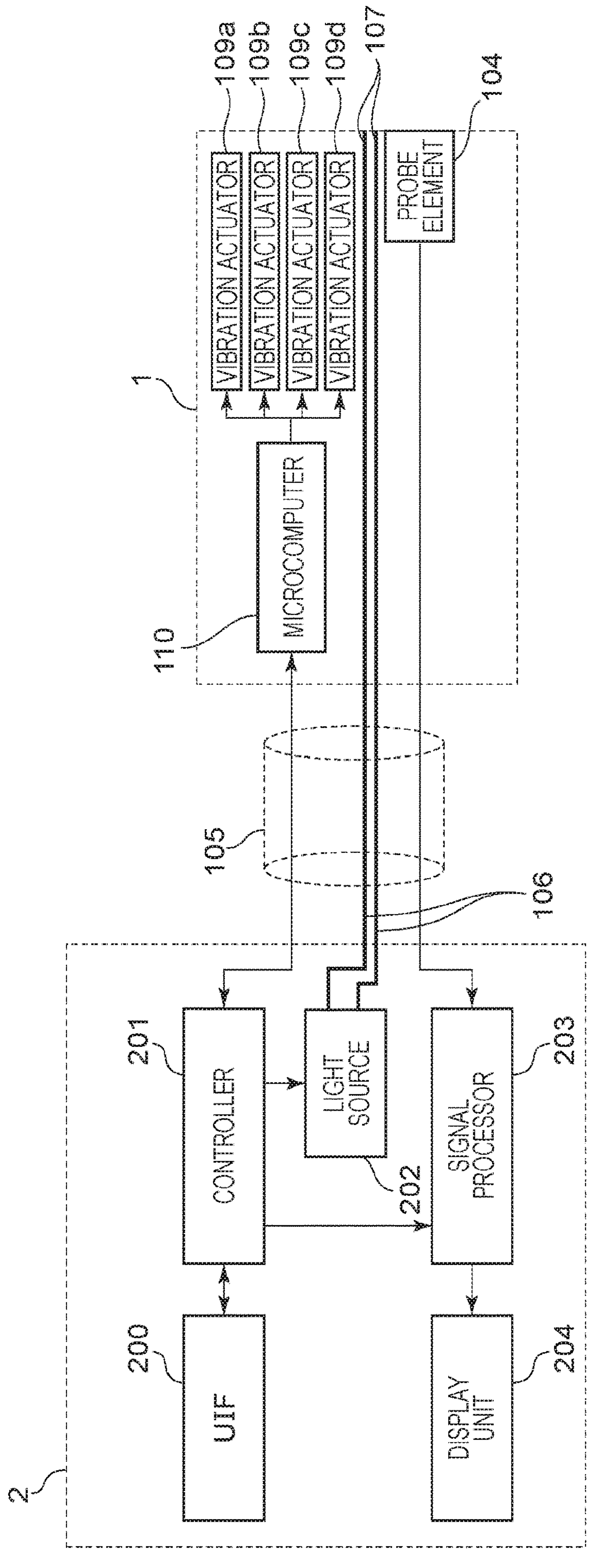

A
B
A
US TRANSMISSION
US RECEPTION
SIGNAL PROCESSING
IMAGE DISPLAY
VIBRATION PERMISSION

FIG. 6



1
109a
109b
109c
109d
107
104
VIBRATION ACTUATOR
VIBRATION ACTUATOR
VIBRATION ACTUATOR
VIBRATION ACTUATOR
PROBE ELEMENT
110
MICROCOMPUTER
105
106
2
200
UIF
201
CONTROLLER
LIGHT SOURCE
202
203
SIGNAL PROCESSOR
204
DISPLAY UNIT

FIG. 7A

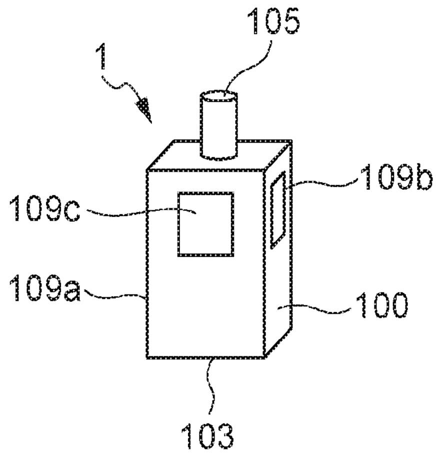


FIG. 7B

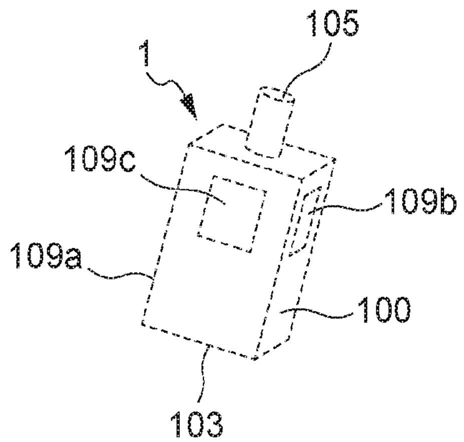


FIG. 8

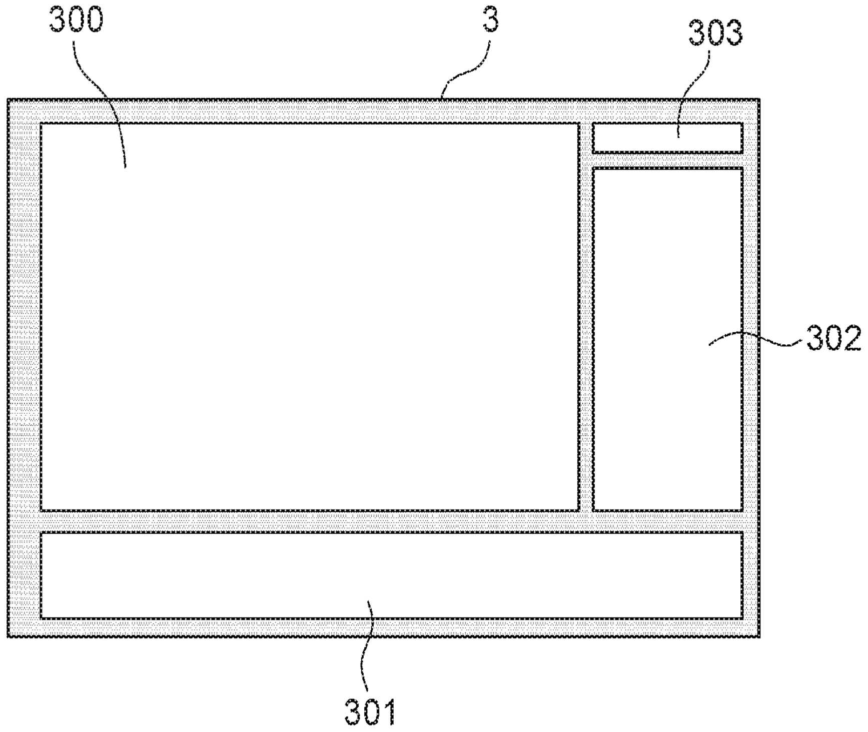
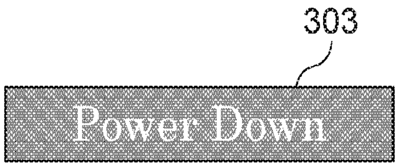


FIG. 9A

FIG. 9B



ULTRASONIC PROBE AND ULTRASONIC IMAGE OBTAINING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation of International Patent Application No. PCT/JP2017/043007, filed Nov. 30, 2017, which claims the benefit of Japanese Patent Application No. 2016-238662, filed Dec. 8, 2016, both of which are hereby incorporated by reference herein in their entirety.

TECHNICAL FIELD

[0002] The present invention relates to an ultrasonic probe and an ultrasonic image obtaining apparatus.

