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(54) ULTRASONIC DIAGNOSTIC APPARATUS

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(57) **ABSTRACT**

Even when a region of interest (ROI) is changed on a frozen image, an elasticity image of ROI after the change can be displayed without executing re-measurement. An ultrasonic diagnostic apparatus **1** has a control unit **110** having a first ROI setting unit **38** and a second ROI setting unit **39**. When ROI is set by the first ROI setting unit **38** of the control unit **110**, an elasticity information calculating unit **32** sets an area larger than ROI as a calculation area, calculates distortion, elasticity modulus, etc. of a tissue corresponding to each measurement point on a tomographic image of the calculation area, generates elasticity information based on the distortion, the elasticity modulus, etc., and outputs the elasticity information to an elasticity information storing unit **33**. The control unit **110** changes the position/size of ROI by the second ROI setting unit **39** under a state that the frozen image is displayed. The elasticity image constructing unit **34** reads the elasticity information corresponding to the changed ROI from the elasticity information storing unit **33**, forms an elasticity image of the changed ROI and displays it on an image display unit **26**.

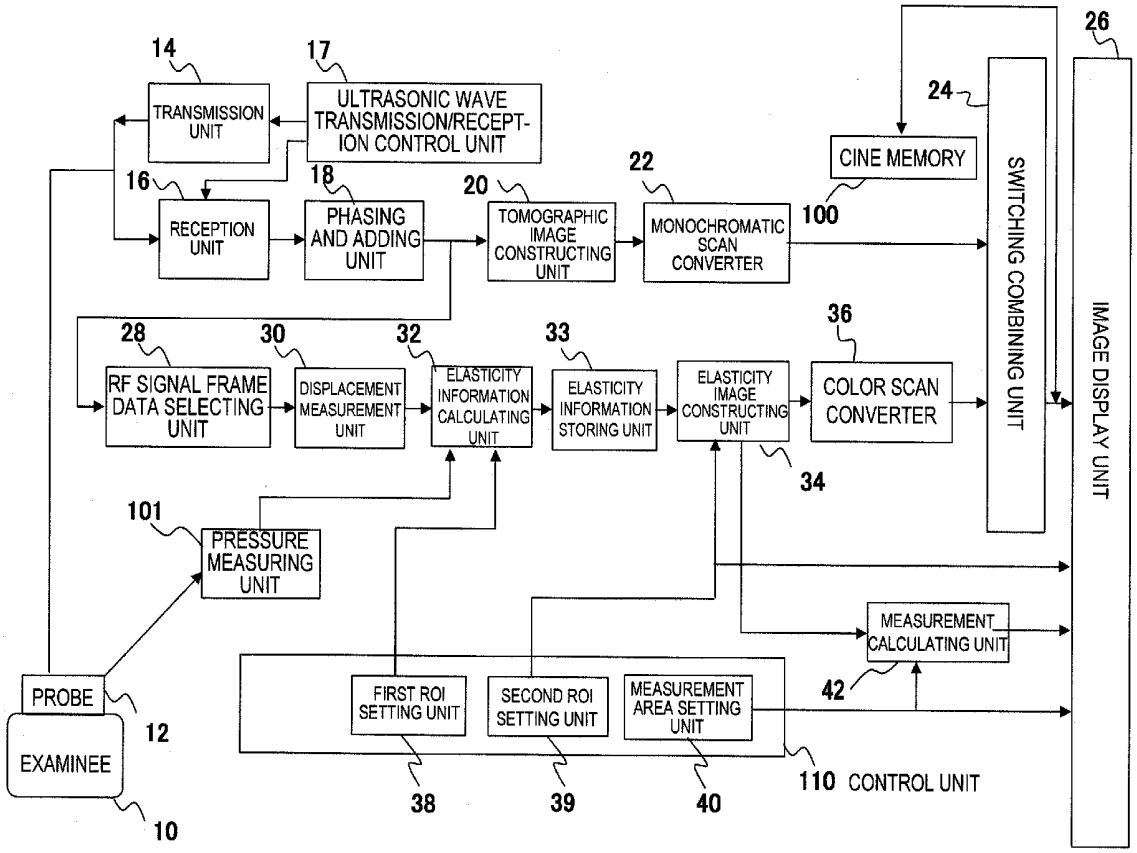


FIG. 1

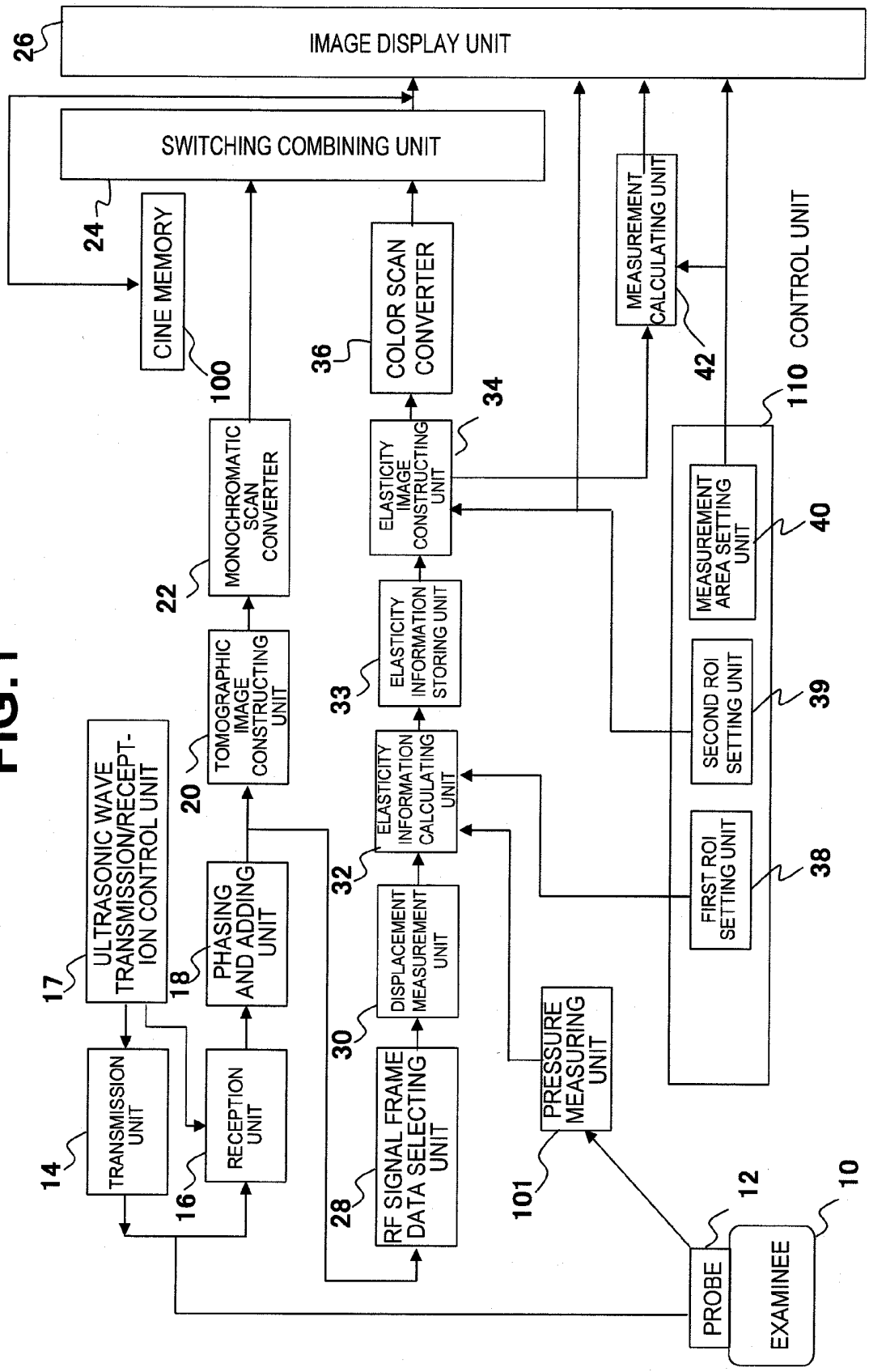


IMAGE DISPLAY UNIT
26
SWITCHING COMBINING UNIT
24
CINE MEMORY
100
MONOCHROMATIC SCAN CONVERTER
22
COLOR SCAN CONVERTER
36
ELASTICITY IMAGE CONSTRUCTING UNIT
34
MEASUREMENT CALCULATING UNIT
42
110 CONTROL UNIT
MEASUREMENT AREA SETTING UNIT
40
SECOND ROI SETTING UNIT
39
FIRST ROI SETTING UNIT
38
TOMOGRAPHIC IMAGE CONSTRUCTING UNIT
20
ELASTICITY INFORMATION STORING UNIT
33
ELASTICITY INFORMATION CALCULATING UNIT
32
ULTRASONIC WAVE TRANSMISSION/RECEPTION CONTROL UNIT
17
PHASING AND ADDING UNIT
18
DISPLACEMENT MEASUREMENT UNIT
30
PRESSURE MEASURING UNIT
TRANSMISSION UNIT
14
RECEPTION UNIT
16
RF SIGNAL FRAME DATA SELECTING UNIT
28
101
PROBE
12
EXAMINEE
10

