US 20100268084A1

(19) **United States**

(12) **Patent Application Publication**
(10) **Pub. No.: US 2010/0268084 A1**

Osaka et al.
(43) **Pub. Date: Oct. 21, 2010**

(54) **ULTRASONIC DIAGNOSTIC APPARATUS**

(76) Inventors: **Takashi Osaka**, Tokyo (JP); **Akiko Tonomura**, Tokyo (JP)

Correspondence Address:
ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET, SUITE 1800
ARLINGTON, VA 22209-3873 (US)

(21) Appl. No.: **12/741,405**

(22) PCT Filed: **Oct. 24, 2008**

(86) PCT No.: **PCT/JP2008/069346**

§ 371 (c)(1),
(2), (4) Date: **May 5, 2010**

(30) **Foreign Application Priority Data**

Nov. 6, 2007 (JP) 2007-288766

Publication Classification

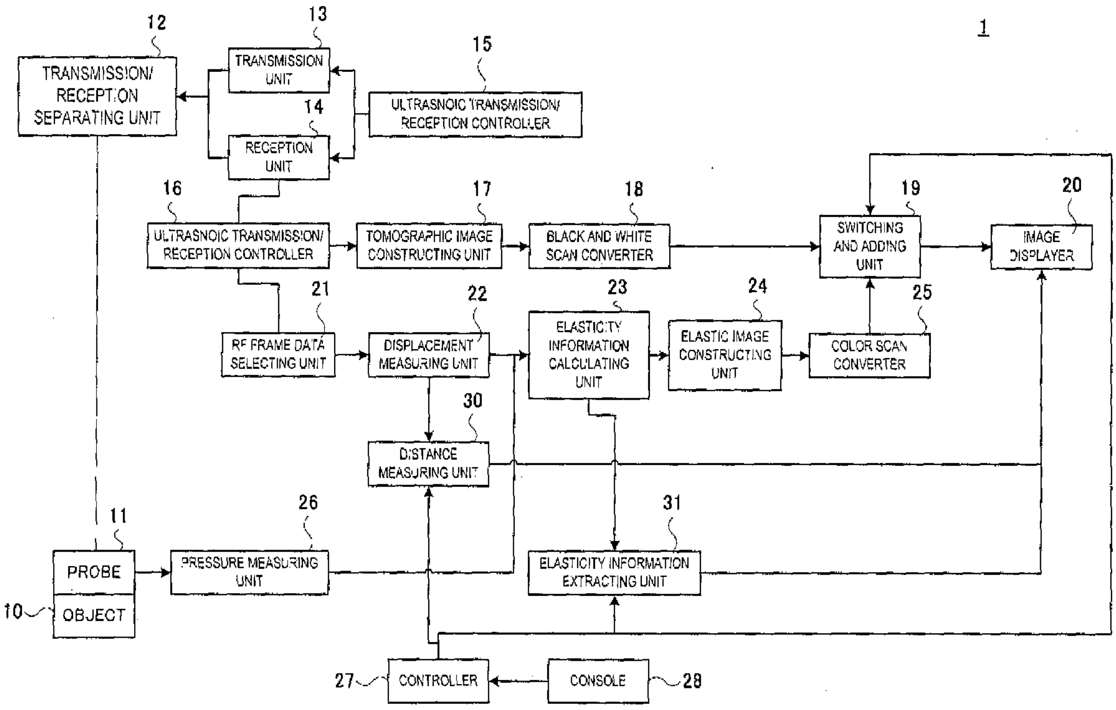
(51) **Int. Cl.**
A61B 8/00 (2006.01)

(52) **U.S. Cl.** **600/443**

(57) **ABSTRACT**

An ultrasonic diagnostic apparatus enabling accurate measurement of elasticity information is provided.

The ultrasonic diagnostic apparatus is characterized in comprising setting means configured to set a first movement reference point and a second movement reference point on a tomographic image and/or an elastic image, and measurement means configured to cause the first movement reference point and the second movement reference point to follow the pulsation of an object and to measure the length of a line segment formed by the first movement reference point and the second movement reference point, and causes display means to display the length of the line segment and elasticity information based on the strain and/or elastic modulus.



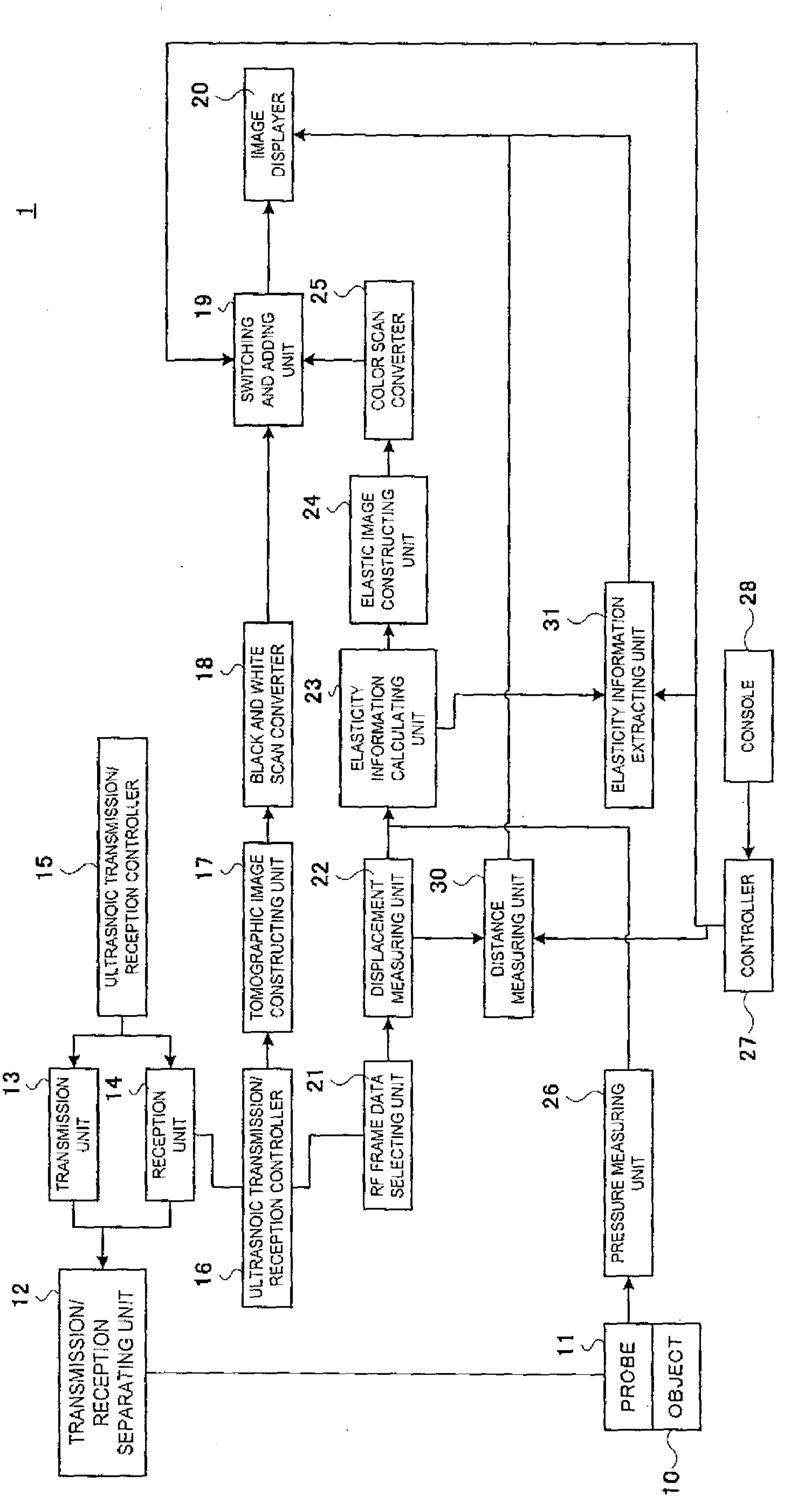

1
TRANSMISSION/ RECEPTION SEPARATING UNIT
12
TRANSMISSION UNIT
13
RECEPTION UNIT
14
ULTRASNOIC TRANSMISSION/ RECEPTION CONTROLLER
15
ULTRASNOIC TRANSMISSION/ RECEPTION CONTROLLER
16
TOMOGRAPHIC IMAGE CONSTRUCTING UNIT
17
BLACK AND WHITE SCAN CONVERTER
18
SWITCHING AND ADDING UNIT
19
IMAGE DISPLAYER
20
RF FRAME DATA SELECTING UNIT
21
DISPLACEMENT MEASURING UNIT
22
ELASTICITY INFORMATION CALCULATING UNIT
23
ELASTIC IMAGE CONSTRUCTING UNIT
24
COLOR SCAN CONVERTER
25
PRESSURE MEASURING UNIT
26
DISTANCE MEASURING UNIT
30
ELASTICITY INFORMATION EXTRACTING UNIT
31
PROBE
11
OBJECT
10
CONTROLLER
27
CONSOLE
28