BACKGROUND ART

[0003] In recent years, photoacoustic imaging apparatuses which generate an image of an inside of a living body utilizing a photoacoustic effect have been studied and developed. Such a photoacoustic imaging apparatus generates an image of an inside of a test object using an ultrasonic wave (a photoacoustic wave) generated from a tissue of the living body which absorbs energy of pulse laser light emitted to the inside of the living body due to the photoacoustic effect. On the other hand, ultrasonic imaging apparatuses (ultrasonic image obtaining apparatuses) which have a probe transmitting an ultrasonic wave and which generates an image based on the ultrasonic wave reflected by an inside of a living body have been used. These apparatuses have a common technique of receiving an ultrasonic wave from an inside of a living body and generating an image of the inside of the living body, and therefore, an imaging apparatus which has functions of the two types of imaging apparatus have also been studied and developed. Furthermore, an ultrasonic imaging apparatus which includes a probe which may be held by a hand which is referred to as a hand-held type ultrasonic probe is dominant. PTL 1 discloses an imaging apparatus having the functions of the two types of imaging apparatus described above using a hand-held type ultrasonic probe.

CITATION LIST

Patent Literature

[0004] PTL 1 Japanese Patent Laid-Open No. 2012-152267

[0005] PTL 2 Japanese Patent Laid-Open No. 2004-16268

[0006] PTL 3 Japanese Patent Laid-Open No. 2014-61137

[0007] In PTL 1, a configuration in which a hand-held type ultrasonic probe has a switch for selecting photoacoustic imaging or ultrasonic imaging is disclosed. On the other hand, when a photoacoustic image or an ultrasonic image is obtained using a hand-held type ultrasonic probe, the probe is required to be in contact with a test object, e.g., a patient. The inventor discusses improvement of usability of the hand-held type ultrasonic probe, and concluded that, when measurement is performed by bringing the probe into contact with the patient, it is effective to give some information except for visual information to an operator in accordance with a state of the measurement, a state of a probe (in a danger case), or the like. Then the inventor thought that a mechanism for transmitting information to the operator by a tactile impression of the ultrasonic probe contributes to improvement of a technique of this field. Accordingly, an object of the present invention is to provide a hand-held type ultrasonic probe capable of transmitting information to an operator by a tactile impression.

SUMMARY OF INVENTION

[0008] A hand-held type ultrasonic probe according to the present invention includes a housing having a reception region portion and a grip portion. The reception region portion includes an ultrasonic element array which receives ultrasonic waves and the grip portion includes a vibration actuator.

[0009] 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

[0010] FIG. **1** is a diagram illustrating a configuration of an example of a hand-held type ultrasonic probe according to the present invention.

[0011] FIG. **2** is a diagram illustrating a configuration of an example of another hand-held type ultrasonic probe according to the present invention.

[0012] FIG. **3** is a diagram illustrating a configuration of an example of a further hand-held type ultrasonic probe according to the present invention.

[0013] FIG. **4** is an entire block diagram illustrating an example of an ultrasonic image obtaining apparatus including the probe according to the present invention.

[0014] FIG. **5** is a timing chart of an image obtainment when the ultrasonic image obtaining apparatus according to the present invention is employed.

[0015] FIG. **6** is an entire block diagram illustrating an example of the other ultrasonic image obtaining apparatus.

[0016] FIG. **7**A is a diagram schematically illustrating the hand-held type ultrasonic probe according to the present invention which is moved in an inclined state.

[0017] FIG. **7**B is a diagram schematically illustrating the hand-held type ultrasonic probe according to the present invention which is moved in the inclined state.

[0018] FIG. **8** is a diagram schematically illustrating an example of display performed by a display unit of the ultrasonic image obtaining apparatus according to the present invention.

[0019] FIG. **9**A is a diagram schematically illustrating a change of a display state of a message area.

[0020] FIG. **9**B is a diagram schematically illustrating the change of the display state of the message area.

DESCRIPTION OF EMBODIMENTS

[0021] Hereinafter, preferred embodiments of the present invention will be described with reference to the accompanying drawings. Note that sizes, quality of materials, shapes, and relative arrangement of components described below are to be appropriately changed depending on a configuration of an apparatus to which the present invention is applied and various conditions. Therefore, the scope of the present invention is not limited to the description below.

[0022] The present invention relates to a technique of detecting an acoustic wave transmitted from a test object and generating and obtaining characteristic information of an inside of the test object.

[0023] The present invention includes an apparatus (a photoacoustic apparatus) which receives an acoustic wave generated in an inside of a test object by irradiating the test object with light and obtaining characteristic information of the test object as image data utilizing a photoacoustic effect. The characteristic information of the present invention indicates information on characteristic values corresponding to different positions in the test object which are generated using photoacoustic signals obtained when ultrasonic waves are received.

[0024] The characteristic information obtained in the present invention indicates values which reflect absorption rates of optical energy. For example, a generation source of an acoustic wave generated due to light emission, an initial sound pressure in the test object, and optical energy absorption density and an optical energy absorption coefficient which are derived from the initial sound pressure may correspond to as "characteristic information based on optical absorption" or "distribution of optical characteristic values in an inside of a test object". Examples of the characteristic information further include concentration associated information of subjects included in a tissue.

[0025] The concentration associated information includes a value associated with concentration of a substance incorporated in the test object which is obtained using the characteristic information based on optical absorption for a plurality of wavelengths. Specifically, the concentration associated information includes a degree of oxygen saturation, a value obtained by weighting intensity of an absorption coefficient or the like to the degree of oxygen saturation, total hemoglobin concentration, oxyhemoglobin concentration, and deoxyhemoglobin concentration. Furthermore, the concentration associated information may be glucose concentration, collagen concentration, melanin concentration, or volume fraction of fat or water. Furthermore, a 2D or 3D characteristic information distribution is obtained based on the concentration associated information in the different positions in the test object. Distribution data may be generated as image data.

[0026] A main object of the photoacoustic imaging apparatus (a photoacoustic image obtaining apparatus) in the embodiments below is to make diagnosis of a malignant tumor and a vascular disease of a person and an animal, to perform follow-up of chemical treatment, and the like. Accordingly, it is assumed that the test object is a portion of a living body, that is, a portion (a breast, an organ, a circulatory organ, a digestive organ, a bone, a muscle, fat, or the like) of a person or an animal. Examples of a substance of an inspection target include hemoglobin, glucose, water in a body, melanin, collagen, and fat. Furthermore, any substance including a contrast agent, such as indocyanine green (ICG), which is internally administered, may be employed as long as an optical absorption spectrum of the substance is characteristic.

[0027] The present invention is applicable not only a photoacoustic imaging apparatus but also various apparatuses including a hand-held type probe for receiving an ultrasonic wave. Furthermore, the present invention includes an imaging apparatus (an image obtaining apparatus) including a hand-held type ultrasonic probe having a vibration actuator inside thereof. The present invention further includes a method for transmitting a message to an operator using an imaging apparatus. The method includes a step of vibrating a vibration actuator in a vibration pattern corresponding to content of the message.

First Embodiment

[0028] Apparatus Configuration

[0029] FIG. **1** is a diagram illustrating a configuration of an example of a hand-held type ultrasonic probe according to a first embodiment of the present invention. In FIG. **1**, a hand-held type ultrasonic probe **1** includes a housing **100** of the hand-held type ultrasonic probe **1**, a grip portion **101** of the hand-held type ultrasonic probe **1** which is held by an operator, and a reception region portion **102** having a probe which receives an ultrasonic wave transmitted from a test object described below. The hand-held type ultrasonic probe **1** further includes a contact surface **103** which is to be brought into contact with the test object and probe elements (an ultrasonic element array) **104** which receive ultrasonic waves transmitted from the test object (photoacoustic waves generated in the test object due to light irradiation) and which are disposed in the reception region portion **102**. As the probe elements **104**, an ultrasonic transducer including an element which performs mechanoelectric conversion based on an ultrasonic wave may be used. As a concrete example, a probe using a capacitive micromachined ultrasonic transducer: CMUT) element or a piezoelectric element may be employed. Furthermore, the probe elements **104** are disposed in a single line as 1D arrangement or in a plurality of lines as 2D arrangement or on a frame of a spherical surface so as to have sensitivity on inner sides thereof, and are implemented such that the probe elements **104** have the sensitivity directed to an outside of the probe **1**. Furthermore, in a case where a photoacoustic imaging apparatus and an ultrasonic imaging apparatus which are described below are switched from one to another, transmission and reception of an ultrasonic wave may be performed using the same probe element, or different probe elements which are optimized for different functions may be disposed.

