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Matsumura

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(45) **Date of Patent: Jan. 15, 2013**

(54) **DIAGNOSTIC ULTRASOUND SYSTEM AND METHOD OF DISPLAYING ELASTICITY IMAGE**

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(73) Assignee: **Hitachi Medical Corporation**, Tokyo (JP)

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PCT Pub. Date: **Dec. 29, 2005**

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Jun. 22, 2004 (JP) 2004-184142

(51) **Int. Cl.**
A61B 5/00 (2006.01)

(52) **U.S. Cl.** **600/437**

(58) **Field of Classification Search** 382/128, 382/131; 600/437, 438, 442, 459

See application file for complete search history.

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(57) **ABSTRACT**

A diagnostic ultrasound system includes an ultrasound transmitting and receiving system for transmitting and receiving ultrasonic waves to and from a object to be examined **10**, an elasticity image capturing system for capturing an elasticity image related to body tissue of the object to be examined on the basis of a signal output from the ultrasound transmitting and receiving system, and a controlling and displaying system for capturing the elasticity image. The elasticity image capturing system obtains compression data related to the compression state of the object to be examined **10**, determines the compression state of the body tissue on the basis of the compression data, and includes a compression direction and range evaluation unit **115** as a compression state evaluating means for reflecting the determination result to the elasticity image. In this way, more accurate diagnosis by objectively and quantitatively grasping the compression state of the body tissue is possible.

28 Claims, 20 Drawing Sheets

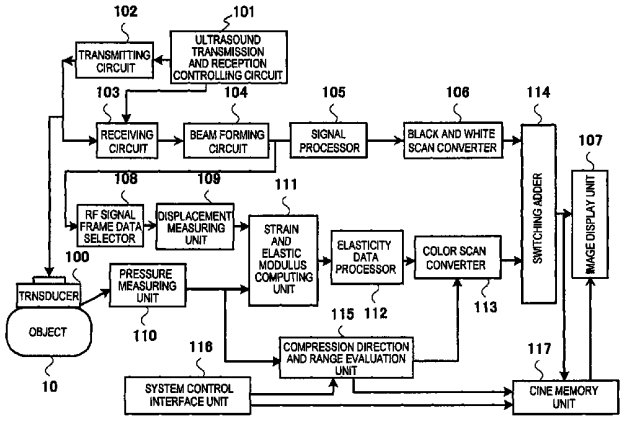


FIG. 1

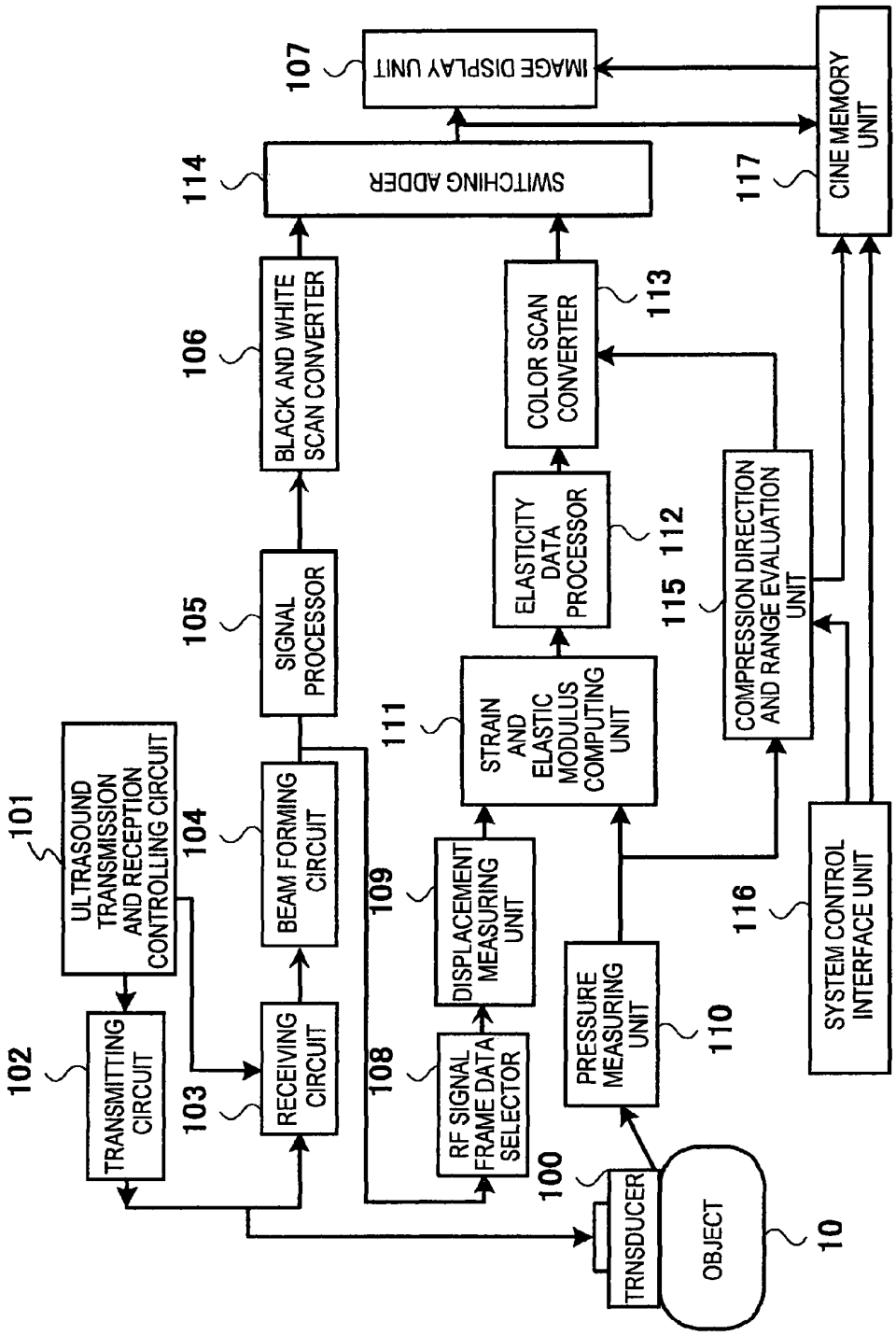


IMAGE DISPLAY UNIT
107
SWITCHING ADDER
114
CINE MEMORY UNIT
117
BLACK AND WHITE SCAN CONVERTER
106
COLOR SCAN CONVERTER
113
SIGNAL PROCESSOR
105
ELASTICITY DATA PROCESSOR
112
COMPRESSION DIRECTION AND RANGE EVALUATION UNIT
115
ULTRASOUND TRANSMISSION AND RECEPTION CONTROLLING CIRCUIT
101
BEAM FORMING CIRCUIT
104
STRAIN AND ELASTIC MODULUS COMPUTING UNIT
111
DISPLACEMENT MEASURING UNIT
109
TRANSMITTING CIRCUIT
102
RECEIVING CIRCUIT
103
RF SIGNAL FRAME DATA SELECTOR
108
PRESSURE MEASURING UNIT
110
SYSTEM CONTROL INTERFACE UNIT
116
TRNSDUCER
100
OBJECT
10

FIG. 2

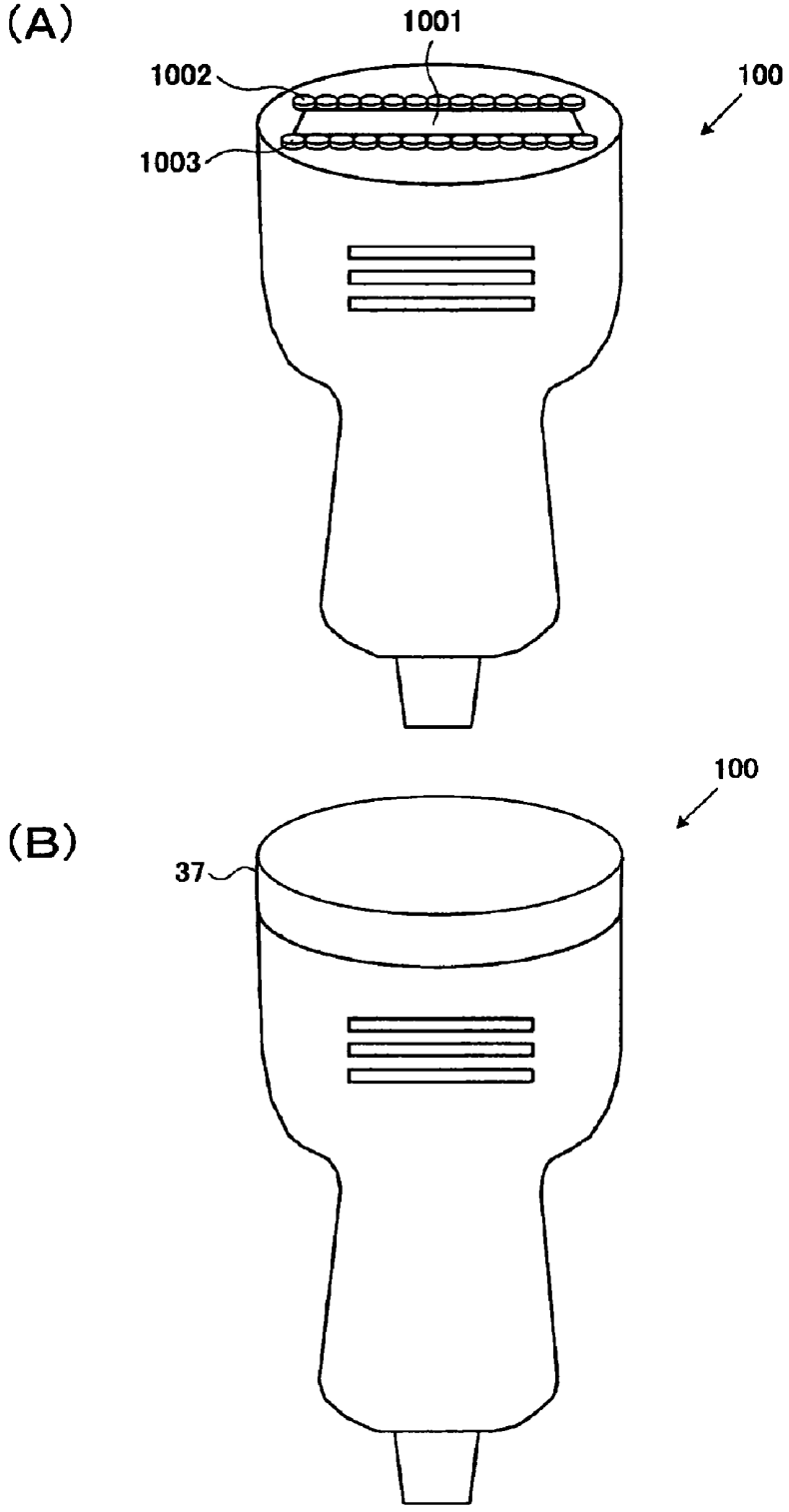


FIG. 3

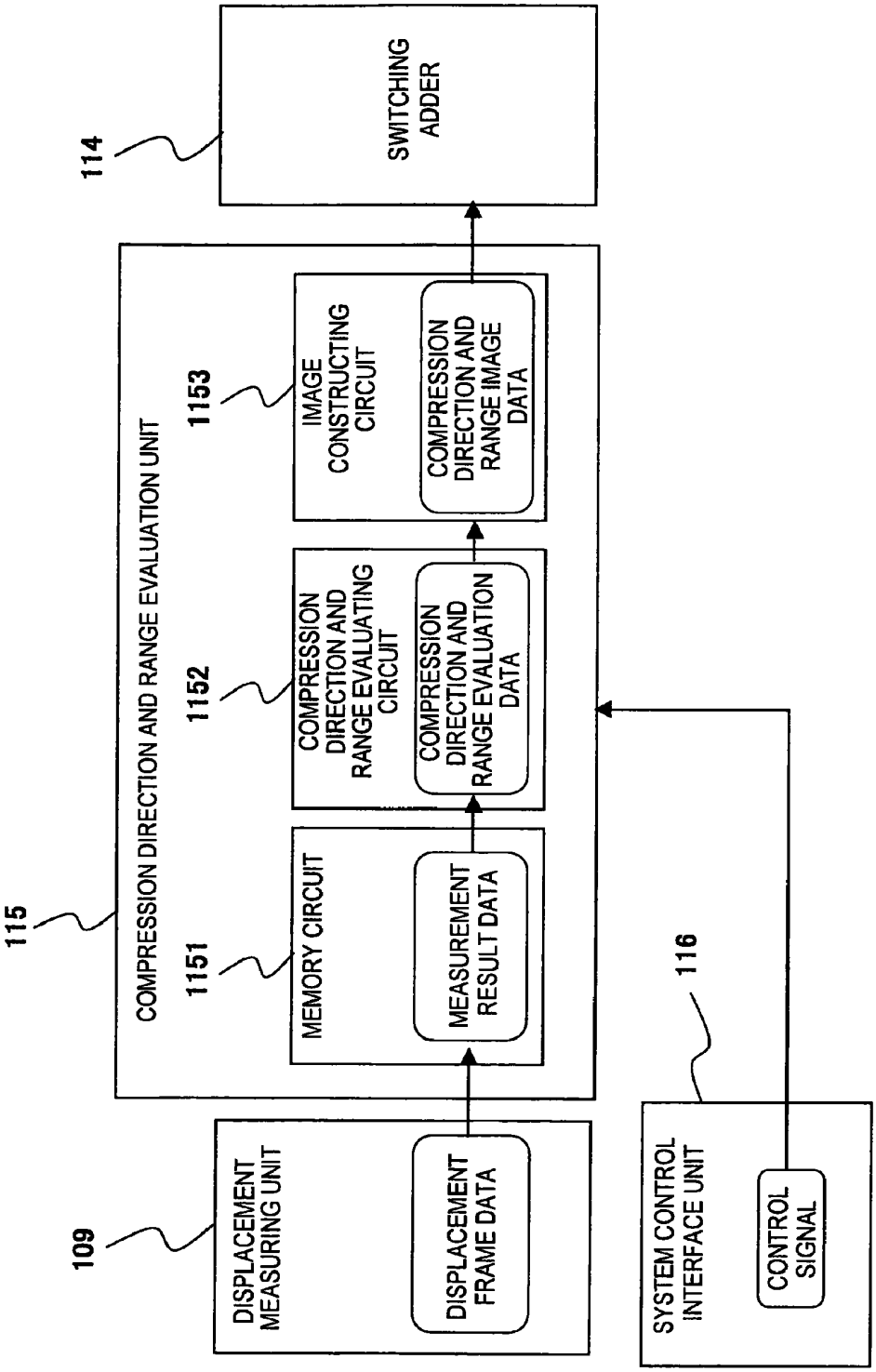

114
SWITCHING ADDER
115
COMPRESSION DIRECTION AND RANGE EVALUATION UNIT
1153
IMAGE CONSTRUCTING CIRCUIT
COMPRESSION DIRECTION AND RANGE IMAGE DATA
1152
COMPRESSION DIRECTION AND RANGE EVALUATING CIRCUIT
COMPRESSION DIRECTION AND RANGE EVALUATION DATA
1151
MEMORY CIRCUIT
MEASUREMENT RESULT DATA
109
DISPLACEMENT MEASURING UNIT
DISPLACEMENT FRAME DATA
116
SYSTEM CONTROL INTERFACE UNIT
CONTROL SIGNAL