FIG.1

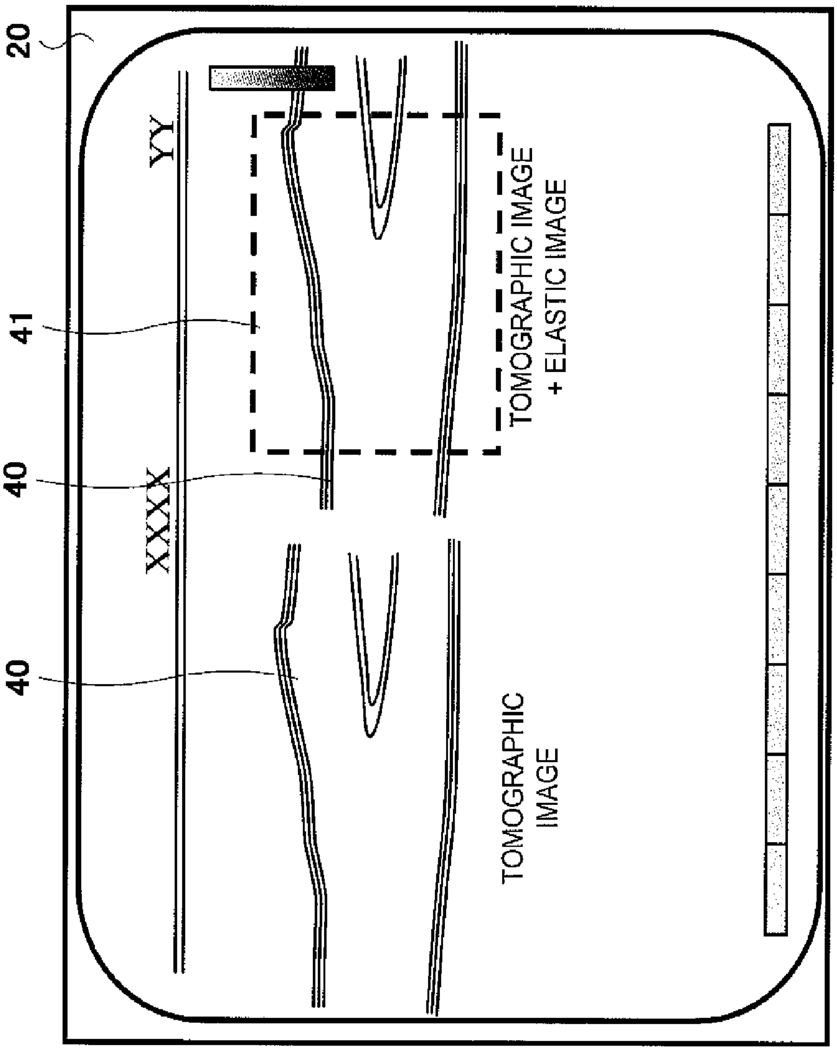
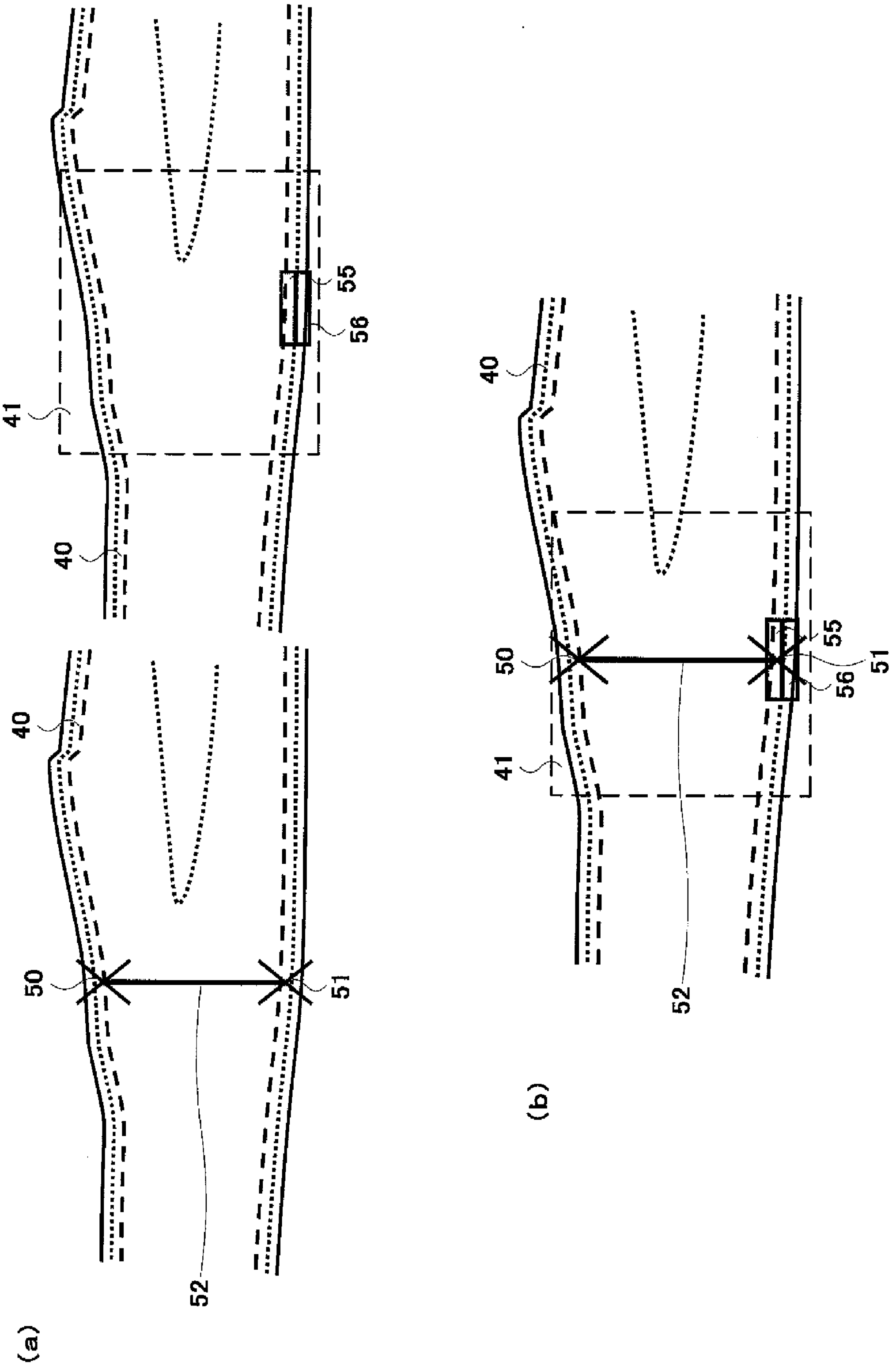