[0030] A cable **105** is connected to a body of the imaging apparatus and optical fibers **106** are bundle fibers, for example, which guide light pulses transmitted from a light source of the imaging apparatus. The cable **105** is configured by integrating the optical fibers **106**, analog outputs (ultrasonic reception signals) of the probe elements **104**, and lines which transmit information between a controller **201** and a microcomputer **110** as a single line. Since the body of the imaging apparatus and the hand-held type ultrasonic probe **1** may be connected to each other only by the single line, operability of the probe **1** is improved. A light irradiation unit (a light emission terminal) **107** which irradiates the test object with guided laser light is disposed on the contact surface **103** in a tip end portion of the cable **105** includes a diffuser panel and a lens optical system.

[0031] A pressure sensor **108** serves as a switch, and a vibration actuator **109** is one of characteristic points of the present invention and is disposed on a back surface of the pressure sensor **108** or in the vicinity of the pressure sensor **108**. The microcomputer **110** realizes a function of a switch similar to that described in PTL 1 by determining an output of the pressure sensor **108** and controlling an operation of the vibration actuator **109**. Furthermore, the microcomputer **110** transmits an output which is a switch signal to the body of the imaging apparatus through the cable **105**. The functions of the microcomputer **110** may be performed by a controller of the body of the imaging apparatus described below. In this case, although the number of electric lines of the cable **105** is increased, the microcomputer **110** is not required to be implemented in the grip portion **101** of the hand-held type ultrasonic probe. A vibration-free member **111** is included in a vibration-free mechanism and suppresses transmission of vibration of the vibration actuator **109** to the reception region portion **102**. An anti-vibration rubber, an anti-vibration gel, or the like is suitably used for the vibration-free member **111**. The vibration-free member **111** suppresses transmission of vibration by converting the vibration into thermal energy. The vibration-free member **111** is useful in a case where noise is generated when vibration of the vibration actuator **109** is added to an output of the probe element in addition to an ultrasonic wave which is to be received when the vibration actuator **109** is implemented in the hand-held type ultrasonic probe **1** which receives ultrasonic waves.

[0032] Here, a function of generating an image of functional information by receiving a photoacoustic wave generated by light irradiation and a function of generating an image of structural information based on a reflection rate of an ultrasonic wave using the ultrasonic wave which has been transmitted, reflected, and returned may be switched from one to another in response to an instruction for operating the pressure sensor **108** disposed on the hand-held type ultrasonic probe **1**.

[0033] FIG. **4** is a block diagram of the entire photoacoustic image obtaining apparatus (the photoacoustic imaging apparatus) according to the first embodiment of the present invention. In FIG. **4**, descriptions of portions which have reference numerals the same as those described above are omitted. In FIG. **4**, the body of the image obtaining apparatus (a body of the imaging apparatus) **2** according to the first embodiment of the present invention is connected to the hand-held type ultrasonic probe **1** through the cable **105**. Although not illustrated, the cable **105** may include a connector so that the hand-held type ultrasonic probe **1** and the imaging apparatus body **2** may be separated from each other. Specifically, the ultrasonic probe **1** connected to the cable **105** through the connector may be connected to the apparatus body **2** and the ultrasonic probe **1** may be separated from the apparatus body **2**. Alternatively, the imaging apparatus body **2** may include a plurality of connectors so that a plurality of hand-held type ultrasonic probes are implemented and one of the probes may be selected where appropriate. Specifically, a plurality of ultrasonic probes having different characteristics may be connected to different cables and the plurality of ultrasonic probes may be connected to the apparatus body **2** with the cables in a replacement available manner.

[0034] The user interface **200** is used to input an instruction issued by the operator using a mouse, a keyboard, a touch panel or the like. The controller **201** controls the entire system based on an instruction issued by the operator using the user interface **200**. The controller **201** will be described in detail hereinafter. A light source **202** emits a light pulse, and a solid-state laser, such as a titanium sapphire laser, a semiconductor laser, or a light emitting diode (LED) may be employed, for example. A signal processor **203** amplifies analog outputs (ultrasonic reception signals) of the probe elements **104** and converts the analog outputs into digital signals using an analog-digital converter (ADC). Then the signal processor **203** calculates ultrasonic image data and photoacoustic image data using the digital signal obtained by the analog-digital conversion. Specifically, the signal processor **203** performs a process of generating image data in accordance with a signal based on a received ultrasonic wave. A personal computer (PC) or a work station which includes calculation resources, such as a central processing unit (CPU), a graphic processing unit (GPU), and a storage device, or dedicated hardware using a field-programmable gate array (FPGA) or the like is suitable for the signal processor **203**.

[0035] To obtain an ultrasonic image, after ultrasonic waves are transmitted from the probe elements **104**, based on the digital signals obtained by converting the analog outputs (the ultrasonic reception signals) of the probe elements **104** using the ADC, B mode image data for calculating a distance and brightness using a period of time (a reflection time) between a time when the ultrasonic waves are transmitted from the probe elements **104** and a time when the ultrasonic reception signals are received and intensity of the received ultrasonic reception signals is generated or image data is generated by a pseudo color process (a Doppler method) of converting a frequency change of a ultrasonic wave in a certain point into a flow rate. On the other hand, to obtain a photoacoustic image, the signal processor **203** performs a reconfiguration process based on the digital signals of the plurality of probe elements **104** which have received after the optical pulse emission so as to generate reconfiguration image data (characteristic information) of the inside of the test object. As the reconfiguration process, an arbitrary general method, such as Delay and Sum, a back projection method, or a Fourier transform method may be used. Furthermore, reconfiguration image data of concentration associated information of a substance included in a tissue may be calculated using light pulses of different wavelengths. A display unit **204** displays ultrasonic image data and photoacoustic image data generated by the signal processor **203** and is realized by a liquid crystal monitor or an electroluminescence (EL) monitor, for example. Note that the generated image data may be output to a network or simply stored in a nonvolatile memory or the like.

[0036] Operation of Apparatus

[0037] An operation of the imaging apparatus which performs control of a switching operation using the pressure sensor **108** of the hand-held type ultrasonic probe **1** according to the first embodiment will now be described. The hand-held type ultrasonic probe **1** described in this example may perform switching between a photoacoustic (PA) mode for obtaining a photoacoustic image and an ultrasonic (US) mode for obtaining an ultrasonic image by transmitting an instruction to the pressure sensor **108**.