FIG.2

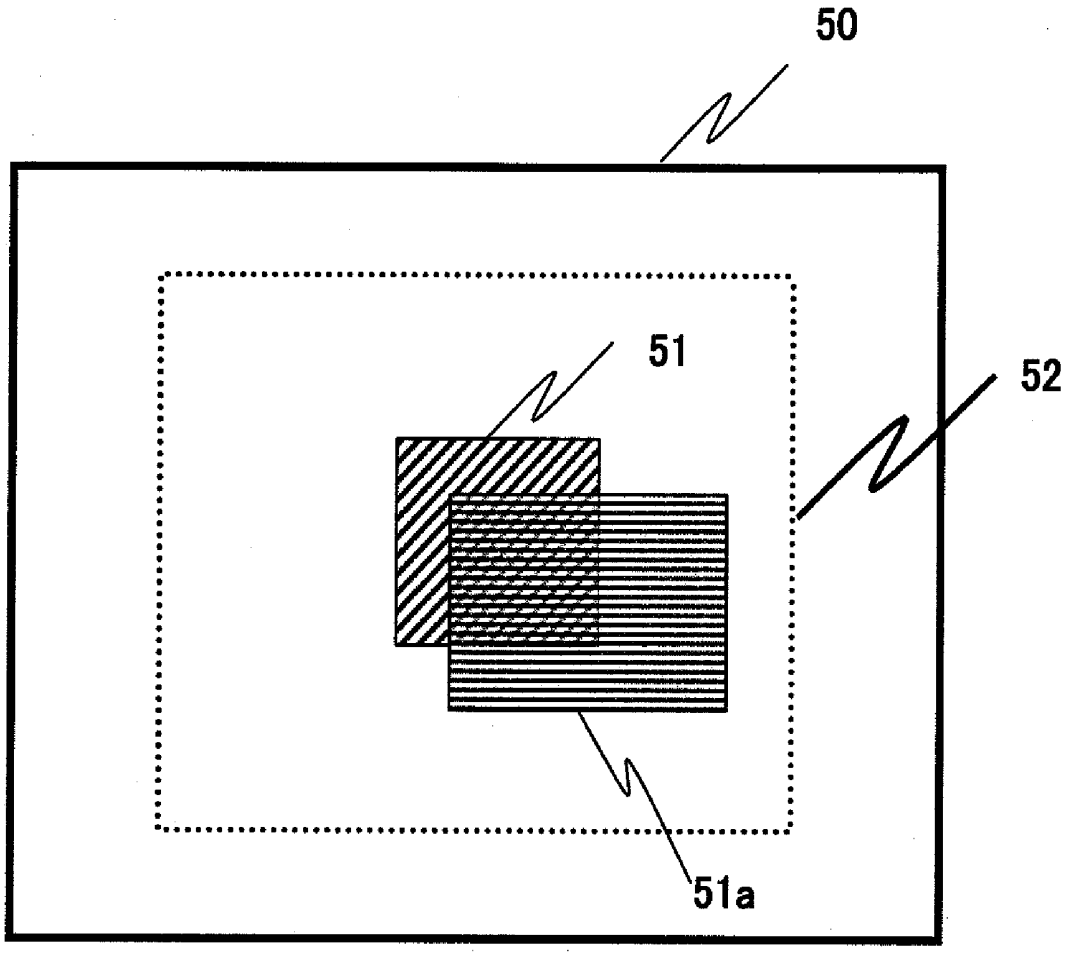


FIG.3

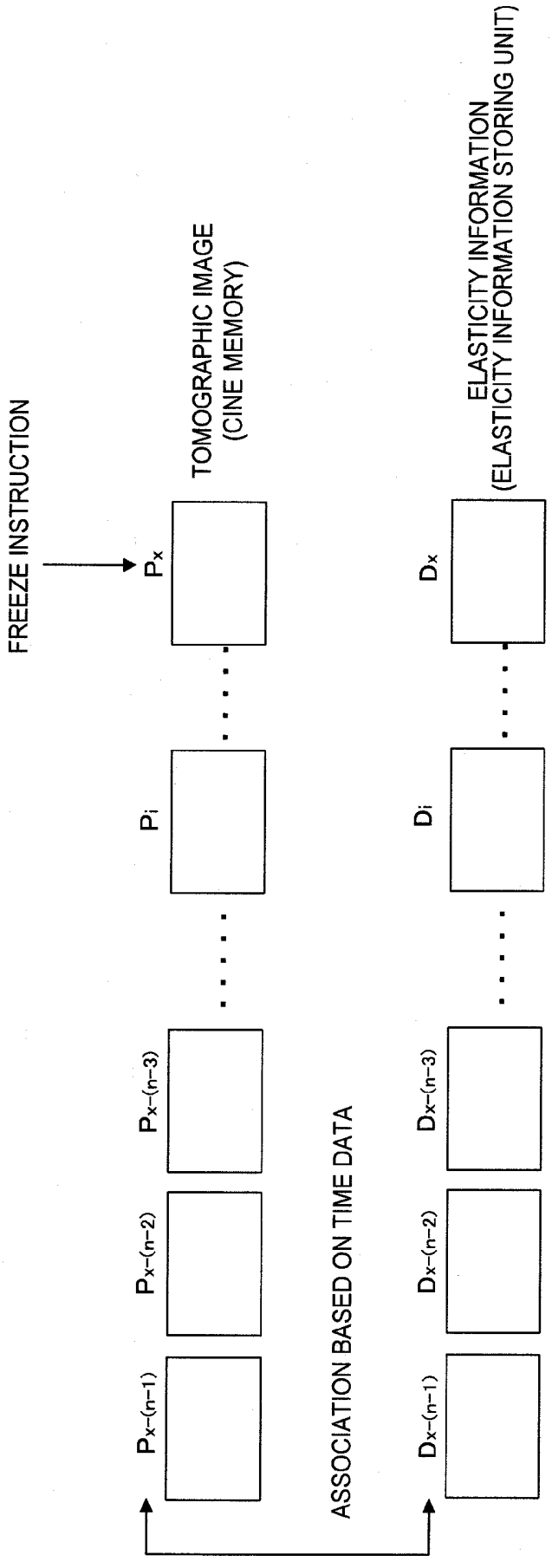

FREEZE INSTRUCTION
TOMOGRAPHIC IMAGE (CINE MEMORY)
ELASTICITY INFORMATION (ELASTICITY INFORMATION STORING UNIT)
Px
Pi
Px-(n-3)
Px-(n-2)
Px-(n-1)
Dx
Di
Dx-(n-3)
Dx-(n-2)
Dx-(n-1)
ASSOCIATION BASED ON TIME DATA

FIG.4

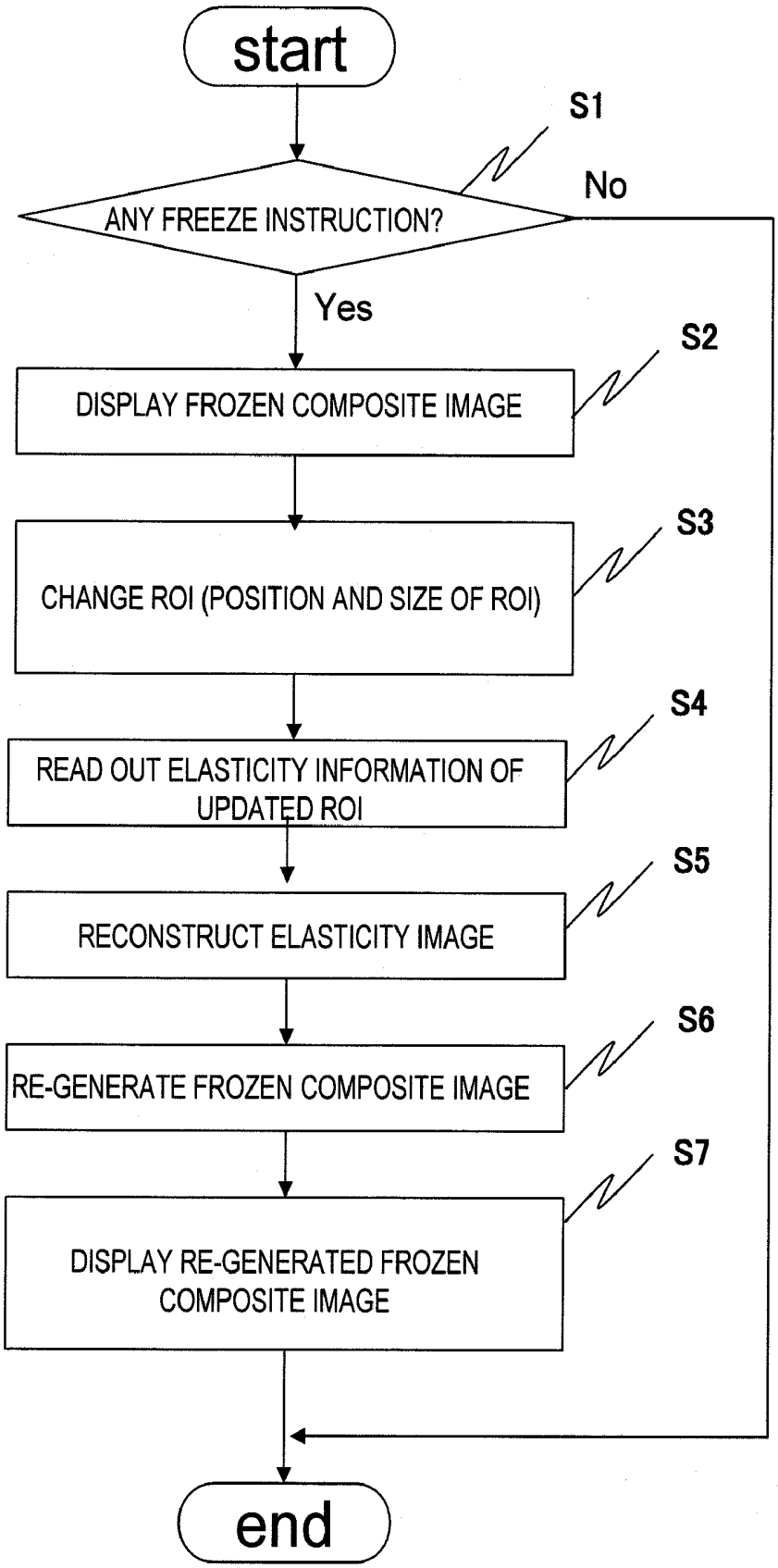

start
S1
ANY FREEZE INSTRUCTION?
No
Yes
S2
DISPLAY FROZEN COMPOSITE IMAGE
S3
CHANGE ROI (POSITION AND SIZE OF ROI)
S4
READ OUT ELASTICITY INFORMATION OF UPDATED ROI
S5
RECONSTRUCT ELASTICITY IMAGE
S6
RE-GENERATE FROZEN COMPOSITE IMAGE
S7
DISPLAY RE-GENERATED FROZEN COMPOSITE IMAGE
end