20
41
40
40
XXXX
YY
TOMOGRAPHIC IMAGE
+ ELASTIC IMAGE
TOMOGRAPHIC
IMAGE

FIG.2

FIG.3



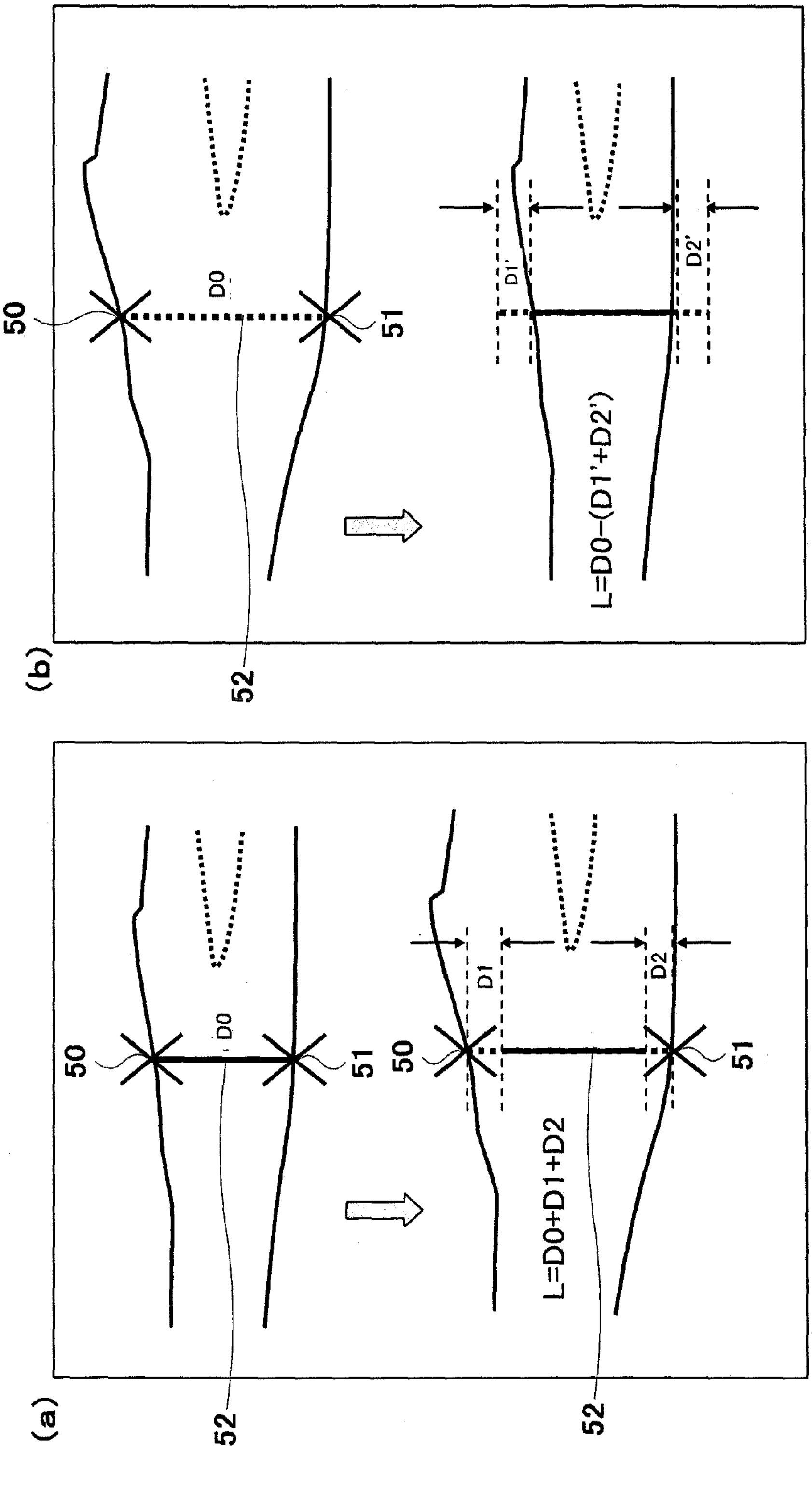


FIG.4

FIG.5

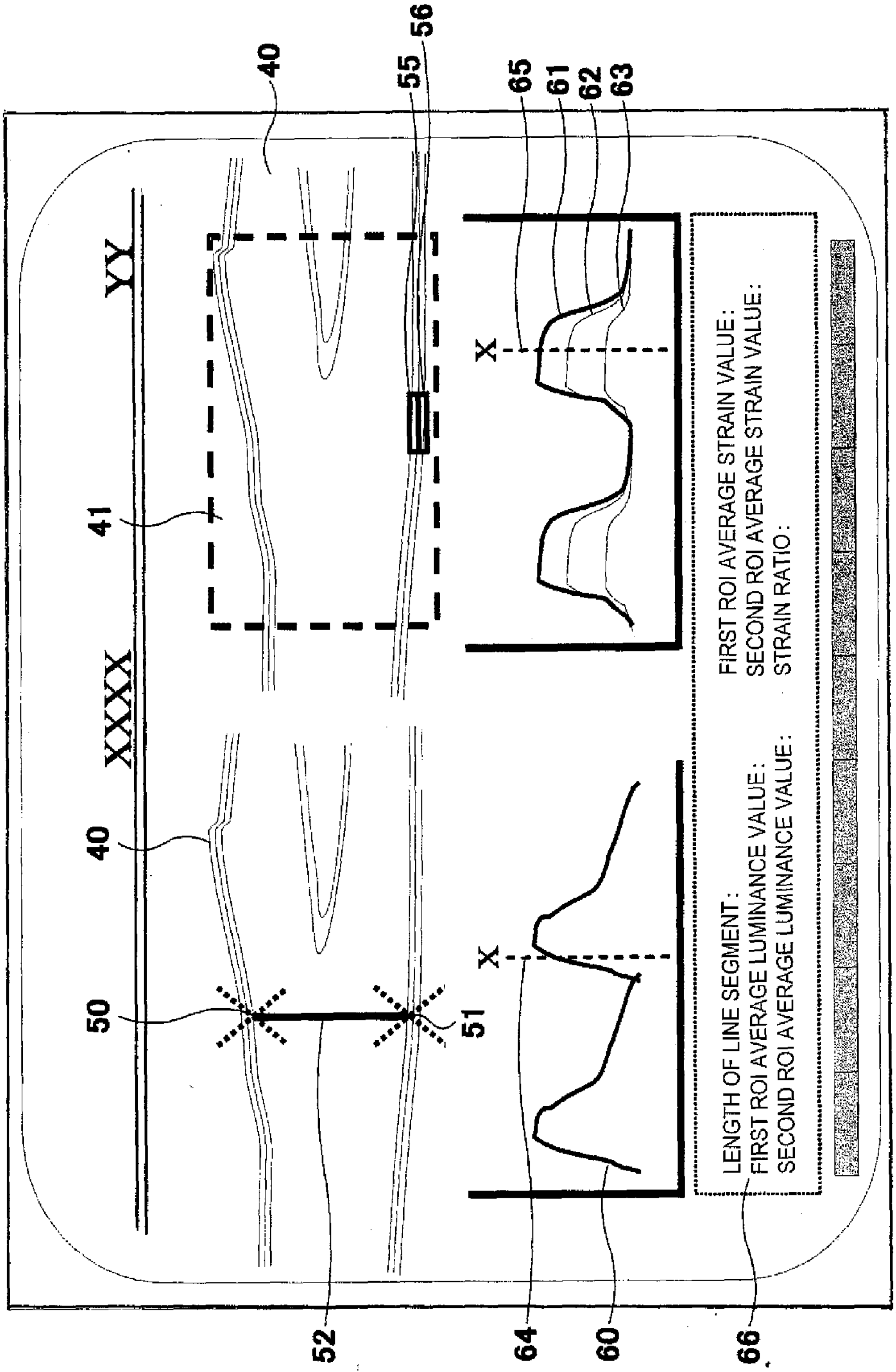

XXXXX
YY
40
41
50
51
52
55
56
60
61
62
63
64
65
66
X
X
LENGTH OF LINE SEGMENT :
FIRST ROI AVERAGE LUMINANCE VALUE :
SECOND ROI AVERAGE LUMINANCE VALUE :
FIRST ROI AVERAGE STRAIN VALUE :
SECOND ROI AVERAGE STRAIN VALUE :
STRAIN RATIO :

FIG.6

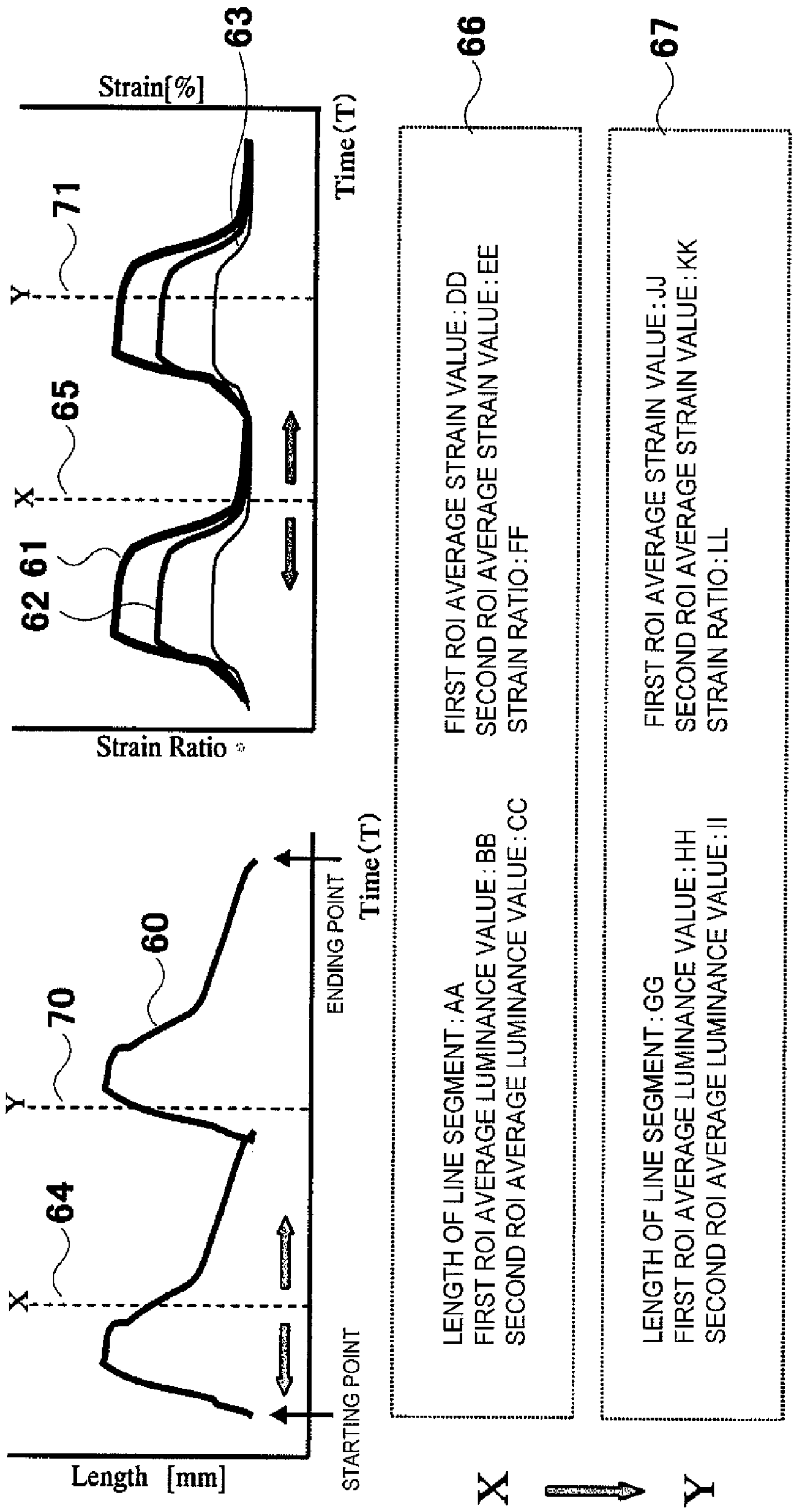
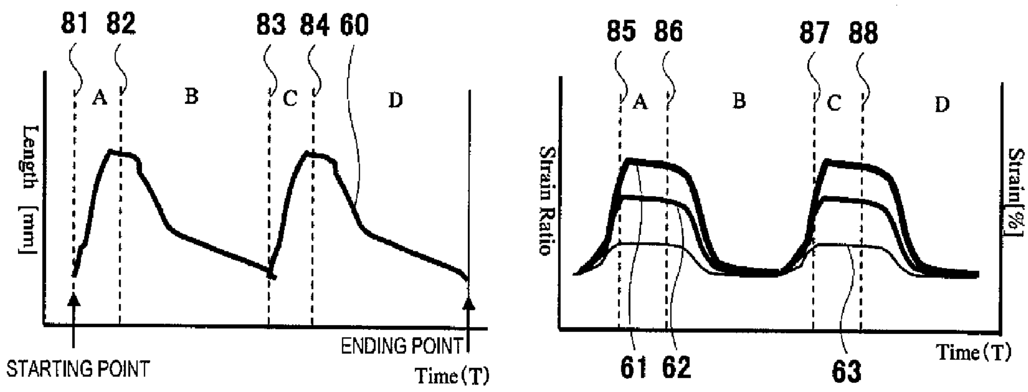

Length [mm]
STARTING POINT
ENDING POINT
Time (T)
X
Y
64
70
60
Strain[%]
Strain Ratio
Time (T)
X
Y
62 61
65
71
63
66
LENGTH OF LINE SEGMENT : AA
FIRST ROI AVERAGE LUMINANCE VALUE : BB
SECOND ROI AVERAGE LUMINANCE VALUE : CC
FIRST ROI AVERAGE STRAIN VALUE : DD
SECOND ROI AVERAGE STRAIN VALUE : EE
STRAIN RATIO : FF
67
LENGTH OF LINE SEGMENT : GG
FIRST ROI AVERAGE LUMINANCE VALUE : HH
SECOND ROI AVERAGE LUMINANCE VALUE : II
FIRST ROI AVERAGE STRAIN VALUE : JJ
SECOND ROI AVERAGE STRAIN VALUE : KK
STRAIN RATIO : LL
X
Y

FIG.7



A

LENGTH OF LINE SEGMENT: A1
FIRST ROI AVERAGE LUMINANCE VALUE: B1
SECOND ROI AVERAGE LUMINANCE VALUE: C1
FIRST ROI AVERAGE STRAIN VALUE: D1
SECOND ROI AVERAGE STRAIN VALUE: E1
STRAIN RATIO: F1
90

B

LENGTH OF LINE SEGMENT: A2
FIRST ROI AVERAGE LUMINANCE VALUE: B2
SECOND ROI AVERAGE LUMINANCE VALUE: C2
FIRST ROI AVERAGE STRAIN VALUE: D2
SECOND ROI AVERAGE STRAIN VALUE: E2
STRAIN RATIO: F2
91