[0038] The microcomputer **110** detects a pressure obtained by the pressure sensor **108** and operates as below. In a case where a small pressure is applied to the pressure sensor **108** (a soft touch), the microcomputer **110** notifies the operator of a current switch state by vibration of the vibration actuator **109**. In the US mode, for example, vibration occurs for a short period of time. On the other hand, in the PA mode, the vibration actuator **109** notifies the operator of the current mode by vibration for a long period of time. The switching operation is realized when the pressure sensor **108** is pressed hard. The microcomputer **110** detects a pressure applied to the pressure sensor **108**. When a large pressure is applied (a hard press), the current mode is changed. That is, in a case where the pressure sensor **108** is pressed hard in the PA mode, a switch state is changed to the US mode. On the other hand, in a case where the pressure sensor **108** is pressed hard in the US mode, a switch state is changed to the PA mode. Here, when the pressure sensor **108** is pressed, the vibration actuator **109** is activated such that the operator feels a clicking sensation, and thereafter, vibration lasts for a short period of time in the US mode or vibration lasts for a longer period of time in the PA mode. The microcomputer **110** performs such operation control so as to output the switch state to the imaging apparatus body **2** through the cable **105**. Furthermore, an operator or a patient is put in danger, if the hand-held type ultrasonic probe **1** is separated from an affected area while the light source **202** outputs a light pulse in the PA mode, and therefore, the light pulse which is leaked from a gap is incident on an eye of the operator or the patient. Accordingly, it is preferable that the microcomputer **110** controls the vibration actuator **109** so that the vibration actuator **109** continuously or intermittently generates imperceptible vibration as an alert.

[0039] Furthermore, an imaging apparatus having a PA/US mode for repeatedly performing an obtainment of a photoacoustic image and an obtainment of an ultrasonic image in addition to the PA mode and the US mode may be realized. In this case, the microcomputer **110** detects a pressure applied to the pressure sensor **108** and operates as below. In a case where a small pressure is applied to the pressure sensor **108** (a soft touch), the microcomputer **110** notifies the operator of a current switch state by vibration of the vibration actuator **109**. In addition to the vibration patterns of the modes described above, in the PA/US mode, the vibration actuator **109** notifies the operator of the current mode by performing vibration for a short period of time, a short break, and vibration for a long period of time. The switching operation is realized when the pressure sensor **108** is pressed hard. The microcomputer **110** detects a pressure applied to the pressure sensor **108**. When a large pressure is applied (a hard press), the current mode is successively changed from the PA mode, the US mode, the PA/US mode, the PA mode, and so on. Here, when the pressure sensor **108** is pressed, the vibration actuator **109** is operated such that the operator feels a clicking sensation, and thereafter, vibration lasts for a short period of time in the US mode, vibration lasts for a longer period of time in the PA mode, and vibration for a short period of time, a short break, and vibration for a long period of time are performed in the PA/US mode. For example, in a case where the first and second modes are simultaneously operated, vibration may be performed in a third vibration pattern which is different from a first vibration pattern in which the vibration actuator **109** is vibrated during the first mode and a second vibration pattern in which the vibration actuator **109** is vibrated during the second mode.

[0040] The microcomputer **110** performs such operation control so as to output the switch state to the imaging apparatus body **2** through the cable **105**. The vibration patterns of the vibration actuator **109** described above are merely examples and other vibration patterns may be employed as long as the individual vibration patterns are unique.

[0041] In the configuration described above, the single pressure sensor **108** and the single vibration actuator **109** are implemented in the hand-held type ultrasonic probe **1**. According to the present invention, different functions may be realized in different portions in a sensitive surface of the pressure sensor **108** by providing a large sensitive area of the pressure sensor **108** and disposing a plurality of pressure sensors **108** and a plurality of vibration actuators **109**, for example. For example, in addition to the mode switching function described above, a function of performing control of turning on a laser in the PA mode may be realized. The operator may discriminate different functions by feeling different vibrations of the vibration actuators **109** disposed in the different portions. Also in this case, the discrimination may be performed using different vibration patterns. According to the present invention, even if the vibration-free member (vibration-free mechanism) **111** is not disposed, noise of an output of the probe element **104** or an uncomfortable feeling of the patient may be suppressed by devising a vibration direction of the vibration actuator **109**, an attachment position of the grip portion **101**, and vibration patterns. For example, the housing **100** is generated using a material of high attenuation rate relative to vibration. As another method, amplitude of vibration is minimized so that an uncomfortable feeling of the patient is removed, and only frequency components except for frequency components required for generating an ultrasonic image and a photoacoustic image are used as a vibration pattern. Specifically, if the vibration actuator **109** does not generate vibration in frequencies equal to or larger than 1 kHz, noise of an ultrasonic image and a photoacoustic image may be separated in a frequency domain. That is, this is easily realized using an analog/digital high-pass filter.

[0042] In other words, vibration is controlled so that a vibration spectrum generated by the vibration actuator **109** is obtained in a frequency band other than a frequency band of a signal (a signal in a reception band) which is transmitted from the probe element **104** and which has a frequency component required for processes performed on the ultrasonic image and the photoacoustic image. Specifically, control may be performed such that a frequency band used by an ultrasonic element array included in the probe element **104** for reception of an ultrasonic wave and a frequency band for vibration of the vibration actuator **109** are different from each other. Furthermore, when it is assumed that a frequency band of the probe element **104** has a frequency characteristic corresponding to a received ultrasonic wave and a portion of maximum receiving sensitivity is **100**, the vibration actuator **109** preferably vibrates in a spectrum equal to or lower than a frequency corresponding to 10% (preferably 3%) of the maximum receiving sensitivity or less. Specifically, when it is assumed that maximum sensitivity in a frequency band used for reception of an ultrasonic wave by the ultrasonic element array is set to **100**, it is preferable that the vibration actuator **109** is vibrated in a frequency band corresponding to 10% of the maximum sensitivity or less.

[0043] To remove frequency components in which vibration is not required in the vibration actuator **109** in which a movement moves in a reciprocal manner, a method for implementing a damper or the like in a stop portion of the movement of the vibration actuator **109** so that vibration in a high frequency caused by collision of mechanism members is suppressed. Furthermore, the frequency components in which vibration is not required may be removed by driving the movement in a driving waveform which does not include high frequency components (driving the movement in a driving waveform which is similar to a sine wave instead of driving in a rectangle wave, for example). Furthermore, the vibration actuator **109** may be disposed so that vibration applied to the probe element **104** and the patient is reduced taking orientation of generation of the vibration of the vibration actuator **109** into consideration. This method is also effective and inexpensive. As another method, a method for implementing portions of the vibration actuator **109** other than portions touched by the operator in the housing **100** in a state in which the portions are surrounded by a vibration-free member may also suppress generation of noise in an output of the probe element **104** and an uncomfortable feeling of the patient. Furthermore, as for noise which may not be removed, an ultrasonic reception signal may be subjected to an analog filter process so that noise is effectively removed in a frequency domain or a digital signal which has been converted by the ADC may be subjected to a digital filtering process so that noise is effectively removed in the frequency domain. Furthermore, a noise generation time point of the vibration actuator **109** is managed by the microcomputer **110**, and therefore, the signal processor **203** may record only a signal waveform of noise and may subtract the waveform of the noise from the ultrasonic reception signal by an analog process or a digital process (a process in a time domain).

[0044] According to the first embodiment of the present invention, since the vibration actuator **109** is disposed on the grip portion **101** and the vibration-free member **111** is implemented between the vibration actuator **109** and the reception region portion **102**, transmission of vibration of the vibration actuator **109** to the patient through the probe element **104** and the contact surface **103** is suppressed. Consequently, generation of noise in an output of the probe element **104** and an uncomfortable feeling of the patient may be suppressed.

Second Embodiment

[0045] A second embodiment of the present invention made by improving the first embodiment is effective in a case where generation of noise in an output of a probe element **104** may not be suppressed or a case where suppression of generation of noise may not be performed due to restriction of cost or the like of a vibration-free member or the like. The second embodiment according to the present invention is also made on assumption that a patient has an uncomfortable feeling due to vibration, and therefore, the second embodiment is preferably combined in one of the methods according to the first embodiment in a case where the uncomfortable feeling of the patient is not reduced.