FIG. 4

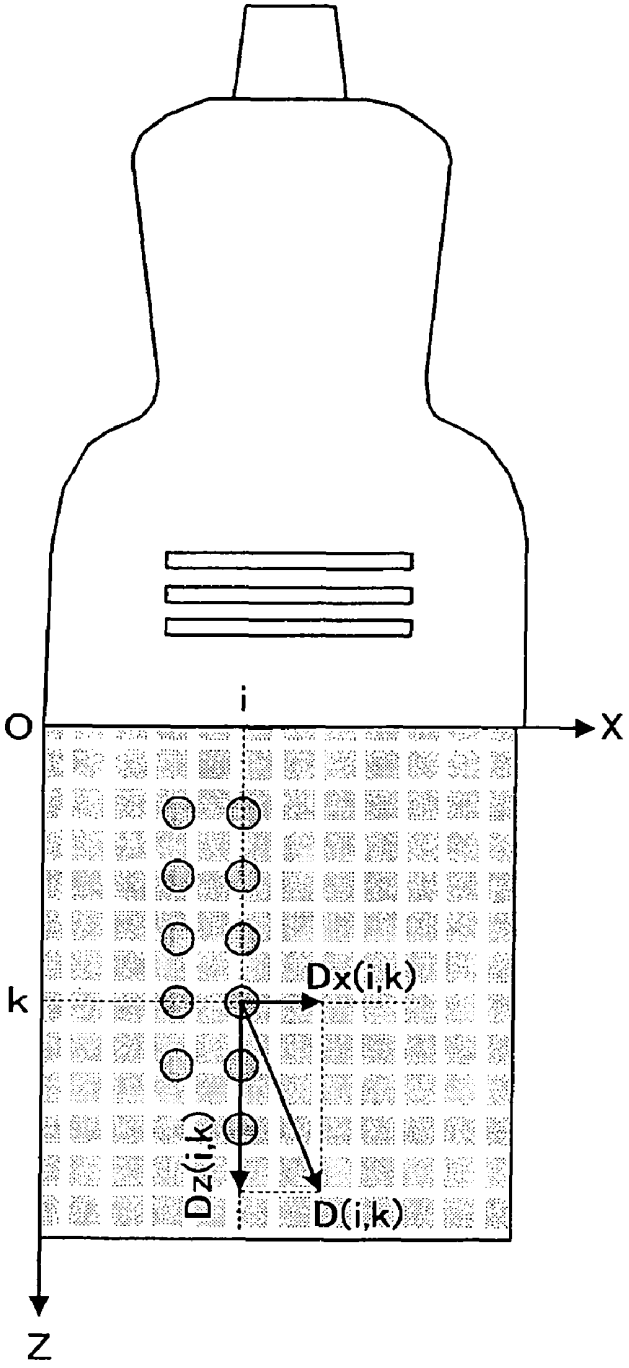


FIG. 5

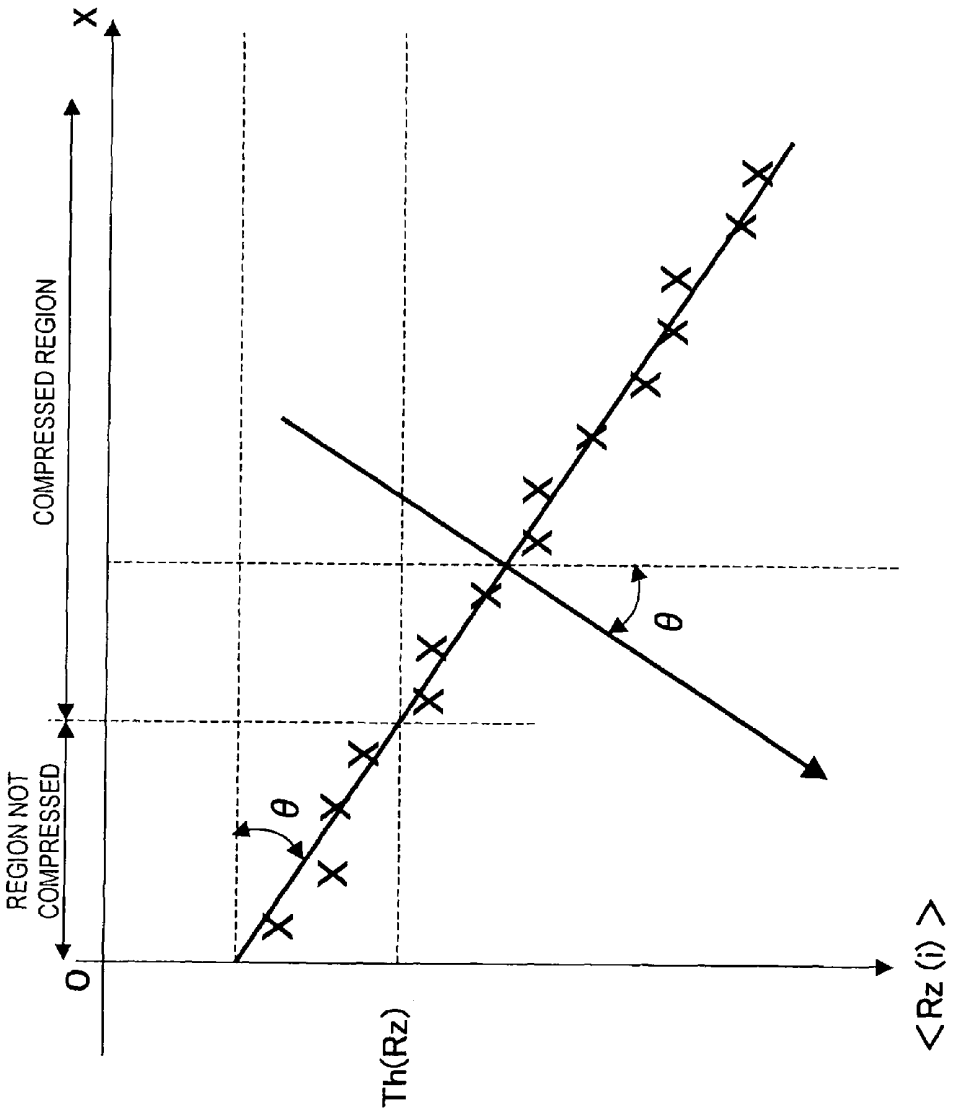


FIG. 6

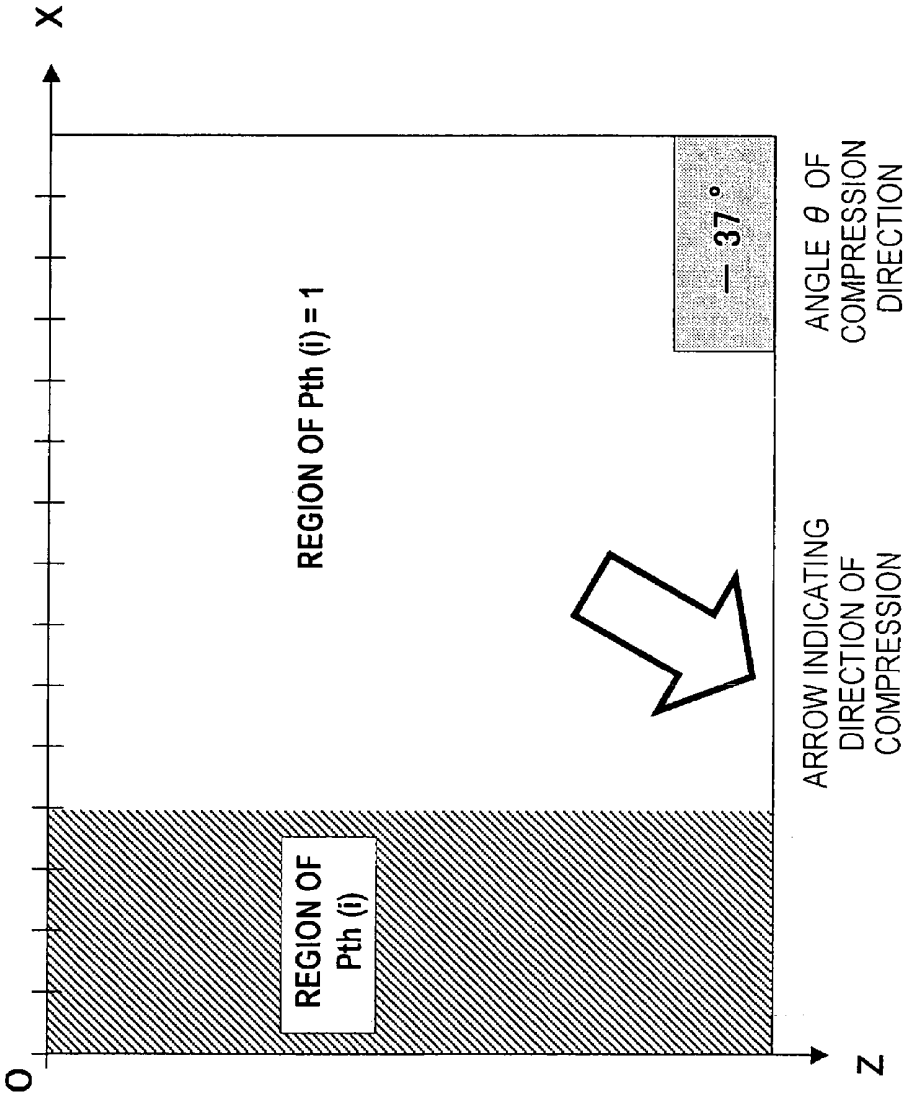
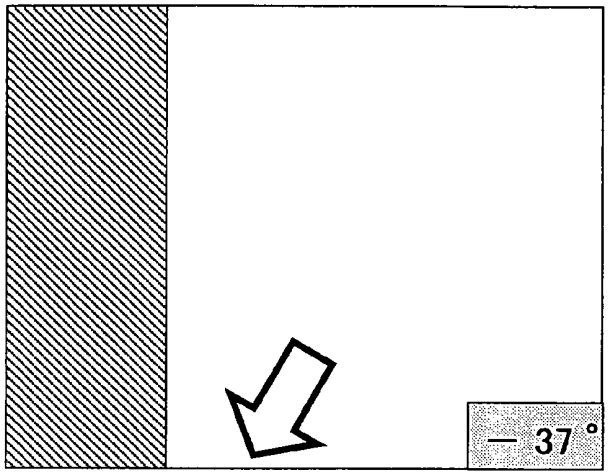
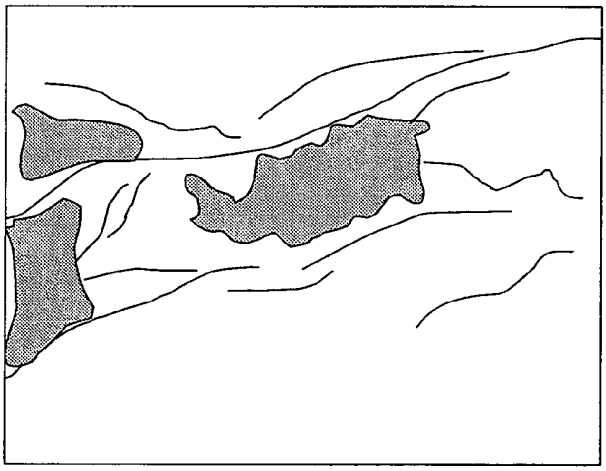

X
O
Z
REGION OF Pth (i) = 1
REGION OF Pth (i)
— 37 °
ANGLE θ OF COMPRESSION DIRECTION
ARROW INDICATING DIRECTION OF COMPRESSION

FIG. 7

(A)



(B)



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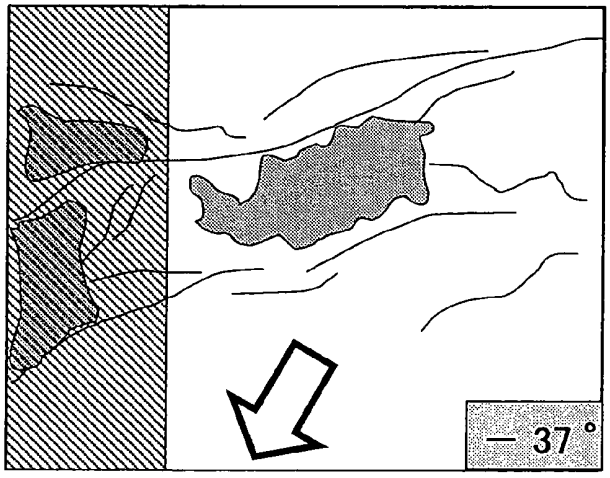