FIG.5

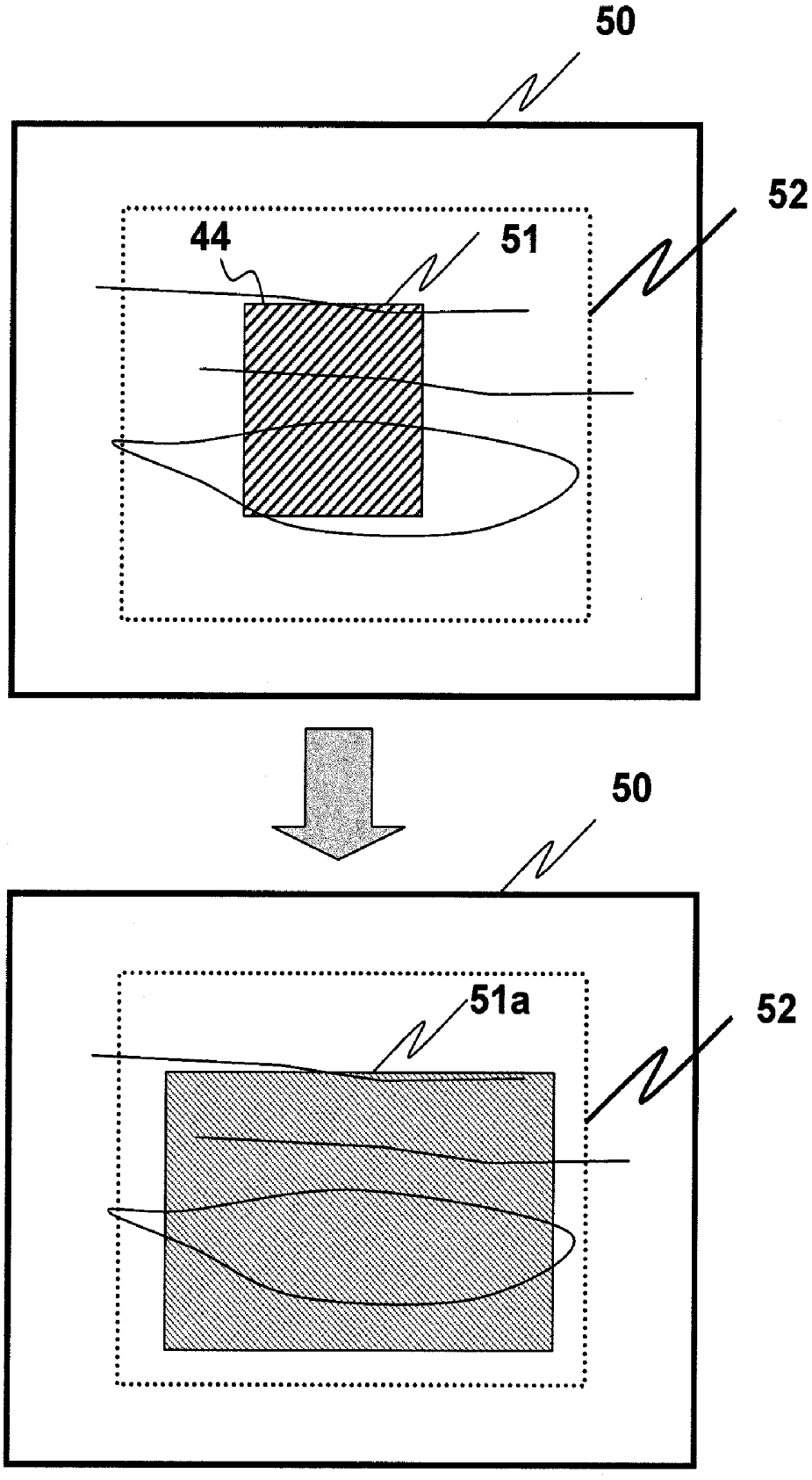


FIG.6

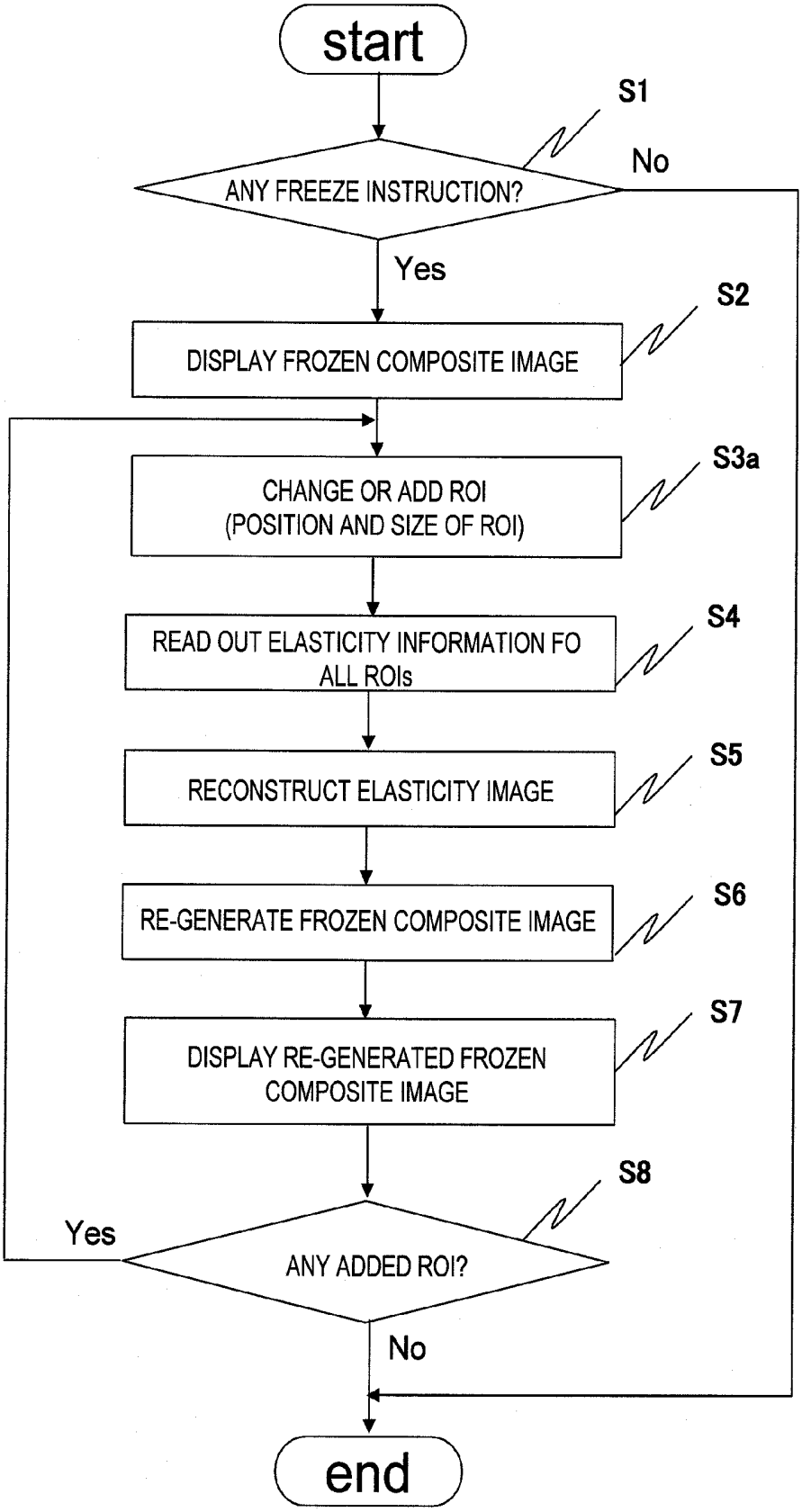

start
S1
ANY FREEZE INSTRUCTION?
No
Yes
S2
DISPLAY FROZEN COMPOSITE IMAGE
S3a
CHANGE OR ADD ROI
(POSITION AND SIZE OF ROI)
S4
READ OUT ELASTICITY INFORMATION FO
ALL ROIs
S5
RECONSTRUCT ELASTICITY IMAGE
S6
RE-GENERATE FROZEN COMPOSITE IMAGE
S7
DISPLAY RE-GENERATED FROZEN
COMPOSITE IMAGE
S8
Yes
ANY ADDED ROI?
No
end