[0046] A configuration of a hand-held type ultrasonic probe **1** and an entire block of an imaging apparatus according to the second embodiment are the same as those according to the first embodiment, and therefore, descriptions thereof are omitted. FIG. **5** is a timing chart for facilitating description of the second embodiment of the present invention. In FIG. **5**, timings when an ultrasonic image is obtained in an US mode are illustrated. In FIG. **5**, an axis of abscissae denotes time. First, a controller **201** of FIG. **4** instructs a timing when the probe element **104** transmits an ultrasonic wave (US transmission). Thereafter, a signal processor **203** converts a signal received by the probe element **104** into a digital signal by an ADC in a period of time in which the ultrasonic wave is transmitted in a distance twice as long as an observation distance (a period of time until the transmitted ultrasonic wave is reflected and returned to the probe element **104**) (US reception). Subsequently, the signal processor **203** calculates ultrasonic image data using the obtained digital signal (signal processing). Thereafter, a display unit **204** displays the calculated ultrasonic image data (image display). The processes are performed at substantially the same timings also in a case where a photoacoustic image is obtained in a PA mode. Specifically, the transmission of an ultrasonic wave is replaced by emission of a light pulse. Furthermore, the period of time for the US reception corresponds to a period of time the signal processor **203** converts a signal received by the probe element **104** into a digital signal by the ADC in a period of time in which the ultrasonic wave is transmitted in the observation distance (a period of time until a photoacoustic wave generated due to the light pulse reaches the probe element **104**). Subsequently, the signal processor **203** calculates photoacoustic image data using the obtained digital signal (signal processing). Thereafter, a display unit **204** displays the calculated photoacoustic image data (image display).

[0047] The controller **201** controls the system by generating such timings for obtaining the various image data. As is apparent from the timing chart of FIG. **5**, in a period A (an ultrasonic signal obtaining period), an ultrasonic wave is transmitted or a light pulse is emitted and an ultrasonic wave is received. If vibration is input from an outside in this period, noise is generated. On the other hand, in a period B, the signal processor **203** performs the signal processing (the calculation) and next transmission of an ultrasonic wave or next emission of a light pulse is waited. Even if vibration is input from an outside to the probe element **104** in the period B, a result of the signal processing (the calculation) is not changed. Specifically, even if large vibration is input to the probe element **104**, image data to be obtained is not affected. The second embodiment of the present invention makes use of this characteristic, and the microcomputer **110** instructs the vibration actuator **109** to be vibrated only in the period B of FIG. **5**. It is more preferable that the microcomputer **110** does not vibrate the vibration actuator **109** until the last moment of the period B but stops vibration of the vibration actuator **109** beforehand taking a period of time required for convergence of vibration of the housing **100** and other structures into consideration.

[0048] The microcomputer **110** actually outputs a signal for driving the vibration actuator **109** after performing logical AND on the signal using a vibration permission signal corresponding to the period B (vibration permission in FIG. **5**). Furthermore, interruption may be performed in rising of the vibration permission signal so that the vibration actuator **109** is driven in a range in which the period B is not exceeded by the interruption process. According to the second embodiment, generation of noise in an output of the probe element **104** may be suppressed in a period in which an ultrasonic signal is input from the probe element **104** even in a case where generation of noise in an output of the probe element **104** may not be suppressed by the method of the first embodiment or a case where the method of the first embodiment is not performed due to restriction of cost or the like of a vibration-free member **111** or the like, and accordingly, deterioration of image quality of resultant ultrasonic image data or resultant photoacoustic image data may be suppressed.

Third Embodiment

[0049] In the foregoing embodiments, an instruction issued by an operator is input to the hand-held type ultrasonic probe **1** using the pressure sensor **108** corresponding to a switch. In a third embodiment, a pressure sensor **108** may not be required.

[0050] According to the third embodiment, as described above, a plurality of connectors are implemented in an imaging apparatus body **2** so that implement of a plurality of hand-held type ultrasonic probes **1** is realized and one of the plurality of hand-held type ultrasonic probes **1** is selected where appropriate in a system. In such an apparatus, a largest problem arises when an operator selects a wrong one of the hand-held type ultrasonic probes **1**. If a hand-held type ultrasonic probe **1** is mistakenly selected, an affected area may not be observed, and in addition, the following problem may arise when the hand-held type ultrasonic probe **1** is used in a PA mode. Specifically, if the operator selects a wrong hand-held type ultrasonic probe, a light pulse is emitted from a probe **1** which is to be selected and which is not in contact with the affected area. In this case, the emitted light pulse may be incident on an eye of the operator or the patient.

[0051] To address this mistake in which the operator selects a wrong hand-held type ultrasonic probe, according to the third embodiment, if the operator holds a probe **1** other than a hand-held type ultrasonic probe **1** specified by a user interface **200** of an imaging apparatus body **2**, a vibration actuator **109** is considerably vibrated so that the operator realizes that the wrong probe **1** is held. If a probe **1** which is not selected is detached from a probe holder, not illustrated, of the imaging apparatus body **2**, the imaging apparatus body **2** controls a microcomputer **110** so that the vibration actuator **109** continuously generates large vibration. A determination as to whether a probe **1** has been detached from the probe holder may be easily made by implementing a switch or the like in the probe holder.

[0052] Furthermore, if the hand-held type ultrasonic probes **1** have respective connectors, a connector of a probe **1** which is not specified may be disconnected. In this case, information indicating that an inappropriate probe **1** has been selected may not be alerted for the operator by continuous large vibration. To address this problem, if a specified probe **1** is detached from a probe holder of the imaging apparatus body **2**, the imaging apparatus body **2** controls the microcomputer **110** of the specified probe **1** so that the vibration actuator **109** is vibrated in a specific vibration pattern. The operator realizes that a wrong probe **1** has not been selected since the operator has knowledge of the specific vibration pattern by well reading an instruction manual. On the other hand, if the probe **1** is not vibrated in the specific vibration pattern, the operator realizes that a wrong probe **1** is held by hand.

[0053] According to the third embodiment of the present invention, the operator may determine whether a probe **1** is the specified hand-held type ultrasonic probe **1** only by holding the hand-held type ultrasonic probe **1** by hand. The determination of the hand-held type ultrasonic probe **1** may be made even when the operator is carefully viewing a display unit **204** of the imaging apparatus body **2** or the user interface **200** (without viewing the probe), and therefore, such hand-held type ultrasonic probes **1** are more preferable for the operator. According to the third embodiment of the present invention, in an imaging system including a plurality of hand-held type ultrasonic probes **1**, since the vibration actuator **109** is vibrated in a specific pattern indicating a specified probe, the operator may determine whether a probe **1** being held by the operator is the specified probe **1** without interrupting other operations.

Fourth Embodiment

[0054] According to the foregoing embodiments, various information may be transmitted to the operator by implementing the vibration actuator **109** in the hand-held type ultrasonic probe **1** and vibrating the vibration actuator **109** where appropriate. However, while the operator does not hold a probe, such a function may not be useful. Furthermore, if an undesired object is accidentally in contact with the hand-held type ultrasonic probe **1**, it is expected that comparatively large sound is output since vibration is enhanced and some may think such sound is uncomfortable. Therefore, a function of stopping vibration of a vibration actuator **109** while the operator does not hold a probe is preferably added. For example, a method for determining that the operator is holding a probe **1** when the probe **1** is not installed in a probe holder which has a switch may be employed. Furthermore, a method for determining whether the probe **1** is being held by the operator in accordance with an output from an infrared sensor or an electrostatic capacitance sensor which is implemented in the hand-held type ultrasonic probe **1** may be employed. By providing such a switch or such a sensor, vibration of the vibration actuator **109** may be suppressed while the operator does not hold the hand-held type ultrasonic probe **1**.