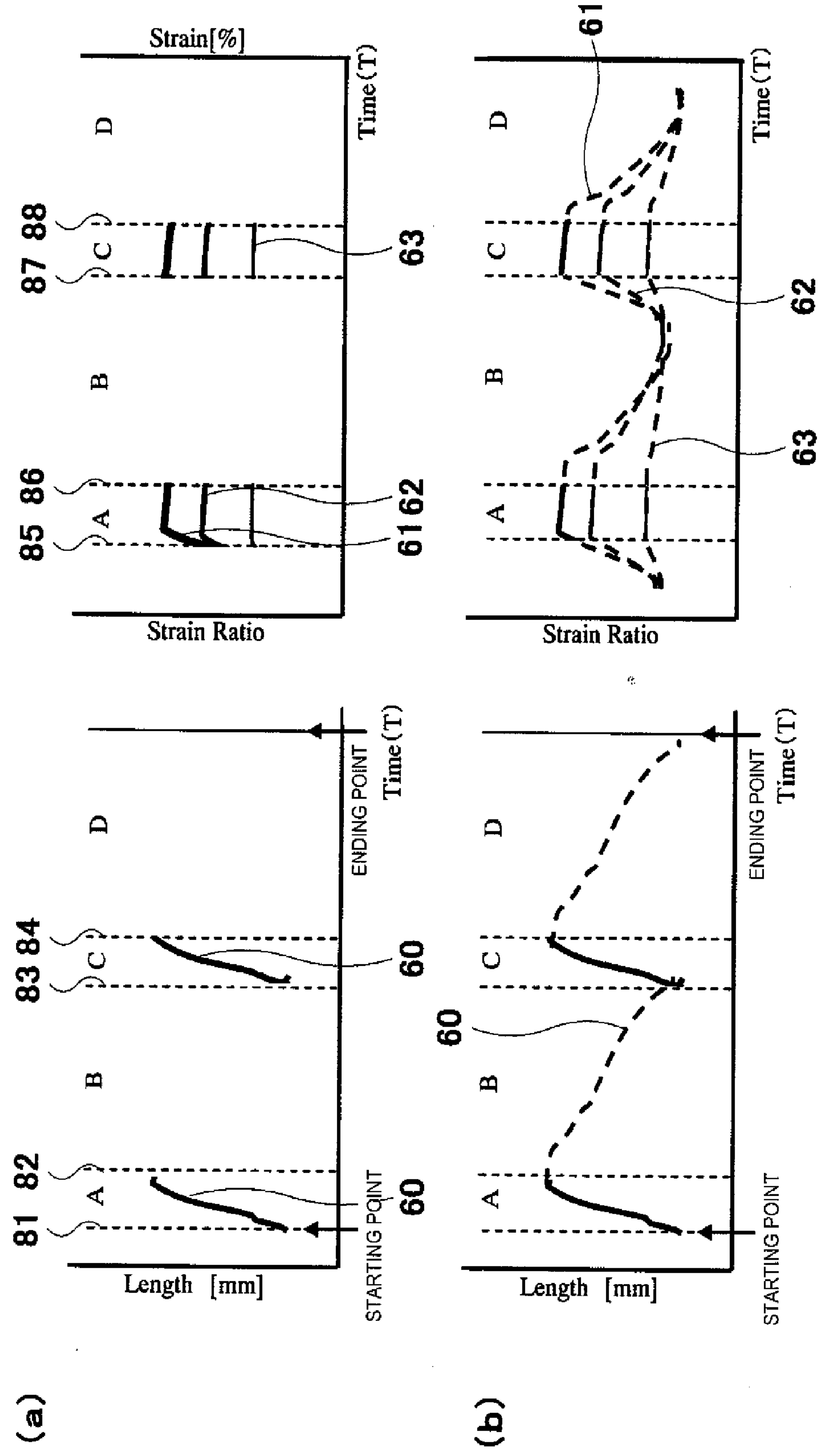
C

LENGTH OF LINE SEGMENT: A3
FIRST ROI AVERAGE LUMINANCE VALUE: B3
SECOND ROI AVERAGE LUMINANCE VALUE: C3
FIRST ROI AVERAGE STRAIN VALUE: D3
SECOND ROI AVERAGE STRAIN VALUE: E3
STRAIN RATIO: F3
92

D

LENGTH OF LINE SEGMENT: A4
FIRST ROI AVERAGE LUMINANCE VALUE: B4
SECOND ROI AVERAGE LUMINANCE VALUE: C4
FIRST ROI AVERAGE STRAIN VALUE: D4
SECOND ROI AVERAGE STRAIN VALUE: E4
STRAIN RATIO: F4
93

FIG.8


(a)
Length [mm]
Time (T)
STARTING POINT
ENDING POINT
A
B
C
D
81
82
83
84
60
Strain Ratio
Strain[%]
85
86
87
88
61
62
63
(b)
Length [mm]
Time (T)
STARTING POINT
ENDING POINT
60
Strain Ratio
61
62
63