FIG.7

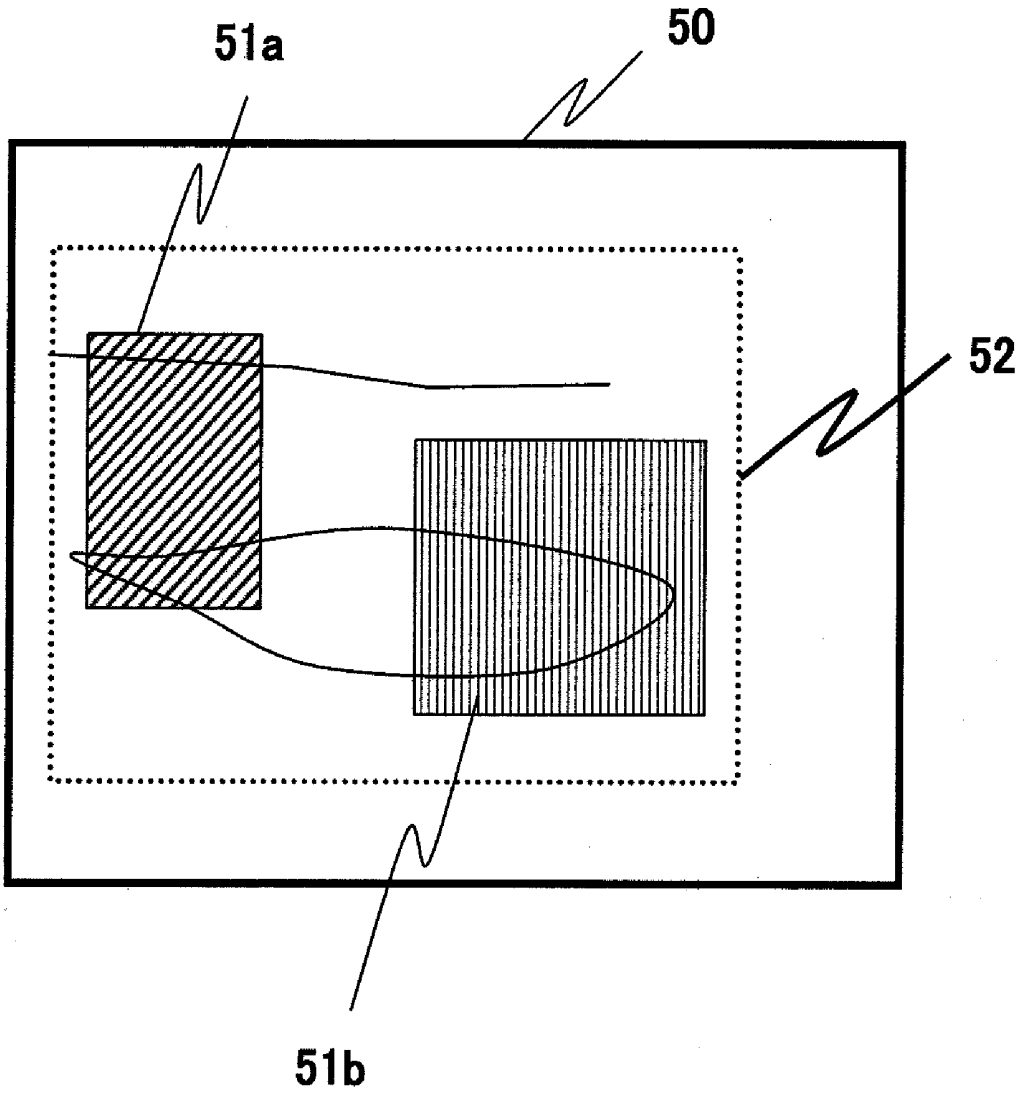


FIG.8

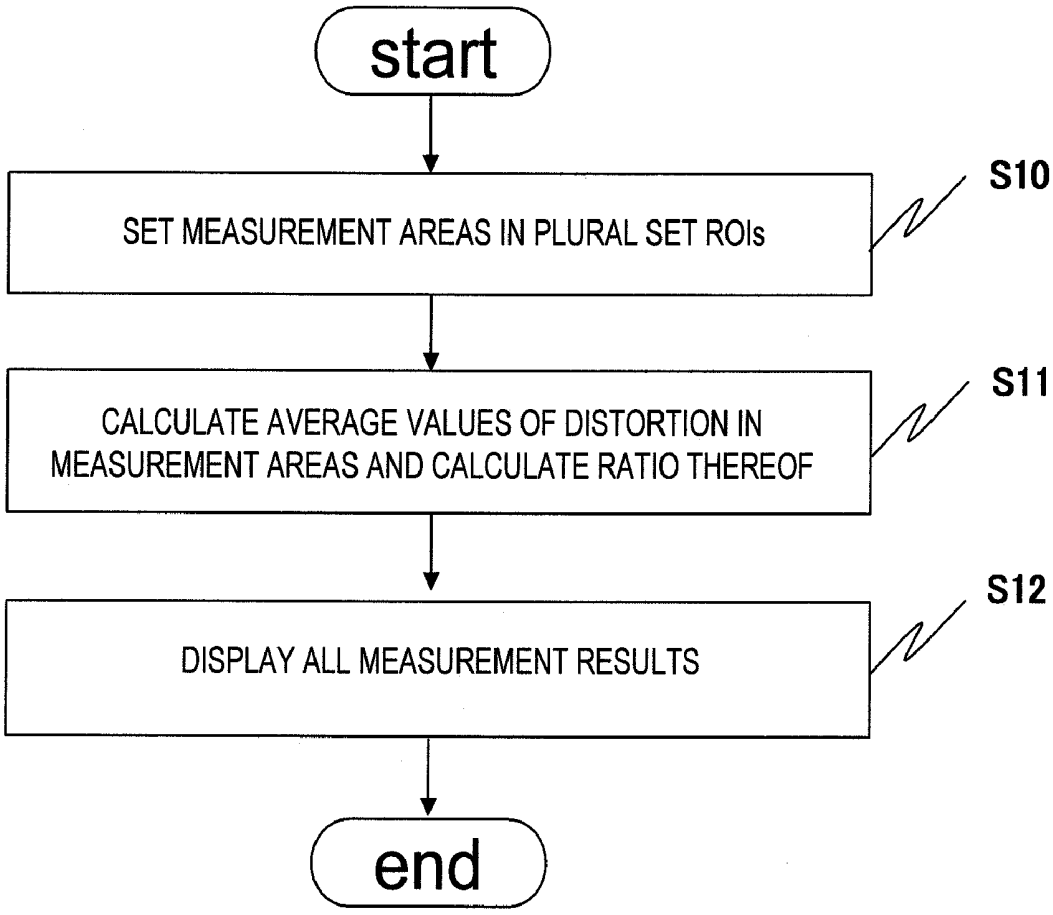

start
SET MEASUREMENT AREAS IN PLURAL SET ROIs
S10
CALCULATE AVERAGE VALUES OF DISTORTION IN MEASUREMENT AREAS AND CALCULATE RATIO THEREOF
S11
DISPLAY ALL MEASUREMENT RESULTS
S12
end

FIG.9

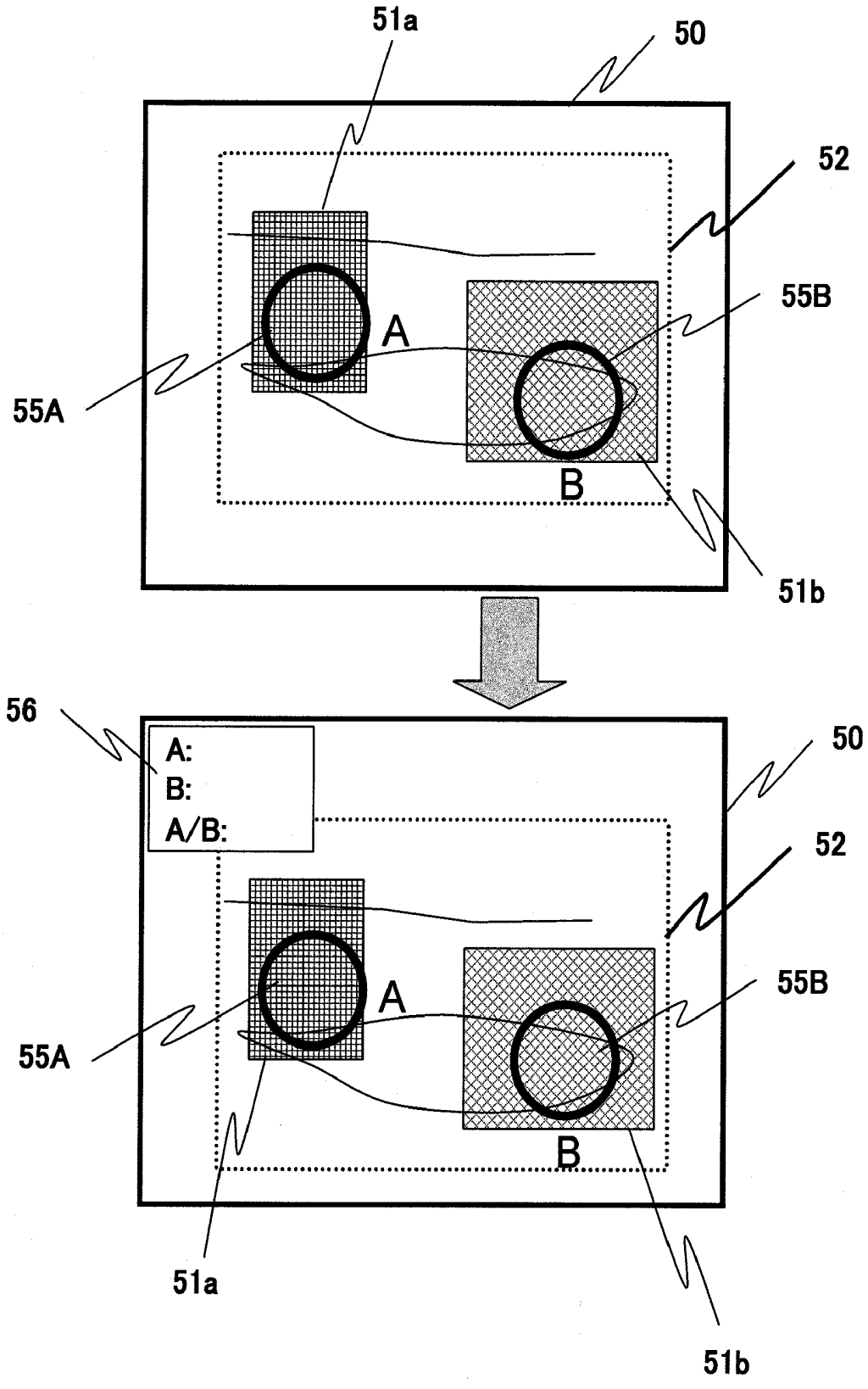


FIG.10

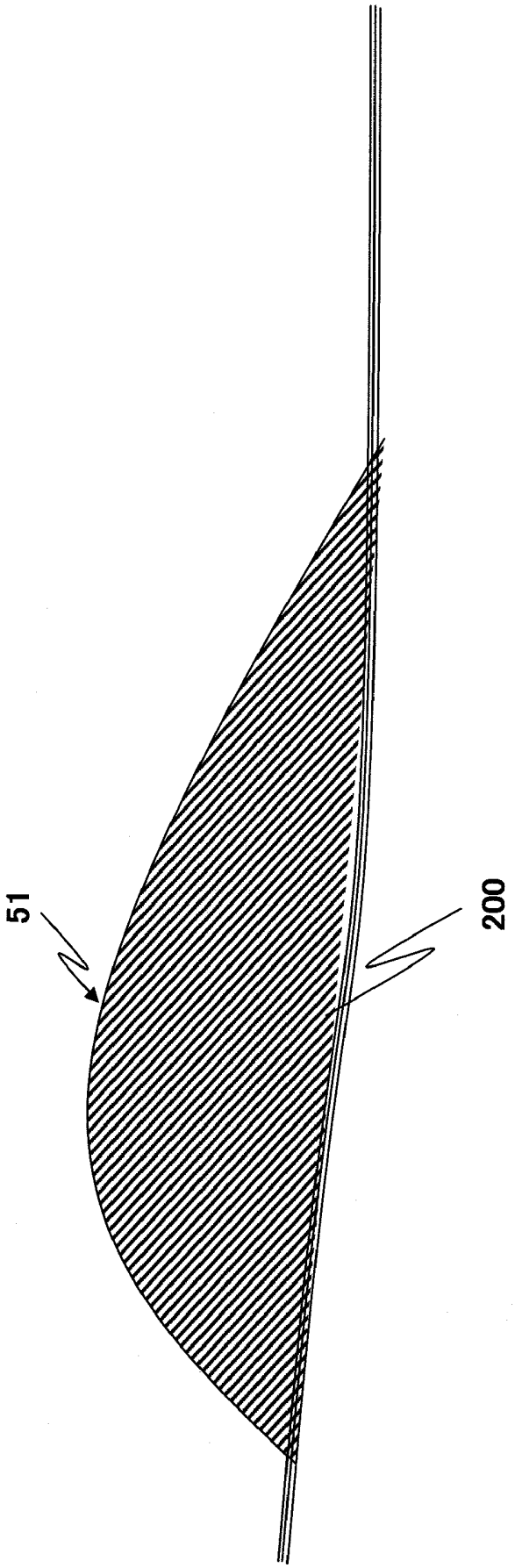


FIG.11

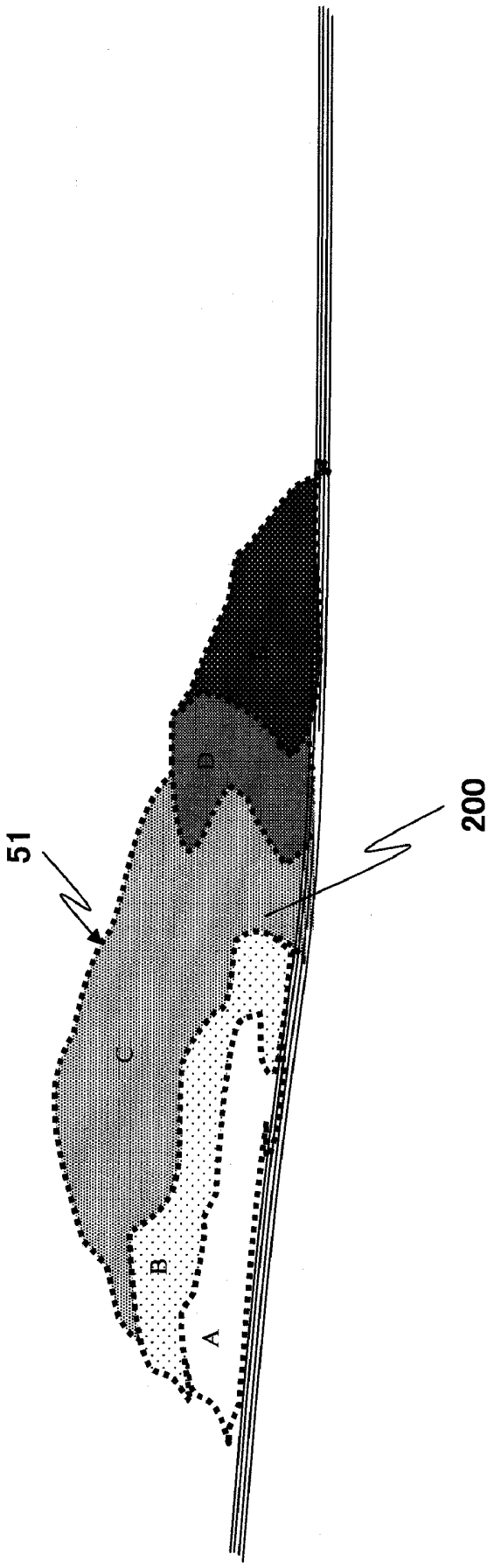
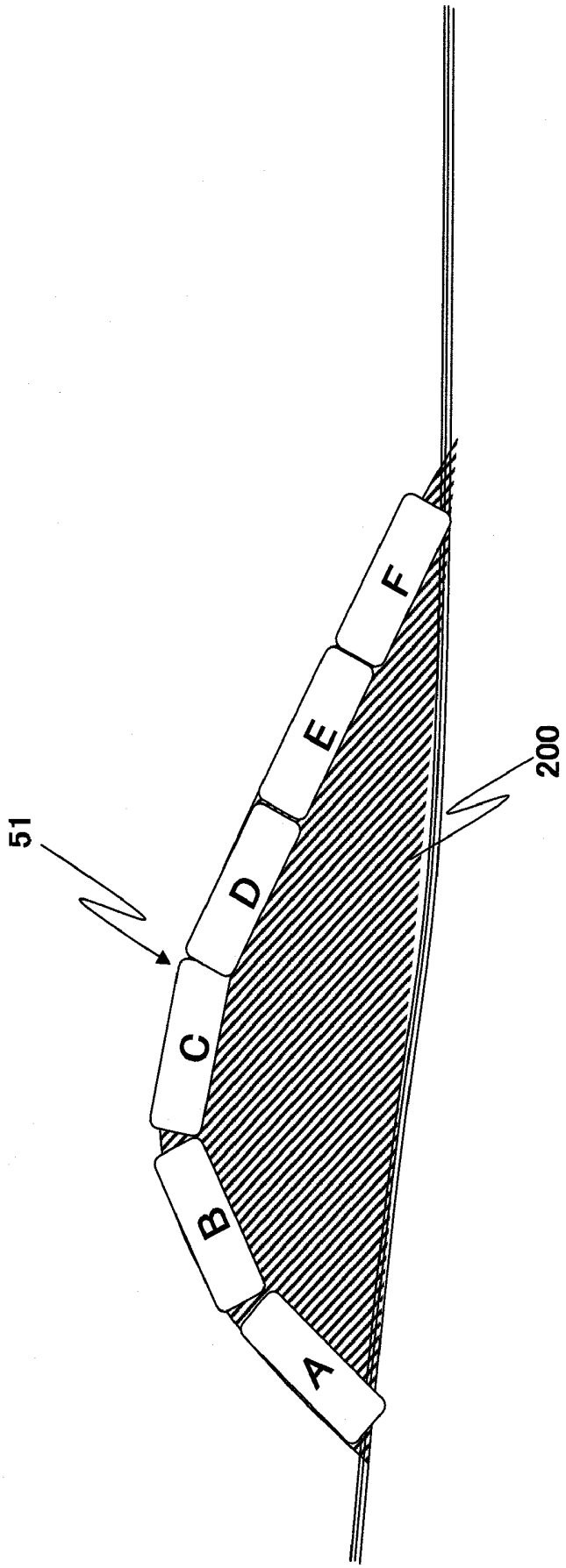