FIG. 8

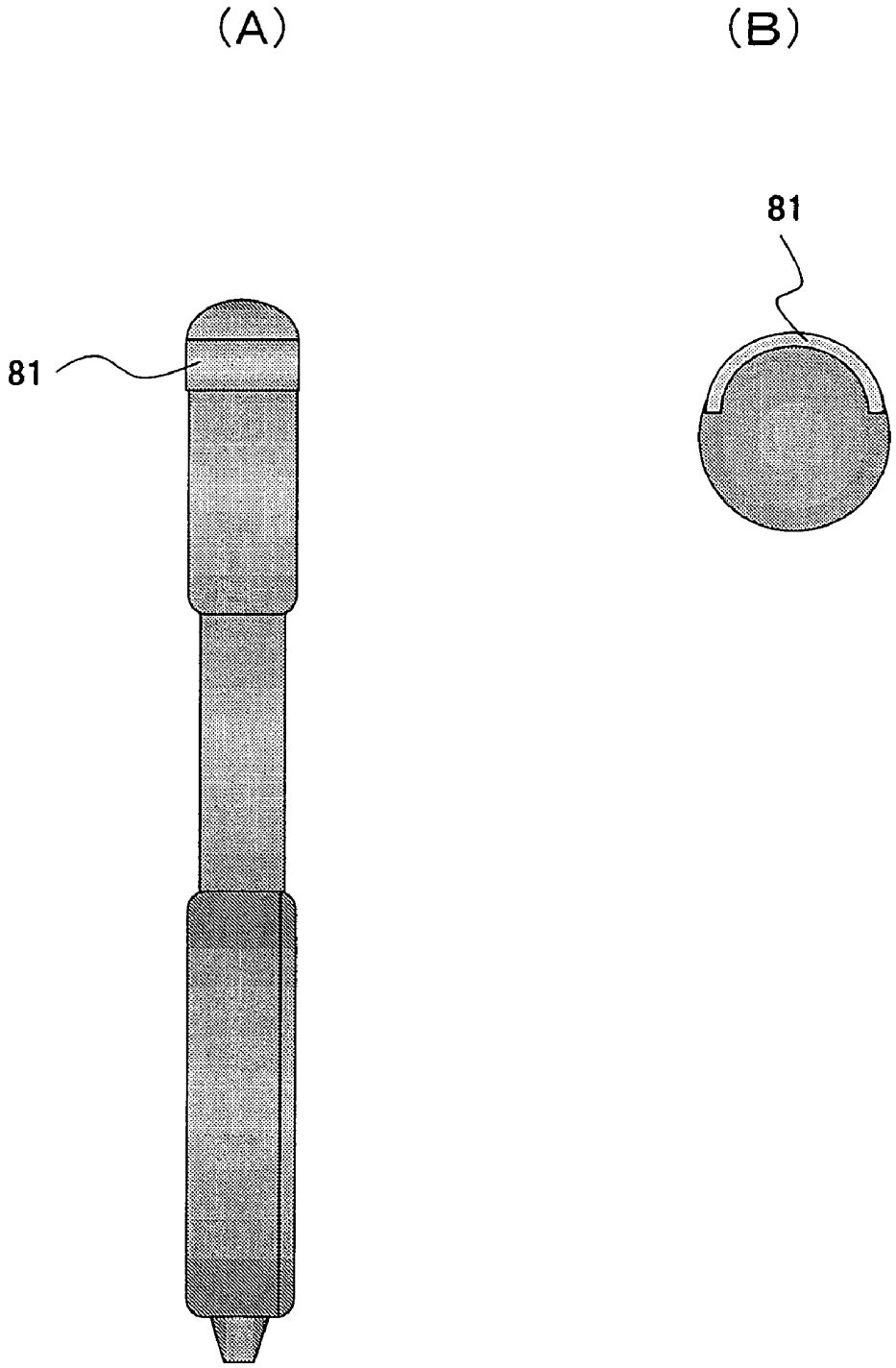


FIG. 9

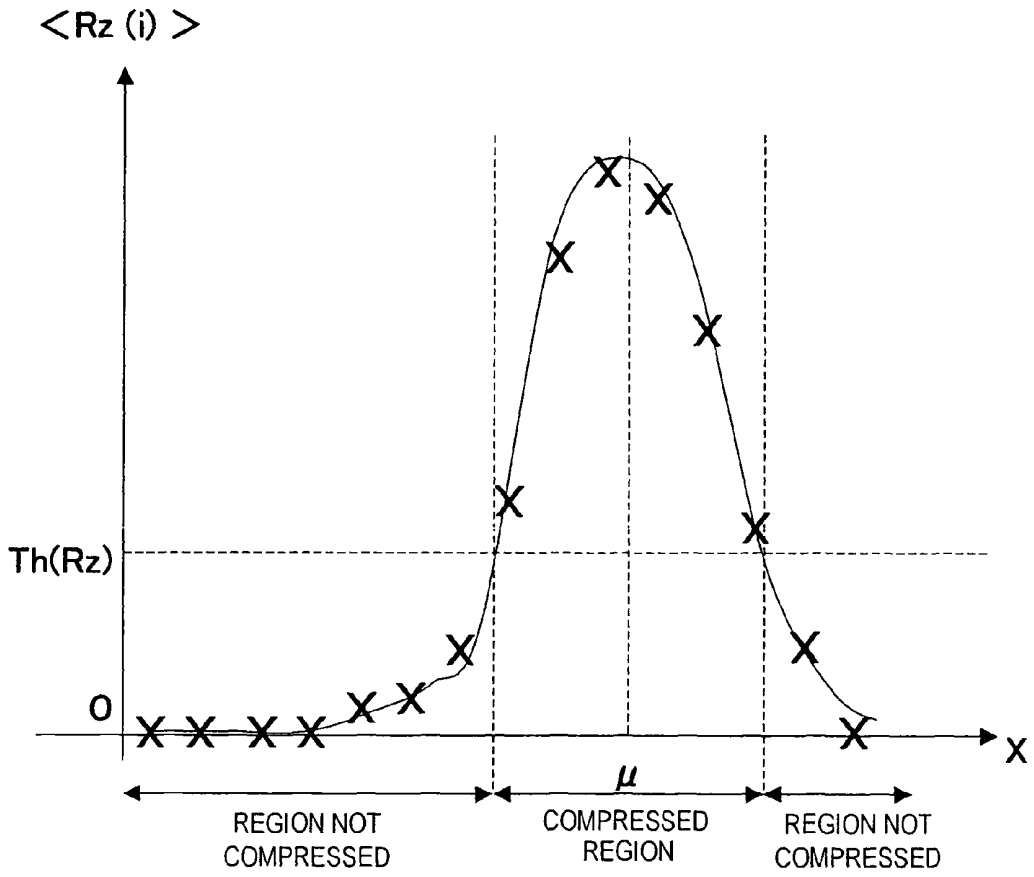

<Rz (i) >
Th(Rz)
0
X
μ
REGION NOT COMPRESSED
COMPRESSED REGION
REGION NOT COMPRESSED

FIG. 10

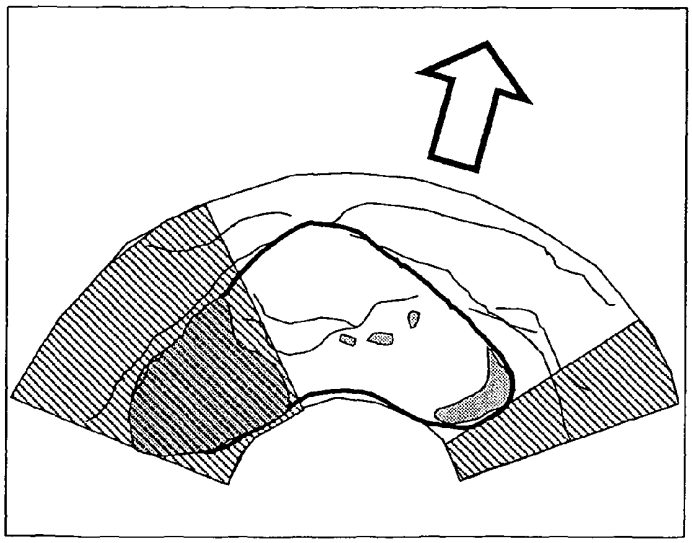


FIG. 11

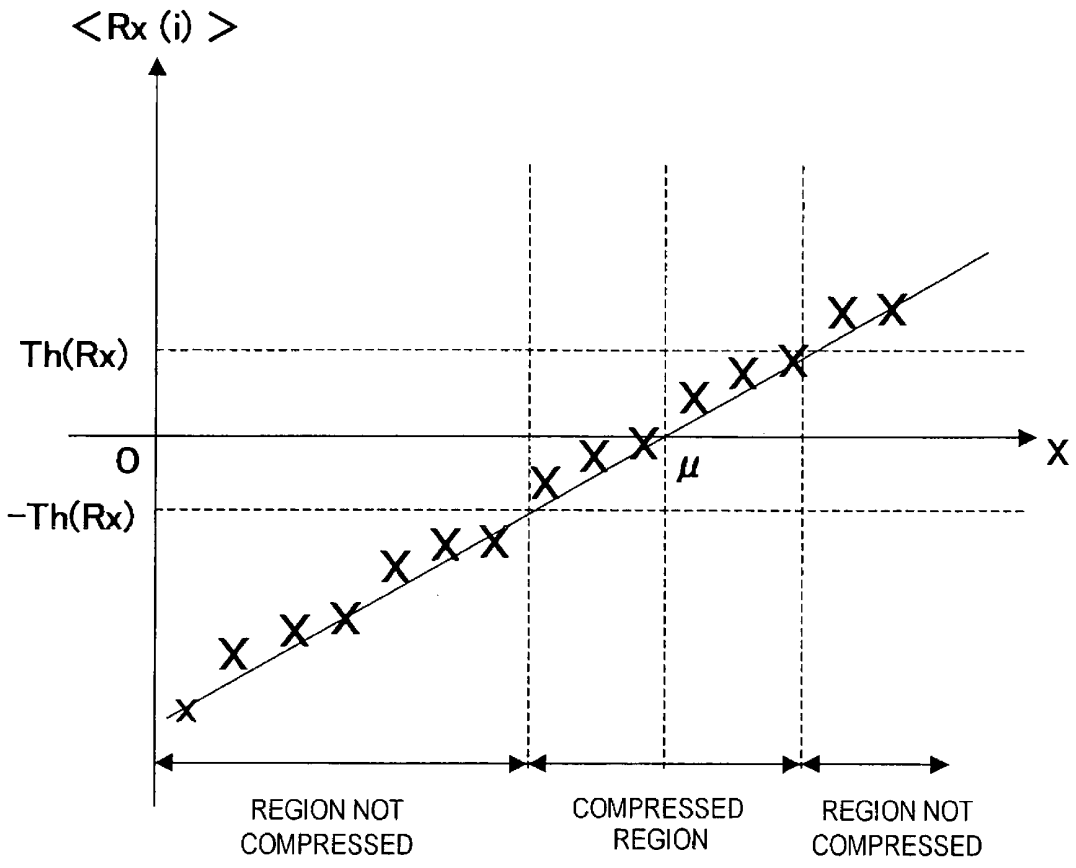

<Rx (i)>
Th(Rx)
0
-Th(Rx)
X
μ
REGION NOT COMPRESSED
COMPRESSED REGION
REGION NOT COMPRESSED

FIG. 12

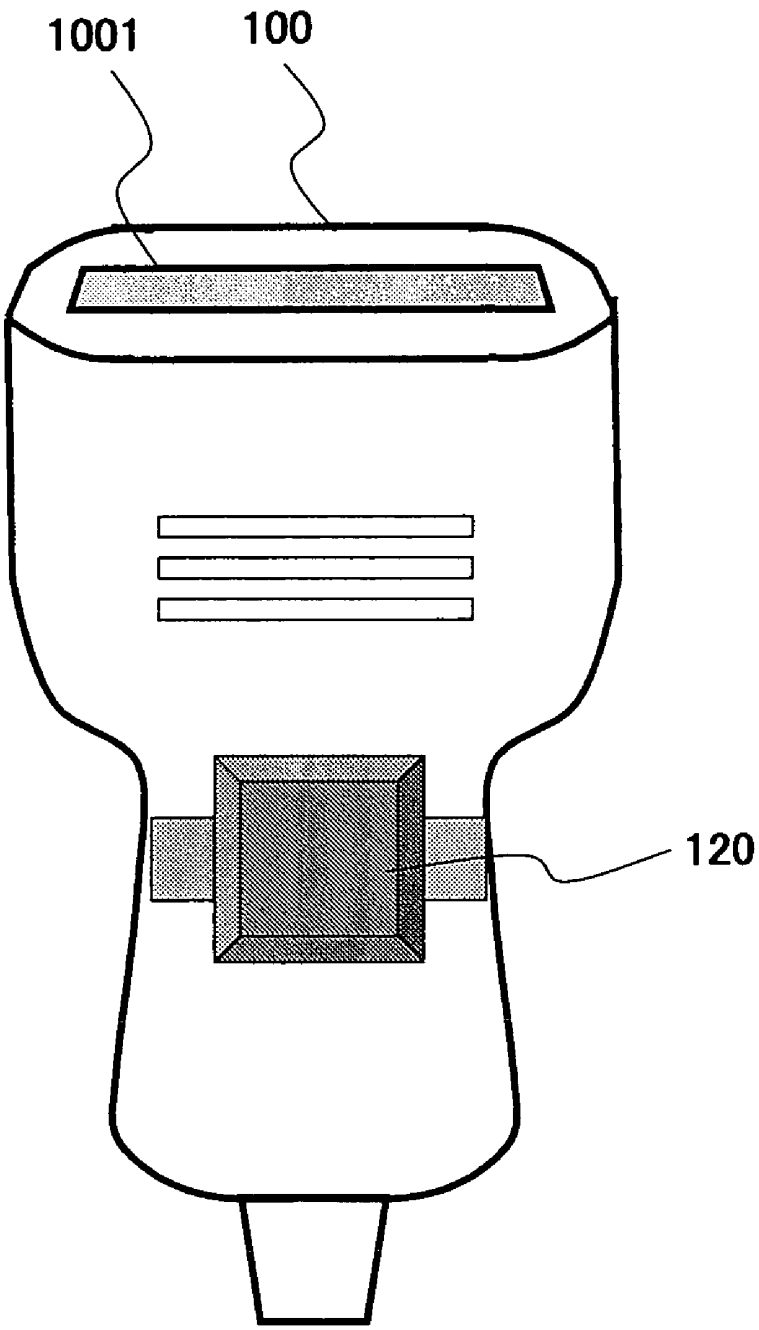


FIG. 13

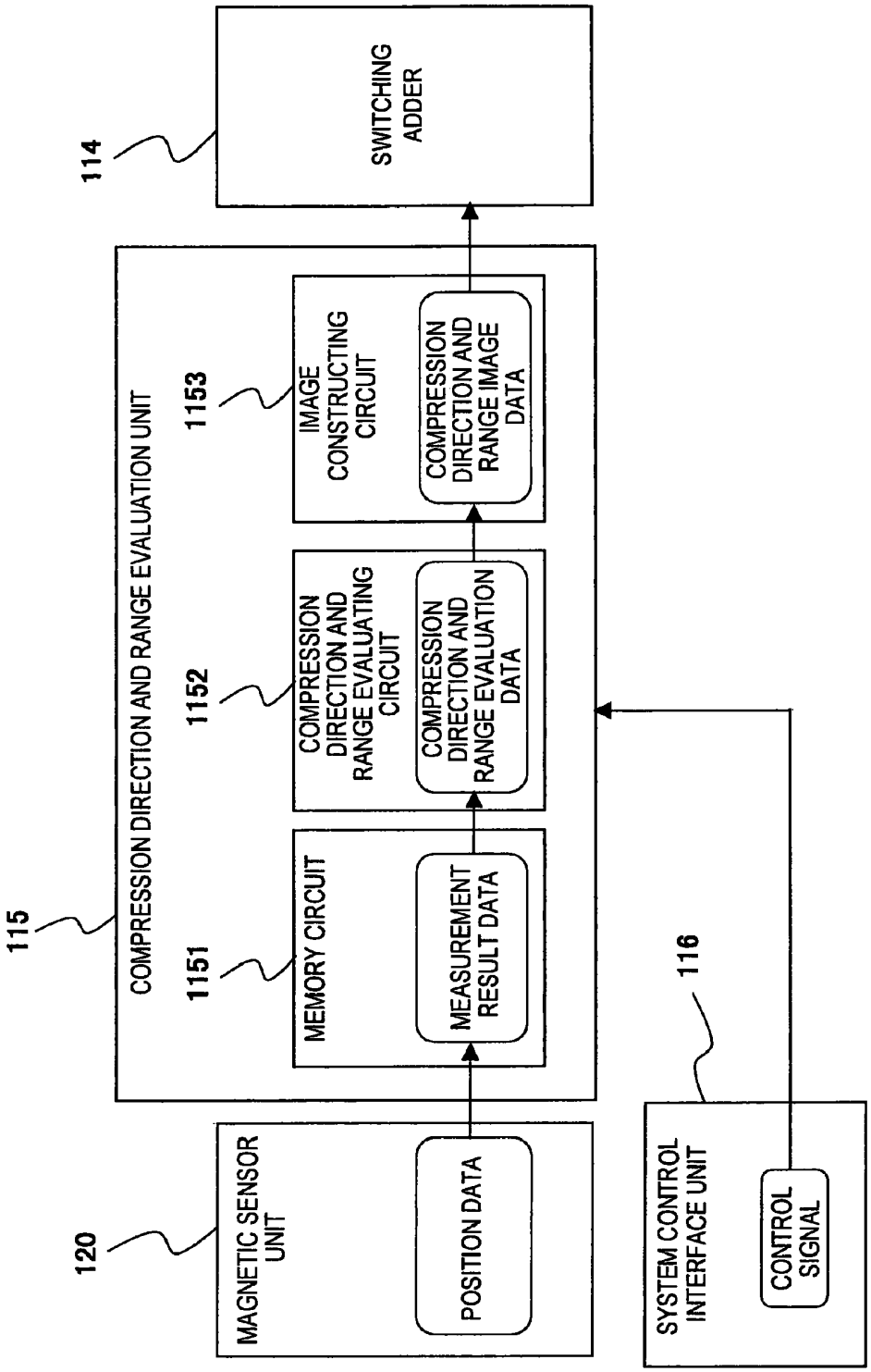
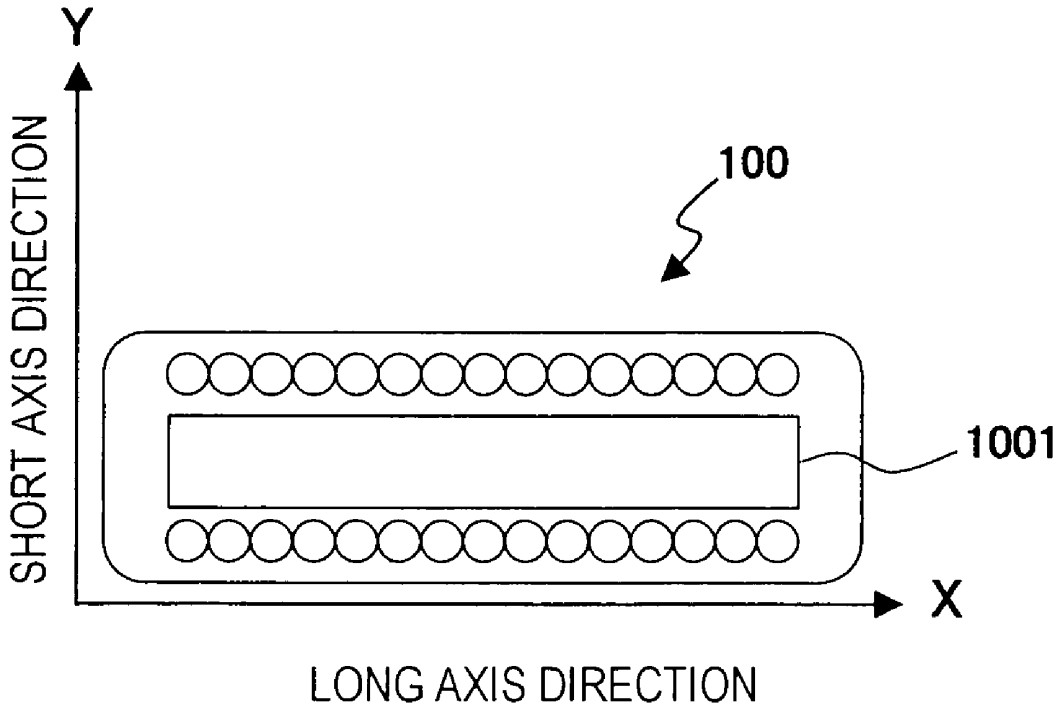

114
SWITCHING ADDER
115
COMPRESSION DIRECTION AND RANGE EVALUATION UNIT
1153
IMAGE CONSTRUCTING CIRCUIT
COMPRESSION DIRECTION AND RANGE IMAGE DATA
1152
COMPRESSION DIRECTION AND RANGE EVALUATING CIRCUIT
COMPRESSION DIRECTION AND RANGE EVALUATION DATA
1151
MEMORY CIRCUIT
MEASUREMENT RESULT DATA
120
MAGNETIC SENSOR UNIT
POSITION DATA
116
SYSTEM CONTROL INTERFACE UNIT
CONTROL SIGNAL

FIG. 14



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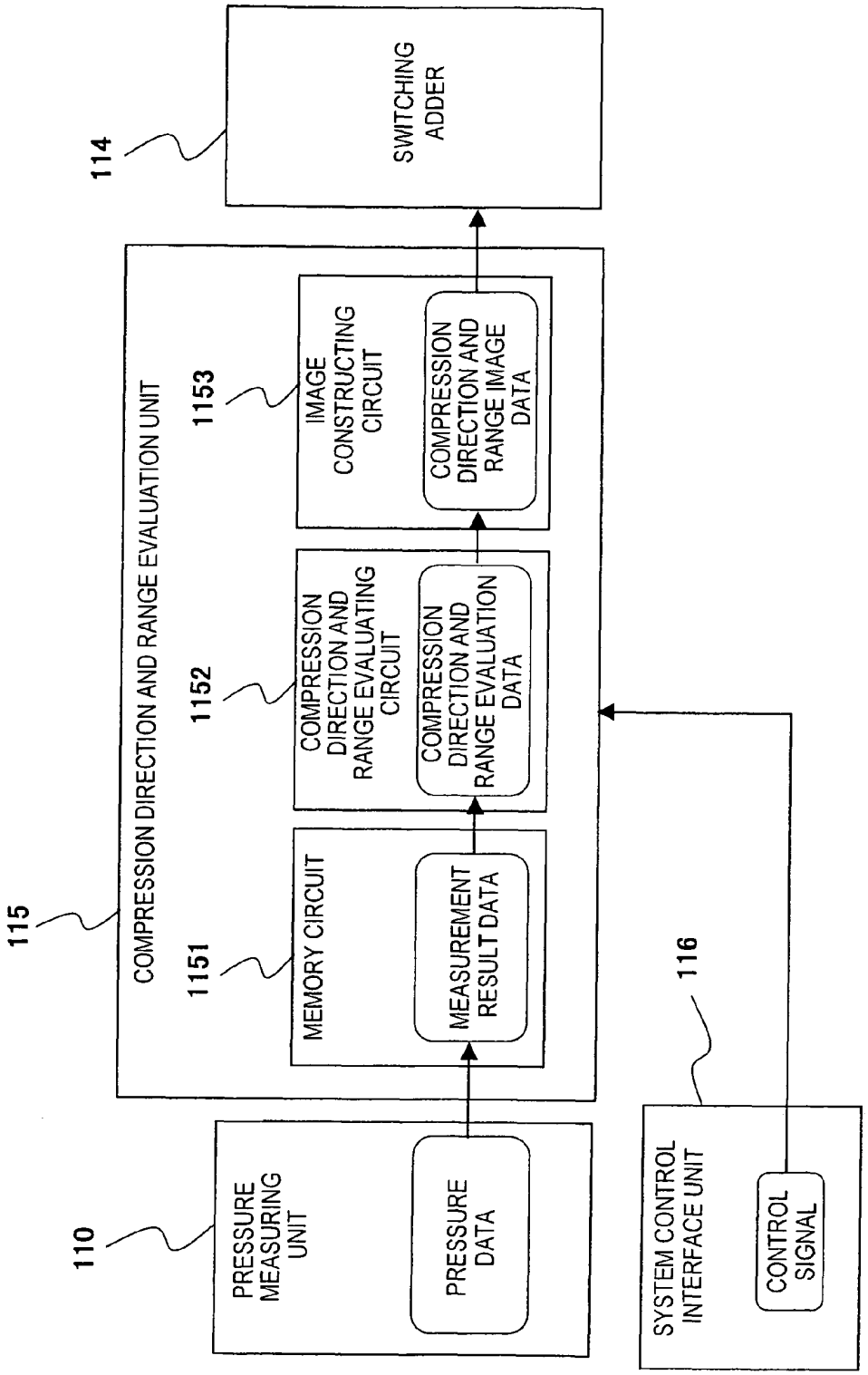
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SWITCHING ADDER
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COMPRESSION DIRECTION AND RANGE EVALUATION UNIT
1153
IMAGE CONSTRUCTING CIRCUIT
COMPRESSION DIRECTION AND RANGE IMAGE DATA
1152
COMPRESSION DIRECTION AND RANGE EVALUATING CIRCUIT
COMPRESSION DIRECTION AND RANGE EVALUATION DATA
1151
MEMORY CIRCUIT
MEASUREMENT RESULT DATA
110
PRESSURE MEASURING UNIT
PRESSURE DATA
116
SYSTEM CONTROL INTERFACE UNIT
CONTROL SIGNAL