[0055] Furthermore, in a case where a mode is informed for the operator by vibrating the vibration actuator **109** due to a mode change or the like, if an imaging apparatus has a large number of modes, the vibration actuator **109** may be vibrated first, and immediately after the vibration, a mode name may be displayed in a specific position in a display unit **204**. In this case, the vibration actuator **109** notifies the user of information indicating that the vibration indicates display of a mode in the specific position in the display unit **204**. If only the display of the mode in the specific position in the display unit **204** is performed, the operator may miss the display since the operator focuses on an obtained image of a test object, for example. However, since the vibration actuator **109** implemented in the hand-held type ultrasonic probe **1** is vibrated, such an oversight may be reduced. At least a notification of the change of a mode for the operator is realized by the vibration of the vibration actuator **109**. To realize the notification, a mode name may be displayed in the specific position after the vibration as described above, or normal display and a negative/positive inversion image may be alternately displayed for a while after the vibration, for example. Specifically, a portion for displaying the mode name is at least changed after the vibration.

[0056] Although the case where a mode name is displayed is illustrated in the foregoing embodiment, other information to be transmitted by the imaging system to the operator may also be displayed by the same operation.

Fifth Embodiment

[0057] Furthermore, the present invention is applicable to an apparatus which guides a movement of a hand-held type ultrasonic probe disclosed in PTL 2. PTL 2 discloses an apparatus which displays a movement direction of a hand-held type ultrasonic probe in a display device so that a movement operation of the probe is navigated. When the method for performing guiding by image display in a display device is employed, a probe is required to be moved while an operator understands an actual direction of the probe and a direction and a movement amount of the probe displayed in the display device, and accordingly, the operator requires high skill. An audio guide may give an uncomfortable feeling to a patient in a silent environment or may not be used in a noisy environment. Furthermore, a method for attaching a display device constituted by liquid crystals or light emitting diodes to the ultrasonic probe is hardly said to be an excellent guiding method since it is difficult for the operator to view the ultrasonic probe while focusing on an ultrasonic image for diagnosis.

[0058] Accordingly, in this embodiment, a mode in which a plurality of vibration actuators **109** are implemented on a grip portion **101** of the hand-held type ultrasonic probe **1** and a movement operation is guided by vibrating one of the vibration actuators **109** corresponding to a movement direction will be described.

[0059] As the hand-held type ultrasonic probe **1** according to this embodiment, a probe **1** illustrated in FIG. **2** is employed. Although the ultrasonic probe **1** illustrated in FIG. **2** is similar to that described in the first embodiment with reference to FIG. **1** except for the plurality of vibration actuators **109**. Here, the difference will be mainly described. In FIG. **2**, vibration actuators **109***a* to **109***c* are illustrated. The vibration actuators **109***a* and **109***b* are disposed in an X direction of a grip portion **101** and the vibration actuator **109***c* and a vibration actuator **109***d*, not illustrated, are disposed in a Y direction such that the operator feels vibration when holding the grip portion **101** of the hand-held type ultrasonic probe **1**. The vibration actuator **109***d* is implemented on a surface opposite to a surface on which the vibration actuator **109***c* is disposed in the grip portion **101** of a housing **100**. Operations of the vibration actuators **109***a* to **109***d* are controlled by a microcomputer **110** in accordance with information supplied from the imaging apparatus body **2** through a cable **105**. FIG. **6** is a block diagram illustrating a photoacoustic image obtaining apparatus (an imaging apparatus) using an ultrasonic probe **1** illustrated in FIG. **2**. The block diagram of FIG. **6** is similar to that described above according to FIG. **4** except that the four vibration actuators **109***a* to **109***d* are illustrated in the hand-held type ultrasonic probe **1**.

[0060] The imaging apparatus of this embodiment illustrated in FIG. **6** calculates a movement direction and a movement amount of the hand-held type ultrasonic probe **1** which are operation assist information. In this embodiment, instead of the guide using the display unit **204** or the audio guide for transmitting a calculated movement direction and a calculated movement amount of a probe, a movement direction is transmitted to the operator by vibration of the vibration actuators. In this embodiment, a movement direction is specified on an XY plane by vibrating the vibration actuators **109***a* to **109***d*. For example, vibration actuators corresponding to an X direction or a Y direction are vibrated when the probe **1** is to be moved to the X direction or the Y direction. Furthermore, when the probe **1** is to be moved to a direction between the X and Y directions, vibration actuators of the corresponding directions are simultaneously vibrated. For example, when a movement direction is to be specified in detail, a magnitude of vibration and a pattern of the vibration are controlled so that a direction of the movement to be performed by the operator is specified. For example, if the vibration actuator **109***b* in the X direction and the vibration actuator **109***c* in the Y direction are alternately vibrated in the same ON/OFF time, an angle of 45 degrees which is in the middle of X and Y axes is indicated, and if the vibration actuator **109***b* and the vibration actuator **109***c* are vibrated with a time ratio of 1:2, a direction of an angle of 30 degrees relative to a direction of a longer time may be specified. Then, the hand-held type ultrasonic probe **1** is moved in a direction obtained by combining the vibration actuators **109***b* and **109***c*. In this way, the direction in the middle of the X and Y axes may be indicated in an analog manner by the vibration of the vibration actuators. Although a direction between the X and Y axes is set in accordance with a period of time the vibration is performed (a vibration duty), the direction between the X and Y axes may be set in accordance with a magnitude of the vibration.

[0061] On the other hand, a guide method employed when a probe is moved in an inclined manner will be described below. For simplicity of description, rotation relative to the Y axis (a movement for inclining a positive direction in the X direction toward a -Z direction) is taken as an example for the description. FIGS. **7**A and **7**B are diagram schematically illustrating a case where the probe **1** is moved in an inclined manner. Reference numerals in FIG. **7** have been described above, and therefore, descriptions thereof are omitted. FIG. **7**A is a diagram schematically illustrating a current position of the hand-held type ultrasonic probe **1**. FIG. **7**B is a diagram illustrating a position to be moved denoted by a dotted line. In this case, when the method for specifying a parallel movement described above is employed, an instruction for movement from a position of the hand-held type ultrasonic probe **1** of FIG. **7**A to a position of FIG. **7**B may not be issued. In this case, a case where the probe **1** is to be inclined to a front side relative to a surface in which a vibration actuator **109** is implemented is indicated by an operation of repeatedly performing short vibration and short stop, and a case where the probe **1** is to be inclined to a back side is indicated by an operation of repeatedly performing long vibration and short stop. A parallel direction is indicated by an operation of repeatedly performing middle vibration and short stop in a case of a direction for movement. Specifically, both of a parallel movement and an inclination may be instructed by a time length of vibration. For example, an instruction for inclining the hand-held type ultrasonic probe **1** rightward illustrated in FIGS. **7**A and **7**B may be realized by performing an operation of long vibration and a short interval on the vibration actuator **109***a* and performing an operation of short vibration and a short interval on the vibration actuator **109***b*. To set a direction between the X and Y axes as described above, when this inclination instruction is issued, the direction between the X and Y axes may be set by a magnitude of vibration. As described above, a movement of the probe **1** may be instructed (guided) for the operator by a vibration pattern of the vibration actuators. The vibration patterns of the vibration actuators described above are merely examples, and another pattern which is uniquely determined for an instruction may be employed. According to this embodiment, information (a direction for movement of a probe) supplied from an imaging apparatus may be transmitted to the operator by vibration of the vibration actuators implemented on the hand-held type ultrasonic probe **1**. According to the present invention, it is effective that a direction for a movement of the hand-held type ultrasonic probe **1** may be more clearly instructed for the operator while the operator focuses on an obtained image when compared with general methods.

Sixth Embodiment

[0062] This embodiment is suitable for a case where an imaging apparatus is to transmit a state of the apparatus or the like (a message) to an operator. Examples of the apparatus state in this embodiment include following states. For example, the examples of the apparatus state include a temperature of a housing, a state of a power-supply voltage, a failure state of a laser device, and the like. As characteristics of the information, information may not be obtained immediately when the operator desires to check the state but the imaging apparatus performs monitoring all the time and notifies the operator of a message only when failure occurs.