FIG.12



ULTRASONIC DIAGNOSTIC APPARATUS

TECHNICAL FIELD

[0001] The present invention relates to an ultrasonic diagnostic apparatus, and relates to an ultrasonic diagnostic apparatus having a function of displaying a tomographic image of an imaging target site in an examinee and an elasticity image representing hardness or softness of a living tissue.

BACKGROUND ART

[0002] The ultrasonic diagnostic apparatus transmits an ultrasonic wave to the inside of an examinee by an ultrasonic probe, receives an ultrasonic-wave reflection echo signal corresponding to acoustic impedance of each part of a tissue from the inside of the examinee to construct a tomographic image such as an ultrasonic tomographic image, and displays the tomographic image for diagnosis.

[0003] Furthermore, according to the ultrasonic diagnostic apparatus, an ultrasonic reception signal is measured while an examinee is pressed by an ultrasonic probe according to a manual or mechanical method, a displacement of each part of a living body caused by the press is determined on the basis of frame data of two ultrasonic reception signals which are different in measurement time, and an elasticity image representing hardness or softness of a living tissue is generated and displayed on the basis of the displacement data (for example, Patent Document 1).

[0004] Furthermore, elasticity information concerning a region of interest set by an operator is calculated, an elasticity image is generated on the basis of the elasticity information, and a tomographic image and an elasticity image are displayed (for example, Patent Document 2).

[0005] When a particularly detailed diagnosis is required, for example, a composite image comprising a tomographic image and an elasticity image is frozen, and a region of interest such as an affected region is observed on the basis of the frozen composite image.

PRIOR ART DOCUMENT

Patent Document

[0006] Patent Document 1: JP-A-2002-304399

[0007] Patent Document 2: JP-A-2007-167291

SUMMARY OF THE INVENTION

Problem to be solved by the Invention

[0008] For example, when an affected region or the like is observed on the basis of a frozen composite image, there is a case where it is required to be observed comparatively with elasticity information of a site of a tissue out of a set region of interest. In this case, it may be considered to move the region of interest on the frozen composite image or change the region of interest by changing the size so as to contain a site to be comparatively observed.

[0009] However, according to the prior arts such as the Patent Document 1, the elasticity information concerning only the region of interest before the change is required, and thus an elasticity image of the region of interest after the change cannot be constructed by merely changing the region of interest.

[0010] The problem to be solved by the invention resides in the fact that an elasticity image of a newly set region of interest can be displayed without re-measurement even when the region of interest is changed on a frozen composite image.

Means of Solving the Problem

[0011] The invention is based on an ultrasonic diagnostic apparatus having a tomographic image constructing unit that constructs a tomographic image on the basis of a reflection echo signal received by an ultrasonic probe for transmitting/receiving ultrasonic waves to/from an examinee; an elasticity information calculating unit that calculates elasticity information at a tomographic site of the examinee on the basis of the reflection echo signal; an elasticity image constructing unit that constructs an elasticity image on the basis of the elasticity information; an image composite unit that generates a composite image comprising the tomographic image and the elasticity image; and an image display unit that displays the composite image.

[0012] Particularly, in order to solve the problem, a freeze control unit configured to the composite image and region-of-interest setting unit that sets a region of interest on the frozen composite image are provided, and the elasticity image constructing unit constructs the elasticity image on the basis of the elasticity information of the region of interest set by the region of interest setting unit.

[0013] As described above, for example, when a composite image to be observed in detail is displayed during real-time measurement, the composite image is frozen, and when the region of interest on the frozen composite image is changed, an elasticity image of the region of interest after the change is constructed on the basis of the elasticity information of the region of interest after the change by the elasticity image constructing unit, and the composite image is constructed and displayed.

[0014] Here, the composite image contains composite images such as a composite image in which a tomographic image and an elasticity image are displayed to be arranged side by side, and a composite image in which both the tomographic image and the elasticity image are displayed to be superimposed on each other. Accordingly, even when a region of interest is changed on a frozen composite image, an elasticity image of a newly set region of interest can be displayed without re-measurement, and thus usability can be enhanced.

[0015] Furthermore, there may be provided an elasticity information storing unit that calculates and stores the elasticity information with respect to a calculation area of the region of interest set by the region-of-interest setting unit.

[0016] Here, the elasticity information calculating unit may calculate elasticity information with respect to a calculation area larger than the region of interest, and store the elasticity information into the elasticity information storing unit. Furthermore, the calculation area larger that the region of interest may be enlarged and set till a field of vision of a tomographic image or the like at maximum. However, it is preferable to set the size of the calculation area in accordance with an affected region or an observation site. Furthermore, the region-of-interest setting unit can set the position and/or size of the region of interest.

[0017] In this case, tomographic image storing unit that stores plural composite images time-sequentially is provided, and the elasticity information storing unit time-sequentially stores the elasticity information corresponding to the plural composite images, the freeze control unit displays a tomographic image read out from the composite image storing unit on the image display unit, and freezes the displayed compos-

ite image. Accordingly, a tomographic image, a composite image and elasticity information are time-sequentially stored in a cine memory, a frame memory or the like by executing a predetermined measurement. After the measurement, the tomographic image or the composite image in the cine memory or the like is reproduced, a composite image to be observed in detail is frozen and a region of interest is set on the frozen composite image, whereby elasticity images of plural sites to be comparatively observed are displayed without re-measurement. Therefore, usability can be enhanced.

[0018] Furthermore, the region-of-interest setting unit can set plural regions of interest on the frozen composite image. In this case, the elasticity image constructing unit can read out the elasticity information of the plural regions of interest from the elasticity information storing unit, construct the elasticity images of the plural regions of interest and output them to the image combining unit.

[0019] Furthermore, when plural regions of interest are set on a frozen composite image, the elasticity image constructing unit has normalization calculating unit that reads out, from the elasticity information storing unit, distortion information out of the elasticity information of the plural regions of interest set by the region-of-interest setting unit, calculates an average value of the distortion information over all the plural regions of interest, and normalizes the distortion information of the plural regions of interest with the calculated average value set as a reference value, and the elasticity image constructing unit can construct elasticity images of the plural regions of interest on the basis of the distortion information calculated by the normalization calculating unit, and output the elasticity images to the image combining unit. Normally, the distortion information is relative information of each region of interest, and thus the distortion information of different regions of interest cannot be compared with one another with no modification. In this point, the distortion information of the plural regions of interest are normalized with the average value set as a reference value, whereby the distortion information of the different regions of interest can be relatively grasped, and thus they can be compared with one another.

[0020] Furthermore, when plural regions of interest are set on a frozen composite image, there my be provided measurement area setting unit that sets a measurement area on each of the plural region of interest, and measurement area calculating unit that calculates the ratio of the elasticity information among the measurement areas, and displays the calculated ratio on the image displaying unit. Accordingly, it is difficult to compare the elasticity information of a site of interest on the basis of the difference in hue, brightness or the like of elasticity images of plural regions of interest which are set to be far away from one another, however, they can be easily compared with one another by displaying the ratio of the elasticity information.

Effect of the Invention

[0021] According to the invention, there is an effect that even when the region of interest is changed on the frozen composite image, an elasticity image of a newly set region of interest can be displayed without re-measurement.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. **1** is a block diagram showing the construction of an ultrasonic diagnostic apparatus according to a first embodiment to which the invention is applied.

[0023] FIG. **2** is a diagram showing an operation area calculated by an elasticity information calculating unit shown in FIG. **1**.

[0024] FIG. **3** is a diagram showing the relationship between frame data of a tomographic image stored in a cine memory and frame data of elasticity information stored in an elasticity information storing unit.

[0025] FIG. **4** is a flowchart showing the flow of processing of changing a region of interest when the ultrasonic diagnostic apparatus of FIG. **1** is frozen.

[0026] FIG. **5** is a diagram showing a state that the region of interest in the processing of FIG. **4** is changed.

[0027] FIG. **6** is a flowchart showing a modification of the flow of the processing of changing the region of interest when the ultrasonic diagnostic apparatus of FIG. **1** is frozen.

[0028] FIG. **7** is a diagram showing a state that the region of interest in the processing of FIG. **6** is changed.

[0029] FIG. **8** is a flowchart showing the flow of processing of changing a region of interest when an ultrasonic diagnostic apparatus according to a second embodiment to which the invention is applied is frozen.

[0030] FIG. **9** is a diagram showing a state that the region of interest in the processing of FIG. **8** is changed.

[0031] FIG. **10** is a diagram showing an example of an ROI setting unit of an ultrasonic diagnostic apparatus according to a third embodiment to which the invention is applied.

[0032] FIG. **11** is a diagram showing another example of the ROI setting unit according to the third embodiment.

[0033] FIG. **12** is a diagram showing another embodiment of the ROI setting unit according to the third embodiment.