FIG. 16

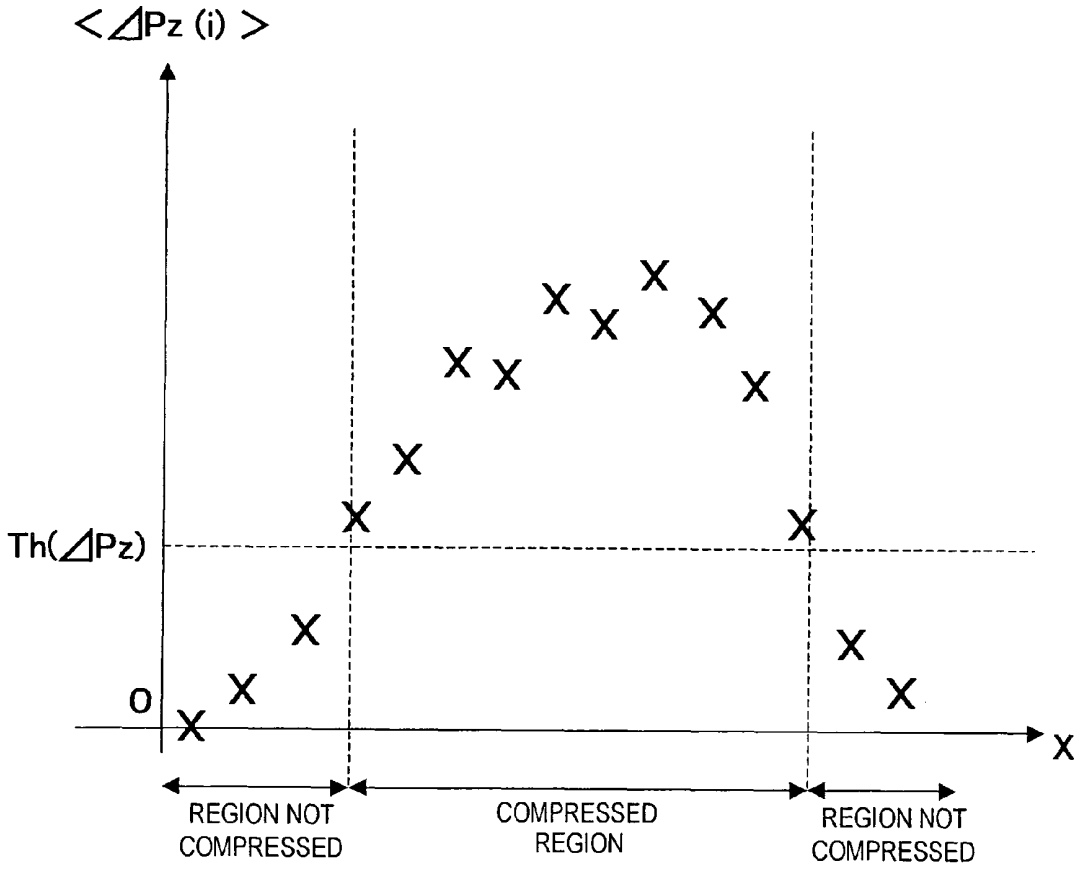

<⊿Pz (i)>
Th(⊿Pz)
0
X
REGION NOT COMPRESSED
COMPRESSED REGION
REGION NOT COMPRESSED

FIG. 17

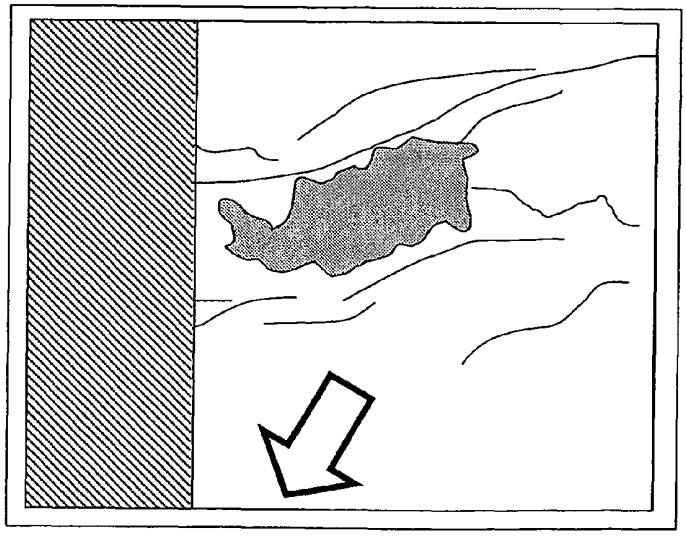


FIG. 18

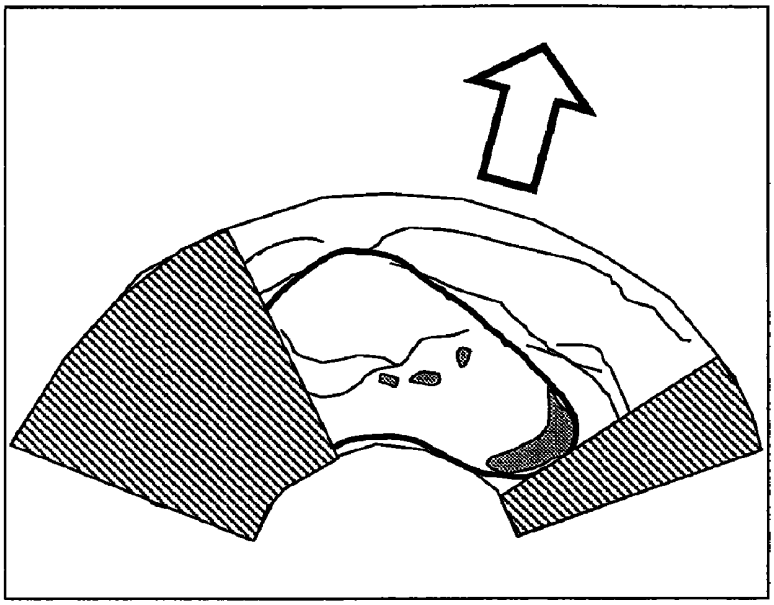


FIG. 19

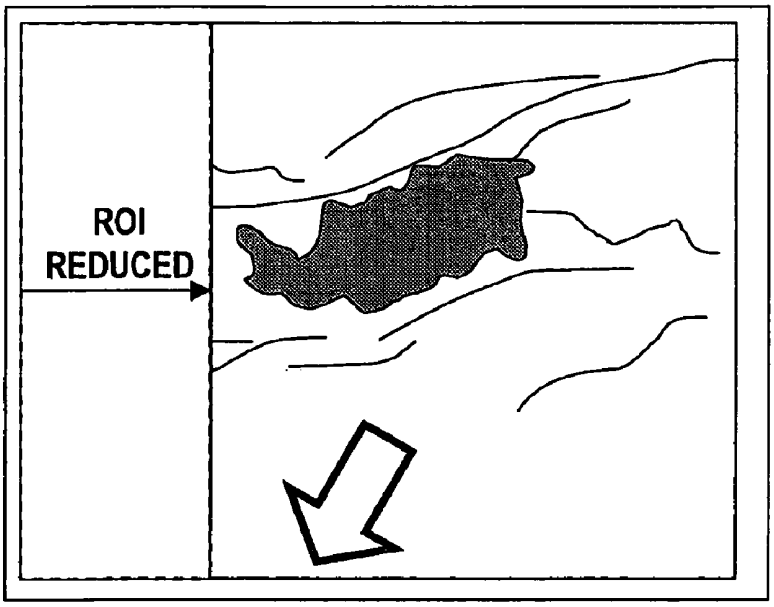


FIG. 20

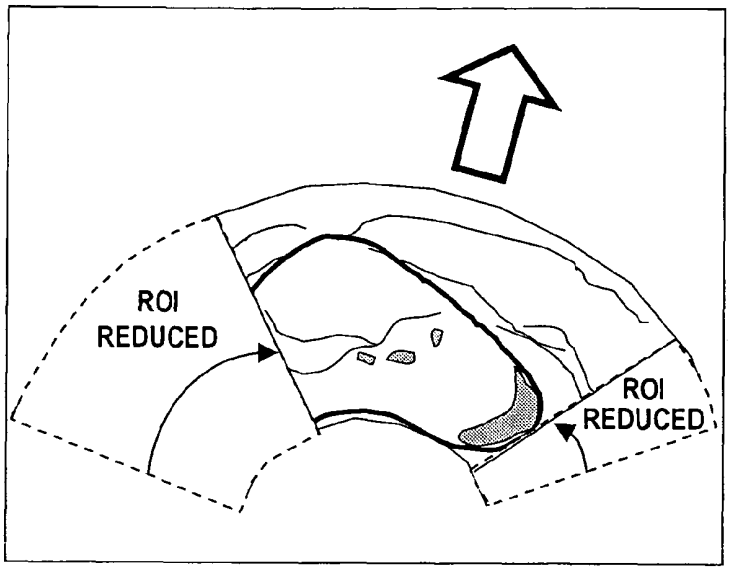


FIG. 21

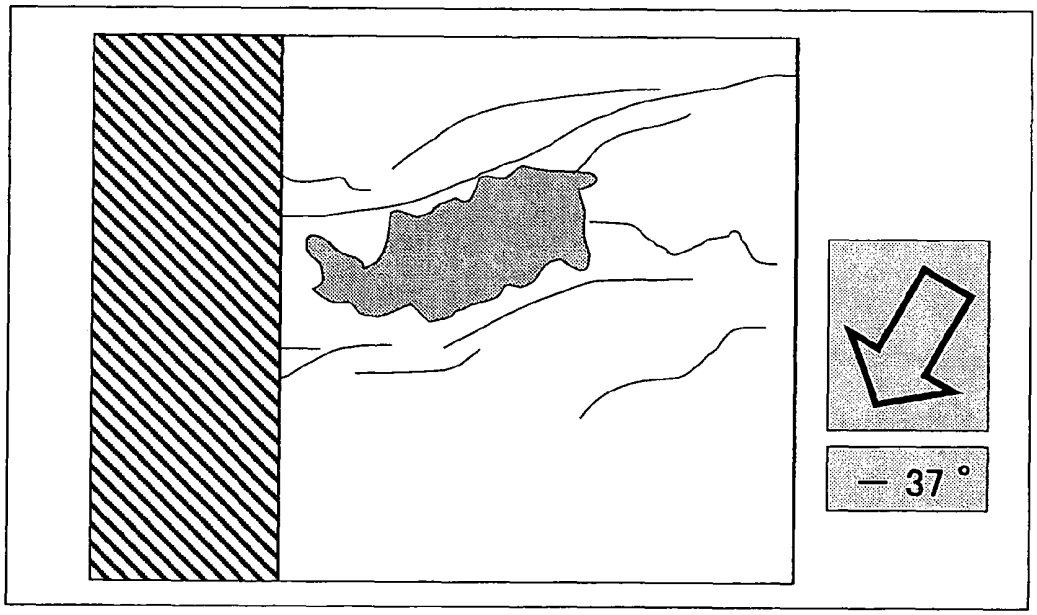


FIG. 22

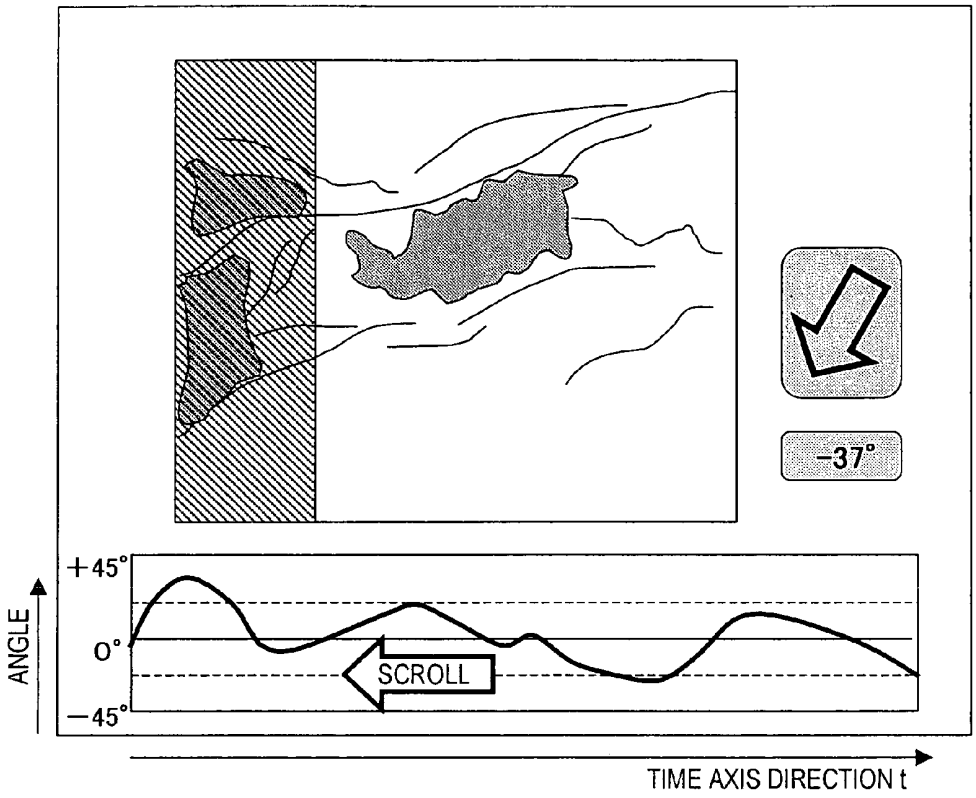

−37°
+45°
0°
−45°
SCROLL
ANGLE
TIME AXIS DIRECTION t

FIG. 23

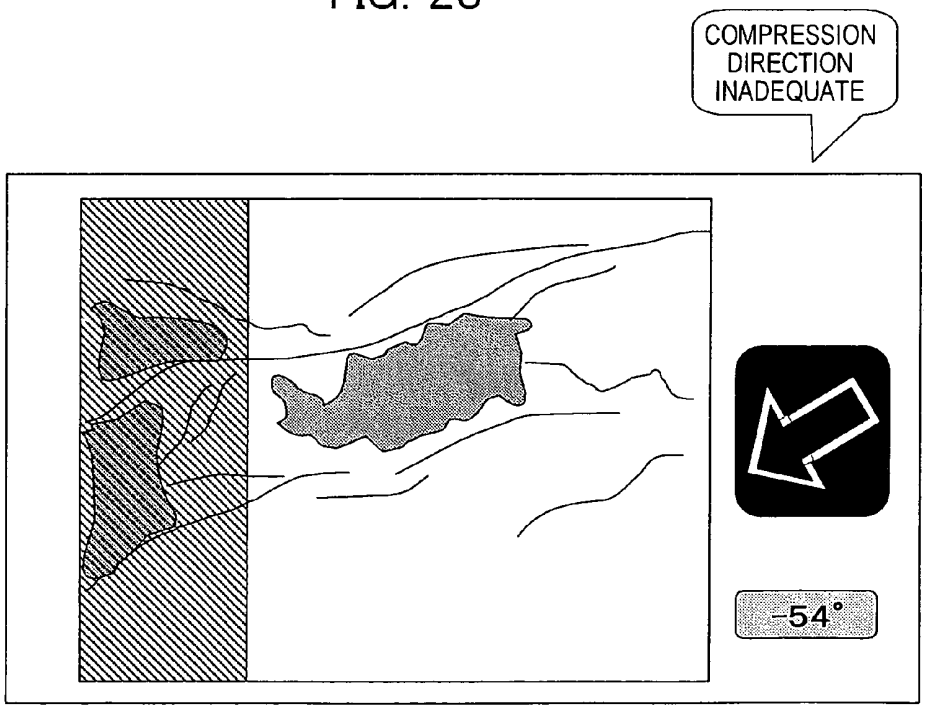

COMPRESSION DIRECTION INADEQUATE
−54°

FIG. 24

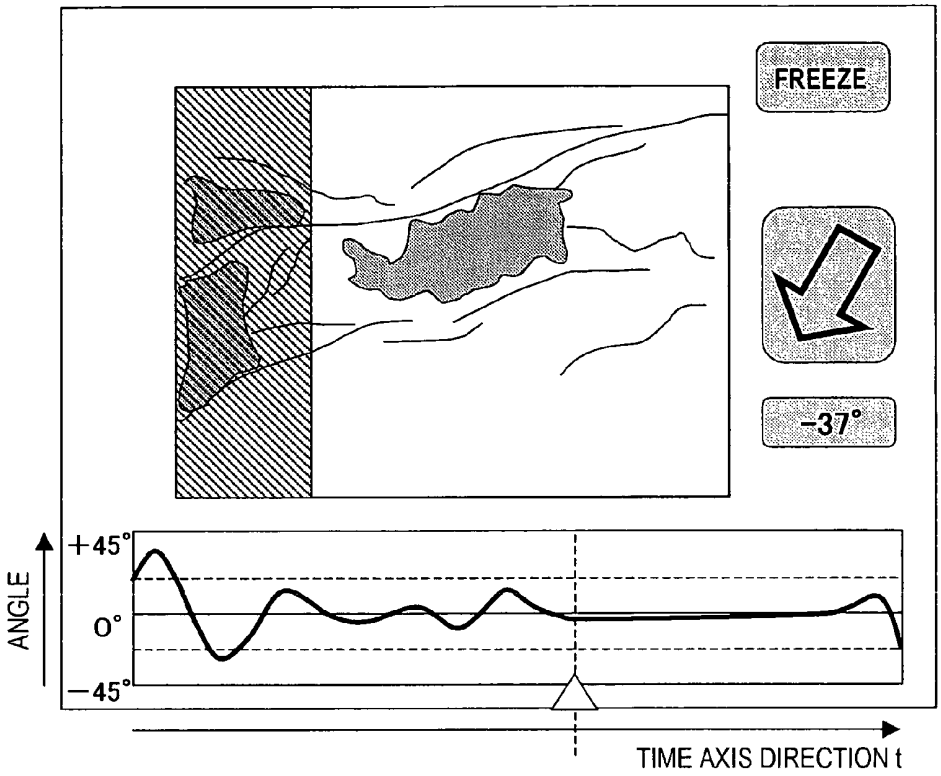

FREEZE
-37°
+45°
0°
-45°
ANGLE
TIME AXIS DIRECTION t

FIG. 25

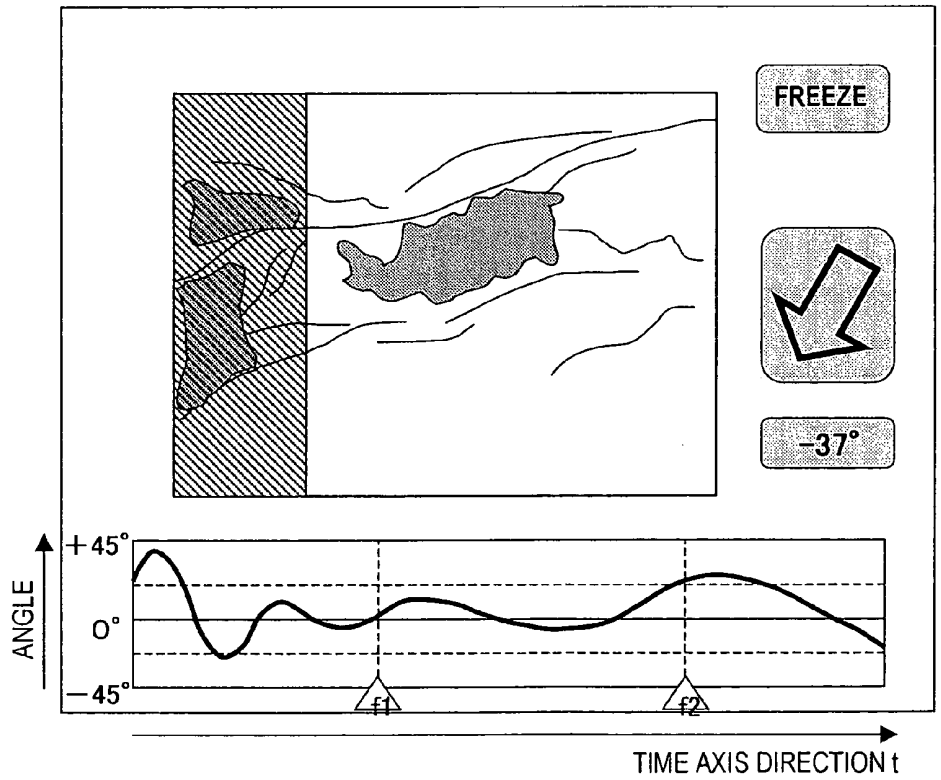
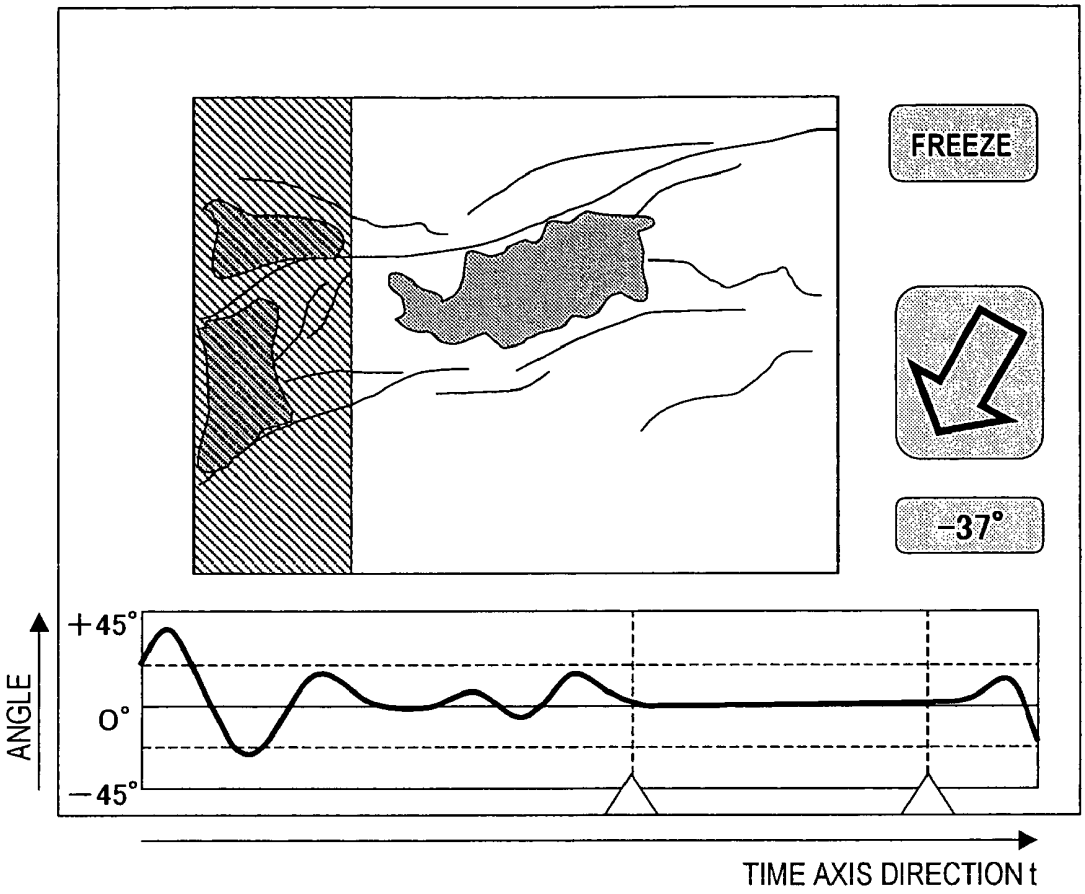

FREEZE
-37°
+45°
0°
-45°
ANGLE
f1
f2
TIME AXIS DIRECTION t

FIG. 26



DIAGNOSTIC ULTRASOUND SYSTEM AND METHOD OF DISPLAYING ELASTICITY IMAGE

TECHNICAL FIELD

The present invention relates to a diagnostic ultrasound system for displaying an elasticity image representing the hardness or softness of living tissue of a object to be examined.

BACKGROUND ART

A diagnostic ultrasound system for capturing an ultrasound image of a object to be examined supplies a driving signal for transmission to an ultrasound transducer, emits an ultrasonic wave to the object to be examined, and reconstructs and displays an ultrasound image on the basis of the signal received at the ultrasound transducer.

As such a diagnostic ultrasound system, there is one that displays an elasticity image representing the hardness or softness of living tissue of a object to be examined. For example, an examiner manually compresses an ultrasound transducer whose ultrasound transmission and reception surface is in contact with the object to be examined against the object to be examined. The diagnostic ultrasound system obtains time-sequential images related to the living tissue when pressure is applied to the object to be examined. Elasticity data related to the living tissue is computed in correlation with the obtained time-sequential images, and an elasticity image is constructed on the basis of the computed elasticity data and is displayed.

More specifically, pressure sensors are provided on the back of a transducer element unit of the ultrasound transducer; the pressure applied to the ultrasound transducer by compressing the object to be examined is determined; and Young's modulus is determined to display an elasticity image. When a predetermined threshold of pressure is exceeded, a light emitting diode provided on the ultrasound transducer is emitted. Such a calculation method is described in Patent Document JP2003-225239A.

However, in the Patent Document, only Young's modulus is calculated by determining the pressure applied to the ultrasound transducer, and there is no mentioning of displaying the compression state on a screen. The operation of the ultrasound transducer to compress the object to be examined is carried out manually by the examiner. Therefore, when compressing the object to be examined, the compression direction may deviate from a predetermined direction due to tilting of the ultrasound transmission and reception surface. As a result, pressure may not be uniformly applied to the object to be examined. In other words, a non-uniform stress distribution may be generated in the living tissue of the object to be examined.

As an ultrasound transducer, for example, there is one whose ultrasound transmission and reception surface is curbed toward the living tissue side. When compression operation is carried out with such an ultrasound transmission and reception surface, the pressure in the compression direction may become the greatest because of the shape of the ultrasound transmission and reception surface. In other words, a non-uniform stress distribution may be generated in the living tissue of the object to be examined.

When a non-uniform stress distribution is generated in the living tissue, regions that are sufficiently compressed with predetermined pressure (hereinafter referred to as 'adequate compression ranges') and regions that are insufficiently compressed (hereinafter referred to as 'inadequate compression ranges') both exist in the living tissue in the visual field of the ultrasound transducer. When an elasticity image related to such living tissue is displayed, it is difficult to determined, for example, whether an image corresponding to an inadequate compression range is caused by non-uniformity of the stress distribution or caused by the hardness of the living tissue. Thus, an image corresponding to an inadequate compression range should not be referred to as diagnostic information. However, the process of identifying an adequate compression range and an inadequate compression range in a displayed image depends on the examiner's experience. For this reason, there is a demand for being able to objectively and quantitatively grasping a compression state of living tissue, such as the adequate compression range, the compression direction, and the compression angle.

DISCLOSURE OF INVENTION

An object of the present invention is to provide a diagnostic ultrasound system and a method of displaying an elasticity image capable of a more accurate diagnosis by objectively and quantitatively grasping the compression state of body tissue.

To achieve the above-described object, the diagnostic ultrasound system according to the present invention includes an ultrasound transducer for transmitting and receiving ultrasonic waves to and from a object to be examined; transmitting means for supplying a driving signal to the ultrasound transducer;

receiving means for processing a reception signal output from the ultrasound transducer; elasticity image imaging means for obtaining an elasticity image related to body tissue of the object to be examined on the basis of a signal output from the receiving means; and displaying means for displaying the elasticity image, wherein the elasticity image imaging means includes compression state evaluating means for obtaining compression data related to a compression state of the body tissue of the object to be examined, determining the compression state of the body tissue on the basis of the compression data, and reflecting the determination result on the elasticity image.

In other words, the compression data corresponds to stress generated in the body tissue. Therefore, the determination result based on the compression data can be used as an objective determination index for grasping the compression state (for example, the adequate compression range or the compression direction) of the body tissue. By reflecting the determination result on an elasticity image, the elasticity image can be used to objectively and quantitatively identify the adequate compression range or the compression direction. By visually confirming such an elasticity image, examiners can accurately and easily grasp the compression state (for example, the adequate compression range or the compression direction) on a displayed image, regardless of their experience.

In such a case, the compression state evaluating means can determine an adequate compression range of the body tissue on the basis of a result of comparing the magnitude of the compression data and a set value.

The compression state evaluating means can determine the compression direction of the body tissue on the basis of a distribution of the magnitudes of the compression data at a measurement points in the body tissue.

The compression state evaluating means can obtain elasticity data related to the body tissue and determined at the elasticity image imaging means as the compression data.

The compression state evaluating means can obtain detection values of a plurality of pressure sensors aligned on an ultrasound transmission and reception surface of the ultrasound transducer as the compression data.

A plurality of the pressure sensors that is aligned in a long axis direction of the ultrasound transmission and reception surface may be employed.

A reference deforming body deformable by compression may be employed as pressure sensors.

The compression state evaluating means may obtain a deformation value of the reference deforming body stacked on the ultrasound transmission and reception surface of the ultrasound transducer as the compression data.

The compression state evaluating means may obtain a detection value of a position sensor attached to the ultrasound transducer as the compression data.

The compression state evaluating means may separate elasticity data of measurement points of the body tissue determined at the elasticity image imaging means into displacement vector components of a longitudinal direction corresponding to the depth direction of the object to be examined and a displacement vector components of a lateral direction orthogonal to the depth direction and may determine the adequate compression range by comparing the magnitude of the displacement vector components of the longitudinal direction or the magnitude of the displacement vector components of the lateral direction with a set value.

The compression state evaluating means may separate elasticity data of the measurement points of the body tissue determined at the elasticity image imaging means into displacement vector components of a longitudinal direction corresponding to the depth direction of the object to be examined and a displacement vector components of a lateral direction orthogonal to the depth direction and may determine the compression direction on the basis of the distribution of the magnitude of the displacement vector components of the longitudinal direction or the distribution of the magnitude of the displacement vector components of the lateral direction.

The compression state evaluating means constitutes image data representing the adequate compression range, and the displaying means may display the image data in an superimposing manner on or adjacent to the elasticity image.

The compression state evaluating means constitutes image data or numerical data representing the compression direction, and the displaying means may display the image data or the numerical data in a superimposing manner on or adjacent to the elasticity image.

The compression state evaluating means constitutes image data representing the border of the adequate compression range and an inadequate compression range, and the displaying means may display the image data in an superimposing manner on or adjacent to the elasticity image.

The displaying means may display a region of interest whose size is changed on the basis of a determination result of the compression state evaluating means.

The compression state evaluating means repeatedly determines the adequate compression range in set intervals, and the displaying means may update and display image data representing the adequate compression range in real-time every time the determination result is updated.

The compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means may update and display image data or numerical data representing the compression direction in real-time every time the determination result is updated.

The compression state evaluating means constitutes image data of an arrow indicating the compression direction or numerical data representing an angle corresponding to the compression direction, and the displaying means may display an image corresponding to the image data or the numerical data in a superimposing manner on or adjacent to the elasticity image.

The compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means may display the time transition of an angle representing the compression direction on the basis of the determination result.

A cine memory for exacting and reading out at least one of the elasticity image stored in advance and image data or numerical data corresponding to the compression state on the basis of compression state evaluation data output from the compression state evaluation unit may be provided.

The compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means may display the elasticity image for when an angle representing the compression direction is included in a set range with reference to zero.

The compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means time-sequentially may display the elasticity image group for when an angle representing the compression direction is included in a set range with reference to zero.

The compression state evaluating means may include announcing means for generating an alert of at least one of an image and audio when the adequate compression range corresponding to outside a set range.

The compression state evaluating means may include announcing means for generating an alert of at least one of an image and audio when the compression direction corresponding to outside a set range.

A method of displaying an elasticity image according to the present invention includes a transmission and reception step of processing a reception signal output from an ultrasound transducer for alternately converting ultrasonic waves and electric signals after a driving signal for transmission is supplied to the ultrasound transducer; determination step for obtaining compression data related to a compression state of body tissue of a object to be examined on the basis of the reception signal output in the transmission and reception step and determining the compression state of the body tissue on the basis of the compression data; and a display step for displaying the elasticity image reflecting the determination result. In the determination step, a compression range or a compression direction of the body tissue is determined as the compression state.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram illustrating the configuration of a diagnostic ultrasound system according to an embodiment of the present invention.

FIG. **2** illustrates an example of an ultrasound transducer configured to obtain pressure information.

FIG. **3** is a block diagram illustrating a process of a compression direction and range evaluation unit.

FIG. **4** is a schematic view of a displacement vector, which corresponds to an element of displacement frame data, wherein the displacement vector is separated into a longitudinal direction (depth direction or Z direction) component and a lateral direction (long axis direction of an ultrasound transmission and reception surface of the probe) component.

FIG. **5** illustrates a computation example of determining an adequate compression range and an inadequate compression range on the basis of the displacement Rz(i,k) in the longitudinal direction.

FIG. **6** illustrates an example of compression direction and range image data for displaying the compression direction and range that is constructed by an image constructing circuit.

FIG. **7** illustrates an operation example of a switching adder for constructing display image data by combining an elasticity image, a cross-sectional image, and a compression direction and range image.

FIG. **8** illustrates the exterior of a transrectal probe.

FIG. **9** illustrates a computation example of determining an adequate compression range and an inadequate compression range on the basis of an average value of depth direction displacement.

FIG. **10** illustrates an example of a method of configuring display image data by combining an elasticity image, a cross-sectional image, and a compression direction and range image.

FIG. **11** illustrates a computation example of determining an adequate compression range and an inadequate compression range on the basis of an average value of lateral direction displacement.

FIG. **12** illustrates an ultrasound transducer provided with a magnetic sensor.

FIG. **13** is a block diagram illustrating an embodiment of a compression direction and range evaluation unit for measuring the compression direction on the basis of position data measured by the magnetic sensor.

FIG. **14** illustrates an ultrasound transducer provided with a pressure sensor group viewed from the ultrasound transmission and reception surface side.

FIG. **15** is a block diagram illustrating an embodiment of a compression direction and range evaluation unit for measuring the compression direction on the basis of pressure data measured by a pressure sensor group.

FIG. **16** is a computation example of determining an adequate compression range and an inadequate compression range on the basis of pressure data measured by a pressure sensor group.

FIG. **17** illustrates a display configuration for when the ultrasound transducer shown in FIG. **2** is used and illustrates a display configuration in which image information of a region corresponding to an inadequate compression range is deleted.

FIG. **18** illustrates a display configuration for when the ultrasound transducer shown in FIG. **8** is used and illustrates a display configuration in which image information of a region corresponding to an inadequate compression range is deleted.

FIG. **19** illustrates a display configuration for when the ultrasound transducer shown in FIG. **2** is used and illustrates a display configuration in which the size of a ROI is changed in accordance with the current compression state.

FIG. **20** illustrates a display configuration for when the ultrasound transducer shown in FIG. **8** is used and illustrates a display configuration in which the size of a ROI is changed in accordance with the current compression state.

FIG. **21** illustrates a configuration for displaying compression direction image data in a display region set as a separate window.

FIG. **22** illustrates a graph representing the time transition of an angle θ representing the compression direction in real-time and illustrates a configuration in which the history of angles θ is scroll-displayed.

FIG. **23** illustrates a configuration for generating an alert when the compression direction or the compression range is determined to be inadequate.

FIG. **24** illustrates a configuration for displaying image data corresponding to an assigned point of time.

FIG. **25** illustrates a configuration for displaying in order the first image data to the last image data corresponding to an assigned period.

FIG. **26** illustrates a configuration for displaying image data for when the compression direction is included in a set range with reference to zero.

BEST MODE FOR CARRYING OUT THE INVENTION

A first embodiment of a diagnostic ultrasound system and a method of displaying an elasticity image employing the present invention will be described with reference to the drawings. FIG. **1** is a block diagram illustrating the configuration of the diagnostic ultrasound system according to this embodiment. The diagnostic ultrasound system captures a cross-sectional image of a region to be diagnosed of a object to be examined **10** by transmitting and receiving ultrasonic waves to and from the object to be examined **10** and captures an elasticity image representing the hardness or softness of living tissue of the region to be diagnosed.

As shown in FIG. **1**, the diagnostic ultrasound system includes an ultrasound transducer **100** (hereinafter referred to as 'probe **100**') for transmitting and receiving ultrasonic waves to and from the object to be examined **10**, a transmitting circuit **102** that is a transmitting means for supplying a driving signal for transmission to the probe **100**, a receiving circuit **103** and a beam forming circuit **104** that are receiving means for processing a reception signal output from the probe **100**, elasticity image imaging means for obtaining an elasticity image related to the living tissue of the object to be examined **10** on the basis of a signal output from the beam forming circuit **104**, and an image display unit **107** that is displaying means for displaying the elasticity image. Here, the elasticity image imaging means includes an RF signal frame data selector **108**, a displacement measuring unit **109**, a strain and elastic modulus computing unit **111**, and a color scan converter **113**.

Here, the diagnostic ultrasound system according to this embodiment includes a compression direction and range evaluation unit **115** that is evaluating means for evaluating the compression state of the living tissue of the object to be examined. The compression direction and range evaluation unit **115** obtains compression data related to the compression state of the living tissue of the object to be examined **10**, determines the compression state (for example, the adequate compression range or the compression direction) of the living tissue on the basis of the compression data, and reflects the determination result on to an elasticity image.

According to this embodiment, a range in the body tissue of the object to be examined **10** that is sufficiently compressed with predetermined pressure is referred to as an adequate compression range, whereas a region insufficiently compressed is referred to as an inadequate compression range. The compression direction is the direction the probe **100** whose ultrasound transmission and reception surface is in contact with the object to be examined **10** is manually pressed against the object to be examined **10**.

The diagnostic ultrasound system will be described in more detail. The diagnostic ultrasound system is broadly classified into an ultrasound transmitting and receiving system, a cross-sectional image capturing system, an elasticity

image capturing system, and a controlling and displaying system. As shown in FIG. **1**, the ultrasound transmitting and receiving system includes the probe **100**, an ultrasound transmission and reception controlling circuit **101**, the transmitting circuit **102**, the receiving circuit **103**, and the beam forming circuit **104**.