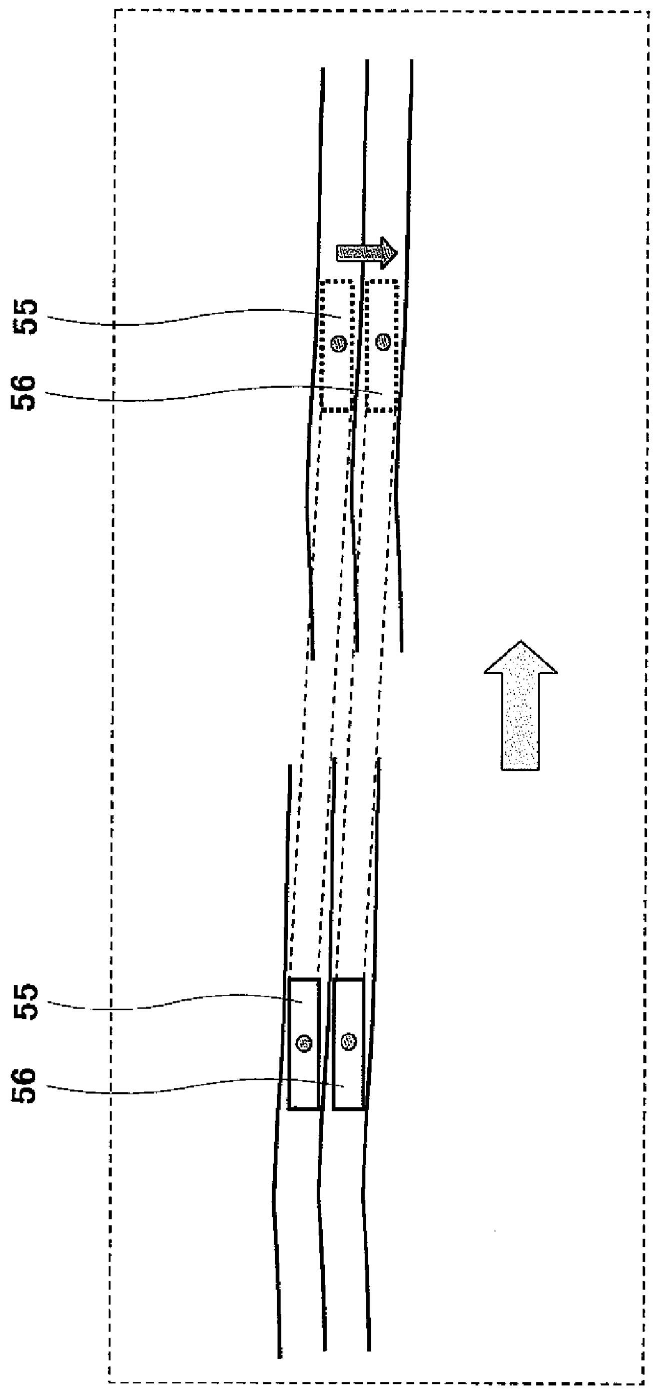


FIG.9

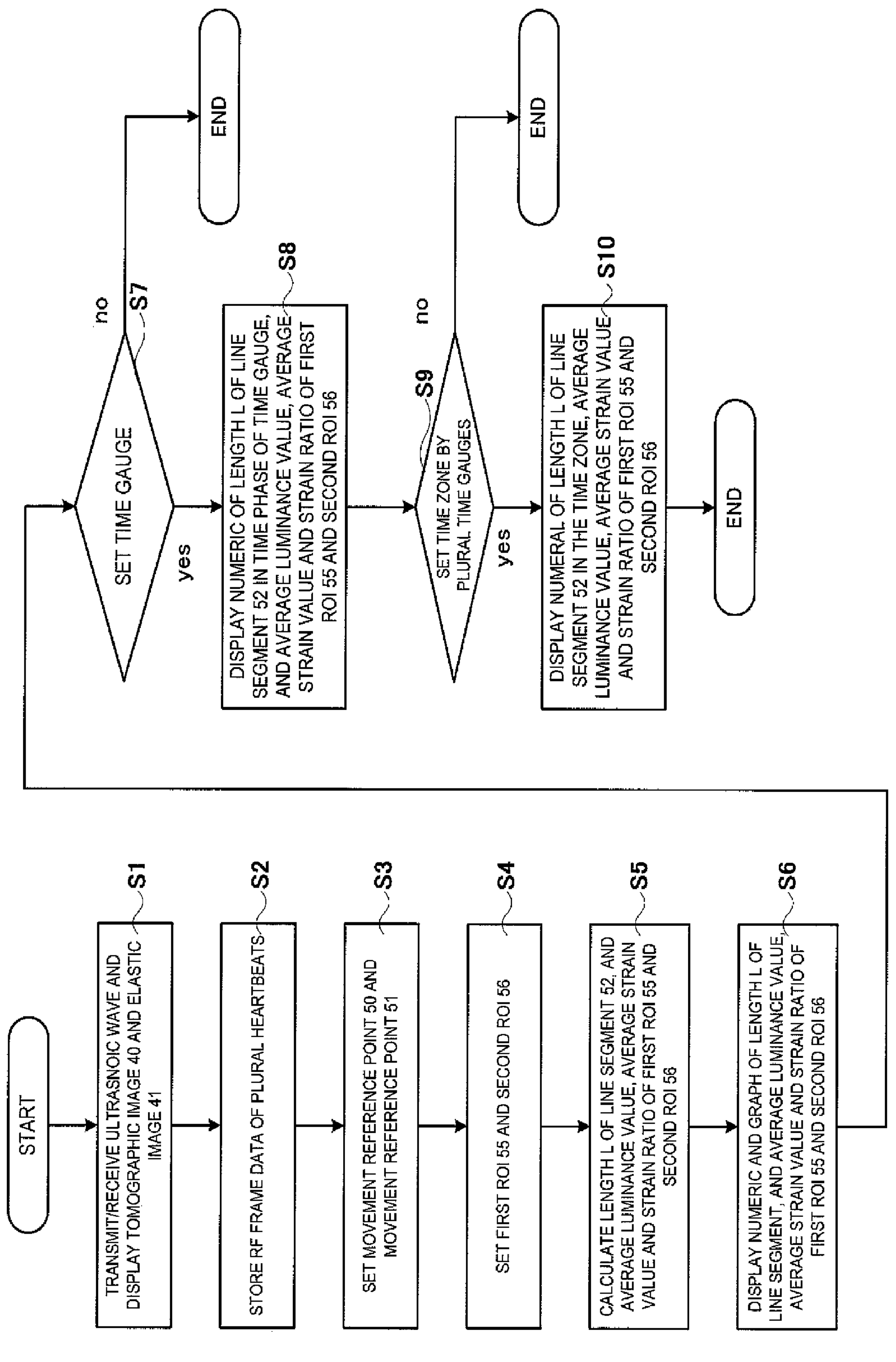

START
TRANSMIT/RECEIVE ULTRASNOIC WAVE AND DISPLAY TOMOGRAPHIC IMAGE 40 AND ELASTIC IMAGE 41
S1
STORE RF FRAME DATA OF PLURAL HEARTBEATS
S2
SET MOVEMENT REFERENCE POINT 50 AND MOVEMENT REFERENCE POINT 51
S3
SET FIRST ROI 55 AND SECOND ROI 56
S4
CALCULATE LENGTH L OF LINE SEGMENT 52, AND AVERAGE LUMINANCE VALUE, AVERAGE STRAIN VALUE AND STRAIN RATIO OF FIRST ROI 55 AND SECOND ROI 56
S5
DISPLAY NUMERIC AND GRAPH OF LENGTH L OF LINE SEGMENT, AND AVERAGE LUMINANCE VALUE, AVERAGE STRAIN VALUE AND STRAIN RATIO OF FIRST ROI 55 AND SECOND ROI 56
S6
SET TIME GAUGE
S7
no
yes
END
DISPLAY NUMERIC OF LENGTH L OF LINE SEGMENT 52 IN TIME PHASE OF TIME GAUGE, AND AVERAGE LUMINANCE VALUE, AVERAGE STRAIN VALUE AND STRAIN RATIO OF FIRST ROI 55 AND SECOND ROI 56
S8
SET TIME ZONE BY PLURAL TIME GAUGES
S9
no
yes
END
DISPLAY NUMERAL OF LENGTH L OF LINE SEGMENT 52 IN THE TIME ZONE, AVERAGE LUMINANCE VALUE, AVERAGE STRAIN VALUE AND STRAIN RATIO OF FIRST ROI 55 AND SECOND ROI 56
S10
END

FIG.10

ULTRASONIC DIAGNOSTIC APPARATUS

TECHNICAL FIELD

[0001] The present invention is related to the ultrasonic diagnostic apparatus that displays tomographic images or elastic images which represents hardness or softness of biological tissues by transmitting/receiving ultrasonic waves to/from an imaging target in an object to be examined.

BACKGROUND ART

[0002] Ultrasonic diagnostic apparatuses transmit an ultrasonic wave to an object to be examined using an ultrasonic probe and receive from the object the reflected echo signal of the ultrasonic wave in accordance with the constitution of the biological tissues, so as to construct and display, for example, a tomographic image.

[0003] In recent years, a technique has been disclosed that measures an ultrasonic reception signal by compressing the object by an ultrasonic probe using manual or mechanical method, acquiring the displacement in the respective regions of the biological tissues generated by the compression based on RF frame data of two ultrasonic reception signals having different measurement times, and generates an elastic image representing elasticity information of the biological tissues based on the displacement data. Also, the technique detects the movement of the biological tissue by electrocardiographic waveforms, reads out the RF frame data of movement of the biological tissue based on the reference time phase, and generates an elastic image (for example, Patent Document 1).

[0004] Patent Document 1: WO2006/132203

DISCLOSURE OF THE INVENTION

Problems to be Solved

[0005] In Patent Document 1, since the R-wave of electrocardiographic waveform by the heart of an object is set as the reference point and the RF frame data in the time phase which is displaced for a predetermined time phase from the reference point is read out, there is a possibility that the displacement of the time phase for reading out the RF frame data is caused depending on the object. In such cases, it is impossible to control the compression, or to execute accurate measurement of elasticity information under a specific compression which repeats precipitous application of pressure and moderate reduction of pressure on a periodic basis.

[0006] The objective of the present invention is to execute measurement of elasticity information accurately.

Means to Solve the Problem

[0007] In order to achieve the objective of the present invention, the ultrasonic diagnostic apparatus comprising:

[0008] an ultrasonic probe,

[0009] tomographic image constructing means configured to generate a tomographic image based on the RF frame data of a cross-sectional region of an object to be examined obtained by the ultrasonic probe;

[0010] elasticity information calculating means configured to obtain strain and/or elasticity modulus of tissues in the cross-section region based on the RF frame data;

[0011] elastic image constructing means configured to generate an elastic image in the cross-section region based on the strain and/or the elasticity modulus obtained by the elasticity information calculating means; and

[0012] display means configured to display the tomographic image or the elastic image,

[0013] characterized in further comprising:

[0014] setting means configured to set a first movement reference point and a second movement reference point on the tomogrpahic image or the elastic image; and

[0015] measuring means configured to cause the first movement reference point and the second movement reference point to follow the pulsation of the object and to measure the length of a line segment formed by the first movement reference point and the second movement reference point,

[0016] and causes display means to display the length of the line segment and elastic information based on the strain and/or the elasticity modulus.

[0017] The setting means sets a region of interest in the vicinity of the first movement reference point or the second movement reference point, and causes display means to display the elasticity information within the region of interest.

[0018] The elasticity information is the average strain value within the region interest. The elasticity information is the strain ratio between the two regions of interest.

[0019] The display means displays a time series graph based on the length of the line segment and/or the elasticity information. The display means displays a time gauge indicating the time phase on the time series graph.

[0020] The measurement means measures the length of the line segment or the elasticity information in a predetermined time zone.

[0021] The display means changes the display pattern of the elastic image based on the variation information of the length of the line segment. Also, the display means changes the display pattern of the time series graph based on the variation information of the length of the line segment.

[0022] Further, the setting means modifies the setting position of the region of interest in accordance with the pressure.

EFFECT OF THE INVENTION

[0023] In accordance with the present invention, it is possible to execute accurate measurement of elasticity information.

BRIEF DESCRIPTION OF THE DIAGRAMS

[0024] FIG. **1** is a configuration block diagram of the present invention.

[0025] FIG. **2** is the display example of image display unit **20** related to the present invention.

[0026] FIG. **3** shows the first embodiment of the present invention.

[0027] FIG. **4** shows the first embodiment of the present invention.

[0028] FIG. **5** shows the first embodiment and the fourth embodiment of the present invention.

[0029] FIG. **6** shows the first embodiment, the second embodiment and the sixth embodiment of the present invention.

[0030] FIG. **7** shows the third embodiment and the fourth embodiment of the present invention.

[0031] FIG. **8** shows the fifth embodiment of the present invention.

[0032] FIG. **9** shows the sixth embodiment of the present invention.

[0033] FIG. **10** shows an operation procedure of the present invention.

DESCRIPTION OF THE REFERENCE NUMERALS

[0034] **10**: object, **11**: probe, **12**: transmission/reception separating unit, **13**: transmission unit, **14**: reception unit, **15**: ultrasonic transmission/reception controller, **16**: phasing and adding unit, **17**: tomographic image constructing unit, **18**: black and white scan converter, **19**: switching and adding unit, **20**: image display unit, **21**: RF frame data selecting unit, **22**: displacement measuring unit, **23**: elasticity information calculating unit, **24**: elastic image constructing unit, **25**: color scan converter, **26**: pressure measurement unit, **27**: controller, **28**: console, **30**: distance measuring unit, **31**: elasticity information extracting unit

BEST MODE FOR CARRYING OUT THE INVENTION

[0035] Ultrasonic diagnostic apparatus **1** to which the present invention is applied will be described referring to FIG. **1**. FIG. **1** is a block diagram showing components of ultrasonic diagnostic apparatus **1** to which the present invention is applied.

[0036] As shown in FIG. **1**, ultrasonic diagnostic apparatus **1** comprises:

[0037] ultrasonic probe **11** configured to use by applying to object **10**;

[0038] transmission unit **13** configured to repeatedly transmit ultrasonic waves to object **10** at time intervals via ultrasonic probe **11**;

[0039] reception unit **14** configured to receive time-series reflected echo signals produced from object **10**;

[0040] transmission/reception separating unit **12** configured to separate ultrasonic waves for transmission and reflected echoes;

[0041] ultrasonic transmission/reception controller **15** configured to control transmission unit **13** and reception unit **14**; and

[0042] phasing and adding means **16** configured to phase and add the reflected echoes received in reception unit **14**.

[0043] It also comprises:

[0044] tomographic image constructing unit **17** configured to construct a grayscale tomographic image, for example, black and white tomographic image of object **10** based on the RF frame data from phasing and adding unit **16**; and

[0045] black and white scan converter **18** configured to convert the output signals from tomographic constructing unit **17** so as to match the output signals to display of image display unit **20**.

[0046] Further, it comprises:

[0047] RF frame data selecting unit **21** configured to store the RF frame data outputted from phasing and adding unit **16**, and to select at least two sets of RF frame data;

[0048] displacement measuring unit **22** configured to measure the displacement of biological tissues of object **10** from the selected RF frame data;

[0049] elasticity information calculating unit **23** configured to acquire elasticity information such as strain or elasticity modulus from displacement information measured by displacement measuring unit **22**;

[0050] elastic image constructing unit **24** configured to construct a color elastic image from the strain or elasticity modulus calculated by elasticity information calculating unit **23**;

[0051] color scan converter **25** configured to convert the output signals of elastic image constructing unit **24** to make them match the display of image display unit **20**;

[0052] switching and adding unit **19** configured to overlap, juxtapose or switch a black and white tomographic image and a color elastic image; and

[0053] image display unit **20** configured to display the composite image.

[0054] Also, it comprises:

[0055] distance measuring unit **30** configured to measure the distance in the reference points being set using the displacement information calculated by displacement measuring unit **22**, and to cause image display unit **20** to display the distance;

[0056] elasticity information extracting unit **31** configured to extract elasticity information in the set region of interest, and to cause image display unit **20** to display the extracted elasticity information; and

[0057] pressure measuring unit **26** configured to measure the pressure condition of the surface of ultrasonic probe **11**.

[0058] Ultrasonic diagnostic apparatus **1** of the present invention will be described below in detail. Ultrasonic probe **11** is formed by arranging a plurality of transducers, and has the function to transmit/receive ultrasonic waves to/from object **10** via the transducers. Transmission unit **13** has the function to generate a transmission pulse for generating an ultrasonic wave by driving ultrasonic probe **11**, and to set the convergent point of the transmitted ultrasonic wave at a certain depth. Also, reception unit **14** amplifies the reflected echo signal received by ultrasonic probe **11** by a predetermined gain so as to generate an RF signal, i.e. reception signal. Transmission/reception separating unit **12** has the switching function for switching circuits for transmitting an ultrasonic wave generated by transmission unit **13** and outputting the reflected echo from object **10** to reception unit **14**. Ultrasonic transmission/reception controller **15** controls transmission unit **13** and reception unit **14**.

[0059] Phasing and adding unit **16** inputs, phases and adds the RF signals amplified in reception unit **14** so as to generate RF frame data by forming ultrasonic beams with respect to one or more convergent points.