BEST MODES FOR CARRYING OUT THE INVENTION

[0034] Embodiments of an ultrasonic diagnostic apparatus to which the invention is applied will be described.

First Embodiment

[0035] A first embodiment of an ultrasonic diagnostic apparatus to which the invention is applied will be described with reference to FIGS. **1** to **9**. FIG. **1** is a block diagram showing the construction of an ultrasonic diagnostic apparatus according to this embodiment, FIG. **2** is a diagram showing a calculation area which is calculated in an elasticity information calculating unit of this embodiment, FIG. **3** is a diagram showing the relationship between frame data of a tomographic image stored in a cine memory of this embodiment, and frame data of elasticity information stored in an elasticity information storing unit, FIG. **4** is a flowchart showing the flow of processing of changing the region of interest which is executed while a composite image in this embodiment is frozen, FIG. **5** is a diagram showing a state that the region of interest in the processing of FIG. **4** is changed, FIG. **6** is a flowchart showing a modification 1 of the flow of processing of changing the region of interest when this embodiment is frozen, FIG. **7** is a diagram showing a state that the region of interest in the processing of FIG. **6** is changed, FIG. **8** is a flowchart showing a modification 2 of the flow of processing of changing the region of interest under freezing in this embodiment of FIG. **1**, and FIG. **9** is a diagram showing a state that the region of interest in the processing of FIG. **8** is changed.

[0036] As shown in FIG. **1**, the ultrasonic diagnostic apparatus **1** has an ultrasonic probe **12** which is used in contact

with an examinee **10**, a transmission unit **14** for repetitively transmitting ultrasonic waves to the examinee **10** through the ultrasonic probe **12** at a time interval, a reception unit **16** for receiving a time-series reflection echo signal occurring from the examinee **10**, an ultrasonic wave transmission/reception control unit **17** for controlling the transmission unit **14** and the reception unit **16**, and a phasing and adding unit **18** for phasing and adding the reflection echo received by the reception unit **16**.

[0037] The ultrasonic probe **12** is formed by arranging plural transducers, and has a function of transmitting/receiving ultrasonic waves by, the transducers to the examinee **10**. The transmission unit **14** has a function of generating a wave transmission pulse for driving the ultrasonic probe **12** and generating ultrasonic waves, and setting a convergence point of the ultrasonic waves to be transmitted to some depth. The reception unit **16** amplifies a reflection echo signal received by the ultrasonic probe **12** with a predetermined gain to generate an RF signal, that is, a wave reception signal. The phasing and adding unit **18** receives the RF signal amplified by the reception unit **16** to perform phase control, and forms ultrasonic wave reception beams for one point or plural convergence points to generate RF signal frame data.

[0038] Furthermore, the ultrasonic diagnostic apparatus **1** is provided with a tomographic image constructing unit **20** as tomographic image constructing unit for constructing a shading tomographic image of an examinee, for example, (monochromatic) tomographic image of an examinee on the basis of RF signal frame data in which the RF signal phased and added in the phasing and adding unit **18** is set as frame data, a monochromatic scan converter **22** for converting an output signal of the tomographic image constructing unit **20** so that the output signal is matched with display of an image display unit **26** as image display unit, and a switching combining unit **24** as image combining unit for changing the combination rate of a tomographic image and an elasticity image (described later) and generating a composite image.

[0039] The tomographic image constructing unit **20** receives RF signal frame data from the phasing and adding unit **18** to perform signal processing such as gain correction, log compression, wave detection, edge enhancement, or filter processing to obtain tomographic image data. A monochromatic tomographic image output from the monochromatic scan converter **22** is input to the switching combining unit **24**.

[0040] Furthermore, the ultrasonic diagnostic apparatus **1** is provided with an RF frame data selecting unit **28** for storing RF signal frame data output from the phasing and adding unit **18**, and selecting two frame data different in measurement time, a displacement measuring unit **30** for measuring the displacement of a tissue of the examinee **10**, an elasticity information calculating unit **32** as elasticity information calculating means for acquiring elasticity frame data as distortion, elasticity information such as elasticity modulus, or viscosity from displacement information measured by the displacement measuring unit **30**, elasticity information storing unit **33** as elasticity information storing means for storing elasticity information calculated in the elasticity information calculating unit **32**, an elasticity image constructing unit **34** as elasticity image constructing means for constructing a color elasticity image (hereinafter merely referred to as elasticity image) from the elasticity information storing unit **33**, and a color scan converter **36** for converting an output signal of the elasticity image constructing unit **34** so that the output signal is matched with a display style of the image display unit **26**.

[0041] When the elasticity information calculating unit **32** acquires an elasticity modulus, stress data at each measurement point is required. Therefore, in order to acquire the elasticity modulus, the ultrasonic diagnostic apparatus **1** is provided with a pressure measuring unit **101**, and the elasticity information calculating unit **32** calculates the stress at a measurement point in the examinee **10** on the basis of the detection signal of a pressure sensor (not shown) provided around the ultrasonic wave transmission/reception face of the probe **12** detected by the pressure measuring unit **101**.

[0042] Furthermore, the ultrasonic diagnostic apparatus **1** can superimpose a monochromatic tomographic image and a color elasticity image on each other or display them side by side with the switching combining unit **24** and the image display unit **26**. Furthermore, a cine memory **100** constitutes the image storing unit, and the tomographic image and/or the elasticity image combined in the switching combining unit **24** is stored as image frame data in the cine memory **100**. The cine memory **100** is configured so that selected image data can be transmitted to a recording medium (not shown) such as MO.

[0043] The RF signal frame data selecting unit **28** stores plural RF signal frame data from the phasing and adding unit **18**, and selects one pair, that is, two RF signal frame data different in measurement time from the stored RF signal frame data group. For example, the RF signal frame data selecting unit **28** successively stores the RF signal frame data generated time-sequentially, that is, on the basis of the frame rate of images from the phasing and adding unit **18** into the RF frame data selecting unit **28**, and selects stored RF signal frame data (N) as first data. Simultaneously, the RF signal frame data selecting unit **28** selects one RF signal frame data (X) from the RF signal frame data group (N−1, N−2, N−3, . . . , N−M) which were stored past in time. Here, N, M, X represent index numbers appended to the RF signal frame data, and are natural numbers.

[0044] The displacement measuring unit **30** executes one-dimensional or two-dimensional correlation processing from the selected pair of data, that is, the RF signal frame data (N) and the RF signal frame data (X) to acquire a displacement and a moving vector of the tissue corresponding to each point of a tomographic image, that is, a one-dimensional or two-dimensional displacement distribution concerning the direction and magnitude of the displacement. Here, the moving vector is detected by using a well-known method such as a block matching method, or a correlation method. For example, the block matching method executes the processing of dividing an image into blocks of N×N pixels, noting a block in a region of interest, searching, from a previous frame, a block which is most approximate to the block being noted, and refers to this block to determine a sample value on the basis of prediction coding, that is, difference.

[0045] The elasticity information calculating unit **32** determines the distortion at each measurement point of a calculation area larger than the set region of interest on the basis of a measurement value output from the displacement measuring unit **30**, for example, a moving vector to generate distortion frame data, and stores the distortion frame data into the elasticity information storing unit **33**. Furthermore, the elasticity information calculating unit **32** calculates an elasticity modulus of the tissue at each measurement point of the calculation area on the basis of the distortion and the pressure (stress) of each measurement point output from the pressure measuring

unit **101**, generates elasticity modulus frame data and stores the elasticity modulus frame data into the elasticity information storing unit **33**.

[0046] At this time, the distortion is calculated by spatially differentiating the movement amount of the tissue, for example, the displacement. The elasticity modulus is calculated by dividing the pressure variation by the distortion variation. For example, when the displacement measured by the displacement measuring unit **30** is represented by L(X) and the pressure measured by the pressure measuring unit **101** is represented by P (X), the distortion value ΔS(X) can be calculated by spatially differentiating L(X), and thus it can be determined by using an arithmetic expression of ΔS(X)=ΔL (X)/ΔX. Furthermore, the Young's modulus Ym(X) as an example of the elasticity modulus is calculated by the arithmetic expression of Ym=(ΔP(X)/ΔS(X). The elasticity modulus of the tissue corresponding to each point of a tomographic image is determined from the Young's modulus Ym, and thus two-dimensional elasticity information can be continuously obtained. The Young's modulus is the ratio of a simple tensile stress applied to an object to distortion occurring in parallel to the tensile.

[0047] The elasticity information storing unit **33** stores elasticity frame data such as the distortion, or the elasticity modulus, calculated by the elasticity information calculating unit **32**. The elasticity information is information representing the hardness or softness of the tissue, and contains physical quantities such as a displacement amount, a distortion amount, or an elasticity modulus, coefficients correlated with these physical quantities, etc.

[0048] The elasticity image constructing unit **34** is configured to contain a frame memory and an image processor, and it secure elasticity information output time-sequentially from the elasticity information calculating unit **32** into the frame memory, and executes image processing on the secured elasticity information.

[0049] The color scan converter **36** has a function of appending hue information to the elasticity information from the elasticity image constructing unit **34**. That is, it performs the conversion to three primary colors of light, that is, red (R), green (G) and blue (B) on the basis of the elasticity information, for example.

[0050] For example, the distortion at each measurement point is normalized with the average value of the distortion of the whole region of interest set as a reference value, the hue of a measurement point having a large distortion is converted to a red-color code, and also the hue of a measurement point having a small distortion is converted to a blue-color code to thereby represent a distortion distribution. A monochromatic scan converter may be used in place of the color scan converter **36**. In this case, an area whose distortion is measured to be large is set to be high in brightness, and conversely an area whose distortion is measured to be small is set to be low in brightness, whereby the distortion distribution can be represented.

[0051] The switching combining unit **24** has a frame memory, an image processor and an image selecting unit. Here, the frame memory stores tomographic image data from the monochromatic scan converter **22** and elasticity image data from the color scan converter **36**. Furthermore, the image processor combines the tomographic image data and the elasticity image data secured in the frame memory while changing the combination ratio therebetween, for example. The composite image contains composite images such as a composite image in which the tomographic image and the elasticity image are displayed side by side, and a composite image in which a tomographic image and an elasticity image are displayed in superposition with each other. The brightness information and the hue information of each pixel of the composite image are obtained by adding respective information of a monochromatic tomographic image and a color elasticity image in the combination ratio. Furthermore, the image selecting unit selects an image to be displayed on the image display unit **26** from the tomographic image data and the elasticity image data in the frame memory and the composite image data of the image processor.

[0052] The ultrasonic diagnostic apparatus **1** has a control unit **110** for controlling the respective parts in the device. The control unit **110** is configured to have a first ROI setting unit **38** as region-of-interest setting means for setting a region of interest (hereinafter referred to as ROI) as an area whose elasticity image is generated. Furthermore, the control unit **110** is configured to have the function of freeze control unit for controlling the read-out of the cine memory **100** or the frame memory of the switching combining unit **24** on the basis of an input instruction to freeze the composite image.

[0053] Next, the construction of the feature portion of this embodiment will be described. A first feature portion of the invention resides in the fact that a freeze control unit for freezing a composite image and a region-of-interest setting unit (second ROI setting unit **39**) for setting a region of interest on the frozen composite image are provided, and the elasticity image constructing unit **34** constructs an elasticity image on the basis of elasticity information of a region of interest set by the region-of-interest setting unit (second ROI setting unit **39**).