As shown in FIG. **2**A, the probe **100** includes an ultrasound transmission and reception surface **1001** for transmitting and receiving ultrasonic waves to and from the probe **100** by carrying out mechanical or electronic beam scanning. Element groups of transducers for alternately converting ultrasonic waves and electric signals are aligned on the ultrasound transmission and reception surface **1001**. The transducer groups are the source of ultrasonic waves transmitted to the object to be examined **10** and receive reflected echo generated at the object to be examined **10**. The probe **100** shown in FIG. **2**A is a linear probe whose ultrasound transmission and reception surface **1001** is formed as a flat plane. Instead, however, the probe **100** may be, for example, a convex probe whose ultrasound transmission and reception surface **1001** is curved toward the object to be examined **10** side. In other words, various types of probe, such as a transrectal probe, a transesophageal probe, an intraoperative probe, or an intravascular probe, may be used.

As shown in FIG. **2**A, pressure sensor groups **1002** and **1003** are disposed in the vicinity of the ultrasound transmission and reception surface **1001** on the probe **100**. For example, a plurality of the pressure sensor groups **1002** and **1003** is aligned and disposed in the long axis direction of the ultrasound transmission and reception surface **1001**. More specifically, the pressure sensor group **1002** is disposed along one of the long sides of the ultrasound transmission and reception surface **1001**. The pressure sensor group **1003** is disposed along the other long side of the ultrasound transmission and reception surface **1001**. However, the configuration is not limited to that shown in FIG. **2**A, and, for example, a reference deforming body **37** may be stacked on the probe **100** on the surface on the object to be examined **10** side, as shown in FIG. **2**B. Here, the surface on the object to be examined **10** side is the surface including the ultrasound transmission and reception surface **1001** of the probe **100**. The main point is that a configuration enabling the measurement of the pressure applied to the object to be examined **10** be employed.

The ultrasound transmission and reception controlling circuit **101** outputs a command for controlling the supply timing of the driving signal for transmission to be supplied to the probe **100** to the transmitting circuit **102**. The ultrasound transmission and reception controlling circuit **101** outputs a command for controlling the reception timing of a signal output from the probe **100** to the receiving circuit **103**. The transmitting circuit **102** includes a signal generating circuit for generating a high-voltage electric pulse for ultrasound transmission as a driving signal and a transmission beam forming circuit for setting the focus point of the ultrasonic waves transmitted from the probe **100** at a predetermined depth in the object to be examined **10**. The receiving circuit **103** includes an amplifying circuit for preliminarily amplifying an electric signal corresponding to the reflected echo received at the probe **100** by a predetermined gain. The beam forming circuit **104** phases and adds the phase of the reception signal output from the receiving circuit **103** and forms an ultrasound reception beam with respect to one or a plurality of focus points.

The cross-sectional image capturing system includes the signal processor **105** and the black and white scan converter **106**. The signal processor **105** carries out signal processing, such as gain correction, log compression, detection, edge enhancement, filtering, on the signal output from the beam forming circuit **104**. The black and white scan converter **106** converts the signal output from the signal processor **105** into a signal for display. More specifically, the black and white scan converter **106** obtains RF signal frame data output from the signal processor **105** at an ultrasound cycle and converts the obtained signal into a digital signal at an analog-digital converter (A/D converter). Next, the black and white scan converter **106** stores the converted signal as a plurality of consecutive and time-sequential cross-sectional image data sets in a plurality of frame memories. The frame memories are installed in the black and white scan converter **106**. The black and white scan converter **106** reads out a cross-sectional data group stored in the frame memories in television synchronization, converts the read out cross-sectional data group into an analog signal, and outputs the analog signal to the switching adder **114**. The black and white scan converter **106** is provided with a controller for outputting control commands to the A/D converter and the frame memories.

The elasticity image capturing system deviates from the output side of the ultrasound transmitting and receiving system and is dispose in series with the cross-sectional image capturing system. The elasticity image capturing system includes the RF signal frame data selector **108**, the displacement measuring unit **109**, the pressure measuring unit **110**, the strain and elastic modulus computing unit **111**, the elasticity data processor **112**, the color scan converter **113**, and the compression direction and range evaluation unit **115**.

The RF signal frame data selector **108** selects, for example, a pair of RF signal frame data sets from the sets of RF signal frame data time-sequentially and continuously output from the beam forming circuit **104**. For example, the RF signal frame data selector **108** stores, in order in the frame memories, the RF signal frame data sets continuously output from the beam forming circuit **104** at the frame rate of the diagnostic ultrasound system. The frame memories are installed in the RF signal frame data selector **108**. Next, the RF signal frame data selector **108** sets the currently stored sets of RF signal frame data included in the sets of RF signal frame data stored in the frame memories and sets the other sets of RF signal frame data stored in the past as RF signal frame data N-**1**, N-**2**, N-**3**, . . . N-M. In accordance with a control command, the RF signal frame data selector **108** selects one set of RF signal frame data from the RF signal frame data N-**1**, N-**2**, N-**3**, . . . N-M as RF signal frame data X and outputs the selected RF signal frame data X together with the RF signal frame data N to the displacement measuring unit **109**. In this way, the RF signal frame data selector **108** has a function for selecting and outputting a pair of RF signal frame data sets (N, X). A case in which the output signal from the beam forming circuit **104** is RF signal frame data has been described. Instead, however, the RF signal frame data may be a signal having an I, Q signal format in which RF signals are complex modulation.

As displacement frame data, the displacement measuring unit **109** measures the amount of displacement or a displacement vector (direction and magnitude of displacement) of the body tissue at each measurement point on the cross-sectional image obtained by the cross-sectional image system on the basis of the pair of RF signal frame data sets output from the RF signal frame data selector **108**. For example, the displacement measuring unit **109** carries out one-dimensional or two-dimensional correlation processing on the pair of RF signal frame data sets output from the RF signal frame data selector **108** so as to determine the one-dimensional displacement distribution or the two-dimensional displacement distribution

($\Delta L_{i,j}$) as displacement frame data. Then, the displacement measuring unit **109** outputs the displacement frame data to the strain and elastic modulus computing unit **111** and the compression direction and range evaluation unit **115**. As methods of measuring the displacement frame data, for example, the block matching method and the gradient method are known. According to the block matching method, an image is divided into, for example, blocks of N×N pixels; a block that is the most similar to the target block in the current frame is retrieved from the previous frame; and predictive coding is carried out by referring to the retrieved block (for example, Japanese Unexamined Patent Application Publication No. 5-317313). However, the method is not limited to the block matching method or the gradient method, and, instead, for example, a method of calculating displacement according to autocorrelation processing in the same regions in two sets of image data may be employed.

The pressure measuring unit **110** measures the pressure applied to the object to be examined **10** through the probe **100** on the basis of signals output from a pressure sensor group **1002** and **1003** of the probe **100**. Then, the pressure measuring unit **110** outputs the measured pressure as pressure data ($\Delta P_{i,j}$) to the strain and elastic modulus computing unit **111** and the compression direction and range evaluation unit **115**. Instead of this configuration, the pressure measuring unit **110** may take in a deformation value of the reference deforming body **37** of the probe **100** and measure the pressure applied to the object to be examined **10** on the basis of the taken in deformation value (for example, Japanese Unexamined Patent Application Publication Nos. 2005-013283 and 2005-066041).

The strain and elastic modulus computing unit **111** computes the strain amount distribution and the elastic modulus of the body tissue at each measurement point on the cross-sectional image obtained by the cross-sectional capturing system, on the basis of the displacement frame data ($\Delta L_{i,j}$) output from the displacement measuring unit **109** and the pressure data ($\Delta P_{i,j}$) output from the pressure measuring unit **110**. The strain amount distribution ($\epsilon_{i,j}$) is calculated by spatially differentiating ($\Delta L_{i,j}/\Delta X$) the displacement frame data ($\Delta L_{i,j}$). Young's modulus $Ym_{i,j}$, which is one type of elastic modulus, is determined by dividing the pressure at each computation point with the amount of strain at the computation point, as represented by Expression 1. The suffix i,j is an index indicating the coordinates of the frame data. The strain and elastic modulus computing unit **111** generates elasticity frame data on the basis of the strain amount distribution and the elastic modulus of each measurement point and outputs the generated elasticity frame data to the elasticity data processor **112**. Instead of using the strain and the elastic modulus of the body tissue when generating elasticity frame data, the strain or elastic modulus calculating unit **111** may use another parameter, such as a stiffness parameter β, a compressive elastic modulus coefficient Ep, or an incremental elastic modulus coefficient Einc (for example, Japanese Unexamined Patent Application Publication No. 5-317313).

$$Ym_{i,j}=(\Delta P_{i,j})/(\Delta L_{i,j}/\Delta X) \quad \text{(Expression 1)}$$

(i,j=1, 2, 3, . . .)

The elasticity data processor **112** carries out various types of image processing on the elasticity frame data output from the strain and elastic modulus computing unit **111**. For example, the elasticity data processor **112** carries out smoothing on the coordinate plane, contrast optimization, and smoothing between the frames in the time axis direction on the elasticity frame data (for example, Japanese Unexamined Patent Application Publication No. 2004-261198). Then, the elasticity data processor **112** outputs the image-processed elasticity frame data to the color scan converter **113**.

The color scan converter **113** includes color information conversion means for adding color information (for example, a red color code, a green color code, or a blue color code) to the elasticity frame data output from the elasticity data processor **112**. For example, the color scan converter **113** automatically or manually takes in an upper limit value and a lower limit value that define a selection range for gradating the elasticity frame data via the system control interface unit **116**. Then, the color scan converter **113** adds color information to the elasticity frame data on the basis of the gradating selection range. More specifically, the color scan converter **113** converts pixel data that corresponds to a region measured to have great strain with respect to the elasticity frame data output from the elasticity data processor **112** into a red color code. In contrast, the color scan converter **113** converts pixel data that corresponds to a region measured to have small strain into a blue color code. Such elasticity image data output from the color scan converter **113** is displayed on the image display unit **107** as an elasticity image, where the region measured to have great strain is displayed in a red color system and the region measured to have small strain is displayed in a blue color system.

Instead of the color scan converter **113**, a black and white scan converter may be used. In such a case, the black and white scan converter increases the brightness of the pixel data of the elasticity frame data that corresponds to a region measured to have great strain. In contrast, black and white scan converter decreases the brightness of the pixel data of the elasticity frame data that corresponds to a region measured to have small strain. Elasticity image data output from such a black and white scan converter is displayed as an elasticity image on the image display unit **107**, where the region measured to have great strain includes bright pixels and the region measured to have small strain includes dark pixels.

The compression direction and range evaluation unit **115** determines the adequate compression range and the compression direction of the body tissue of the object to be examined **10**. First, the compression direction and range evaluation unit **115** obtains compression data related to the compression state of the body tissue of the object to be examined **10**. For example, the compression direction and range evaluation unit **115** takes in, as compression data, at least one of displacement frame data output from the displacement measuring unit **109**, elasticity frame data output from the strain and elastic modulus computing unit **111**, and pressure data output from the pressure measuring unit **110**. The compression direction and range evaluation unit **115** may take in the deformation value of the reference deforming body **37** of the probe **100** as the compression data. Next, the compression direction and range evaluation unit **115** determines the adequate compression range of the body tissue on the basis of the result of comparing the magnitude of the compression data and a set value (threshold value). For example, when the magnitude of the compression data at a measurement point is greater than the threshold value, the compression direction and range evaluation unit **115** determines that the body tissue at the measurement point belongs to the adequate compression range. In contrast, when the magnitude of the compression data at a measurement point is smaller than the threshold value, the compression direction and range evaluation unit **115** determines that the body tissue at the measurement point belongs to an inadequate compression range. Furthermore, the compression direction and range evaluation unit **115** determines the compression direction of the body tissue on the basis of the distribution of the magnitudes of the compression data at the

measurement points. Then, the compression direction and range evaluation unit **115** configures image data or numerical data corresponding to the adequate compression range and the compression direction. Here, the image data is, for example, a line image representing the border of the adequate compression range and the inadequate compression range and an arrow image indicating the compression direction. The numerical data is angular data representing the compression direction. The compression direction and range evaluation unit **115** outputs such image data or numerical data corresponding to the adequate compression range and the compression direction to the color scan converter **113**. In this way, the elasticity image output from the color scan converter **113** reflects the adequate compression range and the compression direction.

FIG. **3** is a block diagram illustrating an embodiment of the compression direction and range evaluation unit **115**. As shown in FIG. **3**, the compression direction and range evaluation unit **115** includes a memory circuit **1151**, a compression direction and range evaluating circuit **1152**, and an image constructing circuit **1153**. The memory circuit **1151** stores the displacement frame data output from the displacement measuring unit **109** as measurement result data. The compression direction and range evaluating circuit **1152** determines the adequate compression range and the compression direction of the body tissue on the basis of the measurement result data read out from the memory circuit **1151**. For example, the compression direction and range evaluating circuit **1152** carries out statistical processing, such as overflow processing and average value calculation, on the measurement result data and outputs the processing result as a determination result to the image constructing circuit **1153**. The image constructing circuit **1153** constructs image data or numerical data corresponding to the determination result output from the compression direction and range evaluating circuit **1152**. Then, the imaging circuit **1153** outputs the image data or the numerical data to the switching adder **114** via the color scan converter **113**.

The controlling and displaying system includes the switching adder **114**, the system control interface unit **116**, the cine memory unit **117**, and the image display unit **107**. The switching adder **114** selects or combines the cross-sectional image data output from the black and white scan converter **106** and the elasticity image data output from the color scan converter **113**. For example, the switching adder **114** selects and outputs one of the cross-sectional image data and the elasticity image data to the image display unit **107**. Alternatively, the switching adder **114** additively combines the cross-sectional image data and the elasticity image data and outputs this to the image display unit **107**. When additively combining the cross-sectional image data and the elasticity image data, the switching adder **114** can additively combine the black and white cross-sectional image and the elasticity image in a manner such that the images are displayed in a two-screen display region (for example, Japanese Unexamined Patent Application Publication No. 2000-60853). The switching adder **114** may additively combine the images in a manner such that the elasticity image is translucently overlapped onto the black and white cross-sectional image. Then, the switching adder **114** outputs the selected or additively combined data as display image data to the image display unit **107** and the cine memory unit **117**.

The system control interface unit **116** outputs a control command to each component of the diagnostic ultrasound system. The system control interface unit **116** includes inputting means, such as a keyboard and a mouse, and outputs a command input via the inputting means to the compression direction and range evaluation unit **115** and the cine memory unit **117**. The cine memory unit **117** stores the display image data output from the switching adder **114** and outputs the display image data to the image display unit **107** in accordance with the control command. The image display unit **107** displays the display image data read out from the switching adder **114** or the display image data read out from the cine memory unit **117** on a display screen.

The basic operation of a diagnostic ultrasound system having the above-described configuration will be described. First, the ultrasound transmitting and receiving system transmits and receives ultrasonic waves to and from the object to be examined **10**. For example, the examiner contacts the ultrasound transmission and reception surface side of the probe **100** with, for example, the body surface of the object to be examined **10**. After the probe **100** contacts the object to be examined **10**, a driving signal for transmission is supplied from the transmitting circuit **102** to the probe **100** at predetermined time intervals in accordance with the command output from the ultrasound transmission and reception controlling circuit **101**. In response to the supplied driving signal, ultrasonic waves are repeatedly transmitted from the probe **100** to the object to be examined **10**. The transmitted ultrasonic waves are reflected as reflected echo during the process of transmitting through the object to be examined **10**. The reflected echo is converted into reception signals by being received in order by the probe **100**. The converted reception signals are processed as time-sequential RF signals by the receiving circuit **103** and the beam forming circuit **104**.

When ultrasonic waves are transmitted to and received from the object to be examined **10**, the examiner manually moves the probe **100** up and down with respect to the body surface of the object to be examined **10**. In this way, the pressure applied to the object to be examined **10** is increased or decreased. The pressure applied to the object to be examined **10** is measure by the pressure measuring unit **110** via the pressure sensor groups **1002** and **1003**.

The cross-sectional image system configures dark and light cross-sectional image data (for example, black and white cross-sectional image data) of the object to be examined **10**. For example, black and white cross-sectional image data is configured by the signal processor **105** and the black and white scan converter **106** on the basis of the time-sequential RF signals output from the beam forming circuit **104**.

The elasticity image capturing system configures elasticity image data (for example, color elasticity image data) of the object to be examined **10**. For example, displacement frame data related to the amount of movement and displacement of the body tissue corresponding to each measurement point of the cross-sectional image obtained by the cross-section capturing system is determined by the RF signal frame data selector **108** and the displacement measuring unit **109** on the basis of the time-sequential RF signals output from the beam forming circuit **104**. Elasticity image data is configured by the strain and elastic modulus computing unit **111**, the elasticity data processor **112**, and the color scan converter **113** on the basis of the determined displacement frame data and the pressure data output from the pressure measuring unit **110**.

An ultrasound image for diagnosis is displayed on a display screen by the controlling and displaying system. For example, the cross-sectional image data output from the black and white scan converter **106** and the elasticity image data output from the color scan converter are selected or additively combined by the switching adder **114** in accordance with a control command. The display image data output from the switching adder **114** is displayed on the image display unit **107**. Alternatively, the display image data output from the

switching adder **114** is stored in the cine memory unit **117**. The stored display image data is read out from the cine memory unit **117** in accordance with a control command. The read out display image data is displayed on the image display unit **107**.

Here, an example of the operation of the compression direction and range evaluation unit **115** employed to the diagnostic ultrasound system according to this embodiment will be described in detail. First, an example of evaluating the compression state of the object to be examined **10** with the compression direction and range evaluation unit **115** on the basis of the displacement data output from the displacement measuring unit **109** will be described. More specifically, a method of computing the compression direction and range from the depth direction component of the displacement frame data will be described.