[0063] This embodiment is realized by the image obtaining apparatus illustrated in FIG. **6** using the probe **1** illustrated in FIG. **2** described in the fifth embodiment. Since the movement direction and the movement amount of the hand-held type ultrasonic probe **1** are not required to be specified according to the second embodiment, only one of the four vibration actuators **109***a* to **109***d* illustrated in FIG. **2** may be implemented. When functions of this embodiment are added to the apparatus according to the fifth embodiment, the vibration actuators **109***a* to **109***d* are not changed.

[0064] FIG. **8** is a diagram illustrating an example of a display method of a display unit according to this embodiment. In FIG. **8**, a display screen **3** is included in the display unit **204**, an image display area **300** displays ultrasonic image data and photoacoustic image data, a command area **301** is used to specify an operation of the imaging apparatus by the operator. The operator may issue an operation instruction to the imaging apparatus using a mouse, a graphic user interface (GUI), and a keyboard of the user interface **200** while viewing the command area **301**. A status area **302** displays an imaging condition, a histogram, and an analysis result of an obtained information. A message area **303** displays content of a message to be displayed for the operator by the imaging apparatus described above. The message of the imaging apparatus may be transmitted by displaying the message in the message area **303**. However, only the display in the message area **303** is performed, the operator may miss the display in the message area **303** when focusing on an image of ultrasonic image data or an image of photoacoustic image data displayed in the image display area **300**.

[0065] In the method of this embodiment, when the imaging apparatus displays a message in the message area **303**, the vibration actuator implemented on the hand-held type ultrasonic probe is activated, and thereafter, a display state of the message in the message area **303** is changed so that the message is transmitted to the operator. Here, the change of the display state of the message is performed within at least several seconds (within 10 seconds at most) immediately after the vibration actuator is vibrated. The display state may be simply changed from a state in which characters to be displayed in the message area **303** are not displayed to a state in which the characters are displayed. Furthermore, as illustrated in FIGS. **9**A and **9**B, the display state may be changed from a negative display state to a positive display state (negative/positive inversion display) at an interval of 0.5 seconds (FIG. **9**B) relative the normal display illustrated in FIG. **9**A. Furthermore, in addition to the negative/positive inversion, a change of a display state by a color phase, contrast, or brightness or a change of a display state by a geometric change, such as scrolling or variety of the magnitude, may be employed.

[0066] With this configuration, even if the operator is performing diagnosis and focuses on the image display area **300**, caution may be issued so that the operator views the predetermined message area **303**. As a result, oversight of a message which is transmitted by the imaging apparatus and which is to be viewed by the operator may be avoided. According to the present invention, a display state is changed for several seconds after the vibration actuator is vibrated, and therefore, the operator may realize the message from the imaging apparatus.

[0067] As described above, the operator may receive a message without missing the message by the method for vibrating the vibration actuator implemented in the hand-held type ultrasonic probe, and thereafter, transmitting the message to the operator after changing a display state of the message displayed in the message area **303** which is performed by the imaging apparatus. Instead of the method for vibrating the vibration actuator implemented in the hand-held type ultrasonic probe, a method for alerting the operator by beep sound may be employed. However, when the method of the present invention is employed, the operator may find the message from the imaging apparatus even in a location where external noise is large. Furthermore, when the method for alerting the operator by beep sound is employed, the patient may fear the beep sound. However, the present invention may resolve such fear.

Seventh Embodiment

[0068] In this embodiment, a method for implementing a sensor which detects a contact state of a hand-held type ultrasonic probe in the probe and controlling vibration of a vibration actuator by the contact state so that the excellent contact state is maintained will be described.

[0069] As disclosed in PTL 3, in a photoacoustic imaging apparatus, a contact surface **103** is required to be in contact with a test object so that a light pulse emitted from a light irradiation unit **107** of a hand-held type ultrasonic probe **1** is not leaked to an outside. In PTL 3, a determination as to whether measurement is to be performed is made after it is determined whether an irradiation light which is leaked from a gap is a safe level for human bodies even if the probe **1** and the test body are not totally in contact with each other. However, it is difficult to easily notify the operator of information indicating one of the probe and the test object which is separated, information indicating a state of the separation, and information indicating one of the probe and the test object to be pressed. For example, even if a portion in the probe to be pressed is displayed in a display unit **204**, it is not easy for the operator to perform an operation of improving the contact state based on the display in the display unit **204** depending on a current position and a direction of the probe.

[0070] A configuration of the hand-held type ultrasonic probe **1** according to this embodiment is illustrated in FIG. **3**. In FIG. **3**, descriptions of portions which have reference numerals the same as those described above are omitted. In FIG. **3**, reference numerals **112***a* and **112***b* denote contact sensors. The contact sensors may be optical sensors disclosed in PTL 3. Any sensor, such as an electrostatic capacitance sensor, may be employed as long as a contact state of a contact surface **103** may be measured. Vibration actuators **109***a* and **109***b* are disposed in positions near a cable **105** in a Z direction of the contact sensors **112***a* and **112***b*. The two contact sensors **112***a* and **112***b* are disposed in an X direction and the respective actuators **109***a* and **109***b* are disposed for simplicity of description according to this embodiment. It is preferable that the vibration actuators corresponding to the contact sensors are also implemented in a Y direction. In the configuration of FIG. **3**, when the contact sensor **112***a* detects the separation of the contact surface **103**, the corresponding vibration actuator **109***a* is vibrated. As a result, the operator realizes that a side including the vibration actuator **109***a* is required to be pressed to the test object, and presses the hand-held type ultrasonic probe **1** as instructed. When the contact sensor detects that the normal contact state of the contact surface **103**, the vibration of the vibration actuator **109***a* is stopped. Similarly, also when the contact sensor **112***b* is separated from the contact surface **103**, the operator realizes the separation by vibration of the vibration actuator **109***b* and may press a side including the vibration actuator **109***b* to the test object. In this way, the normal contact state may be easily maintained by pressing the side corresponding to the vibration so that the vibration of the vibration actuators **109***a* and **109***b* is stopped. When this method is employed, the operator may intuitively improve the contact state irrespective of a current position and a direction of the probe. Since the normal contact state is maintained, an excellent photoacoustic image may be obtained.

[0071] In the foregoing description, the case where the contact surface **103** of the hand-held type ultrasonic probe **1** is separated is assumed. If a problem arises also when the press is too strong, contact sensors **112***a* and **112***b* capable of detecting both of states "excessive press" and "separation" are employed. For example, the vibration actuators **109***a* and **109***b* are controlled by a microcomputer **110** or a controller **201** such that, when the contact surface **103** is separated, vibration is performed such that long vibration and short stop are repeatedly performed, when the contact surface **103** is excessively pressed, vibration is performed such that short vibration and long stop are repeatedly performed, and when the contact surface **103** is in an appropriate position, vibration is not performed. Since the vibration actuators **109***a* and **109***b* are vibrated under this control, the operator may easily press the probe to the test object so that the normal state is attained. Furthermore, for simplicity of description, the configuration in which the contact sensors and the vibration actuators are disposed only in the X direction is described. As described above, contact states in the X and Y direction may be improved by disposing the contact sensors and the vibration actuators also in the Y direction. As described above, according to this embodiment, the user may easily perform an operation of improving a pressing state of the hand-held type ultrasonic probe **1** relative to the separated contact surface **103**.