[0054] Furthermore, the second feature portion of the invention resides in the fact that a measurement area setting unit **40** provided to the control unit **110** and a measurement calculating unit **42** are provided in addition to the first feature. The second feature will be described in connection with a second embodiment described later.

[0055] The elasticity information calculating unit **32** and the elasticity information storing unit **33** according to the first feature have the foregoing constructions. Furthermore, the second ROI setting unit **39** serves as region-of-interest changing means for changing ROI which is set by the first ROI setting unit **38** and displayed on the frozen composite image displayed on the image display unit **26**. The elasticity image constructing unit **34** takes in coordinate data of ROI changed by the second ROI setting unit **39**, and reads out the elasticity information of the area corresponding to the coordinate data concerned from the elasticity information storing unit **33** to generate an elasticity image of ROI after the change. Accordingly, the composite image of the elasticity image of ROI after the change is displayed through the color scan converter **36** and the switching combining unit **24** onto the image display unit **26**.

[0056] Furthermore, as shown in FIG. **2**, when ROI **51** is set on a tomographic image **50** from the monochromatic scan converter **22** by the first ROI setting unit **38** of the control unit **110**, the elasticity information calculating unit **32** sets a preset area larger than ROI **51** as a calculation area **52**, calculates the distortion, the elasticity modulus, etc. corresponding to each measurement point on the tomographic image of the calculation area **52**, generates elasticity information based on the

distortion, the elasticity modulus, etc., that is, elasticity frame data, and outputs the elasticity frame data to the elasticity information storing unit **33**.

[0057] The elasticity image constructing unit **34** constructs (generates) an elasticity image of the set ROI **51** on the basis of the elasticity information stored in the elasticity information storing unit **33**, and outputs the generated elasticity image to the switching combining unit **24**.

[0058] Furthermore, as shown in FIG. **3**, the cine memory **100** successively stores the tomographic image data output from the monochromatic scan converter **22**, and frame-basis tomographic image frame data (Px−(n−1), Px−(n−2), Px−−(n−3), . . . , Pi, . . . Px) (here, n, i, x represent natural numbers). The elasticity information storing unit **33** stores elasticity information frame data (Dx−(n−1), Dx−(n−2), Dx−(n−3), . . . , Di, . . . , Dx) comprising elasticity information which is associated with the tomographic image frame data stored in the cine memory **100** on the basis of time data.

[0059] The elasticity information frame data (Dx−(n−1), Dx−(n−2), Dx−(n−3), . . . , Di, . . . , Dx) time-sequentially correspond to the tomographic image frame data (Px−(n−1), Px−(n−2), Px−(n−3), . . . , Pi, . . . , Px), however, when the elasticity information is not calculated between adjacent frames, but calculated every some frames, past elasticity information frame data which is just near in terms of time is treated as data corresponding to the tomographic image frame data. That is, the elasticity information is calculated by selecting two RF signal frame data different in measurement time from the RF signal frame data group which is stored in the past. Therefore, a pair of RF signal frame data used for the calculation are not necessarily limited to a pair of adjacent RF signal frame data.

[0060] When a freeze instruction for freezing a composite image is input from the control unit **110** through an input unit (not shown), the latest tomographic image Px and the elasticity image Dx which are output from the frame memory of the switching combining unit **24** to the image display unit **26** are freeze-displayed as a still image under real-time measurement. Not limited to the real-time measurement, the image frame data stored in the cine memory **100** may be reproduced and displayed on the image display unit **26** in accordance with an instruction input from the control unit **110**.

[0061] As described with reference to FIG. **2**, the elasticity information Dx is calculated for the calculation area **52** which is an area larger than ROI **51**. According to this embodiment, with respect to the elasticity image constructing unit **34**, for example, a composite image under real-time measurement is frozen. Then, changed ROI **51***a* corresponding to the freeze-displayed composite image is displayed on the frozen composite image on the basis of an instruction of changing ROI **51** (position or/and size) from the second ROI setting unit **39**. The elasticity image constructing unit **34** constructs an elasticity image on the basis of the coordinate data of ROI **51***a* input from the second ROI setting unit **39** by using the elasticity information Dx in the calculation area **52** which is stored in the elasticity information storing unit **33**, and outputs the elasticity image to the color scan converter **36**, whereby the elasticity image of the changed ROI **51***a* is displayed on the image display unit **26**.

[0062] When the composite image is frozen not under the real-time measurement, but by reproducing and displaying the image frame data stored in the cine memory **100**, the elasticity information of the area corresponding to ROI **51***a* of the frozen composite image is read out from the elasticity storing unit **33**, and the elasticity image on the image display unit **26** is changed.

[0063] Next, the flow of the processing of changing the position, size of ROI **51***a* in the second ROI setting unit **39** under the display state of the frozen composite image will be described with reference to FIG. **4**. In this specific example, the control unit **110** changes the position, size of ROI **51***a* by the second ROI setting unit **39** under the display state of the frozen composite image. Specifically, the control unit **110** determines whether there is a freeze instruction from an input unit (not shown) (step S**1**). Ina case where there is a freeze instruction, when the composite image stored in the cine memory **100** is reproduced and displayed on the image display unit **26**, the control unit **110** freezes the composite image at the time when the freeze instruction is input (step S**2**). Subsequently, the position, size of ROI **51***a* on the frozen composite image are changed and displayed on the basis of the instruction input from the second ROI setting unit **39** to the image display unit **26** (step S**3**).

[0064] On the basis of the coordinate data of after-change ROI **51***a* input from the second ROI setting unit **39**, the elasticity image constructing unit **34** reads out elasticity information at the position and/or the size after the change of ROI **51***a* in the calculation area **52** from the elasticity information storing unit **33** (step S**4**), and constructs an elasticity image in the after-change ROI **51***a* (step S**5**).

[0065] FIG. **5** shows variation of the display state from pre-change ROI **51** to after-change ROI **51***a* on the tomographic image **50** when the position and the size of ROI **51** are changed by the second ROI setting unit **39** under the display state of the frozen composite image. The elasticity image constructing unit **34** constructs an elasticity image corresponding to ROI **51***a* by using the elasticity information in the calculation area **52** which is stored in the elasticity information storing unit **33**. The elasticity images constructed by the elasticity image constructing unit **34** are added and combined by the switching combining unit **24** and then displayed on the screen of the image display unit **26**.

[0066] As described above, in this embodiment, a desired area can be set as a new region of interest by the change information of the position and/or size of ROI **51***a* under the state that the composite image under real-time measurement or the composite image when the image of the cine memory **100** is reproduced on a non-real-time basis is freeze-displayed. Accordingly, the elasticity image in the changed ROI **51***a* can be constructed, and detailed information concerning the hardness or softness of the tissue of the changed region of interest can be obtained.

[0067] Accordingly, according to this embodiment, the elasticity information is calculated for the calculation area **52** larger than the set ROI **51**, and stored in the elasticity information storing unit **33**. Therefore, when a composite image which is required to be observed in detail under real-time, measurement is displayed, the composite image is frozen. When the position and size of ROI **51***a* on the frozen composite image are changed, the elasticity information of ROI **51***a* after the change is read out from the elasticity information storing unit **33** by the elasticity image constructing unit **34**, the elasticity image of after-change ROI **51***a* is constructed, and the composite image is constructed and displayed. Accordingly, even when ROI **51***a* is changed on the freeze image, the elasticity image of the after-change region of interest can be displayed without re-measurement. There-

fore, a site to be comparatively observed can be compared on a still image in detail, and thus usability can be enhanced.

[0068] A freeze instruction is made at a suitable timing when a composite image to be observed in detail is displayed while composite images stored in the cine memory **100** are repetitively displayed as a moving image on the image display unit **26**, whereby a suitable diagnosis can be performed.

[0069] (Modification)

[0070] Next, a modification of this embodiment will be described with reference to FIGS. **6** and **7**. In this modification, ROI **51** is changed on the frozen composite image, new ROI **5***a* and ROI **51***b* are set, and distortion information of two ROI **5***a* and ROI **51***b* are normalized to be relatively comparable with each other.

[0071] That is, the second ROI setting unit **39** adds plural ROI **5***a*, ROI **51***b*, etc. on the frozen composite image, and also the positions and/or sizes of the plural ROI **5***a* and ROI **51***b* are changed/set. The flow of the processing is substantially identical to that shown in FIG. **4**, and only the different point will be described.

[0072] In this modification, as shown in FIG. **6**, the control unit **110** outputs the information concerning the position and/or size of ROI set by the second ROI setting unit **39** to the elasticity image constructing unit **34** to thereby instruct the change of ROI **51** (step S3*a*).

[0073] Furthermore, after the processing of the step S**7**, the control unit **110** determines whether there is any ROI to be further added (step S**8**). The control unit **110** returns to the step S3*a* when there is ROI to be added, and finishes the processing when there is no ROI to be added. Accordingly, as shown in FIG. **7**, the control unit **110** sets (changes) plural ROI **51***a* and **51***b*. The other processing is identical to that of FIG. **4**.

[0074] Through this processing, the elasticity image corresponding to each individual area is constructed in the elasticity image constructing unit **34**. The constructed elasticity images are added and combined with one another by the switching and combining unit **24**, and displayed on the screen of the image display unit **26**.

[0075] In this modification 1, a normalization calculating unit is provided to the elasticity image constructing unit **34**, and the normalization calculating unit reads out the distortion information out of the elasticity information of ROI **51***a*, **51***b* set by the second ROI setting unit **39** from the elasticity information storing unit **33**. The average value of the distortion information of two ROIs **51***a*, **51***b* is calculated, and the distortion information of the two ROIs **51***a*, **51***b* is normalized with the calculated average value set as a reference value. The elasticity images of ROIs **51***a*, **51***b* are constructed on the basis of the distortion information of the two ROIs **51***a*, **51***b* calculated by the normalization calculating unit, and output to the image combining unit.

[0076] According to this embodiment, the distortion image represents relative elasticity of each measurement point in one ROI, and thus absolute elasticity cannot be recognized. However, distortion images obtained by normalizing distortions of two sites are compared with each other, whereby the elasticity of an affected region can be relatively recognized. For example, fat, etc. are constant distortion information having little difference among individuals. Therefore, one ROI is set in a fat layer, and the other ROI is set in an affected region, whereby distortion of the affected region can be estimated with remarkable accuracy. Furthermore, one ROI is set to an affected region and the other ROI is set to a different site of the affected region, whereby the difference in elasticity within the same affected region can be objectively estimated.

[0077] Furthermore, in the foregoing description, it is mainly described that the after-change ROI **51***a* is set to be larger than the original ROI **51**. However, the invention is not limited to this embodiment, and the after-change ROI **51***a* may be set to be smaller than the original ROI **51** on the frozen composite image. Accordingly, a distortion distribution image in ROI is obtained, and thus a diagnosis can be performed by observing the hardness of the tissue in more detail.

Second Embodiment

[0078] A second embodiment of an ultrasonic diagnostic apparatus to which the invention is applied will be described with reference to FIGS. **8** and **9**. This embodiment corresponds to a second feature portion of the invention as described above, and is characterized in that a measurement area setting unit **40** provided to the control unit **110** and a measurement area calculating unit **42** are provided in addition to the first embodiment.