[0060] Tomographic image constructing unit **17** executes signal processing such as gain compensation, log compression, detection, edge enhancement or filtering by inputting the RF frame data from phasing and adding unit **16**, so as to obtain tomographic image data. Also, black and white scan converter **18** is configured including an A/D converter for converting the tomographic image data from tomographic image constructing unit into digital signals, a frame memory for storing the converted plurality of tomographic image data in time series, and a controller. The black and white scan converter **18** obtains the tomographic image data of object **10** stored in the frame memory as one image, and reads out the obtained tomographic image data by TV synchronous.

[0061] RF frame data selecting unit **21** stores the plurality of RF frame data from phasing and adding unit **16**, and selects a pair of, i.e. two sets of RF frame data from among a group of stored RF frame data.

[0062] RF frame data selecting unit **21** is formed by a frame memory and a frame selector unit. The frame memory stores/

updates the RF frame data for a given length of time (for example, for two heartbeats) in time series. The frame selector unit selects two frames that are most suitable for generating an elastic image from among the stored RF frame data, and outputs them to displacement measuring unit **22** in the subsequent stage. For example, the RF frame data generated from phasing and adding unit **16** based on the time series, i.e. frame rate of the image is sequentially stored in the frame memory, the stored RF frame data (N) is selected in the frame selector unit as a first data, and one RF frame data (X) is selected by the frame selector unit from among RF frame data group (N-1, N-2, N-3 . . . , N-M) which is temporally stored in the past. Here, N, M and X are index numbers appended to the RF frame data, and are natural numbers.

[0063] Then displacement measuring unit **22** executes one-dimensional or 2-dimensional correlation process from a selected pair of RF frame data, i.e. RF frame data (N) and RF frame data (X), and obtains the displacement or a movement vector, i.e. one-dimensional or two-dimensional displacement distribution in relation to the direction and the size of displacement in the biological tissue corresponding to the respective points on the tomographic image. Here, the block matching method is used for detecting the moving vector. The block matching method divides an image into blocks formed by, for example, N×N pixels, focusing on the block within a region of interest, searches for the block most approximate to the focusing block from the previous frame, and executes predictive coding, i.e. the process for determining the sample value by the difference referring to the searched block.

[0064] Elasticity information calculating unit **23** calculates strain or elasticity modulus of the biological tissue corresponding to the respective points on a tomographic image from the measurement value such as moving vector outputted from displacement measuring unit **22** and pressure value outputted from pressure measuring unit **26**, and generates elasticity frame data based on the calculated strain or the elasticity modulus.

[0065] At this time, the strain is calculated by performing special differentiation on the moving distance, for example, the displacement of the biological tissue. Also, elasticity modulus is calculated by dividing the variation of pressure by the variation of displacement. For example, when the displacement measured by displacement measuring unit **22** is set as L(X) and the pressure measured by pressure measuring unit **26** is set as P(X), since strain ΔS(X) can be calculated by performing special differentiation on L(X), the formula to obtain the strain will be $\Delta S(X)=\Delta L(X)/(X)$. Also, Young's modulus YM(X) of elasticity modulus data can be calculated by $YM=(\Delta P(X))/\Delta S(X)$. Since the elasticity modulus of the biological tissue equivalent to the respective points on the tomographic image can be acquired from this Young's modulus YM, two-dimensional elastic image data can be continuously obtained. The Young's modulus is the ratio between the simple tension stress added to a substance and the strain generated in parallel to the tension.

[0066] Elastic image construction unit **24** executes normalization process or averaging process on the calculated elasticity frame data so as to facilitate stable generation of the continuously calculated elastic images.

[0067] Color scan converter **25** has a function to append hue information on elasticity frame data from elastic image construction unit **24**. That is, it converts elasticity data into light's three primary colors that are red (R), green (C) and blue (B). For example, the elasticity data having large strain is converted into red code, and the elasticity data having small strain is converted into blue code.

[0068] Switching and adding unit **19** comprises therein a frame memory, an image processing unit and an image selecting unit. The frame memory stores tomographic image data outputted from black and white scan converter **18** and elastic image data outputted from color scan converter **25**. The image processing unit synthesizes the tomographic image data stored in the frame memory and the elastic image data by modifying their synthesis ratio. The luminance information and hue information of the respective pixels of the synthetic image consist of the addition of information from each of the black and white tomographic image and the color elastic image using the synthesis ratio.

[0069] Further, the image selecting unit selects the image to be displayed on image display unit **20** from among the tomographic image data and elastic image data in the frame memory and the synthetic image data (elastic image data+tomographic image data) in the image processing unit.

[0070] As an example of the image to be displayed on image display unit **20**, the long axis view upon imaging a carotid artery is shown in FIG. **2**. The left part on the same diagram shows tomographic image **40**. Also, the right part thereof shows the synthetic image of elastic image **41** and tomographic image **40**.

[0071] Here, the first embodiment of the present invention will be described referring to FIG. **3**~FIG. **6**.

[0072] Distance measuring unit **30** sets the length L (the length between the arterial walls) of line segment **52** formed by the two movement reference point **50** and movement reference point **51** being set on a tomographic image or elastic image on image display unit using console **28** as initial length D**0**, and measures the length L of line segment **52** based on displacement D**1**, D**2**, D**1'** and D**2'** of movement reference point **50** and movement reference point **51** measured by displacement measuring unit **22**.

[0073] In concrete terms, as shown in FIG. **3** and FIG. **4**, movement reference point **50** and movement reference point **51** are set using console **28** on the arterial wall of a carotid artery displayed by tomographic image **40**. Here, in order to capture the movement of the arterial wall due to pulsation of the carotid artery, movement reference point **50** and movement reference point **51** are set on the arterial wall of the carotid artery to be facing each other. That is, line segment **52** formed by movement reference point **50** and movement reference point **51** is the same as the diameter of the carotid artery.

[0074] Then distance measuring means **18** calculates the distance in movement reference point **50** and movement reference point **51** using the method such as above-described block matching method. Distance measuring means **18** focuses on a block within the region of interest centering on movement reference point **50** and movement reference point **51**, searches for the block which is most approximated to the focused block from the previous tomographic image data or elastic image data, determines the sample value referring to the searched block using predictive coding, i.e. difference, and measures the distance of movement reference point **50** and movement reference point **51**.

[0075] Then as shown in FIG. **4**, distance measuring means **18** adds or subtracts the measured distances D**1**, D**2**, D**1'** and D**2'** with respect to initial length D**0**. When the carotid artery is expanded in an expansion period, i.e. movement reference point **50** is moved upward and movement reference point **51**

is moved downward, distance measuring means **18** adds distance D**1** and D**2** to initial length D**0** and calculates length L of line segment **52** as the following formula.

$$D=D0+D1+D2 \quad \{\text{Formula 1}\}$$

[0076] Also, when the carotid artery is contracted in a contraction period, i.e. movement reference point **50** is moved downward and movement reference point **51** is moved upward, distance measuring means **18** subtracts distance D**1**' and D**2**' from initial length D**0** and calculates length L of line segment **52** as the following formula.

$$D=D0-D1'-D2' \quad \{\text{Formula 2}\}$$

[0077] Distance measuring means **18** repeats these calculations, and continuously calculates the length L of line segment **52** for a given length of time (for example, for 2 heartbeats).

[0078] Controller **27** may be configured so that movement reference point **50** and movement reference point **51** are set automatically using luminance information or Doppler information of tomographic image **40**. For example, controller **27** sets movement reference point **50** at a place which is a part of the region extending in the lateral direction having high luminance within the region of interest on elastic image **41**, where there is no Doppler signal. Then controller **27** sets movement reference point **51** at the place downward from movement reference point **50** which has high luminance.

[0079] Also, controller **27** may be configured to set movement reference point **50** and movement reference point **51** along the compression direction of ultrasonic probe **11**.

[0080] Also, it may be configured, for example, to set first ROI **55** and second ROI **56** to be adjacent to the tunica interna and tunica externa of a carotid artery via console **28**. At this time, first ROI **55** and second ROI **56** are set in the vicinity of the place where movement reference point **51** is being set. For example, first ROI **55** and second ROI **56** are set so that movement reference point **51** is set on the tangent line of first ROI **55** and second ROI **56**.

[0081] Elasticity information extracting unit **31** extracts elasticity information of first ROI **55** and second ROI **56**. Elasticity information extracting unit **31** performs adding and averaging on the strain in the respective coordinates of first ROI **55** and calculates the average strain in first ROI **55**. Also, elasticity information extracting unit **31** performs adding and averaging on the strain in the respective coordinates of second ROI **56** and calculates the average strain in second ROI **56**.

[0082] Also, elastic information extracting unit **31** calculates the strain ratio of first ROI **55** with respect to second ROI **56** based on the average strain value in first ROI **55** and the average strain value in second ROI **56**. That is, it calculates the strain ratio of the tunica interna with respect to the tunica externa. Also, it calculates the average luminance value of first ROI **55** and second ROI **56** from the black and white tomographic image data constructed in tomographic image constructing unit **17**. Upon calculating the strain ratio, however, first ROI **55** and second ROI **56** may be reversed.

[0083] The average luminance value, the average strain value and the strain ratio extracted by elasticity information extracting unit **31** are displayed on image display unit **20**.

[0084] As shown in FIG. **5**, time sequence graph **60** of length L in line segment **52** formed by movement reference point **50** and movement reference point **51** is displayed in the middle part of image display unit **20**. By the display of time series graph **60** of length L in line segment **52**, it is possible to recognize what time zones are in an expansion period or in an extraction period of the carotid artery. When the length of length L of line segment **52** formed by movement reference point **50** and movement reference point **51** is long, the diameter of the short-axis view of the carotid artery is large. Therefore, the carotid artery is in the expanded state. Also, when the length of length L of line segment **52** formed by movement reference point **50** and movement reference point **51** is short, the diameter of the short-axis view of the carotid artery is small. Therefore, the carotid artery is in the contracted state.

[0085] Time series graph **60**, when the arterial wall is in normal condition, shows the waveform characterized in having precipitous rising edge and moderate trailing edge, resembling blood pressure waveform closely. Since the characteristic often varies depending on illness, there are cases that the condition of illness can be confirmed from the measured waveform.

[0086] Also, in the middle part of image display unit **20**, time series graph **61** indicating the average strain value in first ROI **55**, time series graph **62** indicating the average strain value in second ROI **56** and time series graph **63** indicating the strain ratio are displayed. In the same manner, the time series graphs of the average luminance value can be displayed on image display unit **20**. Here, from the starting-point to the ending-point is shown for the portion of two heartbeats.