FIG. **4** schematically illustrates the elements of the displacement frame data as displacement vectors by separating an element into a longitudinal direction component Dz and a lateral direction component Dx. Here, the longitudinal direction (Z direction) corresponds to the depth direction of the object to be examined or, in other words, the emission direction of the ultrasound beam. The lateral direction (X direction) corresponds to a direction orthogonal to the depth direction of the object to be examined or, in other words, the long axis direction of the ultrasound transmission and reception surface. The longitudinal direction component Dx and the lateral direction component Dx shown in FIG. **4** are represented as Expression 2. Index i in Expressions 2 represents the coordinate in the lateral direction. Index k represents the coordinate in the longitudinal direction. By using indices i and k, the entire displacement frame data group is referred to.

$$Dx(i,k)$$

$$(i=1, 2, 3, \ldots L;\ k=1, 2, 3, \ldots N)$$

$$Dz(i,k) \qquad \text{(Expression 2)}$$

$$(i=1, 2, 3, \ldots L;\ k=1, 2, 3, \ldots N)$$

The displacement frame data groups Dx(i,k) and Dz(i,k) output from the displacement measuring unit **109** are stored in the memory circuit **1151**, shown in FIG. **3**, as measurement result data groups Rx(i,k) and Rz(i,k). The stored measurement result data groups Rx(i,k) and Rz(i,k) are represented as Expressions 3.

$$Rx(i,k)$$

$$(i=1, 2, 3, \ldots L;\ k=1, 2, 3, \ldots N)$$

$$Rz(i,k) \qquad \text{(Expression 3)}$$

$$(i=1, 2, 3, \ldots L;\ k=1, 2, 3, \ldots N)$$

Next, as a computation example for determining an adequate compression range and an inadequate compression range of body tissue, a method using the displacement Rz(i,k) in the longitudinal direction will be described with reference to FIG. **5**. FIG. **5** is a line graph defining the border of the adequate compression range and the inadequate compression range. The line graph includes an axis corresponding to the longitudinal direction (Z direction) and an axis corresponding to the lateral direction (X direction).

First, the strain and elastic modulus computing unit **111** computes a value obtained by computing the average value of the values of the longitudinal direction displacement among coordinate points in the same lateral direction on the basis of Expression 4. In other words, the strain and elastic modulus computing unit **111** computes the average value of the longitudinal direction displacement for each lateral direction coordinate. Next, the strain and elastic modulus computing unit **111** plots the computed values according to Expression 4 on the graph shown in FIG. **5**. Each cross mark shown in FIG. **5** represents the plotted value of <Rz(i)> at each lateral direction coordinate point (i=1, 2, 3, . . . L). In the configuration shown in FIG. **5**, L equals 15 for the sake of explanation, but the value is not limited. Next, the strain and elastic modulus computing unit **111** determines a straight line by carrying out approximation based on, for example, the least-square method on the computed values plot on the graph shown in FIG. **5**.

Then, the strain and elastic modulus computing unit **111** determines that the slope θ of the straight line shown in FIG. **5** is numerical data representing the angle corresponding to the compression direction of the body tissue. When the object to be examined **10** is compressed in the +Z direction or, in other words, pressed with the probe **100**, the value of the displacement is set so that it has a positive (+) sign. In contrast, when the object to be examined **10** is decompressed in the −Z direction or, in other words, when the probe **100** is pulled away from the object to be examined **10**, the value of the displacement is set so that it has a negative (−) sign. A computation method representing the configuration shown in FIG. **5** has been described. However, the computation process is not limited to when the object to be examined **10** is compressed but can also be employed when the object to be examined **10** is decompressed.

$$\langle Rz(i)\rangle=\{\Sigma k Rz(i,k)\}/N \qquad \text{(Expression 4)}$$

The strain and elastic modulus computing unit **111** determines the adequate compression range on the basis of the line graph shown in FIG. **5**. For example, the strain and elastic modulus computing unit **111** sets a threshold value Th(Rz) for the depth direction displacement. The threshold value Th(Rz) is a set value output from the system control interface unit **116** to the compression direction and range evaluation unit **115**. For this set value, a minimum value of the depth direction displacement is determined in advance so as to determine a region that corresponds to the adequate compression range. Then, the strain and elastic modulus computing unit **111** determines that the lateral direction coordinate region exceeding the threshold value Th(Rz) as being the adequate compression range and the lateral direction coordinate region not exceeding the threshold value Th(Rz) as being the inadequate compression range. The coordinate region determined to be the adequate compression range is set as Pth(i)=1. The coordinate region determined to be the inadequate compression range is set as Pth(i)=0. For example, in the case of FIG. **5**, a coordinate region is set as Expressions 5. The strain and elastic modulus computing unit **111** identifies the border of the region whose Pth(i) value is set to "1" and the region whose Pth(i) value is set to "0" as the border of the adequate compression range and the inadequate compression range. By employing such a method, the strain and elastic modulus computing unit **111** sets the data of the compression angle θ and the compression range Pth(i) as the compression direction and range evaluation data.

$$Pth(1\leqq i\leqq 4)=0$$

$$Pth(5\leqq i\leqq 15)=1 \qquad \text{(Expressions 5)}$$

FIG. **6** illustrates an example of compression direction and range evaluation data constructed by the image constructing circuit **1153**, shown in FIG. **3**. Here, the compression direction and range evaluation data is data representing the compression direction and the adequate compression range corresponding to the compression direction and range evaluation data. The image constructing circuit **1153** configures, for

example, compression direction and range evaluation data corresponding to the values of the compression angle θ and the compression range of Pth(i), as shown in FIG. **6**. In the configuration shown in FIG. **6**, a white color code is assigned to the pixel points corresponding to the adequate compression range. On the other hand, a black color code is assigned to a predetermined percentage of the pixel points corresponding to the inadequate compression range. Image data for an arrow corresponding to the compression angle θ and pointing in the compression direction is configured. Moreover, the value of the compression angle θ (for example, "−37°") is configured as image data. According to this embodiment, the image and numerical value corresponding to the compression angle θ and the image corresponding to the adequate compression range are simultaneously displayed on the same screen. However, only one of these may be displayed. Such compression direction and range evaluation image data reflects the current compression state. In other words, when the compression direction or the adequate compression range of the body tissue within the region of interest changes, the image constructing circuit **1153** updates the compression direction and range evaluation image data in real-time by following the change.

FIG. **7** illustrates an operation example of the switching adder **114** employed to the diagnostic ultrasound system according to this embodiment. FIG. **7**A illustrates the compression direction and range image shown in FIG. **6**. FIG. **7**B illustrates a combined image that combines a cross-sectional image obtained by the cross-sectional image capturing system and an elasticity image obtained by the elasticity image capturing system. FIG. **7**C illustrates a display configuration of the image display unit **107**.

The switching adder **114** outputs the compression direction and range evaluation image (FIG. **7**A) output from the compression direction and range evaluation unit **115** and the display image data with an superimposing combined image (FIG. **7**B) of the cross-sectional image and the elasticity image are output to the image display unit **107**. The display image data is displayed on the image display unit **107** as an ultrasound diagnosis image.

According to the method of evaluating a compression state described with reference to FIGS. **4** to **7**, the examiner can diagnose the object to be examined more accurately as a result of being able to objectively determining the compression state (for example, the adequate compression range, the compression direction, and the compression direction) of the body tissue in a quantitative quantity on the display screen. In other words, the compression data according to this embodiment corresponds to the stress generated in the body tissue. Therefore, the determination result based on the compression data (for example, displacement frame data) can be an objective index for grasping the adequate compression range or the compression direction of the body tissue. By reflecting this determination result to the elasticity image, the adequate compression range and the compression direction can be objectively and quantitatively identified from the elasticity image. By visually confirming such an elasticity image, the examiner can correctly and easily grasp the adequate compression range or the compression direction on the display screen, regardless of the difference in their experience.

FIG. **8** illustrates a configuration in which a convex probe **100** is employed to the diagnostic ultrasound system instead of the linear probe **100** shown in FIG. **2**. FIG. **8**A is a side view of the probe **100**. FIG. **8**B illustrates the probe **100** viewed from the tip. The probe **100** shown in FIG. **8** is used for transrectal examination. As shown in FIG. **8**, the probe **100** includes a cylindrical main body and is provided with a head-forming section disposed at the tip of the body. A transducer element group **81** is disposed on the cylindrical surface in the vicinity of the tip of the head-forming section. The circumferential surface of the head-forming section has a relatively large curvature of, for example, 20 mm. In other words, the convex probe **100** is formed such that the ultrasound transmission and reception surface is curved toward the tissue of the object to be examined to be compressed. In a similar manner as the case shown in FIG. **2**A, pressure sensor groups **1002** and **1003** are provided around the ultrasound transmission and reception surface. Furthermore, in a similar manner as the case shown in FIG. **2**B, a reference deforming body **37** may be attached to the ultrasound transmission and reception surface.

FIG. **9** illustrates the operation of the compression direction and range evaluation unit **115** when body tissue is compressed with the probe **100** shown in FIG. **8**. As shown in FIG. **9**, because of the shape of the ultrasound transmission and reception surface of the probe **100**, when the probe **100** is misaligned even slightly from the center of the compression direction, the compression direction is the inadequate compression range. Thus, the compression direction and range evaluation unit **115** obtains a curve such as that shown in FIG. **9** by approximating (fitting) the displacement Rz(i) in the depth direction to, for example, a normal distribution function. Next, the compression direction and range evaluation unit **115** determines the average value μ of the approximated normal distribution function as the average value of the depth direction displacement. Then, the compression direction and range evaluation unit **115** determines the radial axis direction at a coordinate of long axis direction X=μ of the ultrasound transmission and reception surface of the probe **100** as the center of the compression direction. In the same manner as the configuration shown in FIG. **5**, the compression direction and range evaluation unit **115** sets the threshold value Th(Rz) of the depth displacement and determines the adequate compression range and the inadequate compression range separated by the threshold value Th(Rz).

FIG. **10** illustrates an example of a displayed image for when the body tissue is compressed with the probe **100** shown in FIG. **8**. As shown in FIG. **10**, in the fan-shaped displayed image, a white color code is assigned to the pixel points corresponding to the adequate compression range. In contrast, a black code is assigned to a predetermined percentage of the pixel points corresponding to the inadequate compression range. An image of an arrow corresponding to the compression angle θ and pointing in the compression direction is displayed. In this way, for example, when a transrectal probe **100** is used to examine prostate cancer, the body tissue in the inadequate compression range can be prevented from being falsely diagnosed as positive. It is significantly effective to display an objective and quantitative determination index of the compression state (for example, the adequate compression range, the compression direction, and the compression angle) when using a probe **100** configured in a manner shown in FIG. **8**.

FIG. **11** illustrates another example of the computation method described with reference to FIG. **5**. The configuration shown in FIG. **11** differs from the configuration that uses displacement frame data of the longitudinal direction shown in FIG. **5**, in that displacement frame data of the lateral direction is used. More specifically, according to the configuration shown in FIG. **5**, the compression direction and range evaluation unit **115** determines, for example, the compression direction by curve-approximating the displacement distribution in the depth direction (Z direction). In contrast, according to the configuration shown in FIG. **11**, the compression direc-

tion and range evaluation unit **115** curve-approximates the displacement distribution in the lateral direction (X direction).

For example, the displacement distribution in the lateral direction for when the target tissue is compressed with the convex probe **100** will have a configuration shown in FIG. **11**. The cross mark shown in FIG. **11** represents the plotted value of the depth direction average <Rx(i)> of the lateral direction displacement at each lateral direction coordinate point (i=1, 2, 3, . . . L). In this configuration, L equals 15. As shown in FIG. **11**, the points whose average value <Rx(i)> is positive correspond to points having a component displaced in the +X direction. The points whose average value <Rx(i)> is negative correspond to points having a component displaced in the −X direction. Here, as shown in the drawing, the compression direction and range evaluation unit **115** approximates the plotted points of the computation result to a straight line by employing, for example, the least-square method. Next, the compression direction and range evaluation unit **115** sets the intersecting point of the approximated straight line and the X axis as μ. Then, the compression direction and range evaluation unit **115** determines that the body tissue group is located at the center or in the vicinity of the center of the compression direction because the body tissue group distributed from the X=μ coordinate in the radial axis direction does not have many displacement components in the lateral direction.

Similar to the configuration shown in FIG. **5**, the compression direction and range evaluation unit **115** sets a threshold value Th(Rx) of the lateral direction displacement. Then, the compression direction and range evaluation unit **115** interprets that components diverge to the lateral direction of the body tissue in regions whose lateral direction displacement is greater than Th(Rx) and regions whose lateral direction displacement is smaller than −Th(Rx) and determines these regions as inadequate compression ranges. In other words, the compression direction and range evaluation unit **115** determines regions whose absolute value of the lateral direction displacement is greater than the absolute value of Th(Rx) as inadequate compression ranges.

In the configurations shown in FIG. **5** or **8**, the compression direction and range evaluation unit **115** evaluates and estimates the compression state (for example, the adequate compression range, the compression direction, and the compression angle) on the basis of either the longitudinal direction components or the lateral direction components of the displacement vector related to the body tissue. However, the configuration is not limited, and the compression direction and range evaluation unit **115** may evaluate and estimate the compression state on the basis of both the longitudinal direction components and the lateral direction components. In this way, the evaluation accuracy and the estimation accuracy are increased compared with when either the longitudinal direction components or the lateral direction components is used.

In the configurations described with reference to FIGS. **3** to **11**, the compression direction and range evaluation unit **115** uses the displacement frame data output from the displacement measuring unit **109** when evaluating or estimating the compression state. However, the configuration is not limited, and the compression direction and range evaluation unit **115** may use numerical value data (elasticity frame data) of the strain or the elastic modulus output from the strain and elastic modulus computing unit **111**, instead of the displacement frame data.

The compression direction and range evaluation unit **115** may set a detection value of a position sensor attached to the probe **100** as compression data, instead of the displacement frame data or the elasticity frame data. FIG. **12** illustrates the configuration of the probe **100** provided with a magnetic sensor **120** as a position sensor. FIG. **13** illustrates a configuration in which the magnetic sensor **120** is provided on the input side of the compression direction and range evaluation unit **115**. As shown in FIGS. **12** and **13**, the magnetic sensor **120** uses magnetism or light to detect the position of the magnetic sensor **120** as position data. Next, the compression direction and range evaluation unit **115** determines the movement direction of the probe **100** on the basis of the position data output from the magnetic sensor **120**. Then, the compression direction and range evaluation unit **115** evaluates or estimates the compression direction of the body tissue on the basis of the movement direction of the probe **100**. The adequate range of the body tissue may be estimated on the basis of the field range and the compression direction of the probe **100** or on the basis of other methods described above.

The compression direction and range evaluation unit **115** may use the pressure data output from the pressure measuring unit **110**, instead of the displacement frame data, the elasticity frame data, or the position data. FIG. **14** illustrates the probe **100** of FIG. **2**B from the ultrasound transmission and reception surface side. FIG. **15** illustrates the configuration in which the pressure measuring unit **110** is provided on the input side of the compression direction and range evaluation unit **115**. As shown in FIG. **14** or **15**, the pressure sensor groups **1002** and **1003** detect the pressure for when the ultrasound transmission and reception surface is pressed against the object to be examined. The pressure measuring unit **110** sends the signals output from the pressure sensor groups **1102** and **1003**, as pressure data, to the compression direction and range evaluation unit **115**. The compression direction and range evaluation unit **115** may measure the compression state of the body tissue on the basis of the pressure data.

For example, the compression direction and range evaluation unit **115** stores pressure data measured in the past in term of time and determines the amount of time variation in the current pressure data and the pressure data of the past output from the pressure measuring unit **110**. FIG. **16** is a graph representing the amount of change in the pressure data in the lateral direction X. The longitudinal axis ΔPz(i) in FIG. **16** represents the amount of change in the pressure data at the position of each pressure sensor. Index i represents the coordinate in the long axis direction. Index j represents the coordinate in the short axis direction. <ΔPz(i)> represents the average value of the pressure data in the short axis direction at each coordinate of the long axis direction and is calculated on the basis Expression 6.

$$<\Delta Pz(i)>=\{<\Delta Pz(i,k)+<\Delta Pz(i,2)\}/2 \quad \text{(Expression 6)}$$

Next, similar to the case described with referring to FIG. **5** or **11**, the compression direction and range evaluation unit **115** sets a threshold value Th(ΔPz) of the amount of pressure change. Then, the compression direction and range evaluation unit **115** determines the lateral direction coordinate region where the amount of pressure change exceeds the threshold value as the current adequate compression range. In contrast, the compression direction and range evaluation unit **115** determines the lateral direction coordinate region where the amount of pressure change is equal to or below the threshold value as the current inadequate compression range.

According to the configuration described with reference to FIGS. **15** and **16**, the adequate compression range and the inadequate compression range of the body tissue can be determined more accurately compared with when the displacement frame data or the elasticity frame data is used. For example, the displacement frame data or the elasticity frame data is based on the displacement of the body tissue of when

pressure is applied to the object to be examined. Therefore, when the inadequate compression range is determined on the basis of the displacement frame data and the like, it can be presumed that there are cases in which it is difficult to determine whether the range is caused from the hardness of the body tissue or non-uniformity of stress. Thus, by carrying out determination on the basis of the amount of pressure change, an inadequate compression range caused by non-uniformity of stress can be determined more accurately. In other words, the adequate compression range can be determined more accurately.

The compression direction and range evaluation unit **115** may use a value corresponding to the deformation of the reference deforming body **37** shown in FIG. **2**B, instead of the displacement frame data, the elasticity frame data, the position data, or the pressure data. For example, deformation detection means detects the deformation of the reference deforming body **37** and estimates the pressure data on the basis of the detected value. The compression direction and range evaluation unit **115** determines the adequate compression range of the body tissue on the basis of the pressure data output from the deformation detection means. In other words, the compression direction and range evaluation unit **115** obtains one of at least the displacement frame data, the elasticity frame data, the position data of the probe **100**, the pressure data, and the deformation value of the reference deforming body **37**, as compression data, and determines the adequate compression range or the compression direction of the body tissue on the basis of the obtained compression data.

FIG. **17** illustrates another example of the display configuration shown in FIG. **7**C. FIG. **18** illustrates another example of a display configuration shown in FIG. **10**. The displayed images shown in FIGS. **17** and **18** differ from the display configuration shown in FIG. **7**C or **10** in which a black color code is assigned to a predetermined percentage of the pixel points corresponding to the inadequate compression range, in that the cross-sectional image and the elasticity image corresponding to the inadequate compression range are deleted. The processing for deleting images corresponding to the inadequate compression range is carried out by the switching adder **114** in response to a control command. According to such a displayed image, only the images corresponding to the adequate compression range are extracted and displayed. Therefore, the examiner can employ only the adequate compression range as a diagnostic image, and misdiagnosis caused by the inadequate compression range can be reliably prevented.