Eighth Embodiment

[0072] In the foregoing embodiment, the vibration actuators are implemented in the hand-held type ultrasonic probe and vibrated where appropriate so that various information is transmitted to the operator. However, if an operator does not hold a probe, such a function may not be useful. Furthermore, it may be assumed that, when another object is in contact with a hand-held type ultrasonic probe, large sound is generated since vibration is increased, and accordingly, the operator may feel uncomfortable. Therefore, a function of stopping vibration of the vibration actuator **109** while the operator does not hold a probe is preferably added. For example, a method for determining that the operator is holding a hand-held type ultrasonic probe **1** when the probe **1** is not installed in a probe holder which has a switch may be employed. Furthermore, a method for determining whether a probe is being held by the operator in accordance with an output from a temperature sensor, an infrared sensor, or an electrostatic capacitance sensor which is implemented in the hand-held type ultrasonic probe may be employed. By providing such a switch or such a sensor, vibration of the vibration actuator **109** may be suppressed while the operator does not hold the probe **1**. Furthermore, in this case, various information may not be transmitted to the operator. Therefore, when the operator does not hold the hand-held type ultrasonic probe **1**, a large icon, large characters, or the like may be displayed in the display unit **204** in an overlapping manner instead of the vibration of the vibration actuator **109** so that information to be informed is displayed for the operator. Similarly, information to be transmitted to the operator may be indicated by beep sound or the like instead of the vibration of the vibration actuator **109**. In this case, the operator has not been made diagnosis on a patient, and therefore, the patient may not be feel fear. Specifically, since this embodiment includes a step of detecting a hand-held type ultrasonic probe held by an operator and if the operator does not hold a probe, a step of vibrating the vibration actuator **109** is omitted. Accordingly, generation of large sound or the like generated due to enlargement of vibration may be suppressed.

[0073] First Modification

[0074] A configuration described below may be employed as a first modification. According to the foregoing embodiments, the light source **202** is implemented in the imaging apparatus body **2**, light is guided to the hand-held type ultrasonic probe **1** by the optical fibers **106**, and the light irradiation unit **107** irradiates a test object with the light. When this configuration is employed, the cable **105** becomes large and loses flexibility, and therefore, operability of the hand-held type ultrasonic probe is deteriorated. To address this problem, a light source (an LED array light source) using an LED array or a light source (an LD array light source) using a laser diode array may be implemented in a housing of the probe, and the light irradiation unit **107** may emit a light pulse through an optical member such as an optical fiber. In this case, by implementing an LED array light source or an LD array light source in the reception region portion **102**, an optical member and the light irradiation unit **107** may not be implemented.

[0075] Second Modification

[0076] In the foregoing embodiments, the mode which is realized using the single hand-held type ultrasonic probe **1** or simultaneously using the same hand-held type ultrasonic probes is described. Here, in a case where the embodiments described above are to be simultaneously realized, different vibration patterns may be preferably employed for different functions. It is assumed here that, the vibration of the fifth embodiment is small which is smooth and the vibration of the sixth embodiment is comparatively large and lasts for a short period of time so that a clicking feeling is obtained. It is assumed further that the vibration of the seventh embodiment has a magnitude between the vibration of the fifth embodiment and the vibration of the sixth embodiment. The vibration patterns are merely examples, and any vibration pattern may be employed as long as the operator easily distinguishes the vibration pattern.

[0077] The present invention is not limited to the foregoing embodiment, and various changes and modifications may be made without departing from the spirit and the scope of the present invention. Accordingly, claims below are attached to disclose the scope of the present invention.

[0078] 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.

1. An ultrasonic probe including a housing having a reception region portion and a grip portion,

wherein the reception region portion includes an ultrasonic element array which receives ultrasonic waves and the grip portion includes a vibration actuator.

2. The ultrasonic probe according to claim **1**, wherein a vibration-free mechanism which reduces vibration transmitted to the reception region portion from the vibration actuator is disposed between the reception region portion and the grip portion.

3. The ultrasonic probe according to claim **1**, wherein the reception region portion includes a light irradiation unit which irradiates a test object with light.

4. The ultrasonic probe according to claim **1**, wherein the reception region portion includes a light irradiation unit which irradiates a test object with light, and the ultrasonic element array included in the reception region portion transmits the ultrasonic waves.

5. The ultrasonic probe according to claim **4**, wherein different vibration patterns of the vibration actuator are obtained in different modes including a first mode which performs transmission and reception of ultrasonic waves relative to the reception region portion and a second mode in which the reception region portion receives photoacoustic waves generated in the test object due to the light irradiation from the light emission terminal.

6. The ultrasonic probe according to claim **4**, wherein, in a case where the first and second modes are simultaneously operated, vibration may be performed in a third vibration pattern which is different from a first vibration pattern in which the vibration actuator is vibrated during the operation in the first mode and a second vibration pattern in which the vibration actuator is vibrated during the operation in the second mode.

7. The ultrasonic probe according to claim **1**, wherein the vibration actuator is vibrated in a period of time which is different from a period of time in which the ultrasonic waves are received.

8. The ultrasonic probe according to claim **1**, wherein the vibration actuator is vibrated in accordance with a state of contact with the test object or a change of the contact state.

9. The ultrasonic probe according to claim **1**, wherein a frequency band used by the ultrasonic element array for reception of ultrasonic waves is different from a frequency band for vibrating the vibration actuator.

10. The ultrasonic probe according to claim **9**, wherein, when a maximum sensitivity of the frequency band used for reception of ultrasonic waves by the ultrasonic element array is set to **100**, the vibration actuator is vibrated in a frequency band corresponding to 10% of the maximum sensitivity or less.

11. The ultrasonic probe according to claim **10**, wherein the vibration actuator is vibrated in a frequency band corresponding to 3% of the sensitivity or less.

12. The ultrasonic probe according to claim **9**, wherein a frequency band used by the ultrasonic element array for transmission of ultrasonic waves is different from a frequency band for vibrating the vibration actuator.

13. The ultrasonic probe according to claim **1**, wherein an LED array or LD array which emits light from the light irradiation unit are incorporated in the housing.

14. The ultrasonic probe according to claim **13**, wherein the LED array or the LD array is disposed on the reception region portion in the housing.

15. The ultrasonic probe according to claim **1**, wherein the ultrasonic element array is an array of ultrasonic transducers.

16. The ultrasonic probe according to claim **15**, wherein the ultrasonic transducer is electrostatic capacitance transducer.

17. The ultrasonic probe according to claim **15**, wherein a piezoelectric element is used for the ultrasonic transducer.

18. An ultrasonic image obtaining apparatus, comprising:

the ultrasonic probe according to claim **1**;

a signal processor configured to generate image data using a signal based on a ultrasonic wave received by the ultrasonic probe; and

a display unit configured to display an image based on the image data.

19. The ultrasonic image obtaining apparatus according to claim **18**, wherein a body of the ultrasonic image obtaining apparatus includes the signal processor and the display unit and the ultrasonic probe is connected to the body through a cable.

20. The ultrasonic image obtaining apparatus according to claim **19**, wherein the cable has a connector and the ultrasonic probe connected to the cable through the connector is connected to the apparatus body.

21. The ultrasonic image obtaining apparatus according to claim **20**, wherein different ultrasonic probes having different characteristics are individually connected to the cable, and the ultrasonic probes are connected to the apparatus body with the cable in a replacement available manner.

* * * * *

专利名称(译)	超声波探头和超声波图像获取装置		
公开(公告)号	US20190365347A1	公开(公告)日	2019-12-05
申请号	US16/363834	申请日	2017-11-30
[标]申请(专利权)人(译)	佳能株式会社		
申请(专利权)人(译)	佳能株式会社		
当前申请(专利权)人(译)	佳能株式会社		
[标]发明人	ABE NAOTO		
发明人	ABE, NAOTO		
IPC分类号	A61B8/14 A61B8/00 G01N29/06 G01N29/24		
CPC分类号	A61B8/4444 G01N29/0672 G01N29/2418 A61B8/14 A61B5/0095 A61B5/14532 A61B5/14542 A61B8/4416 A61B8/4455 A61B8/13 G01N29/262 G01N2291/02475 G01N2291/106		
优先权	2016238662 2016-12-08 JP		
外部链接	Espacenet USPTO		

摘要(译)

手持式超声波探头包括具有接收区域部分和抓握部分的壳体。 接收区域部分包括接收超声波的超声元件阵列，并且握持部分包括振动致动器。