[0087] With respect to the displayed time series graph, time gauges are set via console **28**. Length L of line segment **52** formed by movement reference point **50** and movement reference point **51** in X-time phase of time gauge **64** being set on tomographic image **40** is displayed by a numerical value in lower part **66** of image display unit **20**. Also, the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** in time gauge **65** which is in the same phase (X-time phase) as time gauge **64** are displayed by numerical values in the lower part **66**.

[0088] The time zone that a carotid artery expands is the time zone that pressure is added to an arterial wall. Therefore, an operator can refer to the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** while confirming whether the carotid artery is in the expansion time zone or in the contraction time zone, whereby making it possible to measure elastic information accurately.

[0089] The second embodiment will be described referring to FIG. **6**. The difference from the first embodiment is that time gauges can be set manually.

[0090] In the case of setting time gauge **64** in manual mode, an operator slides time gauge **64** to the left or to the right via console **28**. Then controller **27** causes time gauge **64** to be slid based on the input information. For example, the operator sets time gauge **64** in the time zone that the carotid artery expands and the compression is added properly.

[0091] Also, controller **27** slides time gauge **65** to make it be in the same time phase as time gauge **64** which has been slid, in time series graph **61** indicating the average strain value in first ROI **55**, time series graph **62** indicating the average strain value in second ROI **56** and time series graph **63** indicating the strain ratio.

[0092] Elasticity information extracting unit **31** displays on the lower part **66** the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** corresponding to the time phase of time gauge **64** and time gauge **65** which have been slid.

[0093] While time gauge **64** is set by manual mode via console **28** above, time gauge **64** can be set also by automatic mode. In concrete terms, controller **27** performs differentiation on the waveform of time series graph **60** of length L of line segment **52** formed by movement reference point **50** and movement reference point **51**. When the slope (differential value) rises, it is in the time zone of an expansion period and the compression is applied properly. Controller **27** slides time gauge **64** so that the time gauge **64** is set in the time zone where the slope (differential value) rises. Controller **27** slides time gauge **65** to left and right to make it to be set in the same time phase as time gauge **64**. In this manner, it is possible to set time gauge **64** and time gauge **65** in the time zone wherein compression is applied properly.

[0094] As shown in FIG. **6**, the waveforms in time series graph **60** consist of a time zone where the slope (differential value) rises upward from left to right and a time zone where the slope (differential value) descends downward from left to right, and these time zones exist alternately. Also, alternate time zones wherein the slope (differential value) rises and descends continue to exist for a given length of time. Since the timing when the slope (differential value) varies from upward to downward is somewhat influenced by a factor such as noise, controller **27** slides, for example, time gauge **64** to be set near the center of the time zone where the slope (differential value) rises, as shown in time gauge **64** of FIG. **5**. Then controller **27** slides time gauge **65** to the left or right to be in the same time phase as time gauge **64**.

[0095] Also, a plurality of time gauges may also be set. As shown in FIG. **6**, time gauge **70** in addition to time gauge **64** is set via console **28**. Length L of line segment **52**, in time phase Y of time gauge **70**, formed by movement reference point **50** and movement reference point **51** is displayed by a numerical value in lower part **67** of image display unit **20**. Also, the average luminance value, the average strain value and the strain ratio in first ROI **55** and second ROI **56** of time gauge **71** which is in the same time phase as time gauge **65** (time phase Y) are displayed in numerical values in lower part **67**, whereby making it possible to measure the elasticity information accurately.

[0096] For example, by setting time gauge **64** (time gauge **65**) and time gauge **70** (time gauge **71**) when the carotid artery is expanded by the above-mentioned manual mode or automatic mode, it is possible to perform comparison in relation to the length L of line segment **52**, the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** in time phase X and time phase Y.

[0097] For example, length L of line segment **52**, the average luminance value, the average strain value and the strain ratio in time phase X and time phase Y being set in the expansion period of the carotid artery are the same, it means that the values in the both phases are reliable. While two time gauges (two time phases) are set in the example above, more than two time gauges (time phases) may be set.

[0098] Next, the third embodiment will be described referring to FIG. **7**. The difference from the first and second embodiments is that the average luminance value, the average strain value and the strain ratio of length L of line segment **52**, first ROI **55** and second ROI **56** are measured in a predetermined time zone.

[0099] Controller **27** sets time gauge **81** and time gauge **83** at the timing when the slope of a waveform (differential value) of time series graph **60** changes from downward to upward (local minimum value). Also, controller **27** sets time gauge **82** and time gauge **84** at the timing when the slope of a waveform (differential value) of time series graph **60** changes from upward to downward (local maximum value). Time gauge **81**~time gauge **84** are respectively set in the time series order.

[0100] Controller **27** sets time gauge **85** which is in the same time phase as time gauge **81** in time series graph **61** of the average strain value in first ROI **55**, time series graph **62** of the average strain graph in second ROI **56** and time series graph **63** of the strain ratio. In the same manner, time gauge **86** which is in the same time phase as time gauge **82**, time gauge **87** which is in the same time phase as time gauge **83** and time gauge **88** which is in the same time phase as time gauge **84** are set by controller **27**.

[0101] Here, the time zone sandwiched between time gauge **81** and time gauge **82** is set as time zone A, the time zone sandwiched between time gauge **82** and time gauge **83** is set as time zone B, the time zone sandwiched between time gauge **83** and time gauge **84** is set as time zone C, and the time zone in the time phase after time gauge **84** is set as time zone D. The carotid artery expands in time zone A and time zone C, and the carotid artery contracts in time zone B and time zone D.

[0102] Elasticity information extracting unit **31** displays the measurement value calculated by dividing the cumulative value of length L of line segment **52**, the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** measured in time zone A when the carotid artery is expanded by the number of measurement points (time average of the respective measurement values measured in time zone A may also be used), on lower part **90** respectively. In the same manner, elasticity information extracting unit **31** displays the respective measured values calculated in time zone B on lower part **91**, displays the respective measured values calculated in time zone C on lower part **92**, and displays the respective measured values calculated in time zone D on lower part **93**.

[0103] Elasticity information extracting unit **31** is capable of measuring elasticity information accurately by displaying the measurement values of time zone A and time zone C on lower part **90** and referring to the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** in the time zone of the expansion period and the contraction period of the carotid artery.

[0104] While the measured value in time zone A which is in the expansion period of the carotid artery in the first cycle is described above, elasticity information extracting unit **31** may display plural cycles (time zone A and time zone C) of measured values. For example, elasticity information extracting unit **31** is capable of displaying the measured value calculated by dividing the accumulative value of length L of line segment **52**, the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** in time zone A and time zone C when the carotid artery is expanded by the measurement score (time average of the respective measurements measured in time zone A and time zone C may also be used), on lower part **90** respectively.

[0105] Next, the fourth embodiment will be described referring to FIG. **5** and FIG. **7**. The difference from the first embodiment~the third embodiment is the change of display patterns by the time zone of the expansion period of the carotid artery and the time zone of the contraction period.

[0106] As shown in the third embodiment, time zone A~time zone D are set first. The image selecting unit of switching and adding unit **19** selects the image to be displayed on image display unit **20** from among the tomographic image data and elastic image data in the frame memory and the synthetic image data in the image processing unit, based on the time zone set by controller **27**. In concrete terms, the image selecting unit of switching and adding unit **19** selects the elastic image data or synthetic image data (elastic image data+tomographic image data) in time zone A or time zone C. Also, the image selecting unit of switching and adding unit **19** selects the tomogrpahic image data in time zone B or time zone D.

[0107] Time zone A and time zone C are suitable for displaying elastic image **41**, since it is the time zone when the carotid artery is expanded and compression is added to the arterial wall. Therefore, elastic image **41** is displayed in time zone A and time zone C. Also, time zone B and time zone D are not suitable for displaying elastic image **41**, since they are the time zones when the carotid artery is contracted including the timing that compression which is not appropriate for generating the elastic image is added. Therefore, elastic image **41** is not displayed in time zone B and time zone D.

[0108] As mentioned above, since elastic image **41** is displayed only in the time zones when the carotid artery is expanded, only elastic images of which the compression is applied appropriately can be displayed, whereby making it possible to achieve accurate display of elastic images.

[0109] Next, the fifth embodiment will be described referring to FIG. **8**. The difference from the first embodiment~the fourth embodiment is the change of display patterns of time series graphs **60~63** by the time zone for expansion period and the time zone for contraction period of the carotid arteries.

[0110] As shown in the third embodiment and the fourth embodiment, time zone A~time zone D are set first. Distance measuring unit **30** changes the display pattern of time series graph **60** of length L of line segment **52** formed by movement reference point **50** and movement reference point **51**, based on the time zone set by controller **27**. In concrete terms, as shown in FIG. **8**(*a*), distance measuring unit **30** causes image display unit **20** to display time series graph **60** in time zone A or time zone C. Also, distance measuring unit **30** causes image display unit **20** not to display time series graph **60** in time zone B or time zone D. As shown in FIG. **8**(*b*), distance measuring unit **30** causes image display unit **20** to display time series graph **60** by a solid line in time zone A or time zone C. Also, distance measuring unit **30** causes image display unit **20** to display time series graph **60** by a broken line or a dotted line in time zone B or time zone D. It may be configured so that distance measuring unit **30** causes image display unit **20** to display time series graph **60** in time zone A or time zone C in blue and to display time series graph **60** in time zone B or time zone D in red.

[0111] As shown in FIG. **8**(*a*), elastic image extracting unit **31** changes the display patterns of time series graph **61** of the average strain value in first ROI **55**, time series graph **62** of the average strain value in second ROI **56** and time series graph **63** of the strain ratio, based on the time zone set by controller **27**. In concrete terms, elasticity information extracting unit **31** causes image display unit **20** to display time series graph **61**~time series graph **63** in time zone A or time zone C. Also, elasticity information extracting unit **31** causes image display unit **20** not to display time series graph **61**~time series graph **63** in time zone B or time zone D. As shown in FIG. **8**(*b*), elasticity information extracting unit **31** causes image display unit **20** to display time series graph **61**~time series graph **63** in time zone A or time zone C by a solid line. Also, elasticity information extracting unit **31** causes image display unit **20** to display time series graph **61**~time series graph **63** in time zone B or time zone D by a broken line or a dotted line. It may be configured so that elasticity information extracting unit **31** causes image display unit **20** to display time series graph **61**~time series graph **63** in time zone A or time zone C in blue and to display time series graph **61**~time series graph **63** in time zone B or time zone D in red.

[0112] In this manner time zone A and time zone C are suitable for displaying time series graph **60**~time series graph **63**, since it is the time zone when the carotid artery is expanded and the compression is added to the arterial wall. Therefore, time series graph **60**~time series graph **63** are displayed in time zone A and time zone C distinctively. Also, time zone B and time zone D are the time zones when the carotid artery is contracted and the blood pressure level gradually declines. When getting closer to the end of the contraction period, the time that the significant difference is not generated in the calculated strain value or strain ratio is also included. Time zone B and time zone D are not suitable for displaying time series graph **60**~time series graph **63**, since they are the time zones when the compression is not applied appropriately. Therefore, time series graph **61**~time series graph **63** are displayed in time zone B and time zone D inconspicuously.