FIG. **19** illustrates another example of the display configuration shown in FIG. **7**C. FIG. **20** illustrates another example of the display configuration shown in FIG. **10**. The displayed images shown in FIGS. **19** and **20** differ from the display configuration of FIG. **7**C or **10** in which the adequate compression range and the inadequate compression range are included in the region of interest (ROI), in that the an image region corresponding to the adequate compression range is re-set as the region of interest. The re-setting processing of the region of interest is carried out by the switching adder **114** in accordance with a control command. For example, the switching adder **114** carries out processing for changing (for example, reducing) the size of the ROI in real-time in accordance with the current compression state. According to such a displayed image, only images corresponding to the adequate compression range are extracted and displayed. Therefore, the examiner can employ only the adequate compression range as a diagnostic image, and misdiagnosis caused by the inadequate compression range can be reliably prevented. Since the display region is decreased when the ROI is reduced, as shown in this configuration, the processing speed of the displayed image is increased.

FIG. **21** illustrates another example of a display configuration shown in FIG. **7**C. The display configuration shown in FIG. **21** differs from the display configuration shown in FIG. **7**C in which an arrow and a numerical value is displayed in an superimposing manner with the ultrasound image, in that the arrow of the compression direction and the numerical value of the compression angle are displayed adjacently with the ultrasound image. In other words, the display configuration shown in FIG. **21** has a specialized display region as a separate window for displaying the arrow and the compression angle. The processing for defining such a specialized display region is carried out by the switching adder **114**. According to this display configuration, the arrow of the compression direction and the numerical value of the compression angle can be easily and visually confirmed.

FIG. **22** illustrates another example of the display configuration shown in FIG. **7**C. The display configuration shown in FIG. **22** differs from the display configuration shown in FIG. **7**C in which the current compression angle is displayed, in that the time transition of the compression angle is displayed as a graph. In other words, in the display configuration shown in FIG. **22**, a graph display region having a longitudinal axis representing the compression angle and a lateral axis representing the amount of image-capturing time that has elapsed is provided. In the graph display region, the history of the compression angles is time-sequentially displayed in real-time as a graph. Furthermore, the history of compression angles of the past may be scroll-displayed. Such graph display processing is carried out by the switching adder **114**. Images obtained by time-sequentially displaying the history of the compression angles in real-time may be referred to as compression direction images. By visually confirming a compression direction image, the time transition of the compression direction can be visually grasped.

FIG. **23** illustrates a configuration for generating an alarm in addition to the display configuration shown in FIG. **21**. For example, the diagnostic ultrasound system according to this embodiment includes alerting means provided as announcing means for generating an alert of at least one of an image and audio when the compression state evaluation data determined at the compression direction and range evaluation unit **115** is outside the set range. For example, the announcing means determines that the compression direction is inadequate when the angle of the compression direction determined at the compression direction and range evaluation unit **115** exceeds a set value. At this time, the alerting means generates, for example, an audio message, "the compression direction is inadequate," as shown in FIG. **23**. Furthermore, the alerting means may flash the arrow indicating the compression direction. The alerting means may change the color of the arrow indicating the compression direction, for example, form white to red. The alerting means may reverse the color of the arrow and the background. In other words, it is acceptable so long as the alerting means generates an alert that can be immediately recognized by the examiner. In this way, since the examiner will be able to quickly correct the compression operation in response to the alert, inadequate compression operation is carried out fewer times, and, thus, the diagnosis efficiency is improved even more. The alerting means may also generate an alert when the compression range is inadequate.

As described above, according to this embodiment, a diagnostic ultrasound system and a method of displaying an elasticity image that enables accurate diagnosis by objectively and quantitatively grasping the compression condition of

body tissue are provided. In other words, according to prior methods, non-uniformity in the stress distribution of body tissue is generated because both an adequate compression range and an inadequate compression range exist in the body tissue corresponding to the display range of an elasticity image. In such a case, since sometimes the inadequate compression range is displayed as a hard region, there is a possibility of diagnosing the tissue in the inadequate compression range as being false-positive. In this regard, according to this embodiment, an adequate compression range and a compression direction of body tissue can be estimated or detected at a predetermined point of time in real-time, and the adequate compression range and the compression direction can be reflected on an elasticity image. By visualizing the adequate compression range and the compression direction and providing them to the examiner as feedback, the examiner can objectively and quantitatively recognize the adequate compression range and the compression direction on the image. Therefore, the examiner can avoid the possibility of misdiagnosing the inadequate compression range as being positive. Moreover, regardless of the differences in the compression operation that depends on the procedures carried out by each examiner, an image diagnosis with assured objectivity and reproducibility becomes possible.

In essence, according to this embodiment, an elasticity image obtained under predetermined compression conditions is extracted on the basis of an objective criterion so as to efficiently carry out objective image diagnosis that does not rely on the examiner's object to be examinedivity. In other words, by providing an elasticity image that is simultaneously stored with information on the compression state, highly objective elasticity image diagnosis becomes possible. In this way, according to this embodiment, a clinically useful diagnostic ultrasound system can be provided.

As described with reference to FIGS. **1** to **23**, the method of displaying an elasticity image according to this embodiment includes a transmission and reception step of processing a reception signal output from the probe **100** after supplying a driving signal for transmission to the probe **100** that alternately converts ultrasonic waves and electrical signals; a determination step of obtaining compression data related to the compression state of body tissue of the object to be examined **10** on the basis of the reception signal output in the transmission and reception step and determining the adequate compression range or the compression direction of the body tissue on the basis of the compression data; and a display step of displaying an image reflecting the determination result to an elasticity image.

Here, a method of displaying an image by using the cine memory unit **117** according to this embodiment will be described. The cine memory unit **117**, shown in FIG. **1**, has functions of storing display image data output from the switching adder **114** in a memory, reading out current or past image data from the memory in response to a command from the system control interface unit **116**, and outputting the image data to the image display unit **107**. Furthermore, the cine memory unit **117** has a function of transferring the image data read out from the memory to a storage medium, such as an MO. Furthermore, the cine memory unit **117** has a function of carrying out processing for reading out image data or extracting optimal compression direction and range on the basis of the compression state evaluation data output from the compression direction and range evaluation unit **115**.

FIG. **24** illustrates a display configuration for describing the operation of the cine memory unit **117**. In this example, a point of time for image-capturing is assigned on the compression direction image shown in FIG. **22**, and the image data of the assigned point of time is read out and displayed. For example, in response to a command of the system control interface unit **116**, the diagnostic ultrasound system is frozen. The examiner assigns a predetermined point of time for image-capturing on the compression direction image by moving a graphical user interface (for example, an arrow), shown in FIG. **24**, via the system control interface unit **116**. The cine memory unit **117** reads out image data corresponding to the assigned point of time and displays the read out image data on the image display unit **107** as an ultrasound diagnosis image. The image data group stored in the cine memory unit **117** is related to the compression direction image on the same time axis. Here, the compression direction image is a time-sequential image of the history of the compression angles displayed in real-time. According to the configuration shown in FIG. **24**, since an elasticity image for when the compression direction is adequate can be quickly and accurately displayed, the diagnosis accuracy and the diagnosis efficiency are improved.

FIG. **25** illustrates a display configuration for describing another operation of the cine memory unit **117**. This example differs from the configuration shown in FIG. **24** in which one point of time for image-capturing is assigned, in that two points of time for image-capturing are assigned on the compression direction image and an image data group for between the first point of time for image-capturing and the second point of time for image-capturing is displayed in order. For example, the examiner assigns two points of time for image-capturing on the compression direction image by moving a graphical user interface (for example, two arrows), shown in FIG. **25**, via the system control interface unit **116**. The cine memory unit **117** reads out, in order, image data (f**1**) corresponding to the first assigned point of time to the image data (f**2**) corresponding to the last assigned point of time from the memory. Then, the cine memory unit **117** displays the time-sequential image data read out from the memory as ultrasound diagnosis image on the image display unit **107**. According to the configuration shown in FIG. **25**, since time-sequential images for when the compression direction is adequate can be quickly and accurately displayed, the diagnosis accuracy and the diagnosis efficiency are improved when diagnosing body tissue with body motion.

FIG. **26** illustrates a display configuration for describing another operation of the cine memory unit **117**. This example differs from the configurations shown in FIGS. **24** and **25** in that an image data group for when compression is carried out in an adequate compression direction is automatically detected and displayed. For example, the cine memory unit **117** automatically detects the first and last points of time for image-capturing of the period in which adequate compression is carried out on the basis of the compression angle output from the compression direction and range evaluation unit **115**, extracts an image data group corresponding to the detected period, and displays the image data group on the image display unit **107**. More specifically, as shown in FIG. **26**, the cine memory unit **117** automatically detects the image-capturing period in which the compression angle output from the compression direction and range evaluation unit **115** belongs to a set range with reference to zero. In other words, the cine memory unit **117** automatically detects an image-capturing period for, for example, when the compression angle is substantially orthogonal to the body surface of the object to be examined. Then, the cine memory unit **117** reads out an image data group corresponding to the period between the first point of time and the last point of time in the detected period and displays this on the image display unit **107**. According to the configuration shown in FIG. **26**, regardless of the differences in the examiners' experience, since an

adequate image-capturing period is set, the diagnosis accuracy and the diagnosis efficiency are improved.

The operation of the cine memory unit **117** has been described with reference to FIGS. **24** to **26**. However, instead of using a compression direction image when displaying an ultrasound diagnosis image, the values of the compression state evaluation data (for example, the adequate compression range and the compression direction) output from the compression direction and range evaluation unit **115** may be used. In the configuration shown in FIGS. **24** to **26**, the cine memory unit **117** can consecutively playback an image data group that is read out from the memory in a repeated loop and display it on the image display unit **107** in accordance with a command of the system control interface unit **116**. The cine memory unit **117** can transfer and store the image data group read out from the memory to and on a storage medium, such as an MO. The storage medium is internally or externally installed to the diagnostic ultrasound system.

The functions of the diagnostic ultrasound system according to this embodiment may be switched appropriately on the basis of commands output from the system control interface unit **116**. For example, the examiner can freely select, with the system control interface unit **116**, one set or a plurality of sets of information constituting image data representing the compression direction and range among the information representing the compression state (for example, the compression direction, the compression angle, and the compression range). Furthermore, the examiner can freely control, with the system control interface unit **116**, the selection of whether or not to display compression direction and range image data and the setting of the display angle range for a compression direction image and the time range of the compression angle history.

In the above, embodiments of a diagnostic ultrasound system employing the present invention was described. However, the diagnostic ultrasound system is not limited to the embodiments. The diagnostic ultrasound system according to the present invention can be employ various other configurations without deviating from the scope and the essential characteristics of the present invention. Therefore, the above-described embodiments are merely examples and are not to be understood as limitations. The scope of the present invention includes modifications and variations that belong to an equivalent scope.

As described above, according to this embodiment, a diagnostic ultrasound system and a method of displaying an elasticity image that enables a more accurate diagnosis by objectively and quantitatively grasping the compression state of body tissue can be provided.

The invention claimed is:

1. A diagnostic ultrasound system comprising:
an ultrasound transducer for transmitting and receiving ultrasound waves to and from an object to be examined;
transmitting means for supplying a driving signal to the ultrasound transducer;
receiving means for processing a reception signal output from the ultrasound transducer;
elasticity image imaging means for obtaining an elasticity image related to a body tissue of the object to be examined on the basis of a signal output from the receiving means; and
displaying means for displaying the elasticity image,
wherein the elasticity image imaging means includes compression state evaluating means for:
obtaining compression data related to a compression state of the body tissue of the object to be examined, and
determining that: a coordinate region with a magnitude of the compression data exceeding a threshold value is within an adequate compression range; and a coordinate region with a magnitude of the compression data not exceeding the threshold value is an inadequate compression range, wherein
at least one of the adequate compression ranges and at least one of the inadequate compression ranges are displayed on the elasticity image, with a border between the adequate compression range and the inadequate compression range.

2. A diagnostic ultrasound system comprising:
an ultrasound transducer for transmitting and receiving ultrasonic waves to and from an object to be examined;
transmitting means for supplying a driving signal to the ultrasound transducer;
receiving means for processing a reception signal output from the ultrasound transducer;
elasticity image imaging means for obtaining an elasticity image related to a body tissue of the object to be examined on the basis of a signal output from the receiving means; and
displaying means for displaying the elasticity image,
wherein the elasticity image imaging means includes compression state evaluating means for:
obtaining compression data related to a compression state of the body tissue of the object to be examined,
determining that: a coordinate region with a magnitude of the compression data exceeding a threshold value is within an adequate compression range; and a coordinate region with a magnitude of the compression data not exceeding the threshold value is an inadequate compression range, wherein at least one of the adequate compression ranges and at least one of the inadequate compression ranges are displayed on the elasticity image, with a border between the adequate compression range and the inadequate compression range,
determining a compression direction of the body tissue on the basis of a distribution of magnitude of the compression data, and
reflecting the compression direction on the elasticity image,
wherein the compression direction is represented by an angle of compression.

3. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means obtains elasticity data related to the body tissue and determined at the elasticity image imaging means as the compression data.

4. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means obtains detection values of a plurality of pressure sensors aligned on an ultrasound transmission and reception surface of the ultrasound transducer as the compression data.

5. The diagnostic ultrasound system according to claim **4**, wherein a plurality of the pressure sensors are aligned in a long axis direction of the ultrasound transmission and reception surface.

6. The diagnostic ultrasound system according to claim **4**, wherein the pressure sensors comprise a reference deforming body deformable by compression.

7. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means obtains a deformation value of a reference deforming body stacked on the ultrasound transmission and reception surface of the ultrasound transducer as the compression data.

8. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means obtains a

detection value of a position sensor attached to the ultrasound transducer as the compression data.

9. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means separates elasticity data of measurement points of the body tissue determined at the elasticity image imaging means into displacement vector components of a longitudinal direction corresponding to a depth direction of the object to be examined and displacement vector components of a lateral direction orthogonal to the depth direction, and determines the adequate compression range by comparing the magnitude of the displacement vector components of the longitudinal direction or the magnitude of the displacement vector components of the lateral direction with a set value.

10. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means separates elasticity data of measurement points of the body tissue determined at the elasticity image imaging means into displacement vector components of a longitudinal direction corresponding to a depth direction of the object to be examined and displacement vector components of a lateral direction orthogonal to the depth direction, and determines the compression direction on the basis of the distribution of the magnitude of the displacement vector components of the longitudinal direction or the distribution of the magnitude of the displacement vector components of the lateral direction.

11. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means generates image data representing the adequate compression range, and the displaying means displays the image data in a superimposing manner on or adjacent to the elasticity image.

12. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means generates image data or numerical data representing the compression direction, and the displaying means displays the image data or the numerical data in a superimposing manner on or adjacent to the elasticity image.

13. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means generates image data representing the border of the adequate compression range and the inadequate compression range, and the displaying means displays the image data in a superimposing manner on or adjacent to the elasticity image.

14. The diagnostic ultrasound system according to claim **1**, wherein the displaying means displays a region of interest whose size is changed on the basis of a determination result of the compression state evaluating means.

15. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means repeatedly determines the adequate compression range in set intervals, and the displaying means updates and displays image data representing the adequate compression range in real-time every time the determination result is updated.

16. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means updates and displays image data or numerical data representing the compression direction in real-time every time the determination result is updated.

17. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means generates image data of an arrow indicating the compression direction or numerical data representing the angle corresponding to the compression direction, and the displaying means displays an image corresponding to the image data or the numerical data in a superimposing manner on or adjacent to the elasticity image.

18. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means displays the time transition of the angle representing the compression direction on the basis of the determination result.

19. The diagnostic ultrasound system according to claim **1**, further comprising:

a cine memory for exacting and reading out at least one of the elasticity image stored in advance and image data or numerical data corresponding to the compression state on the basis of compression state evaluation data output from the compression state evaluating means.

20. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means displays the elasticity image for when the angle representing the compression direction is included in a set range with reference to zero.

21. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means repeatedly determines the compression direction in set intervals, and the displaying means time-sequentially displays the elasticity image group for when the angle representing the compression direction is included in a set range with reference to zero.

22. The diagnostic ultrasound system according to claim **1**, wherein the compression state evaluating means includes announcing means for generating an alert of at least one of an image and audio when the adequate compression range corresponding to outside a set range.

23. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means includes announcing means for generating an alert of at least one of an image and audio when the compression direction corresponding to outside a set range.

24. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means obtains elasticity data related to the body tissue and determined at the elasticity image imaging means as the compression data.

25. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means obtains detection values of a plurality of pressure sensors aligned on an ultrasound transmission and reception surface of the ultrasound transducer as the compression data.

26. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means obtains a deformation value of a reference deforming body stacked on the ultrasound transmission and reception surface of the ultrasound transducer as the compression data.

27. The diagnostic ultrasound system according to claim **2**, wherein the compression state evaluating means obtains a detection value of a position sensor attached to the ultrasound transducer as the compression data.

28. The diagnostic ultrasound system according to claim **2**, further comprising:

a cine memory for exacting and reading out at least one of the elasticity image stored in advance and image data or numerical data corresponding to the compression state on the basis of compression state evaluation data output from the compression state evaluating means.

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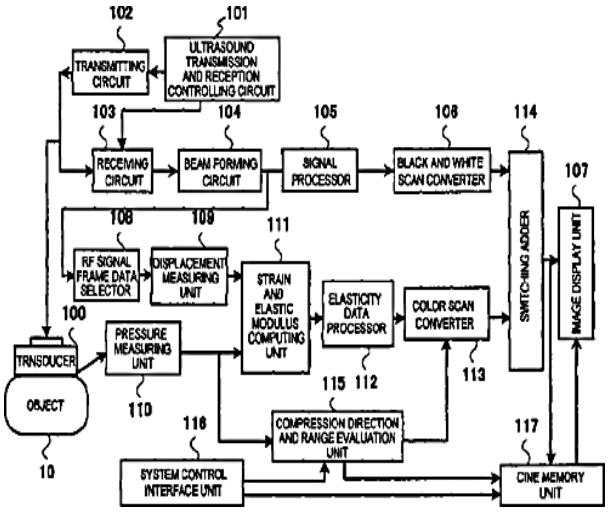
诊断超声系统包括用于向待检查对象10发送超声波和从待检查对象10接收超声波的超声波发送和接收系统，弹性图像捕获系统，用于在基础上捕获与待检查对象的身体组织相关的弹性图像。从超声波发射和接收系统输出的信号，以及用于捕获弹性图像的控制和显示系统。弹性图像捕获系统获得与待检查对象10的压缩状态有关的压缩数据，基于压缩数据确定身体组织的压缩状态，并且包括压缩方向和范围评估单元115作为压缩状态评估装置，用于将确定结果反映到弹性图像。以这种方式，通过客观地和定量地掌握身体组织的压缩状态，可以进行更准确的诊断。