[0079] The measurement area setting unit **40** sets a measurement area in each of plural ROIs displayed on a frozen composite image, and also outputs coordinate data of these measurement areas to the measurement calculating unit **42**. The measurement calculating unit **42** reads out the elasticity information of the areas corresponding to the plural set measurement areas from the elasticity information storing unit **33**, calculates the ratio of the elasticity information among the measurement areas on the basis of the elasticity information of the measurement areas, and outputs the calculation result concerned to the image display unit **26** to perform a numerical display.

[0080] That is, as shown in FIG. **8**, after the processing of the step S**7** of FIG. **4**, the control unit **110** sets measurement areas **55**A and **55**B as shown in FIG. **9** on the plural ROIs **51***a* and **51***b* (step S**10**). The measurement calculating unit **44** calculates the distortion average values "A", "B" in the respective measurement areas **55**A and **55**B and the ratio "A/B" (step S**11**), and numerically displays the calculation result in a calculation display area **56** of the image display unit **26** (step S**12**).

[0081] That is, the ratio in hardness between non-adjacent tissues can be quantitatively estimated by a conventional method. However, it is required to set ROI at a larger size so as to specify a tissue, and thus unnecessary data may affect a quantitative estimation of the ratio. In this embodiment, in addition to the effect of the first embodiment, measurement areas to be particularly noted are respectively set on the non-adjacent plural ROIs in a pinpoint style, whereby elasticity information, for example, distortion is determined at these measurement areas with high precision without re-measurement, and the ratio of these elasticity information is further determined, whereby accurate diagnosis can be performed.

[0082] For example, when ROI **51***b* is set on a fat tissue and ROI **51***a* is set on a tissue being noted, the distortion value in the fat tissue is substantially constant because the distortion of the fat tissue has little difference among individuals. Therefore, the distortion "B" in the measurement area on ROI **51***b* (fat tissue) is set as a reference, and the ratio "A/B" of the distortion value "A" in the measurement area of ROI **51***a* (tissue being noted) to the distortion "B" is calculated and numerically displayed in the calculation display area **56**, whereby information on hardness or softness of the tissue being noted can be numerically (quantitatively) obtained.

[0083] According to this embodiment, in addition to the effect of the first embodiment, the ratio of elasticity information is calculated among plural measurement areas set on plural ROIs, and the ratio is displayed on the image display unit **26**, whereby the hardness can be determined with high precision among measurement areas of plural tissues, and the elasticity information thereof, for example, the ratio of the distortion can be displayed on the composite image, so that the elasticity of a site being noted can be quantitatively estimated.

Third Embodiment

[0084] Here, an example in which the first and second embodiments are applied for a specific ultrasonic diagnosis will be described with reference to FIGS. **10** to **12**. This embodiment is an example suitable for a diagnosis relating to plaque occurring on a blood vessel wall of carotid artery.

[0085] As shown in FIG. **10**, the first ROI setting unit **38** manually or automatically sets ROI **51** in conformity with a given tissue (for example, plaque occurring on the blood vessel wall of carotid artery) **200**. Specifically, the outer frame of plaque **200** may be specified by using the characteristic of the plaque **200**. The characteristic of the plaque **200** resides in the fact that the plaque exists on the surface of the wall of carotid artery, there is no Doppler signal as a blood flow signal, etc.

[0086] In this case, a brightness distribution in the thickness direction of the wall of tomographic image data is obtained. A local maximum point having the maximum brightness of the brightness distribution is set as an outer membrane reference point, and a second local maximum point appearing at the inside (blood flow side) of the outer membrane reference point is set as an inner membrane reference point. A tissue having high brightness at the inside (blood flow side) of the inner membrane reference point is recognized. Furthermore, an area providing no Dropper signal out of the recognized high-brightness tissue is recognized as the plaque **200**, and the outer frame of the plaque **200** is specified. The outer frame is set as the boundary of ROI **51**.

[0087] Furthermore, as shown in FIG. **11**, the first ROI setting unit **38** can set plural, for example, five ROI-A, ROI-B, ROI-C, ROI-D, ROI-E in the given predetermined tissue (for example, the plaque occurring on the blood vessel wall of the carotid artery) **200**. As an example, it is assumed that ROI-A has brightness ranging from 1 to 30, ROI-B has brightness ranging from 31 to 60, ROI-C has brightness ranging from 61 to 90, ROI-D has brightness ranging from 91 to 120 and ROI-E has brightness ranging from 121 to 150. As described above, ROI-A to ROI-E can be automatically set on the basis of the brightness of the tomographic image data, and a detailed diagnosis can be performed on the basis of plural elasticity images in the plaque **200**. In FIG. **11**, "ROI-A" is abbreviated as "A", and "ROI-" is omitted.

[0088] Furthermore, as shown in FIG. **12**, the first ROI setting unit **38** can set plural ROIs on the surface of the plaque **200**. For example, an operator specifies the outer frame of the plaque of the tomographic image by using the first ROI setting unit **38**. Accordingly, the first ROI setting unit **38** sets plural rectangular ROI-A to ROI-F along the specified outer frame of the plaque **200**. For example, the boundary between a place providing no blood flow signal and a place providing a blood flow signal is analyzed as the surface of the plaque **200** by using the Doppler signal, and ROI-A to ROI-F are set to the boundary. Accordingly, no ROI is set between the plaque **200** providing no blood flow signal and the wall providing no blood flow signal. That is, ROI is set on only the surface of the plaque **200**, and a detailed diagnosis based on plural elasticity images in the neighborhood of the surface of the plaque **200** can be performed. In FIG. **12**, for example, "ROI-A" is abbreviated as "A", and "ROI-" is omitted.

DESCRIPTION OF REFERENCE NUMERALS

[0089] **1** ultrasonic diagnostic apparatus, **10** examinee, **12** ultrasonic probe, **20** tomographic image constructing unit, **22** monochoromatic scan converter, **24** switching combining unit, image display unit, **28** RF frame data selecting unit, **30** displacement measuring unit, **32** elasticity information calculating unit, **33** elasticity information storing unit, **34** elasticity image constructing unit, **36** color scan converter, first ROI setting unit, **39** second ROI setting unit, **40** measurement area setting unit, **42** measurement calculating unit, **100** cine memory, **101** pressure measuring unit, **110** control unit

1. An ultrasonic diagnostic apparatus having a tomographic image constructing unit that constructs a tomographic image on the basis of a reflection echo signal received by an ultrasonic probe configured to transmit/receive ultrasonic waves to/from an examinee, an elasticity information calculating unit that calculates elasticity information at a tomographic site of the examinee on the basis of the reflection echo signal, an elasticity image constructing unit that constructs an elasticity image on the basis of the elasticity information; an image composite unit that generates a composite image comprising the tomographic image and the elasticity image, and an image display unit that displays the composite image, further comprising a freeze control unit configured to freeze the composite image and a region-of-interest setting unit that sets a region of interest on the frozen composite image, wherein the elasticity image constructing unit constructs the elasticity image on the basis of the elasticity information of the region of interest set by the region of interest setting unit.

2. The ultrasonic diagnostic apparatus according to claim **1**, further comprising an elasticity information storing unit that calculates and stores the elasticity information with respect to a calculation area of the region of interest set by the region-of-interest setting unit.

3. The ultrasonic diagnostic apparatus according to claim **1**, further comprising a composite image storing unit that stores the plural composite images time-sequentially, wherein the elasticity information storing unit stores the elasticity information corresponding to the plural composite images time-sequentially, and the freeze control unit causes the image display unit to display a composite image read out from the composite image storing unit and to freeze the displayed composite image.

4. The ultrasonic diagnostic apparatus according to claim **1**, wherein the region-of-interest image setting unit is configured to set a plurality of regions of interest on the frozen composite image, and the elasticity image constructing unit constructs elasticity images of the plurality of regions of interest based on the elasticity information of the plurality of regions of interest-set by the region-of-interest image setting unit and outputs the elasticity images to the image combining unit.

5. The ultrasonic diagnostic apparatus according to claim **1**, wherein the region-of-interest setting unit is configured to set a plurality of regions of interest on the frozen composite image, and the elasticity image constructing unit has a nor-

malization calculating unit that determines an average value of distortion information of all the plurality of regions of interest on the basis of the distortion information out of the elasticity information of the plurality of regions of interest set by the region-of-interest setting unit, constructs elasticity images of the plurality of regions of interest on the basis of the distortion information calculated by combining unit.

6. The ultrasonic diagnostic apparatus according to claim **1**, wherein the region-of-interest setting unit is configured to set a plurality of regions of interest on the frozen composite image, and has a measurement area setting unit that sets a measurement area on each of the plurality of regions of interest, and a measurement area calculating unit that calculates the ratio of the elasticity information among the measurement areas and displays the ratio on the image display unit.

7. The ultrasonic diagnostic apparatus according to claim **1**, wherein the region-of-interest setting unit sets the positions and/or sizes of the regions of interest.

8. The ultrasonic diagnostic apparatus according to claim **1**, wherein the region-of-interest setting unit additionally sets a new region of interest, and sets the region of interest.

9. The ultrasonic diagnostic apparatus according to claim **1**, wherein the composite image is a composite image in which the tomographic image and the elasticity image are displayed side by side or a composite image in which the tomographic image and the elasticity image are displayed in superimposition with each other.

* * * * *

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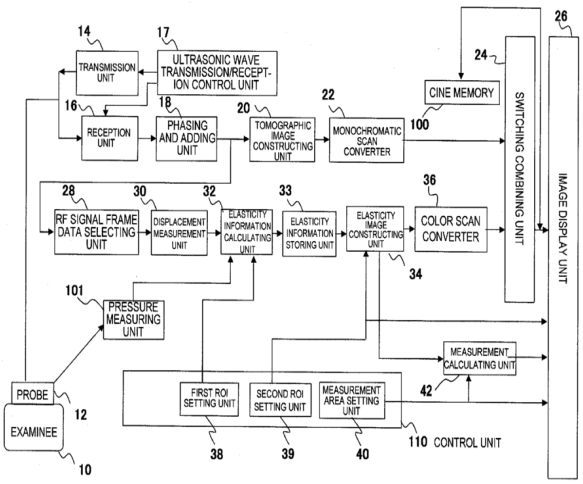
摘要(译)

即使当在冻结图像上改变感兴趣区域（ROI）时，也可以在不执行重新测量的情况下显示改变之后的ROI的弹性图像。超声诊断设备1具有控制单元110，控制单元110具有第一ROI设置单元38和第二ROI设置单元39.当ROI由控制单元110的第一ROI设置单元38设置时，弹性信息计算单元32设置在大于ROI的区域作为计算区域，计算与计算区域的断层图像上的每个测量点对应的组织的变形，弹性模量等，基于变形，弹性模量等生成弹性信息，并且弹性信息输出到弹性信息存储单元33.控制单元110在显示冻结图像的状态下通过第二ROI设置单元39改变ROI的位置/大小。弹性图像构建单元34从弹性信息存储单元33读取与改变的ROI对应的弹性信息，形成改变的ROI的弹性图像并将其显示在图像显示单元26上。