[0113] Consequently, it is possible to achieve accurate measurement of elastic information.

[0114] Next, the sixth embodiment will be described referring to FIG. **6** and FIG. **9**. The difference from the first embodiment~the fifth embodiment is that the setting positions of first ROI **55** and second ROI **56** are modified in accordance with the pressure. For example, the setting positions of first ROI **55** and second ROI **56** are modified based on length L of line segment **52** formed by movement reference point **55** and movement reference point **56**.

[0115] As shown in FIG. **6**, along with pulsation of the carotid artery, movement reference point **50** moves upward and movement reference point **51** moves downward. Movement reference point **50** and movement reference point **51** move upward and downward about the same distance from each other. In other words, the half of the variation of length L of line segment **52** measured in distance measuring unit **30** is the distance that movement reference point **50** and movement reference point **51** moved. In the same manner, as shown in FIG. **9**, controller **27** moves first ROT **55** and second ROI **56** along with movement reference point **51**.

[0116] In the case that length L of line segment **52** is long, controller **27** moves first ROI **55** and second ROI **56** downward for the half portion of variation of length L of line segment **52** based on the variation of movement reference point **50** and movement reference point **51**. In the case that length L of line segment **52** is short, controller **27** moves first ROI **55** and second ROI **56** upward for the half portion of variation of length L of line segment **52** based on the variation of movement reference point **50** and movement reference point **51**.

[0117] In this manner, moving first ROI **55** and second ROI **56** along with the pulsation of the carotid artery makes it possible to set first ROI **55** on the tunica interna of the carotid artery and second ROI **56** on the tunica externa of the carotid artery appropriately. Therefore, the average luminance value, the average strain value and the strain ratio of first ROI **55** and second ROI **56** can be accurately measured, whereby making it possible to achieve accurate measurement of the elasticity information.

[0118] While first ROI **55** and second ROI **56** are moved upward and downward by controller **27** for the half portion of the variation of length L of line segment **52** in the above description, there are cases that movement reference point **50** and movement reference point **51** do not move upward and downward for the same portion as each other due to influence of the factor such as an adjacent bone. In such cases, it is possible to set what percentage of the variation of length L of first ROI **55** and second ROI **56** should be moved upward and forward in controller **27**.

[0119] Also, controller **27** may be set so that a reference point is set on each of first ROI **55** and second ROI **56** via console **28**, and first ROI and second ROI are made to follow the set reference points by applying the method such as the above-described block matching method.

[0120] Next, operation procedure of the present invention will be described referring to FIG. **10**.

(Step 1): Ultrasonic waves are transmitted/received to/from a carotid artery which is the measuring target, and tomographic image **40** and elastic image **41** are displayed on image display unit **20** based on the RF frame data.

(Step 2): The RF frame data for a given length of time (for example, for two pulsations) is stored and updated in a frame memory. Then tomographic image **40** and elastic image **41** are performed with the freezing process using a freezing button of console **28**. The update of RF frame data, along with the freezing, is stopped and the RF frame data for a given length of time (for example, for two pulsations) is stored.

(Step 3): Movement reference point **50** and movement reference point **51** are set via console **28** in order to measure the diameter of the arterial wall which varies in compliance with the pulsation.

(Step 4): First ROI **55** and second ROI **56** are set via console **28** to be adjacent to the tunica interna and the tunica externa of first ROI **55** and second ROI **56**.

(Step 5): The RF frame data stored in RF frame data selecting unit **21** is read in by displacement measuring unit **22**, and displacement distribution of the arterial wall between the frames that varies in compliance with the pulsations is calculated. Distance measuring unit **30** calculates the length of line segment **52** of movement reference point **50** and movement reference point **51** being set on the arterial wall from the calculated displacement distribution data. Also, elasticity information calculating unit **23** calculates the strain distribution data from the displacement distribution data. Elasticity information extracting unit **31** calculates the average strain value and the strain ratio of first ROI **55** and second ROI **56** from the calculated strain distribution data. Elasticity information extracting unit **31** calculates the average luminance value of first ROI **55** and second ROI **56** from the black and white tomographic data outputted from tomographic image constructing unit **17**.

(Step 6): The variation of the length of line segment **52** based on movement reference point **50** and movement reference point **51**, the average luminance value, the average strain value and the strain ratio calculated from first ROT **55** and second ROI **56** are displayed on image display unit **20** by numeric values and time series graphs. The length of line segment **52** calculated based on movement reference point **50** and movement reference point **56** indicates the distance between the arterial walls.

[0121] Also, time series graph **61** of the average strain value in first ROI **55**, time series graph **62** of the average strain value of second ROI **56** and time series graph **63** of the strain ratio are displayed on image display unit **20**. Since the form or amplitude of waveforms vary depending on the progress of disease, it is effective to capture the variation of disease with passage of time, not only the elasticity information by numeric values at the present time.

[0122] By above-described steps, distance between the arterial walls, the average strain value or the strain ratio can be learned by corresponding to each piece of information while confirming the tomographic image or elastic image, whereby making it possible to achieve accurate measurement of elasticity information.

(Step 7): Also, time gauge **64** and time gauge **65** can be set on the displayed time-series graphs via console **28**. Time gauge **64** and time gauge **65** can be set in a segment from a starting-point to an ending-point.

(Step 8): Time gauge **64** is displayed on time series graph **60** showing the distance between the arterial walls. Time gauge **64** is displayed on time series graph **61** of the average strain value in first ROI **55**, time series graph **62** of the average strain value in second ROI **56** and time series graph **63** of the strain ratio. The set time gauge **64** and time gauge **65** are for indicating the same time phases, making it possible to display the respective measurement information in the same timing.

(Step 9): A plurality of time gauges **81~84** and time gauges **85~88** are set with respect to the displayed time series graphs via console **28**. Time gauge **81** and time gauge **83** are set in the timing that the slope of the waveform (differential value) of time series graph **60** varies from upward to downward (minimum value). Also, controller **27** sets time gauge **82** and time gauge **84** in the timing that the slope of the waveform (differential value) of time series graph **60** varies from upward to downward (maximum value). In this manner, the time zone can be divided into the contraction period and the expansion period. By dividing the timings, the accurate measurement of elasticity information can be achieved in the divided contraction period and the expansion period.

(Step 10): The length of the line segment, the average luminance value, the average strain value and the strain ratio in the time zones A~D segmented by time gauges **81~84** are displayed on image display unit **20** by numerical values. In this manner, when the timings are divided into the contraction period and the expansion period of the carotid artery, the average values in the respective time zones are displayed on image display unit **20**.

[0123] Also, by matching time gauges **81~84** to the starting point~ending point, the length of the line segment, the average luminance value, the average strain value and the strain ratio during a given 1 pulsation can be displayed. In the case that the time gauges are moved from time phase X to time phase Y on console **28**, the respective numerical values are updated to the value of time phase Y in accordance with the movement.

1. An ultrasonic diagnostic apparatus comprising:

an ultrasonic probe;

tomographic image constructing means configured to generate a tomographic image based on the RF frame data obtained from the ultrasonic probe, of the cross-sectional region of an object to be examined;

elasticity information calculating means configured to obtain strain and/or elasticity modulus of a tissue in the cross-section region based on the RF frame data;

elastic image constructing means configured to construct an elastic image of the cross-sectional region based on the strain and/or elasticity modulus acquired in the elasticity information calculating means; and

display means configured to display the tomographic image and/or the elastic image,

characterized in further comprising:

setting means configured to set a first movement reference point and a second movement reference point on the tomographic image and/or the elastic image; and

measuring means configured to make the first movement reference point and the second movement reference point follow the pulsation of the object, and to measure the length of a line segment formed by the first movement reference point and the second movement reference point,

and causes the display means to display the length of the line segment and the elasticity information based on the strain and/or the elasticity modulus.

2. The ultrasonic diagnostic apparatus according to claim **1**, wherein the setting means sets a region of interest in the vicinity of the first movement reference point and the second movement reference point, so that the elasticity information of the region of interest is displayed on the display means.

3. The ultrasonic diagnostic apparatus according to claim **2**, wherein the elastic information is the average strain value within the region of interest.

4. The ultrasonic diagnostic apparatus according to claim **2**, wherein the elasticity information is the strain ratio between the two regions of interest.

5. The ultrasonic diagnostic apparatus according to claim **1**, wherein the display means displays a time series graph based on the length of a line segment and/or the elasticity information.

6. The ultrasonic diagnostic apparatus according to claim **4**, wherein the display means displays a time gauge showing a time phase on the time series graph.

7. The ultrasonic diagnostic apparatus according to claim **1**, wherein the measuring means measures the length of a line segment or the elasticity information in a predetermined time zone.

8. The ultrasonic diagnostic apparatus according to claim **1**, wherein the display means changes display pattern of the elasticity information based on variation information of the length of a line segment.

9. The ultrasonic diagnostic apparatus according to claim **5**, wherein the display means changes display pattern of the time series graph based on variation information of a line segment.

10. The ultrasonic diagnostic apparatus according to claim **2**, wherein the setting means changes the setting position of the region of interest in accordance with pressure.

* * * * *

专利名称(译)	超声诊断设备		
公开(公告)号	[US20100268084A1](#)	公开(公告)日	2010-10-21
申请号	US12/741405	申请日	2008-10-24
[标]申请(专利权)人(译)	大阪TAKASHI TONOMURA AKIKO		
申请(专利权)人(译)	大阪TAKASHI TONOMURA AKIKO		
当前申请(专利权)人(译)	日立医疗器械股份有限公司		
[标]发明人	OSAKA TAKASHI TONOMURA AKIKO		
发明人	OSAKA, TAKASHI TONOMURA, AKIKO		
IPC分类号	A61B8/00		
CPC分类号	A61B8/08 A61B8/485 A61B8/463 A61B8/461		
优先权	2007288766 2007-11-06 JP		
外部链接	Espacenet USPTO		

摘要(译)

提供一种能够精确测量弹性信息的超声诊断设备。 超声诊断设备的特征在于包括：设置装置，被配置为在断层图像和/或弹性图像上设置第一移动参考点和第二移动参考点;以及测量装置，被配置为使得第一移动参考点和第二移动参考点跟随物体的脉动并测量由第一运动参考点和第二运动参考点形成的线段的长度，并使显示装置显示线段的长度和弹性信息。应变和/或弹性模量。